मोतीलाल नेहरू राष्ट्रीय प्रौद्योगिकी संस्थान इलाहाबाद
प्रयागराज-211004 [भारत]
Motilal Nehru National Institute of Technology Allahabad
Prayagraj-211004 [India]

MINUTES

Minutes of the **Seventy-second (72nd) meeting** of the Senate held on **August 10, 2021 (Tuesday)** at **11.00 A.M.** through online mode on Microsoft Teams.

Following members of the Senate joined the meeting:

1.	Prof. Rajeev Tripathi, Director	–	Chairman
2.	Prof. M.M. Gore	–	Member
3.	Prof. Rakesh Narain	–	Member
4.	Prof. Anuj Jain	–	Member
5.	Prof. R. K. Singh	–	Member
6.	Prof. P. K. Dutta	–	Member
7.	Prof. Haranath Kar	–	Member
8.	Prof. P. P. Sahay	–	Member
9.	Prof. A. D. Bhatt	–	Member
10.	Prof. R. P. Tiwari	–	Member
11.	Prof. Anil Kumar Sachan	–	Member
12.	Prof. R. K. Tripathi	–	Member
13.	Prof. V. K. Srivastava	–	Member
14.	Prof. R. C. Vaishya	–	Member
15.	Prof. Ram Pal Singh	–	Member
16.	Prof. H. S. Goyal	–	Member
17.	Prof. Vijaya Bhadauria	–	Member
18.	Prof. Neeraj Tyagi	–	Member
19.	Prof. Ravi Prakash	–	Member
20.	Prof. Amit Dhawan	–	Member
21.	Prof. Shubhi Purwar	–	Member
22.	Prof. Shiv Dutt Kumar	–	Member

23.	Prof. S. S. Narvi	–	Member
24.	Prof. K. N. Pandey	–	Member
25.	Prof. R. K. Nagaria	–	Member
26.	Prof. P. K. Mehta	–	Member
27.	Prof. Ravi PrakashTewari	–	Member
28.	Prof. S. J. Pawar	–	Member
29.	Prof. Shivesh Sharma	–	Member
30.	Prof. Anjana Pandey	–	Member
31.	Prof. L. K. Mishra	–	Member
32.	Prof. Rakesh Kumar	–	Member
33.	Prof. Raj Mohan Singh	–	Member
34.	Prof. Anil Kumar Singh	–	Member
35.	Prof. D. K. Yadav	–	Member
36.	Prof. Paulson Samuel	–	Member
37.	Prof. Asheesh Kumar Singh	–	Member
38.	Prof. Rajesh Gupta	–	Member
39.	Prof. Richa Negi	–	Member
40.	Prof. Ram Awadh Mishra	–	Member
41.	Prof. Vijay Shankar Tripathi	–	Member
42.	Prof. Pankaj Srivastava	–	Member
43.	Prof. Mukul Shukla	–	Member
44.	Prof. Avanish Kumar Dubey	–	Member
45.	Prof. Rajeev Srivastava	–	Member
46.	Prof. M.K. Khurana	–	Member
47.	Prof. S. N. Pandey	–	Member
48.	Prof. Ganesh Pd. Sahu	–	Member
49.	Prof. Braj Bhushan	–	Member
50.	Prof. Madhu Dikshit	–	Member
51.	Dr. Sarvesh K. Tiwari, Registrar	–	Secretary

Special Invitees:

1. Dr. Ramesh Pandey , Head, Department of Applied Mechanics.
2. Dr. Vishnu Agarwal, Head, Department of Biotechnology.
3. Dr. Tamal Ghosh, Head, Department of Chemistry.
4. Dr. Sushil Kumar, Head, Department of Chemical Engineering
5. Dr. Ravindra Tripathi, Head, Humanities and Social Sciences
6. Dr. Mukesh Kumar, Department of Mathematics.
7. Dr. Naresh Kumar, Head, Department of Physics.
8. Dr. Tripti Singh, Head, School of Management Studies.

The following members/special invitee could not attend the meeting:

1.	Prof. Vinod Yadava	–	Member
2.	Prof. Geetika	–	Member
3.	Prof. A. K. Singh, CED	–	Member
4.	Prof. R. D. Gupta	–	Member
5.	Prof. R. S. Yadav	–	Member
6.	Prof. Sadhana Sachan	–	Member
7.	Prof. G. K. Mehrotra	–	Member
8.	Prof. D. S. Kushawaha	–	Member
9.	Prof. Nand Kishor	–	Member
10.	Prof. Tanuj Nandan	–	Member
11.	Prof. Jai Prakash Saini	–	Member

The Chairman, Senate extended a warm welcome to all the members and thanked them for taking their time out to join the meeting of the Senate in the online mode.

Agenda item-wise proceedings are as under:

Item No. 72.01 : To confirm the minutes of the Seventy-first (71st) meeting of the Senate held on June 04, 2021.

Resolution : The Senate considered the proposal of confirmation of the minutes of its Seventy-first (71st) meeting held on June 04, 2021 and after detailed deliberation resolved to confirm the minutes with the following modifications in respect of resolution on the following items:

(i) Resolution on item No. 71.05 , may now be **read as:**

"The Senate considered the nomination of Senate members to the Board of Governors of the Institute as its members in terms of the guidelines accepted by the Senate for nomination of two members vide resolution No. 70.07 (ii) of the Seventieth (70th) meeting of the Senate held on March 23, 2021.

The Senate, in consideration of the above, resolved to nominate one Professor and One Associate Professor of the Institute by seniority and consensus to act as members of the Board of Governors as nominee of the Senate, in terms of Section 11 (f) of the NITSER Act-2007.

Accordingly, the Senate resolved to nominate following faculty members as nominees of the Senate to the Board of Governors with consensus, next in the order of seniority to existing/previous members in respective cadres.

(i) Dr. Rakesh Narain, Professor, Department of Mechanical Engineering

(ii) Shri Rajesh Tripathi, Associate Professor, Department of Computer Science & Engineering.

The Senate was also apprised that the term of existing nominees of the Senate to the Board of Governors is coming to an end on 14.06.2021 and the next meeting of the Board of Governors is scheduled in the month of June, 2021. The Senate considering the above to resolved to confirm this resolution."

Item No. 72.02 : **To consider the action taken report on the decisions taken in the Seventy-first (71st) meeting of the Senate held on June 04, 2021.**

Resolution : The Senate noted the action taken by the Institute on the decisions taken in its the Seventy-first (71st) meeting held on June 04, 2021, as circulated.

Item No. 72.03 : **To note and ratify the approval accorded by the Chairman, Senate on the following matters:**

(a) Recommendations of the Ph.D. Oral Boards of different departments.

(b) Recommendations of the Standing Committee and Unfair Means Committee.

(c) Recommendations of the Chairman, SUGC.

(d) Recommendations of the Chairman, SMPC.

(e) Recommendations of the Chairman, SDPC.

Resolution : **(a)** The Senate confirmed and ratified the approval accorded by the Chairman, Senate on the recommendations of Ph.D. Oral Boards of following students of the Institute:

Sl. No.	Registration No.	Name	Department
1.	2017REL08	Ms. Ankita Srivastava	ECED
2.	2015RCE52	Mr. Saurabh Kumar	CED
3.	2015REE53	Mr. Chandra Sekhar Nalamati	EED
4.	2015RME12	Mr. Manish Dixit	MED
5.	2016REL06	Mr. Priyank Khare	ECED
6.	2017RMS04	Ms. Rosangpuii Hmar	SMS
7.	2015REL52	Mr. Vivek Rajpoot	ECED
8.	2014RBT54	Mr. Pramod Kumar Maurya	BTD
9.	2010RCS06	Mr. Vimal Kumar	CSED
10.	2015REL04	Mr. Amrish Kumar	ECED
11.	2010RCS53	Mr. Rohit	CSED
12.	2015RCL02	Mr. Avneesh Kumar Gehlaut	CHEM.
13.	2015RAM52	Mr. Jitendra Kumar	AMD
14.	2015REL13	Mr. Prateek Kishor Verma	ECED
15.	2017REL01	Ms. Richa Singh	ECED
16.	2016RCL51	Mr. Sanjay Singh	CHEM.
17.	2014REE01	Mr. Maloth Naresh	EED

(b) The Senate confirmed and ratified the approval accorded by the Chairman, Senate on the recommendations made by the Standing Committee on Urgent Academic Matters in its meetings held on 20.07.2021.

A copy of the approved minutes of the above meetings of the Standing Committee is placed at **ANNEXURE–I.**

(c) The Senate considered the approval accorded by the Chairman, Senate on the recommendations made by the SUGC the proposal of starting 2- UG programmes based on NEP-2020 by the AMD has already been accepted in-principle in previous Senate Meeting but department was advised to route it through DUGC and SUGC. DUGC and SUGC strongly recommended the proposal without any adverse remarks. Senate deliberated on the proposal of 2-UG programmes based on NEP-2020 thoroughly and reiterated once again that proposal has been accepted in-principle.

The Senate resolved to confirm and ratify the same.

A copy of the approved minutes is placed at **ANNEXURE-II.**

The Senate resolved to constitute a committee to examine feasibility of running both the programmes simultaneously or sequencialy i.e. one by one in subsequent years along with availability of infrastructure and other resources for running the programmes. The report of the committee be placed before the Senate in its next meeting.

(d) (i) The Senate considered the approval accorded by the Chairman, Senate on the recommendations made by the SMPC on revised Course Curriculum of 04 existing PG programme M.Tech. (Engineering Mechanics and Design, Fluids Engineering, Materials Science and Engineering, Biomedical Engineering) based on NEP-2020 of the Applied Mechanics Department with effect from academic session 2021-2022.

The Senate resolved to confirm and ratify the same.

A copy of the revised Course Curriculum of M.Tech. 2 years for 4 PG programme as approved by the Senate is enclosed as **ANNEXURE – III.**

(ii) The Senate confirmed and ratified the approval accorded by the Chairman, Senate on the recommendations made by the SMPC considered the suggestions of Head, Department of Computer Science and Engineering regarding renaming the M.Tech. (Software Engineering) programme as M.Tech. Computer Science and Engineering in (Artificial Intelligence & Data Sciences).

The Senate resolved to recommend the same to the Board of Governors for approval.

(e) The Senate confirmed and ratified the approval accorded by the Chairman, Senate on the recommendations made by the SDPC in its meeting held on 02.07.2021 & 14.6.2021.

A copy of the approved minutes of SDPC is placed at **ANNEXURE-IV.**

Item No. 72.04 : **To consider the list of degree recipients of B.Tech, M.Tech, MBA, MCA, M.Sc. and Ph.D. for the Eighteenth (18th) Annual Convocation of the Institute programme.**

Resolution : The Senate considered the list of degree recipients of B.Tech., M.Tech., MBA, MCA, M.Sc. and Ph.D. programmes to be conferred in the Eighteenth (18th) Annual Convocation-2021 of the Institute, and resolved to recommend the same to the Board of Governors for approval.

A summary of number of degree recipients for each programme is placed at **ANNEXURE-V.**

The Senate also recommends the reports of the Ph.D. Oral Board approved by Chairman, Senate, three days before date of Convocation will be considered for award of degree in the convocation.

Item No. 72.05 : **To consider the list of medal recipients of B.Tech, M.Tech, MBA, MCA and M.Sc. for the Eighteenth (18th) Annual Convocation of the Institute programme.**

Resolution : The Senate confirmed and ratified the approval accorded by the Chairman, Senate on the list of medal recipients of B.Tech., M.Tech., MBA, MCA and M.Sc. programmes to be awarded in Eighteenth (18^{th}) Annual Convocation-2021 of the Institute.

A list of medal recipients for various programmes as approved by Senate is placed at **ANNEXURE-VI**.

Item No. 72.06 : **To discuss the progress of implementation of National Education Policy (NEP) – 2020 in the Institute.**

(a) To discuss the teaching and Examination activities of the institute in regional language.

Resolution : (a) The Senate considered the proposal of Dean (Academic) to discuss the teaching and Examination activities of the institute in regional language as per National Education Policy (NEP) – 2020 in the Institute.

The Senate after deliberation resolved to accept the proposal for teaching B.Tech. first year students in Hindi medium and resolved that the one section may be created for students opting to get them taught in Hindi medium. The Senate also resolved the consent from the first year students will required to teach them in Hindi.

The Senate, further deliberated on the proposal of Prof. L. K. Mishra for starting a new course "Sanskrit for Engineers" and agreed to the same.

The Chairman Senate, advised, Prof. L. K. Mishra to prepare modalities along with course details. The Senate, further desired that the proposal with desired details be put up before the Senate in its next meeting.

Item No. 72.07 : **Any other matter with the permission of the Chair.**

The Senate confirmed and ratified the approval accorded by the Chairman, Senate on the recommendations made by the Standing Committee (Grade Discrepancy) on Urgent Academic Matters in its meeting held on 05.08.2021.

A copy of the approved minutes of the Standing Committee (Grade Discrepancy) is placed at **ANNEXURE–VII**

The meeting concluded with the vote of thanks to the Chair.

06/09/2021
(Sarvesh K. Tiwari)
Registrar / Secretary

Approved

06/09/21
(Rajeev Tripathi)
Director / Chairman

अधिष्ठाता (शैक्षिक) कार्यालय || Office of the Dean (Academic)
मोतीलाल नेहरू राष्ट्रीय प्रौद्योगिकी संस्थान इलाहाबाद, प्रयागराज – २११००४, उत्तर प्रदेश, भारत
Motilal Nehru National Institute of Technology Allahabad, Prayagraj – 211004, UP, INDIA

MINUTES

Minutes of the Senate Standing Committee meeting held on July 20, 2021 (Tuesday) at 04:00 p.m. in the chamber of Dean (Academic).

Following persons were present in the meeting:

1.	Prof. R. K. Singh, Dean (Academic)	–	Chairman
2.	Prof. Vinay Kumar Srivastava, ECED (Senate Nominee)	–	Member
3.	Prof. D. K. Yadav, Dean (Students Welfare) (Officiating)	–	Member
4.	Prof. A. K. Sachan, Chairman, SDPC & SUGC (Oftg.)	–	Member
5.	Prof. R. K. Nagaria, Chairman, SMPC	–	Member
6.	Dr. Mukesh Kumar, Head, Department of Mathematics	–	Special Invitee

The Chairman extended warm welcome to the members and special invitees and thanked them for taking their time out to attend the meeting.

Agenda item-wise proceedings are as under:

Item No. 01 : **To consider Academic Calendar for Session 2021-22.**

Resolution : The dates in the enclosed academic calendar are agreed upon and the academic calendar is recommended for approval.

Item No. 02 : **To discuss regarding Clarification on NET marks/score/percentile.**

Resolution : A request for the clarification regarding UGC NET scores and percentile calculations was raised by Head SMS, Head HSS and Chairperson GIS Cell for the calculation of Merit List components.

Head Mathematics, who was a special invitee remarked that each candidate who had appeared in NET Examination is in receipt of "Total Marks Obtained" in the examination.

Hence, it was decided that the concerned departments should enquire the individual candidate who have submitted the NET percentile scorecards only, regarding their "Total Marks Obtained" in NET Examination for the calculation of Merit List components.

The meeting concluded with the vote of thanks to the Chair.

20.07.2021
(R. K. Nagaria)
Chairman, SMPC

20/7/21
(A. K. Sachan)
Chairman, SDPC & SUGC (Oftg.)

20-07-2021
(V. K. Srivastava)
Professor, ECED

20/07/2021
(D. K. Yadav)
Dean (Students Welfare) (Oftg.)

20/07/2021
(R. K. Singh)
Dean (Academic)

P.T.O. →

In	Out
Date 23/7/2021	Date 24-7-21
Time 5.35 PM	Time 12:30
No. 1137...	

Director

The recommendation of Standup may kindly be approved.

23/07/2021

24/7/21

O

Pl. file.
& copy to the
Concerned sections

26/7

	Orientation Function
1	Start of Classes+
2	
3	
4	
5	
	Independence Day
6	Start of Classes*
7	
8	
	Muharram
9	
	Submission of Home Assignment 1 / Quiz 1
10	
11	
12	
13	
14	
	Submission of Home Assignment 2 / Quiz 2
	Janmashtami

S	4		Submission of Home Assignment 3 / Quiz 3
S	5		
M	6	19	
T	7	20	Display of List of Registered Students
W	8	21	
T	9	22	
F	10	23	
S	11		Submission of Home Assignment 4 / Quiz 4
S	12		
M	13	24	
T	14	25	
W	15	26	
T	16	27	
F	17	28	
S	18		Submission of Home Assignment 5 / Quiz 5
S	19		
M	20	29	
T	21	30	
W	22	31	
T	23	32	First Short Attendance Notification
F	24	33	
S	25		Submission of Home Assignment 6 / Quiz 6
S	26		
M	27	34	
T	28	35	
W	29	36	
T	30	37	

M	4	39		
T	5	38		
W	6	39		
T	7	40		
F	8	41	Submission of Home Assignment 8 / Quiz 8	
S	9		Mid-Sem Break Starts	1
S	10			2
M	11			3
T	12			4
W	13			5
T	14			6
F	15		*Dussehra*	7
S	16			8
S	17		Mid-Sem Break Ends	9
M	18	42		
T	19		*Id-e-Milad*	
W	20	43		
T	21	44		
F	22	45		
S	23		Submission of Home Assignment 9 / Quiz 9	
S	24			
M	25	46		
T	26	47		
W	27	48		
T	28	49	Avishkar + Gnosiomania	
F	29	50		
S	30			

T	4		*Diwali*
F	5	54	
S	6		
S	7		
M	8	55	
T	9	56	
W	10	57	
T	11	58	
F	12	59	
S	13		Submission of Home Assignment 10 / Quiz 10
S	14		
M	15	60	
T	16	61	Practical Examinations Starts
W	17	62	
T	18	63	
F	19		*Guru Nanak Jayanti*
S	20		
S	21		
M	22	64	
T	23	65	
W	24	66	
T	25	67	
F	26	68	
S	27		
S	28		
M	29	69	
T	30	70	Practical Examinations Ends

S	4	
S	5	
M	6	
T	7	
W	8	
T	9	
F	10	
S	11	
S	12	
M	13	
T	14	End Semste Examination E
W	15	
T	16	
F	17	
S	18	Submission of C
S	19	
M	20	
T	21	Online Registr Starts
W	22	
T	23	Declaration of R
F	24	Winter Break S
S	25	*X-Mas*
S	26	
M	27	
T	28	
W	29	
T	30	

S	5		Submission of Home Assignment 3 / Quiz 3	S	5				T	5	49		T	5	66		S	5		5	T	5	
S	6			S	6				W	6	50		F	6	67		M	6		6	W	6	
M	7	23		M	7				T	7	51		S	7			T	7		7	T	7	
T	8	24		T	8				F	8	52		S	8			W	8		8	F	8	
W	9	25		W	9				S	9		Submission of Home Assignment 9 / Quiz 9	M	9	68		T	9	Submission of Grades	9	S	9	
T	10	26		T	10		Mid Semester Examination Ends		S	10			T	10	69		F	10		10	S	10	
F	11	27		F	11		Mid-Sem Break Starts	1	M	11	53		W	11	70		S	11		11	M	11	Supplementary Examination Ends
S	12		Submission of Home Assignment 4 / Quiz 4	S	12			2	T	12	54		T	12	71		S	12		12	T	12	
S	13			S	13			3	W	13	55		F	13	72	Practical Examinations Ends End of Classes	M	13		13	W	13	
M	14	28		M	14			4	T	14		*Mahavir Jayanti*	S	14			T	14		14	T	14	
T	15	29		T	15			5	F	15		*Good Friday*	S	15			W	15	Declaration of Results	15	F	15	
W	16	30	First Short Attendance Notification	W	16			6	S	16		Culray	M	16		*Buddha Purnima*	T	16		16	S	16	Submission of Supplementary Grades
T	17	31		T	17			7	S	17			T	17		End Semester Starts	F	17		17	S	17	
F	18	32		F	18		*Holi*	8	M	18			W	18			S	18		18	M	18	
S	19		Submission of Home Assignment 5 / Quiz 5	S	19			9	T	19	56		T	19			S	19		19	T	19	
S	20			S	20		Mid-Sem Break Ends	10	W	20	57		F	20			M	20	Online Registration Starts	20	W	20	Declaration of Supplementary Results
M	21	33		M	21	38			T	21	58		S	21			T	21		21	T	21	
T	22	34		T	22	39			F	22	59	Second Short Attendance Notification	S	22			W	22	Supplementary Registration Starts	22	F	22	
W	23	35		W	23	40			S	23		Submission of Home Assignment 10 / Quiz 10	M	23			T	23		23	S	23	
T	24	36		T	24	41			S	24			T	24			F	24		24	S	24	
F	25	37		F	25	42			M	25	60		W	25			S	25		25	M	25	
S	26		Submission of Home Assignment 6 / Quiz 6	S	26		Submission of Home Assignment 7 / Quiz 7		T	26	61		T	26			S	26		26	T	26	
S	27			S	27				W	27	62		F	27			M	27	Supplementary Registration Ends	27	W	27	
M	28		Mid Semester Examination Starts	M	28	43			T	28	63		S	28			T	28		28	T	28	
				T	29	44			F	29	64	Practical Examinations Starts	S	29			W	29		29	F	29	Online Registration Ends
				W	30	45			S	30			M	30			T	30		30	S	30	
				T	31	46							T	31		End Semester Ends					S	31	Summer Break Ends

…, if possible and permitted, shall be announced later.

The dates of assignment and quizzes are indicative only and can be changed.

…ne Classes

ANNEXURE–II

02/07/2021

डॉ0 रमेश पाण्डेय
विभागाध्यक्ष

प्रयुक्त यांत्रिकी विभाग
मोतीलाल नेहरू राष्ट्रीय प्रौद्योगिकी संस्थान इलाहाबाद
प्रयागराज–211004 (उ0प्र0), भारत
Department of Applied Mechanics
Motilal Nehru National Institute of Technology Allahabad
Prayagraj-211004 (U.P.) India

पत्रांक सं0 635/प्र0यां0वि0/संचिका सं0 191/2021–22 दिनांक: 01 जुलाई, 2021

श्रीमान अध्यक्ष,
विद्या परिषद स्नातक समिति (एस0यू0जी0सी0)

विषय: विभाग में दो स्नातक कार्यक्रम के शुरूआत करने के संदर्भ में।

महोदय,

आपको यह अवगत कराना है कि दिनांक 01 जुलाई 2021 को विभागीय स्नातक कार्यक्रम समिति की संगोष्ठी अपराह्न 12:45 बजे आनलाइन एम0एस0 टीम प्लेटफार्म पर आहूत की गयी। जिसमें विभागीय अकादमिक बोर्ड से अनुमोदित दो प्रस्तावित स्नातक कार्यक्रम के बारे में विचार विमर्श किया गया। इस संगोष्ठी का कार्यवृत्त तथा दोनो प्रस्तावित स्नातक कार्यक्रम इस पत्र के साथ संलग्नित करके आपके अवलोकनार्थ एवम् अनुमोदनार्थ हेतु आपको प्रेषित है।

रमेश पाण्डेय 01/07/21
(रमेश पाण्डेय)
विभागाध्यक्ष

संलग्नक: 1. विभागीय स्नातक कार्यक्रम समिति संगोष्ठी की सूचना।
2. दिनांक 06 मार्च 2021 को संपन्न विभागीय अकादमिक बोर्ड संगोष्ठी का अनुमोदित कार्यवृत्त।
3. विभागीय स्नातक कार्यक्रम समिति का कार्यवृत्त।
4. आपके द्वारा अनुमोदित विभागीय स्नातक कार्यक्रम समिति की छायाप्रति।
5. विभागीय स्नातक कार्यक्रम समिति संगोष्ठी के दौरान उपस्थित संकाय सदस्यों की उपस्थिती।

SUGC
meeting
20/7/21

MNNIT WEBMAIL

Head Applied Mechanics Department <hamd@mnnit.ac.in>

Fwd: Gentle Memory Recall: DUGC and DMPC meetings_ scheduled on July 01, 2021at 12.45 pm and 01.15 pm

1 message

Head AMD <hamd@mnnit.ac.in>
To: amdf <amdf@mnnit.ac.in>

Thu, Jul 1, 2021 at 12:09 AM

---------- Forwarded message ---------
From: Head AMD <hamd@mnnit.ac.in>
Date: Mon, Jun 28, 2021, 2:51 PM
Subject: DUGC and DMPC meetings_ scheduled on July 01, 2021at 12.45 pm and 01.15 pm
To: amdf <amdf@mnnit.ac.in>

Dear Colleagues,

As per suggestion of Chairman Board of Academics (BoAc) and Dean (Academic), a DUGC meeting is called on July 01, 2021 at 12.45 pm to discuss about the two new proposed UG programmes based on NEP-2020, followed by a DMPC meeting on the same day at 01.15 pm to discuss about the revision of course curriculum of running four PG programmes of the department in accordence with resolutions made in Board of Academics (BoAc) meeting held in March 2021. All the Programme coordinators are requested to incorporate the resolutions in the course content of the programmes and complete all other requirements as per NEP-2020 and send me the final Doc as well as PDF files latest by June 30, 2021.

Thanks and Regards

Minutes of the Meeting of Board of Academics held on March 06, 2021

A meeting of Board of Academics (BoAc) was convened on March 06, 2021 at 10.00 a.m. through MS Teams on-line platform by the Head, Applied Mechanics Department in the Chairmanship of Prof. R. S. Singh, Dean (Academic Affairs). All the members of BoAc attended the meeting along with other faculty members of the department as special invitee. The agenda items of the meeting were as follows:

1. Discussion and approval of two UG Programme based on NEP-2020:

i) B.Tech. in Materials Science and Engineering.

ii) B.Tech. in Engineering and Computational Mechanics.

2. Revision of Course curriculum of running four PG Programmes of the department.

Programme of B.Tech. in Materials Science and Engineering was presented by Dr. Abhishek Kumar and B.Tech. in Engineering and Computational Mechanics was presented by Dr. Ashutosh Kumar Upadhyay. Revision of course curriculum of PG programmes were presented by Programme Coordinators Dr. V. Murari (M.Tech. - Engineering Mechanics and Design), Dr. A. R. Paul (M.Tech. - Fluids Engineering), Prof. S. J. Pawar (M.Tech. - Material Science and Engineering) & Prof. R. P. Tewari (M.Tech. - Biomedical Engineering) respectively. Minutes of proposed UG programmes were compiled and presented by Dr. R. Sujithra, Convener DUGC and minutes of revision of course curriculum of running PG programmes were compiled and presented by Dr. Ashutosh Mishra, Convener DMPC immediately after the commencements of respective programme presentations to incorporate each and every remark of distinguished expert members in totality in the same spirit in which it was expressed. Swapping of courses from one semester to another, proposing some more vibrant and demand driven courses as electives, changes in course contents, change in name of the Programmes etc. were suggested by the distinguished expert members. All the programmes updated after incorporating the expert suggestions have been attached herewith for your kind perusal and further necessary direction. Resolutions needs to be taken into account in due course of time are as follows:

(i) Industrial exposure needs to be enhanced as compared to allocated only in 6th semester at present. Industrial exposure/summer training may be incorporated after IVth semester also.

(ii) Lab component needs to be enhanced to meet the mandate of NEP-2020 which will enhance the skill development and hands on experience of the students.

(iii) Elective courses on Patent, IPR, Entrepreneurship needs to be included at the Institute level.

(iv) MOU can be signed between the Department of Applied Mechanics at IIT Madras, Chennai and MNNIT Allahabad, Prayagraj to promote final year UG and PG students for attending courses and research activities. Furthermore, the students may be extended facility of direct admission in Ph. D programme without separate entrance examinations.

(v) Courses needs to be designed and placed based on the current employability scenario and industrial needs of the country.

(vi) NITs and IITs have to plan on the proposal for the change in GATE syllabus to account for the new introduced interdisciplinary courses.

(vii). Institute needs to think on promoting the students for higher studies in Institute itself based on their CGPA.

As per the suggestion B.Tech Materials Science & Engg name changed to B.Tech Materials Engineering.

(viii) Students needs to be exposed to Biomechanics open software like Open-Sim to understand various protocols.

R. Kalaph	C. Lakshmana Rao	Sunil Mohan	S. Vengadesan	Neelesh Kumar
Chairman	Ext. Member	Ext. Member	Ext. Member	Ext. Member
Anuj Jain	R. P. Tewari	S. J. Pawar	Abhishek Kumar	Vivek Kumar Patel
Member	Member	Member	Member	Member

Ramesh Pandey
Convenor & Head

Through mail.

[illegible] Gentle Memory Recall: Minutes of the Board of Academics (BoAc) meeting _ March 06, 2021

[illegible]

Head Applied Mechanics Department [illegible]

Gentle Memory Recall: Minutes of the Board of Academics (BoAc) meeting _ March 06, 2021

[illegible] messages

Head AMD [illegible]
To: Lakshmana Rao C [illegible], Dr S Mohan [illegible], [illegible], Venkatesan S [illegible], NEELESH KUMAR [illegible]

Fri, Mar 26, 2021 at [illegible] AM

---------- Forwarded message ---------
From: Head AMD [illegible]
Date: Sun 21 Mar, 2021, 10:50 PM
Subject: Minutes of the Board of Academics (BoAc) meeting _ March 06, 2021
To: Dean Academic [illegible], Dean Academic [illegible], Venkatesan S [illegible], Dr S Mohan [illegible], Lakshmana Rao C [illegible], [illegible], Anuj Jain Asst. Prof. AMD FACULTY [illegible], NEELESH KUMAR [illegible], Abhishek Kumar FACULTY [illegible], R.P. Tewari [illegible], S.J. Pawar FACULTY [illegible]
Cc: [illegible] FACULTY [illegible], Rajeev Tripathi FACULTY [illegible]

Respected Sir,

Wishing you a Happy Holi in advance and convey my heartiest greetings for the same.

I wish to convey my heartiest thanks for your kind participation and remarkable observations in introducing two new UG programmes and industry-oriented, need-based revision of course curriculum of five running PG programmes of the department. Your valuable inputs have enriched the academic programmes of the department. I extend my warm welcome for strengthening the bond between us and our institutions/organizations in near future in the same spirit as was expressed by you all in meeting of Board of Academics (BoAc). Your valuable suggestions and observations immediately implementable have already been incorporated by the programme coordinators to the best possible. Your suggestions and observations requiring involvement of other academic/constitutional bodies of the institute are presented in the form of "*Minutes of the BoAc meeting held on March 06, 2021*" and may be implemented sooner or later. Kindly find attached herewith modified and updated programmes of the department with detailed course curriculum for your kind perusal and suggestions (if any).

You are kindly requested to convey your consent for "Minutes of the BoAc meeting agreed in principle", with or without your valuable observations through your reply mail at your earliest possible.

Waiting and Anticipating for your green signal and remarks (if any).

Please feel free to enquire your query, if any.

Thanks and Extreme Regards

[illegible] II Ramesh Pandey
[illegible]
[illegible] II Department of Applied Mechanics
मोतीलाल नेहरू राष्ट्रीय प्रौद्योगिकी संस्थान इलाहाबाद
Motilal Nehru National Institute of Technology Allahabad

[illegible], (उत्तर प्रदेश), भारत II Prayagraj - 211004 (Uttar Pradesh), INDIA
दूरभाष नंबर: [illegible] II Phone No. 0532-2271200
इलेक्ट्रॉनिक पता: [illegible] II Email ID: [illegible]

7 attachments

- Course Curriculum_B.Tech.(Honours)_ECM.pdf
  1259K
- Course Curriculum_B.Tech._Materials Engineering.pdf
  1458K
- Updated Curriculum_EMD.pdf
  302K
- Updated Curriculum_FE.pdf
  1051K
- Updated Curriculum_MSE.pdf
  1507K
- Updated Curriculum_BME.pdf
  1254K
- Minutes of the BoAc meeting_March 06, 2021.pdf
  502K

Dr S Mohan [illegible]
To: Head AMD [illegible]

Fri, Mar 26, 2021 at [illegible] AM

I agree

NEELESH KUMAR [illegible]
To: [illegible]

Fri, Mar 26, 2021 at [illegible] AM

Dear Sir

Congratulations on conducting a fruitful BoAc meeting and thank you for sharing the minutes of the meeting.
I convey my consent to the attached minutes of the BoAc meeting.
I have also seen the updated course curriculum for M.Tech Biomedical Engineering. The highlighted modifications are accepted to me.

With Best Regards
Neelesh

Lakshminarayan Rao C <[illegible]>
To: Head NMD <[illegible]>

Sun, Mar 28, 2021 at 6:26 PM

Dear Prof. Ramesh Pandey,
Greetings.
I have gone through the minutes of the meeting. I am happy to note that most of the points that were discussed in the meeting are reflected in the minutes.

I give my full consent to the minutes of the meeting as stated.

Wishing you all a happy HOLI.
With best regards,
-Lakshminarayan Rao

Minutes of the DUGC Meeting held on July 01, 2021 at 12.45 pm through MS Team online platform

A DUGC meeting was called on July 01, 2021 at 12.45 pm through MS Team on-line platform to freeze the course curriculum of two new proposed UG programmes, B.Tech. in Materials Engineering & B.Tech. in Engineering and Computational Mechanics, based on NEP-2020. All the DUGC faculty members attended the meeting.

Head apprised the members about new proposed UG programmes of the department, "B.Tech. in Materials Engineering & B.Tech. in Engineering and Computational Mechanics", based on NEP-2020 which are brought in the DUGC meeting after incorporating the valuable suggestions of Board of Academics (BoAc) meeting of the department (Approved Minutes of BoAc attached herewith for ready reference) held on March 06, 2021 through MS Teams on-line platform. DUGC members appreciated the efforts of Programme Coordinators, Dr. Abhishek Kumar, Dr. Ashutosh Kumar Upadhyay and contributions of all other faculty members of the department in this hectic and marvelous work. DUGC members found the documents in order and recommended for further processing with their well wishes for its earliest implementation.

1-7-2021

R. Sujithra
(Convener, DUGC)

11/09/2020

प्रयुक्त यांत्रिकी विभाग
मोतीलाल नेहरू राष्ट्रीय प्रौद्योगिकी संस्थान इलाहाबाद
प्रयागराज–211004 (उ0प्र0), भारत
Department of Applied Mechanics
Motilal Nehru National Institute of Technology Allahabad
Prayagraj-211004 (U.P.) India

डॉ0 रमेश पाण्डेय
विभागाध्यक्ष

पत्रांक सं0 119 / प्र0यां0वि0 / संचिका सं0 191 / 2020–21 दिनांक: 11 सितम्बर, 2020

15-9-20

श्रीमान अध्यक्ष
प्रबन्धकारणी स्नातक समिति (एस0यू0जी0सी0)

महोदय, विभाग की स्नातक समिति के सदस्यों की संशोधित सूची आपके अवलोकनार्थ, रिकार्ड एवम् अनुमोदनार्थ नीचे वर्णित है:

विभागीय स्नातक समिति (Departmental Undergraduate Committee)

➢ विभागाध्यक्ष	पदेन सदस्य
➢ डॉ0 आर0 सुजीथ्रा	समन्वयक
➢ डॉ0 आशुतोष कुमार मिश्रा	सदस्य एवम् समन्वयक (विभागीय परास्नातक कार्यक्रम समिति)
➢ डॉ0 आर0 के0 पटेल	बाह्य सदस्य (यांत्रिकी अभियांत्रिकी विभाग)
➢ प्रो0 रवि प्रकाश तिवारी	सदस्य
➢ प्रो0 सुर्याप्पा जयप्पा पवार	सदस्य
➢ डॉ0 अजय भारती	सदस्य
➢ डॉ0 वी0 मुरारी	सदस्य
➢ डॉ0 अनुभव रावत	सदस्य
➢ श्री प्रशांत भाई पटेल (20173058)	छात्र प्रतिनिधि प्रथम (स्नातक अंतिम वर्ष यांत्रिकी अभियांत्रिकी)
➢ सुश्री जागृति अग्रवाल (20171070)	छात्र प्रतिनिधि द्वितीय (स्नातक अंतिम वर्ष जानपदीय अभियांत्रिकी)

Chairman (SUPC)

Please find herewith the modified list of the members of the Departmental Under Graduate Committee for your kind information, record and necessary approval please,

Departmental Under Graduate Committee (DUGC)

Head	Ex. Officio (Chairman)
Dr. R. Sujithra	Convener
Dr. Ashutosh Kumar Mishra	Member & Convener (DMPC)
Dr. R. K. Patel	External Member (Department of Mechanical Engineering)
Prof. Ravi Prakash Tewari	Member
Prof. Suryappa Jayappa Pawar	Member
Dr. Ajaya Bharti	Member
Dr. V. Murari	Member
Dr. Anubhav Rawat	Member
Mr. Prashant Bhai Patel (20173058)	Students Representative I (B.Tech. Final Year, Mechanical Engineering)
Mrs. Jagriti Agarwal (20171070)	Students Representative II (B.Tech. Final Year, Civil Engineering)

Approved

/09/2020

संयोजक (डीयूजीसी) / संचिका

रमेश पाण्डेय
11/09/2020

11/09/20

Full Name	User Actior	Timestamp
Ramesh Pandey	Joined	7/1/2021, 12:42:44 PM
R. Sujithra	Joined	7/1/2021, 12:44:02 PM
Anubhav Rawat	Joined	7/1/2021, 12:45:03 PM
AjayBharti	Joined	7/1/2021, 12:45:31 PM
Rabindra KumarPatel	Joined	7/1/2021, 12:48:50 PM
R.P. Tiwari	Joined	7/1/2021, 12:50:06 PM
R.P. Tiwari	Left	7/1/2021, 12:51:09 PM
R.P. Tiwari	Joined	7/1/2021, 12:52:08 PM
R.P. Tiwari	Left	7/1/2021, 12:53:10 PM
R.P. Tiwari	Joined	7/1/2021, 12:55:32 PM
V. Murari	Joined	7/1/2021, 12:50:14 PM
V. Murari	Left	7/1/2021, 12:50:17 PM
V. Murari	Joined	7/1/2021, 12:52:43 PM
S.J.Pawar	Joined	7/1/2021, 12:50:27 PM
S.J.Pawar	Left	7/1/2021, 12:50:42 PM
S.J.Pawar	Joined	7/1/2021, 12:52:46 PM
S.J.Pawar	Left	7/1/2021, 12:53:02 PM
Ashutosh Mishra	Joined	7/1/2021, 12:51:14 PM
Ashutosh Mishra	Left	7/1/2021, 12:52:19 PM

Bachelor of Technology

in

Engineering and Computational Mechanics

Course Structure, Scheme of Evaluation and Syllabi

Department of Applied Mechanics

Motilal Nehru National Institute of Technology Allahabad

Prayagraj-211004, U.P., India

VISION AND MISSION OF THE INSTITUTE

VISION

To attain a distinct identity for the Institute through technology innovation, knowledge creation and dissemination for the benefit of the society.

MISSION

- To nurture an echo system for continuous enhancement of value based teaching and learning process in the emerging areas of technology.
- To train quality human and knowledge resources in the service of society.
- To develop sustainable products and technologies.

VISION AND MISSION OF THE DEPARTMENT

VISION

To establish itself as a department recognized for its quality post graduate education and research in the broad field of Applied Mechanics and Materials.

MISSION

- To produce high quality human resource in the area of Applied Mechanics and Materials Engineering by way of continuous up gradation of curriculum, improvement in academic processes & ambience, and faculty & infrastructure development.
- To create knowledge resource through research in emerging areas of Applied Mechanics and Materials in collaboration with national & international academic, research and industrial organizations and disseminate the same by contributing and conducting STTP, Workshops, Symposiums and Conferences.

Introduction

The Department of Applied Mechanics was established in 1965. It was initially named as "Department of Applied Mechanics, Hydraulic and Hydraulic Machines", which was replaced by the name "Applied Mechanics Department" at the beginning of this century.

Presently, in addition to offering the Engineering Mechanics course to all the B.Tech first year students, the Department also offers a number of fundamental UG courses for supporting different B.Tech Programme of other departments, like Civil, Mechanical, Production & Industrial Engineering, Chemical Engineering etc. Such UG courses being offered by the department include those of Strength of Materials, Fluid Mechanics, Hydraulic Machines, Structural Analysis, Material Science and Engineering, Kinematics of Mechanics, Dynamics of Machines etc.

The department offers four Post Graduate (M.Tech.) Programmes, namely on: (i) Engineering Mechanics and Design (ii) Material Science & Engineering (iii) Fluids Engineering and (iv) Biomedical Engineering. The department also offers Ph.D. Programmes in the areas relevant to the its PG courses.

To provide the experimental knowledge and hands on training to the students, the department have a number of UG and PG labs. The UG labs include the Engineering Mechanics Lab, Strength of Materials Lab, Structural Analysis Lab, Materials Science & Engineering Lab, Kinematics of

Machines Lab, Fluid Mechanics & Hydraulic Machines Lab etc. The PG Labs of the Department include Experimental Solid Mechanics Lab, Fluids Engineering Lab, Materials Synthesis Lab and Biomedical Engineering Lab. In addition, the Department also has a common Computational Lab, for supporting all the M.Tech Programmes. The department has established research labs for each programme and a computational research laboratory with server and more than 20 high end workstations to cater the needs of research scholars.

All the UG and PG courses of the department are presently being handled by twenty faculty members having specialisations in wide range of areas related to solid and fluid mechanics, biomedical and materials engineering. The faculty members of the department belong to diverse areas / specializations, including Composites and Advanced Materials, Smart materials and Structures, Inflatable structures, Vibration, Damage & Fracture Mechanics, Impact and Energy absorbing structures, multi scale modelling and textile structures Aero-Structures, Aerodynamics, CFD, Propulsion, Multiphase flow, Fluid Structure interaction Heat transfer, Compressible flow, Bone Adaptation, Bone Fracture Healing, Computational Biomechanics, Biofluid Dynamics, Mechanobiology, Poromechanics, Material modelling etc. This diversity is useful for handling the multifaceted courses being offered by the department and gives a unique identity to this department. This also helps in promoting interdisciplinary research within the department and also within the institute in a larger context.

Introducing the Undergraduate Degree Programme

The inherent interdisciplinary nature of the department does not allow to start the established undergraduate level engineering courses but the advancement in technological domain in past few decades have created a demand for engineers and technologists having capability to work in multidisciplinary teams and new fields of energy, environment, biology, medicine etc. It is important to note that the faculty members of this department already inherits knowledge in a number of such courses by virtue of the diverse background of the faculty members of this department. The students should be guided by their interest and passion to a secured foundation for a successful career. The Engineering and Computational Mechanics course has been designed to prepare the students to follow their passion and face the challenges successfully and develop the entrepreneur and leadership skills due to multi disciplinary facet of the programme. The students will go through a set of fundamental and core engineering modules in the first two years that will provide a strong background in the engineering, science, materials, mathematics and computing. A portion of the curriculum is contains the non-engineering modules in areas of basic sciences and Humanities and Social sciences as well.

Engineering and Computational Mechanics shall be the discipline devoted to the solution of real life problems through integrated application of mathematical, scientific, and engineering principles. Special emphasis is placed on the physical principles underlying modern engineering design. The program derives its strength from rigorous treatments of Solid and Fluid Mechanics. These topics form the basis all the mechanical and bio sciences and have wide applicability in modern engineering. Students will also develop a strong background in mathematics and physics along with the extended knowledge domain in core engineering courses. Special emphasis is placed on the application of rapidly emerging field of machine learning and artificial intelligence in mechanics. Laboratory experiments in fluid mechanics and mechanics of materials complement an integrated design sequence.

Keeping NEP-2020 in mind, the certificate, diploma and UG degree courses are designed. While the UG exit course in third year provide the background to students to work in industry in highly competitive multidisciplinary environment, the honours programmes are intended to equip our graduates with the knowledge to function effectively in research and development organizations and shape their tomorrow as successful researcher.

Unique Features of the Programme

1. Focus on fundamentals as well as exposing the students to basic aspects of Electrical, Electronics and Computer Science and Engineering subjects which will improve their experimental and computational skills.
2. Introducing the emerging areas in mechanics such as bio-mechanics, smart materials, Machine learning, Artificial intelligence, Soft computing and Genetic algorithm through essential and elective subjects.
3. Exposing students to latest computational techniques e.g. FEM and CFD
4. Exposing students to fundamental and latest techniques in experiments and its importance for model validation.

Objective of the Programme

Prepare the young minds to analyse complex interdisciplinary phenomena and venture into cutting edge research through computation, analysis and experimentation.

Degree on Offer and Annual Intake

B. Tech/ B. Tech (Honours) in Engineering and Computational Mechanics from Department of Applied Mechanics : 30 students through JEE (Mains)

Programme Requirements and Course Structure

The classified list of essential, core and elective courses of the programme along with Humanities (HSS) and Extracurricular (SA) details are given below. The lecture, tutorial and practical (L-T-P) hours per week and the credits corresponding to each course are also given.

Semester wise Credit distribution

Semester	EE	CES	CEL	HSS	SA	IT/GP	MR/HN	Total Sem credits
I	17	4	0	3	0	0	0	24
II	7	14	0	2	1	0	0	24
III	4	18	0	3	2	0	0	27
IV	0	21	0	3	2	0	0	26
V	0	8	12	3	0	1	0	24
VI	0	7	9	2	0	2	0	20
VII	0	0	0	0	0	0	20	20
VIII	0	0	0	0	0	12	0	12
Total	28	72	21	16	5	15	20	177
BS							145	
BTECH							177	

Component wise Subject Distribution

Humanities and Social Sciences (HSS)		Engineering (Graduate) Essentials - EE	
Communication Skills and Technical Writing	3	Engineering Physics	4
Environment and Ecology	2	Engineering Graphics	2
Economics for Engineers	3	Mathematics	4
Engineering Ethics, IPR and Entrepreneurship	3	Biology for Engineers	3
Organisational Behaviour and Psychology	3	Engineering Chemistry	4
Indian Art and Culture	2	Workshop Technology	3
		Computer Programming	4
		Applied Computational Methods	4

Core Essential (Major) - CES		Core Elective (Major) - CEL	
		V Semester (Any 4)	
Engineering Mechanics	4	Structural Mechanics	4
Basic Electrical Engineering and Measurement	4	Engineering Vibrations	4
Fluids Mechanics	3	Characterization of Materials	4
Basic Electronics and Instrumentation	4	Smart Materials and Structures	4
Material Science and Engineering	4	Compressible Flow and Computations	4
Mechanics of Solids	4	Advanced Heat Transfer	4
Thermodynamics and Heat Transfer	3	Experimental Methods	4
Principles of Engineering Design	3	Aerodynamics	4
Dynamics of Mechanical Systems	3		
Data structures and Operating Systems	4		
Advanced Mechanics of Solids	4	VI Semester (Any 4)	
Advanced Fluids Mechanics	4		
Anatomy and Physiology	3	Basic Control Theory	3
Data Sciences and Machine Learning	4	Robotics	3
Engineering Analysis and Design	3	Mechatronic Systems	3
Continuum Mechanics and Constitutive Modelling	3	Soft Computing	3
Finite Element Methods	4	Genetic Algorithm	3
Analysis of Algorithms	4	Optimization Techniques	3
Computational Fluid Dynamics	4	Mathematics for Geometrical Modelling	3
Artificial Intelligence	3	Product Design and Development	3

Specializations for Honours*

Honours in Solid Mechanics		Honours in Biomedical Engineering	
CES	Theory of Elasticity	CES	Advanced Biomechanics
CES	Theory of Stability	CES	Biomedical Instrumentation
CES	Theory of Plates and Shells	CES	Biofluid Dynamics
CES	Micromechanics	CES	Biomaterials
CEL	Engineering Plasticity	CEL	Biomedical Signal Processing and Analysis
CEL	Fracture Mechanics	CEL	Design, Innovation and Entrepreneurship in Biomedical Engineering
CEL	Impact Mechanics	CEL	Medical Imaging and Diagnostics
CEL	Continuum Damage Mechanics	CEL	Biomimetics
CEL	Multiscale Modelling	CEL	Orthopaedic Biomechanics
CEL	Mechanics of Composite Materials	CEL	Sports Biomechanics

Honours in Fluid Mechanics			
CES	Turbulence Modelling	CEL	Design of Pipe Networks
CES	Boundary Layer Theory	CEL	Particle Technology
CES	Multiphase Flow	CEL	Design of Heat Exchangers
CES	Fluid Structure Interaction	CEL	Design of Hydraulic Turbines
CEL	Design of impeller pumps	CEL	Design and Selection of Power plant Equipment

Minor: Engineering Mechanics

Course Code	Course Name	L	T	P	C
CES	Bio-Mechanics	3	0	2	4
CES	Experimental Methods	3	0	0	3
CES	Principles of Engineering Design	3	0	0	3
CES	Dynamics of Mechanical Systems	3	0	0	3
CEL	Engineering Mechanics	3	0	2	4
CEL	Mechanics of Solids	3	0	2	4
CEL	Engineering Analysis and Design	3	0	0	3
CEL	Mechanics of Fluids	3	0	2	4

**Subjects shown for minors/honours is tentative with maximum 32 credits possible. Student shall be allowed to choose any minor/honours course offered in the institute including current subject area of BTech or through SWAYAM etc. Following may be considered in the design of minors/Honours: (1) Honours for the students of same BTech courses (e.g. CS students opting for minor in CS) - Subjects at advanced level/PG level can be offered and Should be named as HONOURS (2) Minor for the students of other courses can be kept at the diploma level or the subjects offered up to 4th semester i.e diploma level as per NEP 2020. (e.g. Minor in CS for ME/EE/ECE etc students, may contain the subjects offered to CS students up to 4th semester)*

Scheme of Evaluation

Semester I						
Course Code	Domain	Course Name	L	T	P	C
PHXXXXX	EE	Engineering Physics	3	0	2	4
CYXXXXX	EE	Engineering Chemistry	3	0	2	4
MEXXXXX	EE	Engineering Graphics	1	0	2	2
MAXXXXX	EE	Mathematics	3	1	0	4
BTXXXXX	EE	Biology for Engineers	3	0	0	3
AMXXXXX	CES	Engineering Mechanics	3	0	2	4
HSXXXXX	HSS	Communication Skills and Technical Writing	2	0	2	3
Total Hours	29		18	1	10	24

Semester II						
Course Code	Domain	Course Name	L	T	P	C
MEXXXXX	EE	Workshop Technology	1	0	3	3
CSXXXXX	EE	Computer Programming	3	0	2	4
ECXXXXX	CES	Basic Electronics and Instrumentation	3	0	2	4
EEXXXXX	CES	Basic Electrical Engineering and Measurement	3	0	2	4
AMXXXXX	CES	Fluids Mechanics	3	0	0	3
AMXXXXX	CES	Dynamics of Mechanical Systems	3	0	0	3
CEXXXXX	HSS	Environment and Ecology	2	0	0	2
SAXXXXX	SA	NCC/NSS/SPORTS	0	0	2	1
Total Hours	29		18	0	11	24

Semester III						
Course Code		Course Name	L	T	P	C
AMXXXX	EE	Applied Computational Methods	3	0	2	4
AMXXXXX	CES	Mechanics of Solids	3	0	2	4
AMXXXXX	CES	Thermodynamics and Heat Transfer	3	0	0	3
AMXXXXX	CES	Material Science and Engineering	3	0	2	4
CSXXXXX	CES	Data structures and Operating Systems	3	0	2	4
AMXXXXX	CES	Principles of Engineering Design	3	0	0	3
SAXXXXX	SA	Language Course/Club activities	1	0	2	2
HSXXXXX	HSS	Economics for Engineers	3	0	0	3
Total Hours	32		22	0	10	27

Semester IV						
Course Code		Course Name	L	T	P	C
AMXXXXX	CES	Advanced Mechanics of Solids	3	1	0	4
AMXXXXX	CES	Advanced Fluids Mechanics	3	0	2	4
BTXXXXX	CES	Anatomy and Physiology	3	0	0	3
AMXXXXX	CES	Data Sciences and Machine Learning	3	0	2	4
AMXXXXX	CES	Engineering Analysis and Design	3	0	0	3
AMXXXXX	CES	Continuum Mechanics and Constitutive Modelling	3	0	0	3
SAXXXXX	SA	Language Course (French/German etc)	1	0	2	2
HSXXXXX	HSS	Engineering Ethics, IPR and Entrepreneurship	3	0	0	3
Total Hours	29		22	1	6	26

4 Weeks Industrial Training (Total 3 Credits): Independent project in Semester V and VI on the basis of this training

Semester V						
Course Code		Course Name	L	T	P	C
AMXXXXX	IT/GP	Independent Project-I	0	0	2	1
AMXXXXX	CES	Finite Element Methods	3	0	2	4
CSXXXXX	CES	Analysis of Algorithms	3	0	2	4
AMXXXXX	CEL		4	0	0	4
AMXXXXX	CEL		4	0	0	4
AMXXXXX	CEL		4	0	0	4
HSXXXXX	HSS	Organisational Behaviour and Psychology	3	0	0	3
Total Hours	**27**		**21**	**0**	**6**	**24**

Semester VI						
Course Code		Course Name	L	T	P	C
AMXXXXX	IT/GP	Independent Project–II	0	0	4	2
AMXXXXX	CES	Computational Fluid Dynamics	3	0	2	4
AMXXXXX	CES	Artificial Intelligence	3	0	0	3
	CEL		3	0	0	3
	CEL		3	0	0	3
	CEL		3	0	0	3
HSXXXXX	HSS	Indian Art and Culture	2	0	0	2
Total Hours	**23**		**17**	**0**	**6**	**20**

4 Weeks Industrial Training (SSSS) : Minimum 2S required otherwise to be repeated in the summer after VIII Semester

Semester VII						
Course Code		Course Name	L	T	P	C
ANYXXXX	MR/HN	SUBJECTS AS PER MR/HN	20 Credits			

Semester VIII						
Course Code		Course Name	L	T	P	C
AMXXXXX	IT/GP	Industrial Training/Major Project	12 Credits			

Syllabus

Engineering Physics (3-0-2-4)

Physical Optics: Interference: Condition of observing interference, Production of interference fringes and determination of wavelength using Fresnel's Biprism. Stoke's treatment, Interference due to thin films. Wedge shaped films. Newton's rings.

Polarization: Unpolarised, Polarized and partially polarized lights, Polarization by reflection. Double refraction by uniaxial crystals, Nicol prism, Polaroid's, Huygens's theory of double refraction. Half wave and quarter wave plates, Analysis of plane, elliptical and circularly polarized light. Optical activity. Fresnel's theory of optical rotation, Specific rotation, Biquartz and Laurent half-shade polarimeters.

Electrostatics: Gradient, Divergence and curl operations, Gauss divergence theorem and Stoke's theorem, Gauss law in electrostatics and its applications, Poisons and Laplace equations.

Magnetostatics: Biot-Savart's law, Magnetic field of a steady current, Magnetic field due to circular loop at axial points. Working of Helm-holtz galvanometer, Ampere's law and its applications, Force on a charged particle in electric and magnetic fields, Magnetic vector potential.

Electrodynamics and Electromagnetic waves: Faradays' law of electromagnetic induction, Self and mutual inductance, Energy in Magnetic field, Energy of a solenoid, Displacement current, Maxwell's equations (integral and differential forms) in free space, Plane wave solution, Propagation of electromagnetic waves in free space, Poynting's theorem.

Quantum Mechanics: Failure of classical concepts, Wave particle duality, Wave packets, Phase and group velocity, Heisenberg's uncertainty principle and its applications, Wave function and its physical interpretation, Probabilities and Normalization, Time independent and dependent Schrodinger wave equation and its simple applications.

Engineering Chemistry (3-0-2-4)

Chemical Bonding: Lonic Bonding and Covalent Bonding, Valence Bond and Molecular orbital theories of bonding, Bonding in Metals, semiconductors and insulators, Imperfections in solids.

Polymers: Classifications of polymers, types of polymerization and their principles, structure-property relationship, polymer materials of industrial importance, biopolymers.

Water Chemistry: sources and nature of impurities, characteristics of natural water, water treatment processes, municipal supplied water.

Fuels: classification, calorific values, analysis of solid fuels, liquid fuels and its properties, refining, cracking and reforming of petroleum, knocking and octane and cetane rating, anti-knocking agents.

Corrosion: Theories of corrosion, types of corrosion, its prevention and control.

Green Chemistry: Introduction to green chemistry and its importance.

Lubricants: Definition, functions, mechanism and classifications of lubricants, properties of testing of lubricants.

Phase Rule: Derivation of phase rules and its application to one component water system.

Adsorption: Definition and classification of adsorption, adsorption of gases on solids, adsorption from solution, application of adsorption, theories of adsorption.

Engineering Graphics (1-0-2-2)

Fundamentals Drawing standard - BIS, dimensioning, lettering, type of lines, scaling- conventions. Geometrical constructions: Dividing a given straight line into any number of equal parts, bisecting a given angle, drawing a regular polygon given one side, special methods of constructing a pentagon and hexagon – conic sections – ellipse – parabola – hyperbola - cycloid – trochoid. Orthographic projection: Introduction to orthographic projection, drawing orthographic views of objects from their isometric views - Orthographic projections of points lying in four quadrants, Orthographic projection of lines parallel and inclined to one or both planes Orthographic projection of planes inclined to one or both planes. Projections of simple solids - axis perpendicular to HP, axis perpendicular to VP and axis inclined to one or both planes. Sectioning of solids: Section planes perpendicular to one plane and parallel or inclined to other plane. Intersection of surfaces: Intersection of cylinder & cylinder, intersection of cylinder & cone, and intersection of prisms. Development of surfaces: Development of prisms, pyramids and cylindrical & conical surfaces. Isometric and perspective projection: Isometric projection and isometric views of different planes and simple solids, introduction to perspective projection. Computer aided drafting Introduction to computer aided drafting package to make 2-D drawings.

Mathematics (3-1-0-4)

Function of Several Variables: limit, Continuity ($\varepsilon - \delta$ definition) and Differentiability, Partial Differentiation, Homogeneous function-Euler's theorem, change of variables, Jacobian, Taylor's theorem for function of several variables. Extreme of functions of multi-variables, saddle points, Lagrange method of undetermined multipliers.

Integral Calculus: Multiple integrals (Double & Triple integral), change of order of integration, Area of bounded region, arc length of curve, volume and surface area of solid revolution, multiple integral by change of variables, Dirichlet integrals, Moment of inertia, center of gravity.

Vector Calculus: Gradient, Directional derivatives, Divergence and Curl, line integral and Green's theorem, surface and volume integrals, Gauss, Stoke's theorems and their applications.

Ordinary Differential Equation: Existence and Uniqueness of solution of First order ODE, Exact Differential Equation, solution of Linear Differential Equation, Higher order Linear Differential Equation, Solution of Homogenous and Non-homogeneous ODE (CF+PI), Variation of parameters, Undetermined coefficients, Power series method, System of linear simultaneous ODE.

Partial Different Equation: First order PDE, Formation of PDE, Classification of solution: Complete, General and Particular solution, Lagrange's PDE, Non-linear First order PDE, Some Standard form-I, II, III, IV, Charpit's method, Higher Order Homogeneous linear PDE constant coefficient, C, F, & P, I, Non homogeneous PDE with constant coefficients, C, F, & P.I.

Linear Algebra and Matrices: Vector spaces, Subspaces, Linear dependence and independence, Basis and dimension, Dimension theorem, Linear Transformation, Rank-Nulity Theorem (Statement only), Computation of Rank and nullity of LT, Solution of linear simultaneous algebraic equations.

Eigen Values and Eigen Vectors: Eigen values and Eigen vectors, Cayley-Hamilton theorem, Application of Eigen Values and Eigen Vectors: Quadratic form, Diagonalization, Canonical forms and Solving system of first order differential equations.

Biology for Engineers (3-0-0-3)

Darwinian evaluation & molecular perspective; Introduction to phylogeny – Classification systems in biology and relationships; Cellular assemblies – From single cell to multi-cellular organisms: Geometry, Structure ad

Energetics; Comparing natural vs. Human made machines; infection, disease and evolution – synergy and antagonism; Immunology -- An example of permutations and combinations in biology; Cancer biology- Control and regulation; Stem Cell- Degeneracy in biological systems; Engineering designs inspired by biology -- Micro to Macro - scales. Laboratory: Bio safety; Buffers in biology -- Measuring micro litres, Preparation of standard biological buffers, response of cells and plant tissues in different buffering conditions; Observing cell surface and intracellular contents using light and fluorescence microscopy, measuring cellular motions using real-time video microscopy; Measuring and visualizing intracellular molecular components – Proteins and Genomic DNA.

Introductory Biomechanics: Basics concepts of Force Moments and Torque Equilibrium, analysis of systems in equilibrium. Skeletal joints, Skeletal muscle. Mechanics of the elbow, shoulder, Spinal column, Hip, Knee and ankle. Basic assumptions and limitations.

Engineering Mechanics (3-0-2-4)

Review of Force, moment and Couple, Equilibrium of rigid bodies, Centroid and Moment of Inertia, Beams - Shear force and Bending moment diagrams, Trusses, Friction, Virtual Work and stability, Planar Kinematics and Kinetics of rigid bodies.

Communication Skills and Technical Writing (2-0-2-3)

Remedial English Grammar: Common Errors, Articles, Pronouns, Adjectives, Use of Adjectives, Prepositions, Subject-Verb Agreement, Vocabulary building & Comprehensive exercises.

Technical Writing: English usage, when English is a foreign language, Reading a draft, Writing a draft, revising a draft, Writing a technical talk, presenting the technical talk,

Communication theory: Definition of communication, good and effective communication, barriers and filter, exercise, body language, activity on body language, non-verbal behavior interpretation, listening skills: active and passive listening, activity on listening skills, feedback mechanism: giving and receiving feedback activity.

Dealing with feelings: Activity on how to deal with feeling and complex feeling, assertiveness activity, developing assertiveness, activity, self-confidence, quiz on self-confidence, strategies for developing confidence.

The Team concept: Element of Teamwork, activity, effective team, essential building blocks of effective team, team player styles, group discussion: structured and unstructured discussions, strategies for improving decisions, presentation technique.

Business communication: Business communication, writing business letters and applications, minutes and memorandum, resuming writing.

Corporate grooming: Appearing for interview, corporate dressing and grooming, dining etiquette, communication media etiquette, ethics, exercise on ethical dilemmas, exercise on mock Interview.

Workshop Technology (1-0-3-3)

Casting processes: Element of Green Sand Mould; Method of Preparation of Green Sand Mould; Casting Defects

Metalworking processes: Classification of Metalworking processes-brief introduction of bulk and Sheet metal processes, Hot Vs Cold Working; Hot and Cold Rolling; Types of Rolling Mills, Hot and Cold Forging, Hot and Cold Extrusion, Cold Drawing

Machining processes: Classification of Machining processes & machine tools; Construction, Specification and working of Lathe Machine and Drilling Machine; Study about Facing, Turning, parting, Grooving, Threading and Knurling, and Drilling and other hole related operations

Fabrication processes: Classification of welding Operations, types of Joints & welding Positions; Brief description of Arc, Resistance and Gas welding techniques. Brazing and Soldering

Brief Introduction of Newer Machining Processes: Such as EDM, ECM, USM, and LAB, Modern trends in Manufacturing-Automation, Concept of CAD, CAM and CIM.

Computer Programming (3-0-2-4)

Introduction, LINUX commands, editors, Files & Directories, Design of algorithms, Writing a simple program: Learning the form of a C program, Declaring variables, Designing program flow and control, using standard terminal I/O functions, Fundamental Data types and storages classes, Operators and Expression Conditional Program Execution Loops and iteration, Introduction to Abstraction, Functions, Arrays, Pointers, Structures, Introduction to Object Oriented Programming concepts, Classes and Objects, Important C++ constructs, The standard C/C++ preprocessor, The standard C/C++ library.

Basic Electronics and Instrumentation (3-0-2-4)

Diodes-Introduction to pn diode and its applications as rectifier, rectifier as DC Power Supply, Clamper, Clipper, Voltage multiplier etc., Zener diode and its applications as regulator, Tunnel diode and Varactor diode

Transistors-Review of Transistor working, characteristics & its parameters, Transistor as an amplifier, Biasing of bipolar junction transistors, h-parameters & transistor equivalent circuits, small signal single-stage amplifier, frequency response, concept of feedback.

JFET and MOSFET-Basic construction, working, concept of pinch-off, characteristics of JFET, MOSFET (Enhancement and Depletion), FET as a voltage variable resistor

Operational amplifier-Ideal & non-ideal characteristics, concept of summing junction and virtual ground. Application of operational amplifier as: Adder, Subtractor, Differentiator, Integrator, Multiplier, Unity gain amplifier & Logarithmic amplifier

Introduction to Digital Electronics-Review of number systems, complements, codes, Boolean algebra, Logic gates, Minterm and Maxterms, Canonical and Standard forms, Logic functions & Logic circuits. Minimization of Boolean functions using K-map.

Measuring Instruments-Working of Cathode Ray Oscilloscope, Power supply, Multimeter and Function generator.

Basic Electrical Engineering and Measurement (3-0-2-4)

D.C. Network Theory-Circuit Theory Concepts – Mesh and Node Analysis; Network Theorems; Super-position, Thevenin, Norton and Max. Power Transfer Theorem, Star – Delta Transformation.

Steady State Analysis of AC Circuits- Sinusoidal and Phasor Representation of Voltage and Current, Single Phase AC circuit behaviour of R, L & C, Combination of R, L & C in series and parallel, Resonance, Bandwidth and Quality Factor

Three-Phase A.C. Circuits-Line and phase voltage/current relationships for star and delta connection, Power measurement in 3-phase A.C. circuits. Measuring Instruments: Construction & Principle of operation of voltage and current measuring instruments, Introduction to Wattmeter and Energy Meters.

Magnetic Circuits and Transformer: - Magnetic Circuits, Principle of Operation & Construction of 1 ϕ transformer, Phasor diagram, Equivalent Circuit, O.C. and S.C. test, Efficiency and voltage Regulation

Introduction to Rotating Machines: Principle of Electromagnetic Energy Conversion; Types of d.c. machines, emf equation, magnetization and load characteristics, losses and efficiency of d.c. machines, Starting and speed control of d.c. motors, 3- ϕ induction motors - working principle and applications, 1- ϕ induction motor -working principle and applications, Stepper motors.

Power Systems-Generation- Types of power Plant, Functional Block diagram of Generating stations (Hydel & Thermal Stations); Transmission- Standards (AC & DC), Substations, Grids; Distribution- Industrial, Commercial and Domestic Standards; Utilization- Types of loads, UPS and domestic inverters; Domestic Wiring- Materials, accessories & ratings of the wiring materials, types of wiring: fluorescent tube and simple domestic wiring layout, earthing rules.

Fluids Mechanics (3-0-0-3)

Introduction - scope and relevance; Method of analysis - system vs control volumes - differential vs integral approach, Units and dimensions; Fluid properties - continuum, density, viscosity, surface tension, velocity, pressure, temperature; Fluid Statics - Hydrostatics, Fluid forces on planes and curved surfaces, submerged and floating bodies, Buoyancy and stability, Atmosphere as a fluid; Fluid Concepts - Streamlines, streaklines, pathlines, viscous vs inviscid flows, laminar vs turbulent flows, compressible vs incompressible flows; Engineering bernoulli equation; Control Volume analysis: Basic laws - Mass conservation law, thermodynamic laws, Newton's laws, Angular-Momentum principle; Buckingham Pi-theorem; Similitude and modeling - scaling effects; Flows in a pipes and channels - friction factor, flow measurement devices - Venturi meter, Orifice meter.

Dynamics of Mechanical Systems (3-0-0-3)

Introduction to Variational Calculus, Energy methods, D'Alembert's principle, Euler-Lagrange equations of motion, Hamilton's principle, Rotating coordinate systems, Review of dynamics, Euler angles, Euler's equations of rotation, Gyroscopic Motion and stability of aircrafts and vehicles; Kinematic, Static and

Dynamic analysis of planar mechanisms, Cams and Gears, Balancing of rotating and reciprocating masses, Introduction to Multibody Dynamics.

Environment and Ecology (2-0-0-2)

Introduction- Introduction and scope, Indian Scenerio of Natural Resources, Conservation of natural resources.

Ecosystem- Ecosystem and its basic concept, Structure and function of an ecosystem, Food chains, food webs and ecological pyramids, Ecological succession.

Biodiversity- Biodiversity and its conservation, types of biodiversity, Hot spots and threats to biodiversity, National and global scenario, Biodiversity conservation.

Environmental Pollution- Environmental Pollution: Air pollution, Water pollution, Soil pollution, Marine pollution, Noise pollution, Thermal pollution and Nuclear hazards.

Social Issue- Sustainable development, Environmental ethics: Issues and possible solutions, Climate change, global warming, acid rain, ozone layer depletion, nuclear accidents, Wasteland reclamation. Environmental Laws- Environmental laws/Acts, EPA.Act.1986, Water Act. etc.

Applied Computational Methods (3-0-2-4)

Review: Error and its propagation, Eigenvalues and Eigenvectors - Direct and Iterative solvers. Partial Differential Equations (PDEs) - Hyperbolic, Parabolic and Elliptic PDEs, nonlinear PDEs.

Nonlinear Equations: Motivation, Open and bracketing method, Bisection, Fixed point, Newton's method, Secant and False position method, Rate of convergence, Merits and demerits of methods.

Interpolation: Lagrange, Newton divided difference formula, Newton's interpolations, and errors in interpolation. Approximation: least square and uniform approximations.

Differentiation: differentiation using interpolation formulas. Integration using Interpolation: Newton-Cotes formulas, Gauss quadrature rules. Ordinary differential equations: Taylor, Euler and Runge-Kutta methods.

Numerical Integration: Motivation, Newton-Kotes method, Trapezoidal rule, Simpson's rule, Rhomberg integration, Gauss Quadrature, Initial Value Problem: Motivation, Euler's method, Modified Euler method, Runge-Kutta methods, Adaptive Integrations and multistep methods. Boundary-value and Eigen-value Problem: Methods and Applications in Mechanics.

Statistical Computations-Frequency Chart, Regression Analysis, Least Square fit, Polynomial fit, Linear and Nonlinear Regression, Multiple Regression, Statistical Quality Control Methods.

Mechanics of Solids (3-0-2-4)

Concept of stress and strain, Normal and direct shear stresses and strains, Stresses on inclined planes, Cauchy's stress theorem, Stress at a point, Strain-displacement relations, Small displacement theory, Compatibility conditions, Stress and Strain transformation, Principal stresses and strains, Mohr's circle, Constitutive equations, Strain Measurements, Pure bending - Bending and shear stresses in beams, Deflection of beams, Thin walled Shells, Torsion of circular shafts, Springs, Failure theories.

Thermodynamics and Heat Transfer (3-0-0-3)

Basic concepts and definitions -- system-boundary, equilibrium, steady state and others. Thermodynamic properties of a pure substance -- saturated and other states. Work and heat – definition and applications. 1st Law -- internal energy and enthalpy, applications to non-flow/closed and flow/open systems (SSSF and USUF). 2nd Law -- corollaries, Clausius inequality, entropy. Carnot cycle. Basics of gas-vapor mixtures. Vapor power cycles -- Rankine cycle and its modifications. Steam generation and its use – power plants, co-generation, combined cycles. Introduction to transport phenomena: various modes of transport of momentum and energy - diffusion and advective transport. Modes of heat transfer in various applications. Conduction: Heat diffusion equation, 1-D steady state conduction in extended surfaces, infinite and semi-infinite walls, heat generation, lumped capacitance. Convection: Forced and free convection - mass, momentum and energy conservation equations, non-dimensional numbers, hydrodynamic and thermal boundary layers, basics of heat transfer in external and internal laminar and turbulent flows, and use of co-relations. Radiation: properties, Laws, 3-surface network for diffuse-gray surfaces. Familiarization with heat exchangers.

Material Science and Engineering (3-0-2-4)

Introduction- Historical perspective of Materials Science, Structure and properties relationship of Engineering Materials, Classification of materials, Advanced Materials, Nano-materials.

Structure of Solids and Characterization of Materials- Introduction to crystal structures and systems, Metallic structures, Ceramic crystal structures, Crystallographic directions and planes, Miller indices, Density computations, Crystallography, Diffraction methods, Electron microscopy, Metallography, Thermal characterization techniques.

Imperfections in Solids- Point defects, Dislocations, Interfacial Defects, Bulk defects.

Diffusion- Diffusion mechanisms, steady and non-steady state diffusion, Factors that influence diffusion, Law's of diffusion, Applications of Diffusion.

Phase Diagrams and Phase Transformations- Unary, Binary, Equilibrium phase diagrams, Eutectic, Eutectoid, Peritectic and peritectoid reactions, Microstructure and property changes in iron-carbon system, Iron-Carbon (Fe-C or Fe-Fe3C) Diagram, Transformation rate effects and TTT diagrams, Heat treatment of steels.

Mechanical Behaviour of Materials- Elastic and plastic properties, Creep, Fatigue, Fracture.

Ceramic Materials- Ceramic types, Properties, Processing Application, Advanced ceramics

Composites- Introduction, Applications, Particle reinforced composites, Fiber reinforced composites, Structural composites.

Electrical and Magnetic Properties- Electrical conduction theories, Semi conductivity, Super conductivity, Dielectric behaviour, Ferroelectricity, Piezoelectricity, Types of magnetism, Influence of temperature on magnetic behaviour, Domains and hysteresis.

Corrosion and its Prevention- Mechanism of oxidation, Oxidation resistant materials, Principles of corrosion and protection against corrosion.

Economic, Environmental and Social Issues of Material Usage- Economic considerations, Environmental and societal considerations, Recycling issues, Life cycle analysis and its use in design.

Data structures and Operating Systems (3-0-2-4)

Basic Computer Architecture, Function and structure of Hardware and Software Components, CPU, ALU, Memory, I/O devices, System Software, Application Software.

Introduction, Motivation, and Overview of an Operating System with an emphasis on its role as a Manager of Hardware Resources, History of Computer Hardware (including a review of H/W structures) and how Operating Systems Evolved in tandem with the Hardware.

Programming software (Writing software), Program and Process, Program specifications and design, Abstract data types, Basics of C, Time and space complexity of Programs.

Need of Data Structures, Linear and nonlinear Data structure, Stack, Queue, Tree, Graph, B-tree

Processor and Memory Management, Process Management, Concurrent Process, Semaphores, Fork and Join, CPU Scheduling including Preemptive, and Non- Preemptive, Application of Stack and Queue, Sequential and linked implementation, In designing program for CPU and Disk scheduling, Page Tables, Page Replacement Algorithms.

Principles of Engineering Design (3-0-0-3)

Uncertainties: Introduction with examples relevant to different disciplines in science and engineering, Traditional design philosophies: factor of safety approach, partial safety factor approaches, Probability and statistics as tools for uncertainty quantification. Stochastic models for loads and structure capacities. Design philosophies.

Economics for Engineers (3-0-0-3)

Engineering Economics: Introduction to Engineering Economics – Fundamental concepts – Time value of money – Cash flow and Time Diagrams – Choosing between alternative investment proposals – Methods of Economic analysis. The effect of borrowing on investment- Various concepts of National Income – Significance of National Income estimation and its limitations, Inflation –Definition – Process and Theories of Inflation and measures to control, New Economic Policy 1991 – Impact on industry. Accountancy: Accounting Principles, Procedure – Double entry system – Journal – Ledger, Trail Balance – Cash Book – Preparation of Trading, Profit and Loss Account – Balance sheet. Cost Accounting – Introduction – Classification of costs – Methods of costing – Techniques of costing – Cost sheet and preparation of cost sheet- Breakeven Analysis – Meaning and its application, Limitations.

Advanced Mechanics of Solids (3-1-0-4)

Elastic and Inelastic buckling of Columns, Torsion of noncircular shafts, Membrane analogy, Torsion of thin-walled tubes, Inelastic material behavior – Yielding of Ductile metals, Unsymmetrical bending, Shear center, Curved beams, Axisymmetrically loaded members – and Rotating discs, Energy methods, Theory of Photoelasticity.

Advanced Fluids Mechanics (3-0-2-4)

Differential analysis to fluid flow: Conservation of Mass - Coordinate systems, Kinematics - Translation, Rotation, Deformation, derivation of Governing equations of fluid flows - continuity, Euler equations, Potential flows - Bernoulli equation and applications to external aerodynamics, Navier-Stokes equations, Non-dimensional analysis; Exact solutions of Navier-Stokes equations; Internal flows; External flows - Prandtl's Boundary layer theory - flow over a flat plate, concept of similarity; Approximate methods - von Karman Integral analysis; (Thwaites method); Flow separation; Brief introduction to turbulence - characteristics of turbulence, drag crisis

Anatomy and Physiology (3-0-0-3)

Introduction to Human Body: Human as Biological Organism, levels of the organization of human body, homeostasis, Anatomical position and terminology, Body regions and Body cavities.

Cell Structure and Function: Cells and Their Structure, Replication, Transcription and Translation, Mitosis and meiosis, Cellular Communication. Nature of cancer cells, Transport of ions through cell membrane, Resting and action potentials.

Tissues: Epithelial tissue, Connective Tissue, Muscle Tissue, Nervous Tissue.

Integumentary System: Function of the Integumentary System, Structure of the Skin, Physiology of the Skin.

Skeletal System: Structure and Function of Bone, Bone formation, Bones of the axial skeleton, Bone of the appendicular skeleton, Articulations.

Muscle Tissues mode of contraction: Microscopic and macroscopic structure of muscle, mode of muscle contraction.

Muscular System: Muscle terminology, muscle of axial and appendicular skeleton.

Nervous System: Anatomy of Central Nervous System, Peripheral and Autonomic Nervous system, Neuron, Physiology of Nerve conduction, Synapse and Synaptic Transmission. Brain, Blood brain barrier, neurotransmitter and Spinal cord, Cranial nerves, spinal nerves and Reflex arc.

Sensory Organs: Taste, smell, Structure and Function of Eye, structure and Function of ear.

Endocrine System: Hormones, Negative and Positive Feedback Endocrine gland and their secretions.

Cardiovascular System: Function and Composition of Blood, structure of Heart, blood flow thorough heart, Fetal circulation, coronary circulation, conduction system and innervation, cardiac cycle and electrocardiogram, Vessels, arteries, capillaries and veins, Principle systemic arteries and veins, Blood pressure.

Lymphatic System: Lymphatic structure, Nonspecific defense, antibody and cell mediated immunity, transfusion and rejection reactions.

Respiratory System: Respiration, Components of respiratory system, Mechanics of Breathing, Lung Volumes, Gas transport, Regulation of respiration.

Digestive System: digestive processes, Peritoneum, structure and Function of GI track.

Urinary System: Components of urinary system, Structure of nephron and its function, Urine concentration, Acid base balance. Metabolism and temperature regulatory System, Water balance and electrolyte

Mechanical Properties of Bone and Soft Tissues Mechanics of bone, Composition of bone, Mechanical properties of bone, Bone fractures and Bone Remodeling, Biomechanics of Tendon and Ligaments. Biomechanics of Skeletal Muscles. Biomechanics of Articular cartilage.

Data Sciences and Machine Learning (3-0-2-4)

Introduction to Data Science: Concept of Data Science, Traits of Big data, Web Scraping, Analysis vs Reporting

Introduction to Programming Tools for Data Science: Toolkits using Python- Matplotlib, NumPy, Scikit-learn, NLTK, Visualizing Data- Bar Charts, Line Charts, Scatterplots, working with data- Reading Files, Scraping the Web, Using APIs (Example: Using the Twitter APIs), Cleaning and Munging, Manipulating Data, Rescaling, Dimensionality Reduction, Introduction to RStudio

Mathematical Foundations: Linear Algebra- Vectors, Matrices; Statistics- Describing a Single Set of Data, Correlation, Simpson's Paradox, Correlation and Causation; Probability- Dependence and Independence, Conditional Probability, Bayes's Theorem, Random Variables, Continuous Distributions, The Normal Distribution, The Central Limit Theorem; Hypothesis and Inference- Statistical Hypothesis Testing, Confidence Intervals, Phacking, Bayesian Inference

Machine Learning: Overview of Machine learning concepts – Over fitting and train/test splits, Types of Machine learning – Supervised, Unsupervised, Reinforced learning, Introduction to Bayes Theorem, Linear Regression- model assumptions, regularization (lasso, ridge, elastic net), Classification and Regression algorithms- Naïve Bayes, K-Nearest Neighbors, logistic regression, support vector machines (SVM), decision trees, and random forest, Classification Errors, Analysis of Time Series- Linear Systems Analysis, Nonlinear Dynamics, Rule Induction, Neural Networks Learning And Generalization

Applications of Machine Learning in Mechanics: Case Studies include Identifying faulty/healthy wind turbines, Turbulent Flow Analysis, Leakage Detection in Hydraulic Circuits, Fault Detection in Motor-Bearings, Human Activity Recognition, Heart Sound Classification etc.

Deep learning: Introduction to Neural Networks, Convolution and Artificial Neural Networks, Applications In Engineering Mechanics Practical's: MATLAB tools including Curve Fitting Toolbox, Classification Learner App, Deep Network Designer App, Tensor Flow, Training models on GPUs

Engineering Analysis and Design (3-0-0-3)

Analysis: Common causes and mechanism of failure, principles and techniques of failure analysis, fracture mechanics approach to failure problems, ductile and brittle fracture, fracture toughness, elements of design for fatigue, Cyclic Stresses and the S–N Curve, crack initiation and propagation, fatigue failure models, measuring and estimating fatigue failure criteria, high temperature failure and creep, stress and temperature effects, wear failure, design failures, processing failure (forging, casting, machining etc.), failure problems in joints and welds

Design: Modern Design Cycle, Need Analysis and Broad Engineering Specifications, Concept Design, Feasibility study and Evaluation of alternatives, Engineering Economics, Modeling Techniques-Mathematical, Graphical, Analysis and Simulation (e.g. FEM, Monte Carlo, CFD, Dimensional analysis, Experimental Techniques), Design for Manufacture and Reliability, Sustainability and Environment, Safety, Ergonomics and Human Factors, Introduction to design sensitivity analysis, life prediction

Basics of Materials selection: strength, stiffness, and fatigue life consideration, materials indices, the selection strategy and procedure, multiple constraints and conflicting objectives, Selection of materials and shape: shape factors, limits to shape efficiency, exploring the materials shape combinations, materials indices that include shape

Continuum Mechanics and Constitutive Modelling (3-0-0-3)

Mathematical Preliminaries and Introduction: Index notation, range and summation convention, free and dummy indices, Kronecker delta, Levi-Civita symbol, co-ordinate transformations, Cartesian tensor, properties of tensors, tensors as linear operators, invariants of tensor, eigen values and Eigen vectors, polar decomposition, scalar, vector and tensor functions, comma notation, gradient of a scalar, gradient of a vector, divergence and curl of a tensor, integral theorems of vectors and tensors. Notion of a continuum, configuration, mass and density, descriptions of motion, material and spatial coordinates.

Kinematics of Deformation and Motion: Deformation gradient tensor, stretch and rotation, right and left Cauchy-Green deformation tensors, Eulerian and Lagrangian strain tensors, strain-displacement relations, infinitesimal strain tensor, infinitesimal stretch and rotation, compatibility conditions, principal strains and strain deviator, material and local time derivatives, stretching and vorticity, path lines, stream lines, vortex lines, Reynolds transport theorem, circulation and vorticity.

Forces and Stresses: Body and surface forces, Cauchy Stress Tensor, First and Second Piola-Kirchhoff Stress Tensor, Deviatoric and Pressure Components, Principal Stress.

Fundamental Balance Laws of Continuum Mechanics: Balance of Mass – Continuity Equation; Balance of Linear Momentum – Equations of Motion / Equilibrium Equations; Moments of Momentum (Angular Momentum); Balance of Energy - First Law of Thermodynamics, Energy Equation; Equations of State – Entropy, Second Law of Thermodynamics; Clausius-Duhem Inequality, Dissipation Functions

Constitutive Relations and Material Models: Constitutive Assumptions; Ideal Fluids; Elastic Fluids, Hyperelastic Material; Notion of Isotropy; Isothermal Elasticity - Thermodynamic Restrictions, Material Frame Indifference, Material Symmetry; Hooke's law, Stokes problem and Newtonian fluids.

Engineering Ethics, IPR and Entrepreneurship (3-0-0-3)

Values: Concept, Types, Rokeach Value Survey. Different Kinds of Values: Individual, Societal, Material, Psychological, Cultural, Moral and Ethical, Spiritual; The Burgeoning Crises at Each of these levels. Modern Approach to the Study of Values: Analyzing Individual Human Values such as Creativity, Freedom, Wisdom and Love; Value Spectrum for a Good Life; The Indian Concept of Values, Comparison of eastern and western concept of values. Ethics: Values, Morals and Ethics; Need for Ethics in Professional Life; Kohlberg's Theory of

Moral Development and its Applicability to Engineers. Professional Ethics: Values in Work Life; Professional Ethics and Ethos; Codes of Conduct, Whistle-Blowing, Corporate Social Responsibility, Case Studies on Ethics in Business.

Introduction to IPR: Nature and Enforcement, International Character of IPRs, Role of IPRs in Economic Development. Patents: Introduction to Patents, Object of Patent Law, Inventions not Patentable, Obtaining Patents, Rights and Obligations of a Patentee. Copyrights: Introduction to Copyrights, Subject-Matters of Copyright, Rights Conferred by Copyright, Infringement, Assignment and Licensing of Copyrights, Copyright Societies, International Copyright, Performer's Rights. Trademarks: Functions, Significance and types of Trademarks, Distinctiveness and Deceptive Similarity, Registration Procedure, Trademark Registry, Grounds for Refusal of Registration of Trademarks, Concurrent Use, Character Merchandising. Trade Secrets: Meaning, Types of Trade Secrets, Statutory Position of Trade Secrets in India, Proofs Required in Trade Secret Litigation Case.

Entrepreneurship: Concept, Functions, Need and Importance, Types of Entrepreneurs, Entrepreneurship Journey, Innovation and Problem Solving, Market Understanding, Resource Mobilization.

Finite Element Methods, (3-0-2-4)

Introduction: Course objectives, History of FEM, Application Areas, Concept of Discretization and Interpolation, Different Steps in Finite Element Analysis, Demonstration through FE Analysis of Axially Loaded Bar.

Classical Finite Element Methods: Solution of partial differential equations, Ritz Method, Method of Weighted Residuals, Galerkin method, Strong & Weak formulation, One & Two dimensional structural & non-structural boundary value problems involving scalar and vector valued dependent variables.

Finite Element Formulation: Domain discretization, Interpolation models & Shape Functions, C0 and C1 Interpolation, Conventional 1D, 2D & 3D Elements, Special Elements, Sub Parametric, Super Parametric & Isoparametric elements. Derivation of element matrices and Vectors using Variational & Weighted residual methods. Coordinate transformation & Jacobian, Numerical Integration & Calculation of Element Matrices.

Application of FEM: Trusses, Beams and Frames, Heat transfer problems in 1D, Fluid Mechanics – Stream function and potential function formulation for inviscid and incompressible flow

Analysis of Algorithms (3-0-2-4)

Introduction, Review of basic concepts, Advanced data structures like Binomial Heaps, Fibonacci Heaps, Divide and Conquer with examples such as Sorting, Matrix Multiplication, Convex hull etc, Dynamic programming with examples such as Kanpsack, All pair shortest paths etc, Backtracking, Branch and Bound with examples such as Travelling Salesman Problem etc, Algorithms involving Computational Geometry, Selected topics such as NP-completeness, Approximation algorithms, Randomized algorithms, String matching

Organisational Behaviour and Psychology (3-0-0-3)

Introduction: Historical development; concept of organization; elements of organizational structure; scope of organizational behaviour. Motivation and job satisfaction: Major theories; content and process; (Adams, Maslow, Vroom, Herzberg). Intrinsic and extrinsic motivation; incentive systems: Job satisfaction; concept and determinants. Leadership: Functions and approaches; trait, behavioural and contingency models; characteristics of successful leaders; role of power in leadership. Communication: Communication process: types of communication; communication channels and networks; barriers to communication. Group behaviour and conflict: Defining and classifying groups; stages of group development; concept, causes and consequences of conflicts; methods of conflict-resolution. Definition of Industrial and Organisational Psychology, Major Fields of Industrial/Organisational Psychology: Personnel Psychology, Ergonomics, Vocational and Career Counselling, Organisation Development, Industrial Relations.

Computational Fluid Dynamics (3-0-2-4)

Basic ideas of CFD: Introduction to CFD, role of CFD and its applications, future of CFD.

Governing equations (GE's) of Fluid dynamics: Modeling of flow, control volume concept, substantial derivative, physical meaning of the divergence of velocity. Continuity equation, momentum equation, energy equation and its conservation form. Equations for viscous flow (Navier-Stokes equations), equations for inviscid flow (Euler equation). Different forms of GE's, initial and boundary conditions.

FVM for Diffusion Problems: FVM for 1D steady state diffusion, 2D steady state diffusion, 3d steady state diffusion. Solution of discretised equations- TDMA scheme for 2D and 3D flows.

FVM for Convection-Diffusion Problems: FVM for 1D steady state convection-diffusion, Central differencing scheme, Conservativeness, Boundedness, Transportiveness, Upward differencing scheme, Hybrid differencing scheme for 2D and 3D convection-diffusion, Power-law scheme, QUICK scheme.

Solution Algorithm for Pressure-velocity Coupling in Steady Flows: Concept of staggered grid, SIMPLE, SIMPLER, SIMPLEC, PISO algorithm.

FVM for Unsteady Flows: 1D unsteady heat conduction (Explicit, Crank-Nicolson, fully implicit schemes), Implicit mecthods for 2D and 3D problems, Discretization of transient convection-diffusion problems, solution procedure for transient unsteady flow calculations (transient SIMPLE, transient PISO algorithms).

Grid Generation: General transformation of the equations. Metices and Jacobians. Types of grids- structured and unstructured grids, grid generation methods- algebraic, differential and hybrid methods. Coordinate stretching, boundary-fitted coordinate systems. Elliptic and hyperbolic grid generation methods, orthogonal grid generation for Navier-Stokes equations, Multi-block grid generation.

Artificial Intelligence (3-0-0-3)

Introduction, Intelligent agents, reactive, deliberative, goal-driven, utility-driven, and learning agents, Artificial Intelligence programming

Defining problems at state space search, Production system, Problem and production system characteristics, Forward and backward, state-space, blind, heuristic, problem reduction, A, A*, AO*, minimax, constraint propagation, neural, stochastic, and evolutionary search algorithms, sample applications. Issues in design of search programs

Foundations of knowledge representation and reasoning, issues in knowledge representation, representing and reasoning about objects, relations, events, actions, time, and space; predicate logic, situation calculus, description logics, reasoning with defaults, sample applications.

Planning as search, partial order planning, construction and use of planning graphs, planning and acting in the real world

Basics of utility theory, decision theory, sequential decision problems, elementary game theory, sample applications.

Learning from memorization, examples, explanation, and exploration. Supervised and unsupervised learning, learning nearest neighbor, naive Bayes, and decision tree classifiers, Q-learning for learning action policies, applications. Sample Applications of AI

Indian Art and Culture (2-0-0-2)

An Introduction to Indian Culture- History and Culture through ages: Ancient India, Medieval India, Modem India, Languages and Literature: Indian Languages and Literature-I, Indian Languages and Literature-II, Religion and Philosophy: Religion and Philosophy in ancient India, Religion and Philosophy in Medieval India, Religious Reform Movements in Modem India, Painting, Performing Arts and Architecture: Indian Painting, Performing Arts: Music, Dance and Drama, Indian Architecture SCIENCE AND TECHNOLOGY: Science and Technology In India, Scientists of Ancient India, Science and Scientists of Medieval India, Scientists of Modern India EDUCATION: Education in India, SOCIAL STRUCTURE: Indian Social Structure, Socio-Cultural Issues in Contemporary India SPREAD OF INDIAN CULTURE ABROAD: Spread of Indian Culture Abroad

CORE ELECTIVE SUBJECTS (SEMESTER-V): Each Course (4-0-0-4)

Structural Mechanics

Analysis of Plane Structures: Introduction and Classification of Structures, Review of AFD, SFD and BMD for Beams, Degrees of Freedoms, Static and Kinematic Indeterminacy of Structures, Analysis of Compound and Complex Trusses, Analysis of Plane Frames, Displacements of Plane Structures, Maxwell's Reciprocal & Betti's Theorem, Unit Load method, Deflection of trusses and plane frames

Rolling loads and Influence Line Diagrams: Introduction, Influence Line Diagrams for Beams & Trusses, Absolute Maximum Bending Moments, Muller- Breslau principle and its applications

Matrix Method of Analysis: Introduction, Flexibility Method- Application to Beams, Trusses, Frames and Grid Structures; Stiffness Method- Application to Beams, Trusses, Frames and Grid Structures (including plane and space structures)

Plastic Analysis of Structures: Introduction, Plastic Analysis of Beams, Frames & Gable Frames.

Arches, Cables and Suspension Bridges: Introduction, Linear Arch, Eddy's Theorem, Three-Hinged & Two-Hinged Arches, Spandrel Braced Arch, Influence Lines for Arches, Analysis of Cables, Suspension bridges with three and two hinged stiffening girders

Engineering Vibrations

Fundamentals of vibrations: Objectives, Types of Loadings, Essential Characteristics of Dynamic Problems, Discrete & Continuous systems, Simple harmonic motion, Combination of two simple harmonic motions, Beats, Fourier analysis, Rigid body dynamics vs. Vibration, Formulation of Vibration Problems: Taught String, Axial Vibration of Bar, Torsional Vibration of Shaft, Flexural Vibration of Beam, Membrane

Single degree of freedom system: Analysis of Free and Forced Vibrations, Response to Harmonic, Periodic & Impulsive Loadings, Duhamel's Convolution Integral, Vibration Isolation, Response to General Dynamic Loading

Two degree of freedom system: Free vibrations of spring coupled system, general solution, Torsional vibrations, mass coupled system, bending vibrations in two degree of freedom system, forced vibrations of an undamped, two degree of freedom system, dynamic vibration absorber, forced damped vibrations

Multi-Degree of Freedom Systems: Modeling of Continuous systems as Multi-degree of Freedom systems, Evaluation of Structural Property Matrices and Influence Coefficients, Eigen value problem, solution of the Eigen value problems -- solution of the characteristic equation, orthogonality of normal modes, repeated Eigen values, Reduction of dynamic matrices, Analysis of Dynamic Response - Superposition method, Iteration method, transformation method, Rayleigh's Method- Properties of Rayleigh's Quotient, Dunkerley's formula, Holzer's Method-Torsional systems, Jacobi's method, Stodola method, Fundamental Frequency of Beams and Shafts, Direct time integration of linear systems – Explicit & Implicit methods

Frequency Domain Vibration Analysis: Over view, machine-train monitoring parameters Data base development-vibration data acquisition-trending analysis-failure- node analysis-signature analysis-root cause analysis.

Vibration Control In Structures: Introduction, State space representation of equations of motion, Passive control, Active control and semi active control, Free layer and constrained damping layers, piezo electric sensors and actuators for active control, semi active control of automotive suspension systems.

Characterization of Materials

Crystallography: Overviews in bonding, Bravais lattices, Miller indices, imperfections in crystals, crystal structures of common metal, ceramics, polymers. symmetries in crystals, point groups, space groups, reciprocal lattice, morphology

X-ray Diffraction Techniques: Production of X-rays, its properties and hazards, photon scattering, X-ray diffraction and Bragg's law, intensities calculations, Laue techniques, Debye-Scherrer techniques. modern diffractometers, diffractometer measurements, determination of crystal structure of powder sample, small angle scattering, line broadening, particle size, crystallite size, residual stress measurement, plane indexing, precise parameter measurement, phase identification, phase quantification, phase diagram determination, stereographic projection, pole figure, preferred orientation (texture analysis) and chemical analysis, profile fitting and Rietveld analysis.

Optical Microscopy: Principles and operations of microscopy, resolution, magnification, numerical aperture, depth of field, viewing area, contrast, geometry of optical microscopes, application of microscopy in metallurgical studies (qualitative and quantitative), morphology and symmetry, grain boundaries and dislocations, phase contrast microscopy, polarised light microscopy, hot-stage microscopy, sample preparation.

Electron Microscopy: Electron sources, electron diffraction, principles and operation of scanning electron microscope. geometry of electron microscopes, specimen handling and preparation, secondary electron image, backscattered electron image, image processing, analysis of electron micro-graphs and fractography studies, transmission electron microscopy (TEM).

Scanning Probe Microscopy: Principles and operation of scanning probe microscopes, scanning tunnelling microscope, atomic force microscope, magnetic force microscopy, topography studies, nanoindentation and its probing.

Thermal Analysis: Thermo gravimetric analysis, differential thermal analysis, differential scanning calorimetry, thermo-mechanical analysis and their applications.

Smart Materials and Structures

Introduction to Smart Material Systems; Overview of smart materials, Modeling mechanical, thermal and electrical systems (thermo mechanics and electrostatics);Piezoelectric materials: constitutive modelling, piezoelectric beam static and vibration analysis Shape memory alloys (SMA): constitutive modelling, actuation models for SMA, electrical actuation Brief overview of Electroactive Polymers, Magnetostrictive materials, Electro and Magneto Rheological Fluids Mechanics of smart composite structures Transducer applications: Vibration control and damping using piezoelectric materials. Case study: Sensing and control of Smart beams and plates.

Compressible Flow and Computations

Basics: Introduction and review of Thermodynamics; Integral form of conservation equations; One-dimensional Flow - Area-Velocity Relations and Isentropic Relations, Wave Propagation, Speed of Sound, Shock Waves, Normal Shock Waves; Flow Through Nozzles and Duct, Flow with Heat addition and friction; Two - dimensional Compressible Flow: Oblique Shocks, Expansion Waves, Shock Interactions, Detached Shocks, Shock-Expansion Technique; Unsteady Wave Motion; Analytic Methods: Method of Characteristics

Computation: Mathematical nature of Euler equations: Various forms of Euler equations; Hyperbolic Equations; Riemann Problem. Basic Numerical Methods: Centered and upwind discretization. Artificial Viscosity, CFL condition and Numerical stability. Brief Historical Evolution of the computational methods for compressible flow and their classification. Central Schemes, First and Second order upwind scheme. Roe and McCormack methods. Flux-Vector Splitting, Godunov Methods, High Resolution Schemes: TVD and Flux-limiters. Boundary Conditions: Treatments for physical and numerical Boundary Conditions. Modern Compressible Flow and Current Research; Numerical Methods available in commercial and open-source software.

Advanced Heat Transfer

Introduction - Review of fundamentals of heat transfer. Conduction: General heat conduction equation, Analytical solutions of two-dimensional steady state heat conduction; Transient conduction. Convection: Governing equations, boundary layer equations, Forced convection over external surfaces and internal ducts; Similarity solutions. Free and Mixed convection flows, Conjugate heat transfer analysis. Radiative Heat Transfer: Thermal radiation, Emissive Power, Solid Angles, Radiative Intensity, Heat Flux, Pressure and Characteristics, Radiative transport equation.

Experimental Methods

Experimental Analysis: Types of measurements and errors, Relative frequency distribution, Histogram, True value, Precision of measurement, Method of least squares, the curve fitting, General linear regression, Theory of errors, Binomial and Gaussian distribution, Chi-square test.

Experimental Methods: Principles of Measurement, Basic Elements of a Measuring Device.

Displacement measurement, Force and Torque Measurement, Temperature Measurement, Pressure Measurement, Fluid Velocity Measurement, Miscellaneous measurements, Dynamics of Measurements: Dynamic Response of a Measuring Instrument, Response to Transient and Periodic Signals, First and second order systems as well as their Dynamic Response Characteristics.

Laboratory: The experiments have been designed to understand Experimental Analysis physically, Laboratory will enable the students to apply various statistical methodologies (viz. Mean, Median, Mode, Std Dev. etc) to get the optimum output from the day-to-day Engineering life experiment.

Aerodynamics

Introduction to Aerodynamics: Hot air balloon and aircrafts, Various types of airplanes, Wings and airfoils, lift and Drag, Centre of pressure and aerodynamic center, Coefficient of pressure, moment coefficient, Application of potential flow in aerodynamic problems.
Incompressible Flow Theory: Design of airfoils using conformal transformation, Kutta condition, Karman – Trefftz profiles, Thin aerofoil Theory and its applications. Vortex line, Horse shoe vortex, Biot - Savart law, Prandtl lifting line theory, Panel methods.
Compressible Flow Theory: Potential equation for compressible flow, small perturbation theory, Prandtl-Glauert Rule, Linearised supersonic flow, Method of characteristics.
Airfoils, Wings and Airplane configuration in High-Speed Flows: Critical Mach number, Drag divergence Mach number, Shock stall, super critical airfoils, Transonic area rule, Swept wings (ASW and FSW), supersonic airfoils, wave drag, delta wings, Design considerations for supersonic airplanes.
Viscous Flow Measurements: Types of wind tunnels – Flow visualization processes -- Measurement of force and moments in wind tunnels. Measurement of pressure, velocity and wall shear stress, Flow visualizations.
Latest developments and trends in Aerodynamics: UAV, MAV.

CORE ELECTIVE SUBJECTS (SEMESTER-VI): Each Course (3-0-0-3)

Basic Control Theory

Introduction to Control System-Introduction, Closed-loop control versus open-loop control

Mathematical Modelling of Control Systems-Control hardware and their models, various physical system modelling, Block diagram reduction, Signal flow graph, Basic characteristics of Feedback, Modes of feedback control: proportional, integral and derivative, PID, The performance of Feedback systems

Transient Response Analysis-Time response analysis, Concepts of Stability and Routh's Stability Criteria, Steady-state error analysis

Root-Locus Analysis& the Frequency-Response Method-Root-locus plots, Rules of constructing Root Loci, Root-locus analysis of control systems

Frequency Response Analysis- Bode plots, Polar plots, The Nyquist Stability Criterion and Stability Margins, Closed loop frequency response (M & N circles)

Design and Compensation Techniques-Design considerations, Lag Compensation, Lead Compensation, Lag-lead Compensation, Compensator Design Using Root-locus and Frequency Response methods

Robotics

Introduction to Robotics: Types and components of a robot, Classification of robots, closed-loop and open loop control systems. Kinematics systems; Definition of mechanisms and manipulators, Social issues and safety.

Robot Kinematics and Dynamics: Kinematic Modelling- Translation and Rotation Representation, Coordinate transformation, DH parameters, Jacobian, Singularity, and Statics Dynamic Modelling- Equations of motion: Euler-Lagrange formulation

Sensors and Vision System: Sensor- Contact and Proximity, Position, Velocity, Force, Tactile etc.; Introduction to Cameras, Camera calibration, Geometry of Image formation, Euclidean/Similarity/Affine/Projective transformations; Vision applications in robotics.

Robot Control: Basics of control- Transfer functions, Control laws: P, PD, PID; Non-linear and advanced controls

Robot Actuation Systems: Actuators- Electric, Hydraulic and Pneumatic; Transmission: Gears, Timing Belts and Bearings, Parameters for selection of actuators.

Control Hardware and Interfacing: Embedded systems: Architecture and integration with sensors, actuators, components, Programming for Robot Applications

Mechatronic Systems

Overview of mechatronic systems - mathematical modeling of systems - introduction to control - sensors and transducers - signal conditioning - amplification, filtering, analog-to-digital converters and digital-to-analog converters - data presentation systems - actuators - electrical, mechanical, pneumatic, hydraulic - analog electric circuits, operational amplifiers - digital logic circuits, microprocessors, microcontrollers, DSPs, Programmable Logic Controllers - programming in assembly and C - communication interfaces - RTOS - machine vision systems - robotics

Soft Computing

Competitive learning models: Principal Component Analysis (PCA); Self-organizing maps (SOM); Information theoretic methods: Entropy, mutual information, K-L divergences; Independent component analysis (ICA), Maximum entropy method; Pulsed neural networks: Spiking neuron model, Integrate-and-fire neurons; Fuzzy Logic and Fuzzy systems, Fuzzy neural networks, Fuzzy K-means algorithm; Genetic Algorithms: Evolutionary computation, Genetic operators

Optimization Techniques

Introduction to Optimization: Design variables, Design constraints, Objective function Design space, feasible region, Problem statement, Local and Global optima, Classification of optimization problems, Solution by calculus and numerical methods.

Linear Programming: Simplex method, Geometric Programming: Application to simple problems.

Non-Linear Programming: Method of approximation programming, Kelly's Cutting Plane method.

Gradient Methods: Steepest descent and Side step method. Conjugate Gradient method, Rosin's Gradient Projection Method, Zotendik's method of feasible directions, Unconstrained minimization, and penalty function technique search procedures.

Introduction to Genetic Algorithm: Artificial Neural Network, Dynamic programming

Genetic Algorithm

Basics of Optimization, Optimization Problems, Point to Point Algorithms, Simulated Annealing; Population Based Algorithms, Brief Overview of Evolutionary Computation, Genetic Algorithms (Theory and Advanced Operators), Genetic Representation, search operators, selection schemes and selection pressure; Operators on Real-valued Representations, Niche and fitness sharing, Particle Swarm Optimization, Memetic Algorithms; Evolution Strategies, Genetic Programming, Evolutionary Programming, Differential Evolution; Constraint Handling in optimization problems, Real Life application of optimization Algorithms, Introduction of Multi-objective Evolutionary Algorithms

Mathematics for Geometrical Modeling

Introduction: Historical Development, Explicit and Implicit Equations, Intrinsic Equations, Parametric Equations, Coordinate Systems.

Curves: Fundamental of Curve Design, Parametric Space of a Curve, Reparameterization, Space Curves: Spline Curves, Bezier Curves, B-Spline Curve, Rational Polynomials, Rational curves, NURBS.

Surfaces: Fundamental of Surface Design, Parametric Space of a Surface, Reparameterization of a Surface patch, Sixteen point form, Four Curve Form, Plane, Cylindrical and Ruled Surfaces, Surfaces of Revolutions, Bezier Surface, B-Spline Surface.

Solids: Fundamental of Solid Design, Parametric Space of a Solids; Continuity and composite Solids, Surface and Curves in a Solid.

Solid Modeling: Topology and Geometry, Set theory, Euler Operators, Regularized Boolean Operators, Construction Criteria, Graph Based Models, Instances and Parameterized Shapes, Cell-decomposition and Spatial Occupancy Enumeration, Sweep representation, CGS, BRep, Wireframe Analytical properties, Relational properties and Intersection. Applications in Biomedical Engineering Design.

Product Design and Development

Introduction-Introduction to product design, Significance of product design, product design and development process, sequential Engineering design method, the challenges of product development, Development Process and Organizations-Generic Development Process, Concept Development, Adapting the generic PD process flows, AMF development Process, Product Development Organizations, The AMF Organization.

Product Planning and Identifying Customer Needs-Product Planning process, interpret raw data in terms of customers need, organize needs in hierarchy and establish the relative importance of needs, review of the process. Product Specifications Establish target specifications, setting final specifications.

Concept Generation-Activities of concept generation, clarifying problem, search both internally and externally, explore the output, Concept Selection-Overview, concept screening and concept scoring, methods of selection. Concept Testing-Elements of testing: qualitative and quantitative methods including survey, measurement of customers' response. Product Architecture-Modular and integral architecture, implications, establishing the architecture, Delayed differentiation, Platform Planning. Industrial Design-Assessing need for industrial design, Impact of industrial Design, industrial design process, management of industrial design process, assessing quality of industrial design.

Embodiment Design: Design for Manufacturing, prototyping. Robust Design. Intellectual Property and Environmental Guidelines-Intellectual Property: Elements and outline, patenting procedures, claim procedure, Environmental regulations from government, ISO system.

Honours (Solid Mechanics) (4-0-0-4)

Theory of Elasticity

Analysis of Stress: Concept of Stress, Stress Components, Equilibrium Equations, Stress on a General Plane (Direction Cosines, Axis Transformation, Stress on Oblique Plane through a point, Stress Transformation), Principal Stresses, Stress Invariants, Deviatoric Stresses, Octahedral Stresses, Plane Stress, Stress Boundary Condition Problem.

Analysis of Strain: Deformations (Lagrangian Description, Eulerian Description), Concept of Strain, Strain Components (Geometrical Interpretation), Compatibility Equations, Strain transformation, Principal Strains, Strain Invariants, Deviatoric Strains, Octahedral Strains, Plane Strain, Strain Rates.

Stress-Strain Relations: Introduction, One-Dimensional Stress-Strain Relations (Idealized Time independent and Time–dependent stress-strain laws), Linear Elasticity (Generalized Hooke's Law), Stress-Strain Relationships for Isotropic and Anisotropic Materials (Plane stress and Plane Strain)

Basic Equations of Elasticity for Solids: Introduction, Stresses in Terms of displacements, Equilibrium Equations in terms of displacements, Compatibility equations in Terms of Stresses, Special cases of Elasticity equations (Plane Stress, Plane strain, Polar Co-ordinates), Principle of Superposition, Uniqueness of Solution, Principle of virtual work, Potential and Complementary energy, Variational Principles, St. Venant's Principle, Methods of analysis for Elastic Solutions, Elastic solutions by Displacement and stress Functions, Airy's Stress Function (Plane stress, Plane strain, Polar Co-ordinates).

Torsion: Introduction, Circular shaft, Torsion of non-circular cross-section, St. Venant's theory, Warping function, Prandtl's stress function, Shafts of other cross-sections, Torsion of bars with thin walled sections.

Viscoelasticity: Introduction, Viscoelastic models (Maxwell, Kelvin-Voigt, Generalized Maxwell and Kelvin models), Viscoelastic stress-strain relationships.

Theory of Stability

Introduction and Buckling of Columns: Concepts of Stability, Equilibrium path, Stability criteria, Method of Neutral Equilibrium; Recapitulation of Critical Load for Euler Column, Columns with Different Boundary Conditions, Effective-length concept and design curve, Effects of Imperfections / Initial curvature, Eccentricity of loading etc.; Inelastic buckling of columns, Double and Tangent Modulus theory, Shanley's theory.

Beam-columns and Frames:: Governing equation for Beam-columns, Displacement solution and stability for single concentrated transverse load, Beam-Columns with other transverse loading and boundary conditions, Semi-analytic / Series solution based on Energy Principles, Post-buckling behavior;

Introduction to buckling of Frames, Modes of Buckling, Critical Load of a Frame by Slope-Deflection Equations and Matrix Analysis, Effect of Initial Bending, Framed Columns.

Torsional and Lateral Stability: Stability of Thin-walled open sections, buckling by torsion and torsion-flexure; Lateral stability of beams with various loadings and end conditions.

Stability of Plates and Shells: Differential Equations of plate Buckling linear theory, stability of Rectangular plates under axial compression and shear, Effect of imperfections, Post-buckling behavior of plates;

Stability of cylindrical Shells under uniform axial pressure and torsion, Effect of imperfections.

Approximate Methods of Analysis: Energy Principles and Variational Calculus, Rayleigh-Ritz and Galerkin method, Finite Difference and Finite Element Method.

Theory of Plates and Shells

Introduction: Line and surface structures, Membrane, Thin and thick plates.

Pure Bending of Plates: Slope and curvature of slightly bent plates. Relations between moments and curvatures.

Small Deflection theory of Laterally Loaded Plates: Governing differential equation and boundary conditions. Bending of Rectangular Plates. Simply supported rectangular plates. Naviers' solution, Rectangular plates with various loading and edge conditions, levy's solution.

Bending of Circular plates: Governing equation, Axisymmetric loading, Various types of circular plates, Design of Circular Plates, Plate on elastic

Shells: Classification of shells, Engineering use of shell structures.

Membrane Theory: Cylindrical shells and shell of revolution, Axisymmetric and unsymmetrical loading. Solution for stress resultants and displacements. Cylindrical, spherical and conical shells supported at isolated points. Analysis for wind and periodic loads.

Bending Theory of Cylindrical Shell: Governing equations for stresses and displacements for symmetric and general conditions. Flugge and Donnel theories. Cylindrical shells with uniform and Non-uniform thickness.

Design of Plates & Shells: Design Considerations, Design load and other criterions, Design of Rectangular Plates, Design of Shells of Revolution, Design of Cylindrical Shells, Indian Codes of Practice, Other Design Codes, Design of Thin-Walled Industrial Structures.

Micromechanics

Introduction: Scalars, Vectors, Tensors, Mathematical framework and notations, Mechanics, Micromechanics, Review of linear elasticity

Inclusions and inhomogeneities: General theory of eigenstrains, Eigenstrains and eigenstresses, Fundamental solutions to eigenstrain problems, Fourier series and integrals, Three-dimensional Green's function, Eshelby's solution for the inclusion problem, Ellipsoidal inhomogeneities, Eshelby's equivalence principle, Interaction between inhomogeneities

Effective properties of heterogeneous media: Average strains and stresses, Hill's lemma, Voigt and Reuss approximations, Upper and lower bounds, Hashin-Shtrikman bounds, Dilute inclusion method, Self-consistent method, Generalized self-consistent method, Differential self-consistent method, Mori-Tanaka method, Composite spheres and composite cylinders models, Effective thermal and electrical properties

Homogenization techniques for heterogeneous media: Representative volume elements, Boundary conditions for representative volume elements, Random and Periodic microstructures, Perturbation methods, Non-linear homogenization methods, Direct numerical homogenization schemes, Computational methods, Numerical examples involving programming in MATLAB / FORTRAN /PYTHON, Numerical practice in applying periodic boundary conditions for computational homogenization using finite element software ABAQUS®

Micromechanical modeling: Micromechanical modeling ofviscoelastic and viscoplastic constitutive behavior of composites,numerical implementation of constitutive behavior in finite element software ABAQUS® by user material subroutines through FORTRAN programming

Engineering Plasticity

Crystal plasticity: Resolved shear stress & strain, Lattice slip systems, Hardening, Yield surface, Flow rule, Micro to Macro plasticity.

Stresses and Strains: The Stress–Strain Behaviour, Analysis of Stress, Mohr's Representation of Stress, Velocity gradient and rate of deformation, Kinematics of large deformation, The Criterion of Yielding, Yielding of materials under complex stress state, Choice of yield function.

Non-Hardening & Elastic-Perfect Plasticity: Classical theories and its application to uniform & non uniform stress states, Hencky vs. Prandtl-Reuss, Elastic–Plastic Torsion and Bending of Beams, Thick walled cylinders.

Theory of the Slipline Field: Formulation of the Plane Strain Problem, Properties of Slipline Fields and Hodographs, Stress Discontinuities in Plane Strain, Construction of Slipline Fields and Hodographs, Analytical and Matrix Methods of Solution, Explicit Solutions for Direct Problems, Some Mixed Boundary-Value Problems, Superposition of Slipline Fields.

Limit Analysis: Collapse of Beams & Structures, Transverse loading of circular plates.

The Flow Curve: Uniaxial tests, Torsion tests, Compression tests, Bulge test, Equations to flow curve, Strain & work hardening hypothesis.

Plasticity with Hardening: Isotropic hardening, Non associated flow rules, Prandtl-Reuss flow theory, Kinematic hardening.

Plastic Instability: Inelastic buckling of struts, buckling of plates, Tensile instability, Circular bulge instability, Plate stretching.

Fracture Mechanics

Introduction: Modes of loading, Crack growth and fracture mechanisms, Need for fracture mechanics, Linear elastic fracture mechanics and elastic plastic fracture mechanics.

Energy Release Rate: Surface Energy, Resistance, Griffith Theory of fracture, Extension of Griffith Theory by Irwin and Orowan, R-Curve, Pop-in phenomena, Crack branching. Necessary and sufficient conditions for fracture.

Crack-Tip Stress and Displacement Fields: Airy's stress function, Westergaard's approach, Generalized Westergaard's approach, William's Eigen function approach, Multi-parameter stress field equations, Influence of the T-stress and higher order terms, Role of photoelasticity on the development of stress field equations in fracture mechanics.

Stress Intensity Factor: Equivalence between SIF and G, Various methods for evaluating Stress Intensity Factors.

Crack Tip Plastic Zone: Modeling plastic zone at the crack-tip, Irwin and Dugdale models.

Fracture Toughness Testing: Qualitative toughness testing, K_{IC} testing, K-R curve testing, J_{IC} measurements, J-R curve testing, CTOD testing.

Micromechanics of Fracture: Cohesive strength of solids, Cleavage fracture, Intergranular fracture, Ductile fracture, Crack detection methods.

Impact Mechanics

Elastic impact: Propagation of 1D stress pulse, coaxial collision of bars, reflection and superposition, Navier's equations, dilatational and shear waves, Rayleigh and Lamb waves. Plastic impact: lower and upper bound theorems of plasticity, applications to static plastic deformations in beams, propagation of 1D stress pulse in elasto-plastic material, Taylor impact test, one dimensional impact on metal foams, plastic deformation of beams subjected to impact, dynamic buckling of beams.

Propagation of 1D stress pulse, coaxial collision of bars, reflection and superposition, review of continuum mechanics, dilatational and shear waves, Rayleigh and Lamb waves, longitudinal, torsional and flexural vibrations of rods, Pochhammer equations for cylindrical bars, design of a split Hopkinson bar for high strain rate characterization, propagation of 1D stress pulse in elastoplastic material, Taylor impact test, one dimensional impact on metal foams, plastic deformation of beams subjected to impact.

Continuum Damage Mechanics

Essentials of Continuum mechanics: Tensorial notation, stress, strain, invariants, equilibrium equations, Domain and validity of continuum damage mechanics, concept of representative volume element.

Phenomenological aspects of damage: Damage, measurement of damage, modeling of damage through effective area reduction, void volume fraction and stiffness reduction, representation of damage through different orders of tensors, concept of effective stress, hypothesis of strain equivalence, strain energy equivalence, and complementary strain energy equivalence.

Thermodynamics of damage: State variables, damage as state variables, first and second law of thermodynamics, thermodynamics potentials, dissipation potentials, constitutive equations, evolution equations.

Kinetic Laws of Damage Evolution: Unified formulation of damage laws, damage laws for brittle, quasi-brittle, ductile, creep, low cycle and high cycle fatigue.

Damage Analysis of Structures: Implementation of isotropic damage theory, case studies from literature.

Multiscale Modelling

Introduction: Examples and motivation for exploring multiscale behaviour of materials, Relevant material properties at different scales.

Review of Preliminaries: Prerequisite mathematics, Fundamentals of Thermodynamics and statistical mechanics.

Molecular Dynamics and Related Issues: Particle-based methods, EAM/MEAM potentials: bridging from QM, Atomistic Plasticity, Damage & Fatigue, Molecular Dynamic Simulation Methods.

Meso-scale methods: Overview and need, Quasi-continuum methods, Density Functional method.

Homogenization and Bridging: Multi-scale homogenization and stochastic homogenization, inter-scale exchange and Scale bridging.

Computational Application: Variational multiscale methods, Numerical resolution and asymptotic behaviour of stochastic PDEs, Enriched continuum models and design.

Mechanics of Composite Materials

Introduction: Classification and characteristics of composites, Conventional vs. Composite materials, Advantages and limitations, Salient applications in various fields, Fabrication technologies, Properties of matrix and reinforcement materials.

Micromechanics: Fiber volume fraction, micro-mechanical relations, determination of strength and stiffness, Environmental effects-Hygro-thermal behavior.

Macromechanics: Basic stress-strain relationships for anisotropic materials, engineering constants for orthotropic materials, stress-strain relations for a lamina of arbitrary orientation, effective moduli, invariant properties of anorthotropic lamina, special cases of laminate stiffness, laminate strength analysis, concept of inter-laminar stresses and delamination.

Failure theories and Damage mechanics: Failure mechanisms, maximum stress theory, maximum strain theory, Tsai-Hill theory, Tensor polynomial failure criterion, first ply failure theory, Introduction to damage theory based on continuum damage mechanics.

Honours (Fluid Mechanics)

Turbulence Modelling

Introduction: Flow instability and transition to turbulence, Nature of Turbulence, Indicial notation for tensors, Fourier transforms and Parseval's theorem.

Governing Equations of Turbulence:

Eulerian, Lagrangian and Fourier descriptions of turbulence:

Statistical description of turbulence: Reynolds Averaged Navier-Stokes equations, Reynolds stress evolution equations.

Kolmogorov's Hypothesis: Diffusivity of turbulence and turbulence length scale.

Filtered Description of Turbulence: Bridging methods and large eddy simulation (LES).

Turbulent Free Shear Flows: Free Shear Flows- jet flows including heat transfer- 2D flows, wall jet and plane jets, its structure; turbulent jets, turbulent mixing layer and buoyancy effects- its structure; turbulent wake flows, wake of self-propelled bodies; wall-bounded shear flows- its structure; boundary layer flows; thermal plume.

Wall Bounded Turbulent Flows: Turbulent flows in pipes, channels and boundary layers, Law-of-the-wall, Effects of surface roughness on turbulence.

Development of Turbulent closure models: Boussinesq approximation, Reynolds stress evolution closures.

Rapid Distortion Theory (RDT) of Turbulence:

Dynamics of Turbulence: Linear Instability Theory, Nonlinear Stability Analysis, Dynamical Systems, Introduction to Chaos. Vorticity dynamics- Reynolds stress and vorticity, vortex stretching, mean vorticity equation, kinetics energy and mean flow, kinetic energy of fluctuations, energy cascade, dissipation, material element deformation, mixing Navier-Stoke's equation for turbulent flow, turbulent energy dissipation equation.

Turbulence modelling: General comments on turbulence models; Method of solving turbulent equations- Direct numerical simulation (DNS), Large-eddy simulation (LES), Reynolds averaged Navier-Stokes equation (RANS), k-ε models, Turbulence models: Eddy viscosity models -zero equation models (constant eddy viscosity and mixing length models), one equation models, two equation models; Reynolds stress transport models (RSM), Wall treatments.

Boundary Layer Theory

Incompressible Laminar Boundary Layers: Exact solutions of the Navier-Stokes equation exhibiting boundary layer at low viscosity. The boundary-layer equations in the spirit of Prandtl. Scaling, non-dimensionalisation and Reynolds number. Limitations of potential flow past a cylinder. Prandtl's boundary-layer equations in two dimensions deduced by order-of-magnitude arguments. Blasius solution: displacement thickness, skin friction, drag.
Transition and Incompressible Turbulent Boundary Layers: Concept of stability; basis of boundary layer stability analysis; physics of transition to turbulence. Reynolds stresses, mean velocity and shear stress in a turbulent boundary layer; the log law and power law profiles. Turbulent boundary layers in zero and non-zero pressure gradients. Separation in adverse pressure gradients. Concept of and occurrence in steady flows, and at rear stagnation point of impulsively started cylinder.
Boundary Layer Separation & Flow Control: Causes of boundary layer separation and its consequences, active and passive flow control, various different flow control techniques and their applications.
Introduction to Perturbation Theory: Regular and singular perturbations. Examples from algebraic equations and ordinary differential equations. The classical boundary-layer equations of Prandtl as the leading term in a matched asymptotic expansion. Exact solutions of the classical boundary-layer equations like Flow past a wedge: Falkner Skan. Far wake of a flat plate. Two-dimensional jet. Lock's mixing layer. Prandtl transformation. Prandtl-Glauert law for subsonic flow; Ackeret's law and applications. Axisymmetric flows: Mangler's transformation. Split disc Ekman layer problems: Stewartson layers. Glauert wall jet.
Thermal Boundary Layer: Introduction to thermal boundary layer, heat transfer in boundary layer, convective heat transfer, importance of non dimensional numbers, Prandtl number, Nusselt number, Lewis number etc.

Multiphase Flow:

Introduction to Multiphase Flow: Introduction, Estimation of flow patterns, Classification and characteristics of complex Mixture.
Fundamental Concept of the Flow of Multiphase Mixtures: mechanics of transportation, Description of general two phase systems, Continuity equation, Momentum equation, Mechanical energy equation, Slip and Hold up effect.
Flow of Gas-Liquid and Liquid–Liquid Mixture in Pipes: Flow patterns, Holdup, Empirical overall correlations, Pressure gradient, Bubble flow pattern, Slug flow, Stratified flow, Wave flow and Annular-mist flow.
Flow of Gas-Solid and Liquid–Solid Mixture in Pipes: Flow patterns, Holdup, General correlations.
Freight Pipelines: Slurry transportation System, Pneumatic transportation System, Capsule transportation System, Measurement techniques.
Modeling Multiphase Flows: Introduction, General Multiphase Model, Volume of Fluid (VOF) Model Theory, Mixture Model Theory, Eulerian Model Theory, Modeling Mass Transfer in Multiphase Flows, Modeling Species Transport in Multiphase Flows, and Solution Strategies for Multiphase Modeling.

Fluid Structure Interaction:

Introduction to Fluid-structure Interaction: Concept of fluid-structure interaction, brief history of fluid-structure interaction, dimensional analysis, concept of the hydrodynamic mass (added mass), hydrodynamic mass matrix.
Mathematical formulation of a simple fluid-structure interaction problem: Fluid domains, solid domains, coupling of the equations for fluid and structure.
Analysis Methods for Fluid-structure interaction problems: One-way separate analysis method (Hydrodynamics mass and damping method), Two-way coupled analysis method.
Vortex Induced Vibration: Vortex wake of a stationery cylinder, Strouhal number, effects of cylinder motion on wake, analysis of vortex-induced vibration and its reduction.
Galloping and Flutter: Introduction to galloping, galloping instability, galloping response, vortex shedding, turbulence and galloping, flutter, prevention of galloping and flutter.
Instability of tube and cylinder arrays: Description of elastic instability, theory of fluid elastic instability, vibration of pairs of cylinders.
Vibration induced by Oscillatory flow: Inline forces and their maximum, inline motion, fluid force coefficients, transverse force and response, reduction of vibration induced by oscillating flow, ship motion in a seaway.
Vibration induced by turbulence and sound: Elements of the theory of random vibrations, sound and turbulence-induced vibration of panels, turbulence-induced vibration of tubes and rods, wind-induced vibration, response of aircraft to gusts, reduction of vibration induced by turbulence.
Fluid Coupling: Concentric cylinders with open ends of fluid filled annular gap, concentric cylinders with closed ends of fluid annular gap.

Damping of structures: Elements of damping, Definitions of damping coefficient and damping ratio, total damping, fluid (hydrodynamic) damping, structural (or support) damping, damping of bridges, towers, buildings, piping and aircraft structures.

Sound induced by Vortex shedding: Sound from single and vibrating cylinders, sound from multiple tubes and heat exchangers; sound from flow over cavities.

Examples of Fluid-structure interaction analyses: One-way separate analysis of fluid-induced vibration of steam generator tubes, two-way coupled analysis of flow-induced vibration of two tubes. Latest development in Fluid-Structure interaction.

Design of Impeller Pumps

Introduction: Classification of pumps, layout of rotodynamic pumps, head, discharge, power and efficiencies. Dimensional analysis, non-dimensional parameters, condition of similarity, specific speed and its significance. Elements of pumps- impeller, casings, diffusers etc.

Centrifugal Pumps: Classification, single stage and multi-stage pumps, components, priming, pressure rise in pumps, cavitation, NPSH, Thomas cavitation factor, axial thrust.

Flow through Impeller: Euler's fundamental equations, theoretical head for an infinite number of blades, influence of a finite number of blades, pressure and velocity distribution in impeller passages, influence of circulation in impeller passages, influence of pre-whirl on head, choice of blade outlet angle, stalling and surging.

Axial & Mixed Flow Pumps: Geometry of the axial flow impeller vanes, experimental design factors- impeller hub ratio, chord spacing ratio, number of vanes, vane curvature and thickness. Airfoil theory of vanes. Helical pumps and diagonal pumps.

Impeller Design: Geometrical velocity fields, evolution of impeller shapes, impellers with blades of single and double curvature, design calculation of the impeller- principal dimensions. Blade design- blade surface area, blade shape and blade angles, method of determining blade angle for centrifugal and axial impellers. Relation between overall efficiency and specific speed.

Pump Casing: Flow at the outlet of the impeller, volute casing, volute design for optimum efficiency, circular volutes. Crossover, diffusion casing and diffusion rings, axial diffusers.

Pump Characteristics: Classification of characteristics, non-dimensional characteristics, pump operation at off-design conditions, affinity of characteristic curves, iso-efficiency curves, flow conditions corresponding to the optimum efficiency, influence of flow conditions on pump operation,. Pump in series and parallel. Matching of pumps to system characteristics; multi-stage pumps. Losses in pumps, total head-discharge curves.

Pump for special duties: Deepwell pump– submersible pump and vertical turbine pump. Storage pump, turbine pump, boiler-feed pump, circulating pump, condensate pump, non-clog pump, marine pump, self-priming pump.

Design of Pipe Networks:

Introduction: uses, requirements, flow and pressure, Layout, PIPE GRAPHICS, Main sizing, Storage and pumping, Pipe valve fittings, Water meter, installation and testing

Basic Principles of Pipe Flow, Head Loss Equations.

Pipe Network Analysis Methods, Loop flow correction method, linear method. **Cost Considerations.**

General Principles of Pipe Network Synthesis: Water Transmission Lines, Water Distribution Mains, Single Input Source Branched Systems, Single Input Source Looped Systems, Multi Input Source Branched Systems, Multi Input Source Looped Systems, Decomposition of a Large Water System and Optimal Zone Size, Reorganization of Water Distribution Systems.

Optimal design of branched pipe networks by linear programming problems (LPP): Dynamic and nonlinear programming for looped networks.

Reliability of distribution system

Fluid transients: water hammer: theory, boundary conditions, water column separation unsteady flow analysis by rigid column method graphical water hammer analysis air in pipeline.

Operation and maintenance of Pipe networks.

Term Paper: Development of program for Analysis and optimization of pipe network.

Particle Technology

Overview of industrial applications of powder processing:
Ash in Thermal Power plants, Pharmaceutical powders, Food Powders, Minerals.
Characterization of powders:
Size distribution, shape, Particle density, flowability.
Unit operations for processing particulate materials:
Single particle fluid systems, Multiple particle fluid systems, Colloids and fine powders, Size enlargement and size reduction, solid-liquid and solid-gas separation, mixing, storage and flow of powders-Hopper design, pneumatic conveying, fluidization, Slurry conveying.
Nanoparticle technology:
Production, properties and behavior.
Powders and their effects on Human:
Powders and Human Respiratory system, Fire and explosion hazards of powders, industrial dust control and health risks.
Case Studies:
High Windbox Pressure in a Fluidized Bed Roaster, Inappropriate Use of an L-valve, Fluidized Bed Dryer, Aeration of a Hopper Leads to Air Shortage at a Coal Plant, Limestone Hopper Extension Overloads Feeder, The Use of Inserts in Hoppers, Dust Emission Problems during Tanker Unloading Operations, Pneumatic Conveying and Injection of Mill Scale

Design of Heat Exchangers

Introduction, classification and selection; heat exchanger thermo-hydraulic fundamentals;
heat exchanger design; compact heat exchangers; shell and tube heat exchanger design; regenerators; plate heat exchangers and spiral plate heat exchangers; Boilers, Re-boilers, condensers, Air cooled Heat exchangers,
Heat exchanger network design, Targeting and super targeting, Pinch design method, Network optimization,
heat-transfer augmentation; fouling; corrosion;
flow-induced vibration of shell and tube heat exchangers; mechanical design of shell and tube heat exchangers;
material selection and fabrication; quality control and quality assurance and nondestructive testing.
Latest advancement in Heat exchangers.

Design of Hydraulic Turbines

Hydropower plants: Types, main components. Plant load factor, load duration curve, installed capacity, firm power, secondary power, and load prediction.
Penstocks and Water Hammer: Types of penstocks and their design criteria, Economical diameter of penstock, Valves, Bends, Manifolds, Effect of Water-hammer in penstock, Surge tanks.
Introduction to Hydraulic Turbines: Definition of head, discharge, power and efficiency of hydraulic turbines and hydro-unit. Classification based on head, specific speed, degree of reaction and direction of flow. Energy losses in turbines. Euler's energy equation, blade surface equation.
Impulse Turbines: Energy conversion in Pelton turbine, design parameters, design of turbine runner, nozzle, spear.
Reaction(Francis)Turbines: Classification, flow in runner, design parameters, determination of meridional flow, one-dimensional method of designing runner blades, relationship between the shape of blades and two-dimensional flow within runners. Blade designing in potential and rotational meridional flow. Draft tube- design and application. Deriaz turbine.
Reaction (Axial Flow) Turbines: Major definitions and relations concerning the flow within a runner, design parameters, flow upstream and downstream of the runner, determination of velocity triangles at inlet and outlet of the runner. Airfoil method of blade designing –cascade analysis and its performance, loss mechanism, blade profiles, forces acting on blades
Cavitation In Hydraulic Turbine: Condition, types, consequences, remedy. Turbine cavitation coefficient, NPSH. Similarity laws in cavitating flows. Method of cavitation investigation in hydraulic turbines at laboratories and hydropower plants.
Turbine Performance Characteristics: Main characteristics and operating characteristics, iso-efficiency characteristics, Determination of major prototype turbine parameters on the basis of model characteristic curves. Derivation of the complete characteristics of prototype turbine. Distorted model, scale effect and efficiency.
Latest Trends and Development in Hydraulic Turbines: State-of-art for last few decades, latest design trends, newer applications in micro and pico-hydel power stations.

Design and Selection of Power plant Equipment

Introduction to thermal power plant and its basic components:
Basic working principle of thermal power plants, Introduction to principal Components of thermal power plants: Boiler, Drum, turbine, Condenser, Reheater, Burner, draft fan, cooling tower, generator, Air preheater, economiser, Ash Handling unit.

Steam Turbine and Gas turbines:
Steam Turbine: Principle of operation, types of steam turbines, compounding of steam turbines, impulse turbine – velocity diagram, calculation of work, power and efficiency, condition for maximum efficiency, Reaction turbines – velocity diagram, degree of reaction, reheat factor, governing of steam turbine – throttle, nozzle and bypass governing, Methods of attachment of blades to turbine rotor, Labyrinth packing, Losses in steam turbine, Special types of steam turbine- back pressure, pass out and mixed pressure turbine.
Gas Turbine: Classification, open and closed cycle, gas turbine fuels, actual Brayton cycle, optimum pressure ratio for maximum thermal efficiency, work ratio, air rate, effect of operating variables on the thermal efficiency and work ratio, and air rate, simple open cycle turbine with regeneration, reheating and Intercooling, Combined steam and gas turbine plant, requirements of combustion chamber, types of combustion chambers.

Pumps and Compressors:
Pumps: Classification of rotodynamic pumps, components of centrifugal pump, types of heads, velocity triangles and their analysis, effect of outlet blade angle, cavitation, NPSH, Thoma"s cavitation factor, priming of pumps, installation, specific speed, performance characteristics of centrifugal pump, series and parallel operation of pumps, system resistance curve, selection of pumps.
Compressors: Classification of rotodynamic compressors, blowers, fans. Centrifugal compressor: Construction, flow process on T-S Diagram, velocity diagram and Euler's work, slip factor and its effect on work input, actual work input, dimension parameters, pre-whirl losses, surging, choking, stalling characteristics.

Ash Handling Units:
Location of generation and classification of coal ash in thermal power plants, Electro static precipitators, Hoppers, Characterization techniques and application of coal ash, transportation of coal ash; slurry, pneumatic, capsule, hazards to human respiratory system, storage of ash, utilization of ash.

Honours (Biomedical Engineering)

Advanced Biomechanics

Applications of Principles of Biomechanics in Two- and three-dimensional kinematics.
Kinematics: Body segment parameters: Method of measuring and estimating body segment parameters, two dimensional and three-dimensional computational methods.
Two dimensional inverse dynamics: Planar motion analysis, numerical formulations, Human joint kinetics.
Three-dimensional Kinetics: Data required for Three-dimensional analysis, anthropometry and three-dimensional kinetics calculations.
Electromyographic Kinesiology: Physiology of the EMG Signals, Acquisition, interpretation and Analysis of EMG Signals. Applications of EMG Techniques in Biomechanics related problems.
Computer simulation of Human Movement: Mathematical formulations, free body diagrams, Lagrange's equation of motion, numerical solution techniques, control theory, advantages and limitation of computer models.
Elastic Behavior of Biological Materials: Strain and stress relationship, Plastic deformation, Biological material properties based on strain and stress diagram.
Viscoelastic Behavior of Soft Tissues:
Viscoelasticity, Analogies based on Spring and dashpots, Empirical models of Viscoelasticity, Time-dependent material response, Bio viscoelastic solids, Structure of Skeletal Muscle, Sliding element theory of muscle action, Hill's Equation for skeletal muscle, Modified Hill equation, Hypothesis of Cross Bridge Theory. Other recent muscle models.

Biomedical Instrumentation

Basic concepts of Medical Instrumentation: Generalized medical instrumentation System, Medical Measurement constraints, Classification of Biomedical Instruments, Generalized static and dynamic characteristics, Design criteria, Commercial Medical Instrumentation Development process, Regulation of Medical Devices.

Theory, Analysis and design of biomedical transducers: optical, photo-electric, electrochemical, electrical, mechanical, electromechanical and thermoelectric, Applications to biomedical systems, Transducer characteristics sensors for physical measurands, sensors for measurement of chemicals. Medical measurands sensor characteristics and design for measurement of medical parameters like ECG, arterial blood pressure heart sounds, bio-potential amplifiers, Various types of electrodes used in ECG, EEG and EMG, Measurement of EEG, EMG and their diagnostic applications in Medicine, Flow and pressure measuring instruments in biomedical engineering, Development of non-invasive diagnostic instruments for tissue abnormalities, Medical Ultrasonography, Latest biomedical Instruments, Electro surgical unit, Pulse Oximeter, Defibrillators, Foetal ECG.

Biofluid Dynamics

Introduction to Fluid Mechanics: Fluid properties, basic laws governing conservation of mass momentum and energy; laminar flow, couette flow and hagen-poiseuille equation.

Blood Rheology: Blood system network and physiology, blood rheology, Vessel structure and mechanical properties, Large artery hemodynamics, Blood flow in small vessels, Flow of Newtonian and non-Newtonian fluids in rigid tubes, flexible tubes and collapsible tubes.

Circulatory system: Anatomy of the vasculature, Heart and pumping process, Cardiac cycle; Qualitative description of cardiac pumping, Arterial pulse propagation, Systolic and diastolic pressure, Windkessel model, Arterial wall structure and elasticity, Pressure–flow relationships: purely oscillatory flow, Osmotic pressure The capillaries, The veins, Cardiac valve dysfunctions and heart failure, Components and functions of arterial and venous systems, pressure-flow relations in vascular beds.

Respiratory system: Gross anatomy and Physiology, Biofluid dynamics of breathing, Lung elasticity and surface tension effects, Flow behavior in upper and lower human respiratory system during different breathing conditions, studies of wall shear stress and its implications, Mass transfer in lungs, Particle transport in the lung, Dispersion and deposition of aerosols/inhaled particles in respiratory system, critical airways, tumorous airways.

Biomaterials

Classes of biomaterials, Bulk Properties of Materials, Surface properties and surface characterization of materials, Properties of biomaterials: Physical, thermal, electrical and optical properties of bio-materials. Biocompatibility, Bio-functionality, Mechanical and Biological Testing of Biomaterials, Regulatory issues and medical ethics

Metallic Implant Materials: Stainless steels, Co-based alloys, Ti and Ti-based alloys and Other metals. Corrosion of metallic implants.

Ceramic Implant Materials: Aluminum oxides, Calcium Phosphate, Glass Ceramics and Carbons. Medical applications of Ceramic Materials.

Polymeric implant: Polymerization, Polymeric implant materials, Degradable Polymers used for Biomedical Applications. Silicone used for Biomaterials, Hydrogels, Smart Polymers as biomaterials, Polymers used for drug delivery and Tissue Engineering Applications. Natural polymers found in human body, Composites as Biomaterials.

Applications in Cardiovascular, Orthopedic, and Ophthalmological implants and devices, Biomaterials used for artificial skin and dental implant applications.

Recent advances in the field of Biomaterials.

Biomedical Signal Processing and Analysis

Introduction to bioelectric phenomenon, generation, transmission and interaction of signals in nervous systems. Discussion of initiation and propagation of action potential along the nerve fibers. Voltage clamp experiments, synaptic transmission and transduction process and receptors. Frequency modulation of the electrical signals. Use of mathematical models particularly electrical circuits models and describing behavior of cell membrane. Neural control mechanism, genesis and characteristics of EEG, ECG, EMG and Evoked potentials.

Design, Innovation, and Entrepreneurship in Biomedical Engineering

Design Process: Creative and Design Thinking, Minimum Viable Product, Business Model Development, Business Plan and Access to Funding. Elements of design process including need identification, concept generation, concept selection and implementation with specific applications in HealthCare. System Synthesis, Design analyses, optimization, impact on patient health and comfort, healthcare costs, clinical trials and regulatory issues and medical ethics.

Orthopedic Implant Design: Design Concepts, Clinical Problems Requiring Orthopedic Implants for Solution, Principles of Orthopedic Implant Design, Design Parameters.

Tissue Engineering: Scaffolds, Cells and Regulators, Case Study of Organ Regeneration, Design Parameters, Design Specifications: Biomaterials, Biocompatibility: Local and Systemic Effects, Design Specifications, Biocompatibility: Scar Formation and Contraction, Degradation of Devices: Corrosion and Wear, Regulation of medical Devices,

Cardiovascular Prostheses Design: Heart Valves and Stents, Devices for Nerve Regeneration, Musculoskeletal Soft Tissues: Meniscus, Intervertebral Disk, Dental and Ear Implants,

Design and application of electromechanical biomedical devices, Concept of prototype development and testing of medical instrument.

Innovations in Healthcare: Idea generation, market research, product development and financing, Team development and business model for commercialization of healthcare innovations.

Introduction to entrepreneurship: Healthcare start- ups. Recent Innovations in Healthcare.

Mini Project: Design and analysis of any innovative healthcare product

Medical Imaging and Diagnostics

Introduction to medical imaging and different medical Imaging modalities. Review of Signals and system, Fourier transform, Transfer functions, Hankel transform, Sampling theorem.

Image Quality: Contrast, Modulation transfer function, resolution, Noise, Signal to noise ratio, accuracy, etc.

Radiography: Atomic structure (review), Ionization, forms of Ionizing radiation and their properties, Radiation dosimetry.

Projection Radiography: X-Ray production, X-ray interaction with biological matters, Instrumentation for medical X-ray system, Filters, contrast agents, X- Films and intensifiers, Image formation, Noise and artifacts.

X-Ray Computed Tomography: CT Instrumentation, Different generations of CT Scanner, Imaging principle, Image formation, Redon transform, Back Projection Theorem, Helical CT Reconstruction, Cone Beam CT, Image quality in CT.

Application of Projection radiography: Mammography, Fluoroscopy, Angiography, etc.

Nuclear Medical Imaging: Radio Active Decay, Modes of decay, Radio traces, Instrumentation for planer scintigraphy, Image Formation and Image quality. Instrumentation for PET and SPECT, Image Quality in PET and SPECT.

Ultrasound Imaging: Physics of Ultrasound, interaction of ultrasound with biological matter, Ultrasound beam patterns and focusing. Instrumentation for ultrasound imaging system, ultrasound transducer and probes, pulse echo imaging, A Mode, B Mode and M Mode imaging. Doppler ultrasound imaging.

Magnetic Resonance Imaging:

Instrumentation for MRI System, Concept of MRI Imaging, Magnetization, RF excitation, relaxation, Pulse echo sequences and contrast mechanism. MRI data acquisition, Image Reconstruction and Image quality.

Biomimetics

Intro to bio inspired design, Case Studies. Biological vs Human Solutions, Evolution and rate of innovation, Nature as mentor, source of inspiration, Self-healing, Self-assembly, Hierarchal structures, Structure-function relationship in biological systems, Biomineralization, Bioprocesses, Systems Organization: Bees as a model, Locomotion: Control, balance, gait Bio-inspired robotics, Design Challenges, Design Process, Requirements, abstraction, process, Problem decomposition, Representation and Analogical thinking, Inventions inspired by nature for biomedical applications

Orthopedic Biomechanics

Physiology of neuro-musculoskeletal system, loads and motion in the musculoskeletal system; bone tissue mechanics, soft tissue mechanics, structural analysis of musculoskeletal systems, bone-implant systems, bone mechanotransduction; biomechanics of fracture healing, fracture fixation devices, total hip replacements, total knee replacements, articulating surfaces, design of orthopedic implant.

Sports Biomechanics

Muscle Action in Sport and Exercise - Biomechanical view: Mechanical Properties and Performance in Skeletal Muscles, Muscle-Tendon Architecture and Athletic Performance - Eccentric Muscle Action in Sport and Exercise - Stretch–Shortening Cycle of Muscle Function - Biomechanical Foundations of Strength and Power Training.

Jumping and Aerial Movement: Aerial Movement - The High Jump - Jumping in Figure Skating, Throwing and Hitting, Principles of Throwing, The Flight of Sports Projectiles - Javelin Throwing: An Approach to Performance Development - Shot Putting - Hammer Throwing: Problems and Prospects.

Injury Prevention and Rehabilitation: Mechanisms of Musculoskeletal Injury - Musculoskeletal Loading during Landing - Sport-Related Spinal Injuries and their Prevention - Impact Propagation and its Effects on the Human Body - Neuromechanics of the Initial Phase of Eccentric Contraction-Induced Muscle Injury.

Special Olympic Sports: Manual Wheelchair Propulsion, Sports after Amputation. Biomechanics of Dance, Biomechanics of Martial arts.

Biomechanics of YOGA: Introduction, Definition of Yoga, Origin of the word Yoga, Meaning of the word Hatha, Stages of Yoga, Types of Yoga, Karma yoga, Gnana Yoga, Bhakti Yoga, Kriya Yoga, Buddhism and Yoga, Yoga as a Universally accepted term

Bachelor of Technology

in

Materials Engineering

Course Structure,
Scheme of Evaluation
&
Syllabi

Department of Applied Mechanics

Motilal Nehru National Institute of Technology Allahabad

Prayagraj, U.P. -211004, INDIA

MOTILAL NEHRU NATIONAL INSTITUTE OF TECHNOLOGY ALLAHABAD

VISION

To establish a unique identity for the institute amongst national and international academic and research organizations through knowledge creation, acquisition and dissemination for the benefit of society and humanity.

MISSION

- To generate high quality human and knowledge resources in our core areas of competence and emerging areas to make valuable contribution in technology for social and economic development of the nation. Focused efforts to be undertaken for identification, monitoring and control of objective attributes of quality and for continuous enhancement of academic processes, infrastructure and ambience.
- To efficaciously enhance and expand, even beyond national boundaries, its contribution to the betterment of technical education and offer international programmes of teaching, consultancy and research.

DEPARTMENT OF APPLIED MECHANICS

VISION

To establish department recognized globally for its quality education and research in the broad field of Applied Mechanics, Materials and Bio-medical Engineering.

MISSION

- To produce high quality skilled human resource in the area of Applied Mechanics, Materials and Bio-medical Engineering.
- To carry out quality research having social & industrial relevance and keep abreast with rapid strides of technology.
- Improve academic standards through innovative teaching and learning processes and disseminate the same by contributing and conducting STTP, Workshops, Symposiums and Conferences.
- Establish academic linkages with leading industries to provide technical support to growing entrepreneurs and existing industries for mutual benefit.

Graduate Attributes (GAs):

1. **Scholarship of Knowledge**: Acquire in-depth knowledge of specific discipline or professional area, including wider and global perspective, with an ability to discriminate, evaluate, analyze and synthesize existing and new knowledge, and integration of the same for enhancement of knowledge.
2. **Critical Thinking**: Analyze complex engineering problems critically, apply independent judgment for synthesizing information to make intellectual and/or creative advances for conducting research in a wider theoretical, practical and policy context.
3. **Problem Solving:** Think laterally and originally, conceptualize and solve engineering problems, evaluate a wide range of potential solutions for those problems and arrive at feasible, optimal solutions after considering public health and safety, cultural, societal and environmental factors in the core areas of expertise.
4. **Research Skill**: Extract information pertinent to unfamiliar problems through literature survey and experiments, apply appropriate research methodologies, techniques and tools, design, conduct experiments, analyze and interpret data, demonstrate higher order skill and view things in a broader perspective, contribute individually/in group(s) to the development of scientific/technological knowledge in one or more domains of engineering.
5. **Usage of modern tools**: Create, select, learn and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modeling, to complex engineering activities with an understanding of the limitations.
6. **Collaborative and Multidisciplinary work**: Possess knowledge and understanding of group dynamics, recognize opportunities and contribute positively to collaborative-multidisciplinary scientific research, demonstrate a capacity for self-management and teamwork, decision-making based on open-mindedness, objectivity and rational analysis in order to achieve common goals and further the learning of themselves as well as others.
7. **Project Management and Finance**: Demonstrate knowledge and understanding of engineering and management principles and apply the same to one's own work, as a member and leader in a team, manage projects efficiently in respective disciplines and multidisciplinary environments after consideration of economical and financial factors.
8. **Communication**: Communicate with the engineering community, and with society at large, regarding complex engineering activities confidently and effectively, such as, being able to comprehend and write effective reports and design documentation by adhering to appropriate standards, make effective presentations, and give and receive clear instructions.
9. **Life-long Learning**: Recognize the need for, and have the preparation and ability to engage in life-long learning independently, with a high level of enthusiasm and commitment to improve knowledge and competence continuously.
10. **Ethical Practices and Social Responsibility**: Acquire professional and intellectual integrity, professional code of conduct, ethics of research and scholarship, consideration of the impact of research outcomes on professional practices and an understanding of responsibility to contribute to the community for sustainable development of society.
11. **Independent and Reflective Learning**: Observe and examine critically the outcomes of one's actions and make corrective measures subsequently, and learn from mistakes without depending on external feedback.

DEPARTMENT OF APPLIED MECHANICS

Bachelor of Technology in Materials Engineering

Objective of the Programme

Prepare the young minds to understand the need of materials for engineering and strategic applications. The course focuses on the engineering and development of materials including cutting edge research through computations and experimentations.

Degree on Offer and Annual Intake

B. Tech/ B. Tech (Honours) in Materials Engineering from Department of Applied Mechanics: 30 students through JEE (Mains).

PROGRAM EDUCATIONAL OBJECTIVES

PEO-1	To understand the importance of materials in life and the relationship between structure, properties and processing to evaluate the performance of materials in engineering applications.
PEO-2	To characterize materials and to practice amicable selection of materials for various applications.
PEO-3	To develop effective and eco-friendly materials for generic and sustainable applications.
PEO-4	To inculcate ability in student to pursue life-long learning to acquire skill-sets for professional practices.

Mapping of Mission statements with program educational objectives Mission Statement

Mission statements	PEO-1	PEO-2	PEO-3	PEO-4
MS1	√	√	√	
MS2			√	√
MS3		√	√	√
MS4	√	√	√	√

Mapping of program educational objectives with graduate attributes

PEO	GA1	GA2	GA3	GA4	GA5	GA6	GA7	GA8	GA9	GA10	GA11
PEO-1	√	√	√	√		√			√		
PEO-2	√	√	√		√		√				√
PEO-3	√	√	√		√					√	
PEO-4			√	√	√	√	√	√	√	√	√

PROGRAM OUTCOMES: At the end of the program the student will be able to:

PO1	To understand the correlation between structure and properties, their constitutive equations; phenomena to improve the performance of materials.
PO2	Materials synthesis and structural modification for improvement in the properties of materials.
PO3	Study and understanding of materials/products for their material behavior.
PO4	Understanding of metallurgical processes to produce products as per specifications.
PO5	Knowledge of different fabrication techniques of materials such as metals, alloys and composites.
PO6	Characterize and evaluate materials for specific applications.
PO7	Understanding of Materials modeling and simulations
PO8	Understanding of sustainable eco-friendly development of materials for different applications.
PO9	Academic and industrial project management and logistics.
PO10	Life-long learning, practices of professional ethics, moral and human values to improve professionalism.

Mapping of program outcomes with program educational objectives

PO	PEO1	PEO2	PEO3	PEO4
1.	3		2	
2.	2	3	2	
3.	1	2	3	1
4.	3	2	2	1
5.	1	2	3	
6.	2	3	2	1
7.	3		2	
8.	2	2	3	1
9.		1	2	3
10.	1	1	1	3

1: Slightly 2: Moderately 3: Substantially

Course Structure

I[st] Semester (Total Credits = 24):

Course Code	Subject Name	L	T	P	Credits	Distribution of Marks out of 100		
						TA	Mid Sem. Exam	End Sem. Exam
PH*****	Engineering Physics	3	0	2	4	20	20	60
CY*****	Engineering Chemistry	3	0	2	4	20	20	60
ME*****	Engineering Graphics	1	0	3	3	20	20	60
MA*****	Engineering Mathematics-1	3	0	0	3	20	20	60
AM*****	Engineering Mechanics	3	0	2	4	20	20	60
BT*****	Biology for Engineers	3	0	0	3	20	20	60
HS*****	Communication Skill and Technical Writing	2	0	2	3	20	20	60
	Total =	18	0	11	24			

II[nd] Semester (Total Credits = 24):

Course Code	Subject Name	L	T	P	Credits	Distribution of Marks out of 100		
						TA	Mid Sem. Exam	End Sem. Exam
CS*****	Computer Programming	3	0	2	4	20	20	60
EC*****	Basic Electronics and Instrumentation	3	0	2	4	20	20	60
EE*****	Basic Electrical Engineering and Measurement	3	0	2	4	20	20	60
ME*****	Workshop Technology	1	0	3	3	20	20	60
MA*****	Engineering Mathematics-2	3	0	0	3	20	20	60
AM*****	Fluid Mechanics	3	0	0	3	20	20	60
HS*****	Environment and Ecology	2	0	0	2	20	20	60
SA*****	NCC/NSS/SPORTS	0	0	2	1	20	20	60
	Total =	15	0	11	24			

III[rd] Semester (Total Credits = 24):

Course Code	Subject Name	L	T	P	Credits	Distribution of Marks out of 100		
						TA	Mid Sem. Exam	End Sem. Exam
AM*****	Structure of Materials	3	0	2	4	20	20	60
AM*****	Phase Diagrams	3	0	0	3	20	20	60
AM*****	Mechanics of Solids	3	0	2	4	20	20	60
AM*****	Transport Phenomenon	3	0	0	3	20	20	60
AM*****	Applied Computational Methods	3	0	2	4	20	20	60
SA*****	Language Course/Club activities	3	0	0	3	20	20	60
HS*****	Economics for Engineers	3	0	0	3	20	20	60
	Total =	21	0	6	24			

IVth Semester (Total Credits = 23):

Course Code	Subject Name	L	T	P	Credits	Distribution of Marks out of 100		
						TA	Mid Sem. Exam	End Sem. Exam
AM*****	Metallurgical Thermodynamics and Kinetics	3	0	0	3	20	20	60
AM*****	Non-ferrous Metals and Alloys	3	0	0	3	20	20	60
AM*****	Materials Characterization	3	0	2	4	20	20	60
AM*****	Polymer Science and Composites	3	0	2	4	20	20	60
AM*****	Iron and Steel Making	3	0	0	3	20	20	60
SA*****	Language Course (French/German/Japanese etc...)	3	0	0	3	20	20	60
HS*****	Engineering Ethics, IPR and Entrepreneurship	3	0	0	3	20	20	60
	Total =	21	0	4	23			

Compulsory Summer Training (30-45 days) (Total 3 Credits: Independent project in Semester V and VI on the basis of this training)

Vth Semester (Total Credits = 26):

Course Code	Subject Name	L	T	P	Credits	Distribution of Marks out of 100		
						TA	Mid Sem. Exam	End Sem. Exam
AM*****	Mechanical Metallurgy	3	0	2	4	20	20	60
AM*****	Heat Treatment and Phase Transformation	3	0	2	4	20	20	60
AM*****	**	3	0	2	4	20	20	60
AM*****	**	3	0	2	4	20	20	60
AM*****	**	3	0	2	4	20	20	60
HS*****	Organizational Behaviour and Psychology	3	0	0	3	20	20	60
AM*****	Independent Project-I	0	0	2	1			
	Total =	21	0	10	24			

VIth Semester (Total Credits = 26):

Course Code	Subject Name	L	T	P	Credits	Distribution of Marks out of 100		
						TA	Mid Sem. Exam	End Sem. Exam
AM*****	Introduction to Computational Material Science	3	0	2	4	20	20	60
AM*****	Corrosion Science and Engineering	3	0	2	4	20	20	60
AM*****	***	3	0	0	3	20	20	60
AM*****	***	3	0	0	3	20	20	60
AM*****	***	3	0	0	3	20	20	60

HS*****	Indian Art and Culture	3	0	0	3	20	20	60
AM*****	Independent Project-II	0	0	4	2			
	Total =	21	0	10	22			

Compulsory Summer Training (30-45 days) (Evaluation: SSSS; minimum 2S required otherwise to be repeated in the summer after VIII Semester)

VII[th] Semester (Total Credits = 20):

Course Code	Subject Name	L	T	P	Credits	Distribution of Marks out of 100		
						TA	Mid Sem. Exam	End Sem. Exam
AM*****	Modelling & Simulation in Materials Processes	3	0	2	4	20	20	60
AM*****	Machine Learning in Materials Science	3	0	2	4	20	20	60
AM*****	Ceramics and Refractories	3	0	0	3	20	20	60
AM*****	**	3	0	0	3	20	20	60
AM*****	**	3	0	0	3	20	20	60
AM*****	**	3	0	0	3	20	20	60
	Total =	18	0	4	20			

VIII[th] Semester (Total Credits = 16):

Course Code	Subject Name	L	T	P	Credits	Distribution of Marks out of 100		
						TA	Mid Sem. Exam	End Sem. Exam
AM*****	Industrial Training/ Major Project	0	0	16	16	20	20	60

Note: The distribution of thesis evaluation marks will be as follows:

1. Supervisor(s) evaluation component: 60%
2. Oral Board evaluation component: 40%

List of Core Electives

S No	V[th] Semester	
1.	AM***** Finite Element Method	3(L) - 0(T) – 2(P) – 4(Cr)
2.	AM***** Powder Metallurgy	3(L) - 0(T) – 2(P) – 4(Cr)
3.	AM***** Mechanical Processing of Materials	3(L) - 0(T) – 2(P) – 4(Cr)
4.	AM***** Non-Destructive Testing	3(L) - 0(T) – 2(P) – 4(Cr)
5.	AM***** Materials Selection and Design	3(L) - 0(T) – 2(P) – 4(Cr)
6.	AM***** Electrical, Electronic and Magnetic Materials	3(L) - 0(T) – 2(P) – 4(Cr)
7.	AM***** Additive Manufacturing	3(L) - 0(T) – 2(P) – 4(Cr)
8.	AM***** Biomaterials	3(L) - 0(T) – 2(P) – 4(Cr)
VI[th] Semester		
9.	AM***** MEMS & Bio-MEMS	3(L) - 0(T) – 0(P) – 3(Cr)

10.	AM***** Electroacoustic Transducers	3(L) - 0(T) – 0(P) – 3(Cr)
11.	AM***** Nanomaterials and Nano Technology	3(L) - 0(T) – 0(P) – 3(Cr)
12.	AM***** Energy Materials	3(L) - 0(T) – 0(P) – 3(Cr)
13.	AM***** Smart Materials and Systems	3(L) - 0(T) – 0(P) – 3(Cr)
14.	AM***** Smart Materials and Structures	3(L) - 0(T) – 0(P) – 3(Cr)
15.	AM***** Electronic Ceramics	3(L) - 0(T) – 0(P) – 3(Cr)
16.	AM***** Physical Chemistry of Steels	3(L) - 0(T) – 0(P) – 3(Cr)
17.	AM***** Alternate Route to Steel Manufacturing	3(L) - 0(T) – 0(P) – 3(Cr)
VIIth Semester		
18.	AM***** Plasma Technology	3(L) - 0(T) – 0(P) – 3(Cr)
19.	AM***** Fatigue and Fracture of Materials	3(L) - 0(T) – 0(P) – 3(Cr)
20.	AM***** High Temperature Materials	3(L) - 0(T) – 0(P) – 3(Cr)
21.	AM***** MEMS & Bio-MEMS	3(L) - 0(T) – 0(P) – 3(Cr)
22.	AM***** Carbon Nanotube and Carbon Nanostructures	3(L) - 0(T) – 0(P) – 3(Cr)
23.	AM***** Nuclear Materials	3(L) - 0(T) – 0(P) – 3(Cr)
24.	AM***** Tribology	3(L) - 0(T) – 0(P) – 3(Cr)
25.	AM***** Thin Films/Coatings and Applications	3(L) - 0(T) – 0(P) – 3(Cr)
26.	AM***** Automotive and Aerospace Materials	3(L) - 0(T) – 0(P) – 3(Cr)

Semester-wise Summary of Credits

<table>
<tr><td rowspan="4">Summary of Credits</td><td colspan="8">B.Tech (Honours)</td></tr>
<tr><td colspan="6">B.Tech</td><td colspan="2" rowspan="3">177 Credits</td></tr>
<tr><td colspan="4">Diploma</td><td colspan="2" rowspan="2">141 Credits</td></tr>
<tr><td colspan="2">Certificate</td><td colspan="2">95 Credits</td></tr>
<tr><td>Semester</td><td>1st</td><td>2nd</td><td>3rd</td><td>4th</td><td>5th</td><td>6th</td><td>7th</td><td>8th</td></tr>
<tr><td>Credits</td><td>24</td><td>24</td><td>24</td><td>23</td><td>24</td><td>22</td><td>20</td><td>16</td></tr>
</table>

Summary of Credits

S No	NEP Details	Credit Required	Credit Present
1.	Engineering (Graduate) Essentials	24	28
2.	Core Essential (Major)	60±8	65
3.	Core Elective (Major)	40±8	21
4.	Industrial Training/ Group Project	16	19
5.	Humanities and Social Sciences	16	14
6.	Language/Sports/NCC/NSS/Music/Yoga/Dance/Arts	8	10
7.	Minor/ Honors	24±8	20
	Total	188±24	177

PH***** Engineering Physics		
Designation	:	Compulsory
Pre-requisites	:	None
Credit and Contact hrs	:	3(L) - 0(T) - 2(P) - 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 50 marks **Internal Assessment: (Scheme)** 50 marks (10 marks for attendance + 40 marks shall be for the day-to-day assessment of performance in the all the Lab Sessions evaluated through daily preparedness for conducting Experiments, participation in conduct of Experiments, Report Writing and submission, Interaction, Sincerity, Attendance and Quizzes.
Course Outcomes	:	**The successful student will learn:** 1. Solve engineering problems using the concepts of wave and particle nature of radiant energy 2. Understand the use of lasers as light sources for low and high energy applications 3. Understand the nature and characterization of acoustic design, nuclear accelerators and new materials 4. Apply the concepts of light in optical fibers, light wave communication systems, and holography and for sensing physical parameters 5. Construct a quantum mechanical model to explain the behaviour of a system at microscopic level
Modes of Delivery	:	Demonstration in laboratory and Power point presentations etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	√	√	√	√				√		√
CO2	√	√	√	√	√	√		√	√	√
CO3		√	√		√			√		
CO4		√			√	√	√	√	√	√

Syllabus

Physical Optics: Interference: Condition of observing interference, Production of interference fringes and determination of wavelength using Fresnel's Biprism. Stoke's treatment, Interference due to thin films. Wedge shaped films. Newton's rings.

Polarization: Unpolarised, Polarized and partially polarized lights, Polarization by reflection. Double refraction by uniaxial crystals, Nicol prism, Polaroid's, Huygens's theory of double refraction. Half wave and quarter wave plates, Analysis of plane, elliptical and circularly polarized light. Optical activity. Fresnel's theory of optical rotation, Specific rotation, Biquartz and Laurent half-shade polarimeters.

Electrostatics: Gradient, Divergence and curl operations, Gauss divergence theorem and Stoke's theorem, Gauss law in electrostatics and its applications, Poisons and Laplace equations.

Magnetostatics: Biot-Savart's law, Magnetic field of a steady current, Magnetic field due to circular loop at axial points. Working of Helm-holtz galvanometer, Ampere's law and its applications, Force on a charged particle in electric and magnetic fields, Magnetic vector potential.

Electrodynamics and Electromagnetic waves: Faradays' law of electromagnetic induction, Self and mutual inductance, Energy in Magnetic field, Energy of a solenoid, Displacement current, Maxwell's equations (integral and differential forms) in free space, Plane wave solution, Propagation of electromagnetic waves in free space, Poynting's theorem.

Quantum Mechanics: Failure of classical concepts, Wave particle duality, Wave packets, Phase and group velocity, Heisenberg's uncertainty principle and its applications, Wave function and its physical interpretation, Probabilities and Normalization, Time independent and dependent Schrodinger wave equation and its simple applications.

References books

1. Halliday, Resnic and Walker, Fundamentals of Physics, 9th Ed.,John Wiley, 2011.
2. Beiser A, Concepts of Modern physics, 5th Ed., McGraw Hill International, 2003.
3. Ajoy Ghatak, Optics, 2nd Ed., Tata McGraw Hill, 1994.
4. M. Arumugam, Engineering Physics, Anuradha Agencies, 2003 Physics for Engineers-M.R.Srinivasan

CY***** Engineering Chemistry		
Designation	:	Compulsory

Pre-requisites	:	Nil
Credit and Contact hrs	:	3(L) - 0(T) - 2(P) - 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment: (Scheme)** 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise Tests, Term paper etc)
Course Outcomes	:	**The successful student will learn:** 1. Understand and apply the concepts in electrochemistry and corrosion science 2. Understand the concepts in molecular interactions 3. Understand the synthesis and analysis of modern materials 4. Apply the concepts of organic chemistry for synthesis 5. Understand the synthesis and applications of polymer science 6. Identify the structure of organic molecules using photo chemistry and chemical spectroscopy
Modes of Delivery	:	Talk and chalk, Power point presentations, and practical etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	√			√			√	√		
CO2			√				√	√		√
CO3			√			√		√		
CO4	√		√			√		√		

Syllabus

Chemical Bonding: Ionic Bonding and Covalent Bonding, Valence Bond and Molecular orbital theories of bonding, Bonding in Metals, semiconductors and insulators, imperfections in solids.

Polymers: Classifications of polymers, types of polymerization and their principles, structure-property relationship, polymer materials of industrial importance, biopolymers.

Water Chemistry: sources and nature of impurities, characteristics of natural water, water treatment processes, municipal supplied water.

Fuels: classification, calorific values, analysis of solid fuels, liquid fuels and its properties, refining, cracking and reforming of petroleum, knocking and octane and cetane rating, anti-knocking agents.

Corrosion: Theories of corrosion, types of corrosion, its prevention and control.

Green Chemistry: Introduction to green chemistry and its importance.

Lubricants: Definition, functions, mechanism and classifications of lubricants, properties of testing of lubricants.

Phase Rule: Derivation of phase rules and its application to one component water system.

Adsorption: Definition and classification of adsorption, adsorption of gases on solids, adsorption from solution, application of adsorption, theories of adsorption.

References books

1. A Text Book of Engineering Chemistry, S.Chawla, Dhanpat Rai & Co., New Delhi, 2004.
2. Engineering Chemistry: Theory & Practices, J.N.Gurtu and N.Singhal, Pragati Prakashan, Meerut, 2004.
3. Engineering Chemistry, Jain & Jain, Dhanpat Rai & Co., New Delhi, 2000.

ME*** Engineering Graphics**

Designation	:	Compulsory
Pre-requisites	:	Nil
Credit and Contact hrs	:	1(L) - 0(T) - 3(P) - 3(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment: (Scheme)** 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise Tests, Term paper etc)
Course Outcomes	:	The successful student will learn: 1. Irrespective of engineering discipline, it has become mandatory to know the basics of Engineering graphics. The student is expected to possess the efficient drafting skill

		depending on the operational function in order to perform day to day activity. 2. Provide neat structure of industrial drawing. 3. Enables the knowledge about position of the component and its forms Interpretation of technical graphics assemblies. 4. Preparation of machine components and related parts.
Modes of Delivery	:	Talk and chalk, Power point presentations, and practical etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	√			√					√	
CO2			√		√	√		√	√	
CO3			√		√	√		√		
CO4				√					√	

Fundamentals Drawing standard - BIS, dimensioning, lettering, type of lines, scaling- conventions. Geometrical constructions: Dividing a given straight line into any number of equal parts, bisecting a given angle, drawing a regular polygon given one side, special methods of constructing a pentagon and hexagon – conic sections – ellipse – parabola – hyperbola - cycloid trochoid. Orthographic projection: Introduction to orthographic projection, drawing orthographic views of objects from their isometric views - Orthographic projections of points lying in four quadrants, Orthographic projection of lines parallel and inclined to one or both planes Orthographic projection of planes inclined to one or both planes. Projections of simple solids - axis perpendicular to HP, axis perpendicular to VP and axis inclined to one or both planes. Sectioning of solids: Section planes perpendicular to one plane and parallel or inclined to other plane. Intersection of surfaces: Intersection of cylinder & cylinder, intersection of cylinder & cone, and intersection of prisms. Development of surfaces: Development of prisms, pyramids and cylindrical & conical surfaces. Isometric and perspective projection: Isometric projection and isometric views of different planes and simple solids, introduction to perspective projection. Computer aided drafting Introduction to computer aided drafting package to make 2-D drawings

References books

1. Bhatt, N. D. and Panchal, V.M., 'Engineering Drawing', Pub.: Charotar Publishing House, 2010.
2. Natarajan, K. V., 'A Text Book of Engineering Graphics', Pub.: Dhanalakshmi Publishers, Chennai, 2006.
3. Venugopal, K. and Prabhu Raja, V., 'Engineering Drawing and Graphics + AutoCAD', Pub.: New Age International, 2009.
4. Jolhe, D. A., 'Engineering drawing', Pub.: Tata McGraw Hill, 2008.
5. Shah, M. B. and Rana, B. C., 'Engineering Drawing', Pub.: Pearson Education, 2009.
6. Trymbaka Murthy, S., 'Computer Aided Engineering Drawing', Pub.: I.K. International Publishing House, 2009.

MA*** Engineering Mathematics-I**

Designation	:	Compulsory
Pre-requisites	:	Nil
Credit and Contact hrs	:	3(L) - 0(T) – 0(P) – 3(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment: (Scheme)** 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise Tests, Term paper etc)
Course Outcomes	:	**The successful student will learn:** 1. Solve linear system equation 2. Determine the Eigen values and vectors of a matrix 3. Determine the power series expansion of a function 4. Estimate the maxima and minima of multivariable functions 5. Solve any given first order ordinary differential equation 6. Solve any higher order linear ordinary differential equation with constant coefficients
Modes of Delivery	:	Talk and chalk, Power point presentations, and practical etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	√	√		√					√	√
CO2			√	√				√	√	√

CO3			√	√	√	√		√	√	

Syllabus

Infinite series & Mean Value Theorems- Sequences and series, Convergence, Comparison test, Integral test, D'Alembert ratio test, Rabbe's test, logarithmic test, Cauchy root test, Leibnitz's rule, Rolle's Theorem, Lagrange and Cauchy Mean Value Theorem.

Function of Several Variables- Limit, Continuity (Ɛ-δ definition) and Differentiability, Partial differentiation, Homogeneous Functions- Euler's theorem, change of variables, Jacobian, Taylor's theorem for functions of several variables. Extrema offunctions of multi-variables, saddle points, Lagrange method of undetermined multipliers.

Integral Calculus- Multiple integrals (Double & Triple Integral), change of order of integration, Area of bounded region, arc length of curve, volume and surface area of solid of revolution, multiple integral by change of variables, Dirichlet integrals, Moment of inertia, Center of gravity.

Beta and Gamma Functions-Improper integrals, Beta Function, Gamma functions, Improper Integrals involving a parameter.

Vector Calculus- Gradient, Directional derivatives, Divergence and Curl, line integral and Green's theorem, surface and volume integrals, Gauss, Stoke's theorems and their applications.

Ordinary Differential Equation- Existence and Uniqueness of solutions of First order ODE, Exact Differential Equation, Solution of Linear Differential Equation, Higher order Linear Differential Equation, Solutions of Homogeneous and Non-homogeneous ODE (CF+PI), Variation of parameters, Undetermined coefficients, Power series method, System of linear simultaneous ODE.

References books

1. Jain and Iyenger, Advanced Engineering Mathematics, Narosa Pub. House
2. Thomas and Finney, Calculus,Addison Wesley
3. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers.
4. Erwin Kreyszig, Advanced Engineering Mathematics, John Wiley & Sons.

BT*** Biology for Engineers**

Designation	:	Compulsory
Pre-requisites	:	None
Credit and Contact hrs	:	3(L) - 0(T) – 0(P) – 3(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment: (Scheme)** 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise Tests, Term paper etc)
Course Outcomes	:	**The successful student will learn:** To introduce students to modern biology with an emphasis on evolution of biology as a multi-disciplinary field, to make them aware of application of engineering principles in biology, and engineering robust solutions inspired by biological examples.
Modes of Delivery	:	Talk and chalk, Power point presentations, and practical etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1					√	√	√		√	
CO2			√		√		√			√
CO3			√			√		√		

Syllabus

Darwinian evaluation & molecular perspective; Introduction to phylogeny – Classification systems in biology and relationships; Cellular assemblies – From single cell to multi-cellular organisms: Geometry, Structure ad Energetics; Comparing natural vs. Human made machines; Infection, disease and evolution - synergy and antagonism; Immunology – An example of permutations and combinations in biology; Cancer biology- Control and regulation; Stem Cell- Degeneracy in biological systems; Engineering designs inspired by biology – Micro to Macro – scales. Laboratory: Bio safety; Buffers in biology – Measuring micro litres, Preparation of standard biological buffers, response of cells and plant tissues in different buffering conditions; Observing cell surface and intracellular contents using light and fluorescence microscopy, measuring cellular motions using real-time video microscopy; Measuring and visualizing intracellular molecular components – Proteins and Genomic DNA.

Introductory Biomechanics: Basics concepts of Force Moments and Torque Equilibrium, analysis of systems in equilibrium. Skeletal joints. Skeletal muscle. Mechanics of the elbow, shoulder, Spinal column, Hip, Knee and ankle. Basic assumptions and limitations.

References books

1. Miko, I. & Lejeune, L., eds. Essentials of Genetics. Cambridge, MA: NPG Education, 2009.
2. O'Connor, C. M. & Adams, J. U. Essentials of Cell Biology. Cambridge, MA: NPG Education, 2010.
3. Watson JD, Baker, TA, Bell SP, Gann A, Levin M, Losick R, Molecular Biology of the Gene, Pearson Education. 2004.
4. Dawkins, R. The Greatest Show on Earth: The Evidence For Evolution, Bantam Press, Transworld Publishers, Random House Group, London, 2009.
5. Dawkins, R. The Blind Watchmaker, W. W. Norton & Co., NY, 1996.
6. Watson, J. D. The Double Helix: A Personal Account of the Discovery of the Structure of DNA (Copyright © 1968, 1996 by James D. Watson), Simon & Schuster Inc., first Touchstone Edition (2001).

AM***** Engineering Mechanics

Designation	:	Compulsory
Pre-requisites	:	Nil
Credit and Contact hrs	:	3(L) - 0(T) - 2(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam. 60 marks Mid Semester Exam: 20 marks **Internal Assessment: (Scheme)** 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise Tests, Term paper etc)
Course Outcomes	:	**The successful student will learn:** Determine the resultant force and moment for a given system of forces Analyze planar and spatial systems to determine the forces in members of trusses, frames and problems related to friction Calculate the motion characteristics of a body subjected to a given force system Determine the deformation of a shaft and understand the relationship between different material constants Determine the centroid and second moment of area
Modes of Delivery	:	Talk and chalk, Power point presentations, and practical etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	√		√	√				√		
CO2			√					√	√	
CO3			√		√	√		√	√	

Syllabus

Introduction to Forces, Moments, Stresses and Strains- Idealizations in Mechanics, Equilibrium of forces and moments, Free body diagram, Simple Stress and Strain, Axially loaded members and Hooke's law.
Centroid & Moment of Inertia- Introduction, Center of Gravity and Centroid, Moments of inertia - Area and Mass Moment of Inertia, Product of inertia, Principal axes and Principal moments of inertia, Transformation of Moment of Inertia.
Structures- Introduction, Classification, Analysis of Plane Trusses- Method of Joints, Method of Sections, Method of Tension Coefficients, Graphical Method, Beams- Shear force and Bending MomentDiagrams.
Friction-Introduction, Laws of Coulomb friction, Angle offriction, Angle of Repose, Cone of Friction, Sliding and Rolling Friction, Rope and Belt Friction, Screw Friction, Wedge Friction.
Principle of Virtual work and Energy- Strain Energy, Virtual Displacement, Principle of Virtual work, Mechanical Efficiency, Work of a force/couple (springs etc.), Potential Energy and equilibrium, stability.
Kinematics and Kinetics of Rigid Bodies- Introduction, Types of motions in plane and space, Rotation of rigid bodies, General Plane motion, D'Alemberts Principle, Force, Mass and Acceleration, Work and Energy, Impulse and Momentum, Gyroscopic motion.
Vibration- Introduction, Free and Forced Vibration, Vibration of rigid bodies.

References books

1. Beer F.P. and Johnston E.R., Mechanics for Engineers-Volume I -Statics, Volume-II -Dynamics, McGraw Hill, New York.
2. Meriam J.L. and Kraige L.G., Engineering Mechanics, Volume I-Statics, Volume-II -Dynamics, John Wiley &

Sons, New York.
3. Shames L.H., Engineering Mechanics, Prentice Hall, New Delhi.
4. R. C. Hibbler, Engineering Mechanics, Volt and II, Pearson Press, 2002

HS*** Communication Skill and Technical Writing**

Designation	:	Compulsory
Pre-requisites	:	Nil
Credit and Contact hrs	:	2(L) - 0(T) - 2(P) - 3(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment: (Scheme)** 20 marks (5 marks for attendance + 15 marks for assignment submission, presentation, group discussions etc)
Course Outcomes	:	**The successful student will learn:** Communication professionally, write professional letters and will be confident in attending interviews
Modes of Delivery	:	Talk and chalk, Power point presentations, and practical etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1										
CO2										
CO3										

Syllabus

Remedial English Grammar: Common Errors, Articles, Pronouns, Adjectives, Use of Adjectives, Prepositions, Subject-Verb Agreement, Vocabulary building & Comprehensive exercises.

Technical Writing: English usage, when English is a foreign language, Reading a draft, Writing a draft, revising a draft, Writing a technical talk, presenting the technical talk,

Communication theory: Definition of communication, good and effective communication, barriers and filter, exercise, body language, activity on body language, non-verbal behavior interpretation, listening skills: active and passive listening, activity on listening skills, feedback mechanism: giving and receiving feedback activity.

Dealing with feelings: Activity on how to deal with feeling and complex feeling, assertiveness activity, developing assertiveness, activity, self-confidence, quiz on self-confidence, strategies for developing confidence.

The Team concept: Element of Teamwork, activity, effective team, essential building blocks of effective team, team player styles, group discussion: structured and unstructured discussions, strategies for improving decisions, presentation technique.

Business communication: Business communication, writing business letters and applications, minutes and memorandum, resuming writing.

Corporate grooming: Appearing for interview, corporate dressing and grooming, dining etiquette, communication media etiquette, ethics, exercise on ethical dilemmas, exercise on mock- interview

References books

1. Communication by C.S. Raayudu, Himalaya Publications.
2. Developing Communication Skills by Krishna Mohan, Macmillan India Limited
3. Corporate Grooming and Etiquette by Sarvesh Gulati, Rupa publications.
4. Group Discussions and Interviews by Priyadarshi Patnayak, foundation books publications

Semester-II

CS*** Computer Programming**

Designation	:	Compulsory
Pre-requisites	:	Nil
Credit and Contact hrs	:	3(L) - 0(T) - 2(P) - 4(Cr)
Assessment Methods	:	Theory Examination: (Scheme) End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment: (Scheme)** 20 marks (5 marks for attendance + 15 marks for assignment

		submission, Surprise Tests, Term paper etc)
Course Outcomes	:	The successful student will learn: 1. To learn the fundamentals of computers. 2. To learn the problem solving techniques writing algorithms and procedures. 3. To learn the syntax and semantics for C programming language. 4. To develop the C code for simple logic. 5. To understand the constructs of structured programming including conditionals and iterations.
Modes of Delivery	:	Talk and chalk, Power point presentations, and practical etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	√			√					√	
CO2			√		√	√		√	√	
CO3			√		√	√		√		
CO4				√					√	

Syllabus

Introduction, LINUX commands, editors, Files & Directories, Design of algorithms, Writing a simple program: Learning the form of a C program, Declaring variables, Designing program flow and control, using standard terminal I/O functions, Fundamental Data types and storages classes, Operators and Expression Conditional Program Execution Loops and iteration, Introduction to Abstraction, Functions, Arrays, Pointers, Structures, Introduction to Object Oriented Programming concepts, Classes and Objects, Important C++ constructs, The standard C/C++ preprocessor, The standard C/C++ library

References books

1. How to solve it by Computer by R. J. Dromey
2. The C Programming Language by Brian W. Kernighan, Dennis M. Ritchie
3. On to C++ by PH Winston (also available online)
4. Structure and Interpretation of Computer Programs by Harold Abelson and Gerald Sussman with Julie Sussman, (Also available online)
5. Herbert Schield, Complete reference inC.

EC*** Basic Electronics and Instrumentation**

Designation	:	Compulsory
Pre-requisites	:	None
Credit and Contact hrs	:	3(L) - 0(T) – 2(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment:** (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise Tests, Term paper etc)
Course Outcomes	:	**The successful student will learn:** This course facilitates the students to get a comprehensive exposure to electronics engineering.
Modes of Delivery	:	Talk and chalk, Power point presentations, and practical etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	√	√					√		√	√
CO2		√	√	√	√			√	√	√
CO3			√		√	√		√	√	

Syllabus

Diodes-Introduction to pn diode and its applications as rectifier, rectifier as DC Power Supply, Clamper, Clipper, Voltage multiplier etc., Zener diode and its applications as regulator, Tunnel diode and Varactor diode

Transistors-Review of Transistor working, characteristics & its parameters, Transistor as an amplifier, Biasing of bipolar junction transistors, h-parameters & transistor equivalent circuits, small signal single-stage amplifier, frequency response, concept of feedback.

JFET and MOSFET-Basic construction, working, concept of pinch-off, characteristics of JFET, MOSFET (Enhancement and Depletion), FET as a voltage variable resistor

Operational amplifier-Ideal & non-ideal characteristics, concept of summing junction and virtual ground. Application of operational amplifier as: Adder, Subtractor, Differentiator, Integrator, Multiplier, Unity gain amplifier & Logarithmic amplifier

Introduction to Digital Electronics-Review of number systems, complements, codes, Boolean algebra, Logic gates, Minterm and Maxterms, Canonical and Standard forms, Logic functions & Logic circuits. Minimization of Boolean functions using K-map.

Measuring Instruments-Working of Cathode Ray Oscilloscope, Power supply, Multimeter and Function generator.

References books

1. A. P. Malvino, *Electronic Principles*, Tata McGraw-Hill, New Delhi, 1993.
2. R. A. Gayakwad, *Op-Amps and Linear Integrated Circuits*, PHI, New Delhi, 2002.
3. R.J. Tocci, *Digital Systems*, 6th Ed., 2001.

EE****** Basic Electrical Engineering and Measurement

Designation	:	Compulsory
Pre-requisites	:	None
Credit and Contact hrs	:	3(L) - 0(T) – 2(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment: (Scheme)** 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise Tests, Term paper etc)
Course Outcomes	:	**The successful student will learn:** This course facilitates the students to get a comprehensive exposure to electrical engineering.
Modes of Delivery	:	Talk and chalk, Power point presentations, and practical etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	√	√					√		√	√
CO2		√	√	√	√			√	√	√
CO3			√		√	√		√	√	

Syllabus

D.C. Network Theory-Circuit Theory Concepts – Mesh and Node Analysis; Network Theorems; Super-position, Thevenin, Norton and Max. Power Transfer Theorem, Star – Delta Transformation.

Steady State Analysis of AC Circuits- Sinusoidal and Phasor Representation of Voltage and Current, Single Phase AC circuit behaviour of R, L & C, Combination of R, L & C in series and parallel, Resonance, Bandwidth and Quality Factor

Three-Phase A.C. Circuits-Line and phase voltage/current relationships for star and delta connection, Power measurement in 3-phase A.C. circuits. Measuring Instruments: Construction & Principle of operation of voltage and current measuring instruments, Introduction to Wattmeter and Energy Meters.

Magnetic Circuits and Transformer: - Magnetic Circuits, Principle of Operation & Construction of 1 φ transformer, Phasor diagram, Equivalent Circuit, O.C. and S.C. test, Efficiency and voltage Regulation

Introduction to Rotating Machines: Principle of Electromagnetic Energy Conversion; Types of d.c. machines, emf equation, magnetization and load characteristics, losses and efficiency of d.c. machines, Starting and speed control of d.c. motors, 3- ϕ induction motors - working principle and applications, 1- ϕ Induction motor -working principle and applications, Stepper motors.

Power Systems-Generation- Types of power Plant, Functional Block diagram of Generating stations (Hydel & Thermal Stations); Transmission- Standards (AC & DC), Substations, Grids; Distribution- Industrial, Commercial and Domestic Standards; Utilization- Types of loads, UPS and domestic inverters; Domestic Wiring- Materials, accessories & ratings of the wiring materials, types of wiring; fluorescent tube and simple domestic wiring layout, earthing rules

References books

1. Clayton Paul, Syed A Nasar and Louis Unnewehr, 'Introduction to Electrical Engineering', 2nd Edition, McGraw-Hill, 1992.
2. Kothari D.P. & Nagrath I.J., 'Basic Electrical Engineering', 2nd Edition, Tata McGraw-Hill, 2001.
3. P.S. Dhogal, 'Basic Electrical Engineering - Vol. I& II', 42nd Reprint, McGraw-Hill, 2012.

ME*** Workshop Technology**

Designation	:	Compulsory
Pre-requisites	:	None
Credit and Contact hrs	:	1(L) - 0(T) – 3(P) – 3(Cr)
Assessment Methods	:	**Theory Examination:** (Scheme) End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment:** (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise Tests, Term paper etc)
Course Outcomes	:	**The successful student will learn:** 1. Study and practice on machine tools and their operations 2. Practice on manufacturing of components using workshop trades including fitting, carpentry, foundry and welding 3. Identify and apply suitable tools for machining processes including turning, facing, thread cutting and tapping 4. Apply basic electrical engineering knowledge for house wiring practice
Modes of Delivery	:	Talk and chalk, Power point presentations, and practical etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1				√						
CO2	√	√		√		√			√	
CO3		√								
CO4					√	√	√		√	√

Syllabus

Casting processes: Element of Green Sand Mould; Method of Preparation of Green Sand Mould; Casting Defects

Metalworking processes: Classification of Metalworking processes-brief introduction of bulk and Sheet metal processes, Hot Vs Cold Working; Hot and Cold Rolling; Types of Rolling Mills, Hot and Cold Forging, Hot and Cold Extrusion, Cold Drawing

Machining processes: Classification of Machining processes & machine tools; Construction, Specification and working of Lathe Machine and Drilling Machine; Study about Facing, Turning, parting, Grooving, Threading and Knurling, and Drilling and other hole related operations

Fabrication processes: Classification of welding Operations, types of Joints & welding Positions; Brief description of Arc, Resistance and Gas welding techniques. Brazing and Soldering

Brief Introduction of Newer Machining Processes: Such as EDM, ECM, USM, and LAB, Modern trends in Manufacturing-Automation, Concept of CAD, CAM and CIM.

References books

1. Raghuwanshi B.S., Workshop Technology Vol. I & II, Dhanpath Rai & Sons.
2. Kannaiah P. and Narayana K.L., Workshop Manual, 2nd Edn, Scitech publishers.
3. John K.C., Mechanical Workshop Practice. 2nd Edn. PHI 2010.
4. Jeyapoovan T.and Pranitha S., Engineering Practices Lab Manual, 3rd Edn. Vikas Pub.2008.

AM*** Engineering Mathematics-II**

Designation	:	Compulsory
Pre-requisites	:	Mathematics – I
Credit and Contact hrs	:	3(L) - 0(T) - 0(P) - 3(Cr)
Assessment Methods	:	**Theory Examination:** (Scheme) End Semester Exam: 60 marks Mid Semester Exam: 20 marks

		Internal Assessment: (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise Tests, Term paper etc)
Course Outcomes	:	The successful student will learn: 1. Solve linear differential equations using Laplace transforms 2. Evaluate multiple integrals and improper integrals 3. Convert line integrals to area integrals 4. Convert surface integrals to volume integrals 5. Determine potential functions for irrotational force fields
Modes of Delivery	:	Talk and chalk, Power point presentations etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	√			√	√		√		√	
CO2			√		√		√			√
CO3			√			√		√		

Syllabus

Partial Differential Equation- First order PDE, Formation of PDE, Classification of solution: Complete, General and Particular solution, Lagrange's linear PDE, Non-Linear First Order PDE, Some Standard form -I, II, III, IV. Charpit's method. Higher Order Homogeneous linear PDE with constant coefficients, C. F. & P.I., Nonhomogeneous PDE with constant coefficients, C. F. & P.I.

Application of Partial Differential Equation- Classification of Linear PDE of second order: Elliptic, Parabolic and Hyperbolic, Solution of separation of variables. Interior and Exterior BVP: Heat & Wave equation, Laplace Equation.

Laplace Transform- Laplace transformation and its properties, Unit - step, Impulse and Periodic functions, Error Function, Inverse Laplace Transform, Convolution Theorem, Evaluation of Integral by Laplace Trans-form, Application of Laplace transform to solution of ODE & PDE.

Fourier Series & Fourier Transform- Fourier series, Convergence of Fourier Series, Half range series, Fourier Integral, Fourier sine and Cosine Integral, Complex form of Fourier Integral, Fourier Transform, Fourier Sine and Cosine Transform, Finite sine and cosine transform, Convolution theorem, Application of Fourier Transform to boundary value problems..

Linear Algebra and Matrices- Vector spaces, Subspaces, Linear dependence and independence, Basis and dimension, Dimension theorem. Linear Transformation, Rank- Nullity Theorem (Statement only), Computation of Rank and nullity of LT, Solution of linear simultaneous algebraic equations.

Eigen Values and Eigen Vectors- Eigen values and Eigen vectors, Cayley-Hamilton theorem, Application of Eigen Values and Eigen Vectors: Quadratic form, Diagonalization, Canonical forms and Solving system of first order differential equations.

References books

1. Jain and Iyenger, Advanced Engineering Mathematics, Narosa Pub. House
2. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers.
3. Erwin Kreyszig,Advanced Engineering Mathematics, John Wiley & Sons

AM*** Fluid Mechanics**

Designation	:	Compulsory
Pre-requisites	:	Nil
Credit and Contact hrs	:	3(L) - 0(T) – 0(P) – 3(Cr)
Assessment Methods	:	Theory Examination: (Scheme) End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment: (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise Tests, Term paper etc)
Course Outcomes	:	The successful student will learn: 1.
Modes of Delivery	:	Talk and chalk, Power point presentations, and practical etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	√			√	√		√			

CO2						√		√		
CO3										

Syllabus

Introduction - scope and relevance; Method of analysis - system vs control volumes - differential vs integral approach, Units and dimensions; Fluid properties - continuum, density, viscosity, surface tension, velocity, pressure, temperature; Fluid Statics - Hydrostatics, Fluid forces on planes and curved surfaces, submerged and floating bodies, Buoyancy and stability, Atmosphere as a fluid; Fluid Concepts - Streamlines, streaklines, pathlines, viscous vs inviscid flows, laminar vs turbulent flows, compressible vs incompressible flows; Engineering bernoulli equation; Control Volume analysis: Basic laws - Mass conservation law, thermodynamic laws, Newton's laws, Angular-Momentum principle; Buckingham Pi-theorem; Similitude and modeling - scaling effects; Flows in a pipes and channels - friction factor, flow measurement devices - Venturi meter, Orifice meter

References books

1. Som, S.K. & Biswas G, Introduction to fluid mechanics & Fluid Machines, TMH, 2000, 2nd edition.
2. S.K.Agarwal, Fluid Mechanics & Machinery, TMH, New Delhi.
3. Garde, R.J., 'Fluid Mechanics through Problems', New Age International Pvt. Ltd, New Delhi, 2nd Edition.
4. Hunter Rouse, 'Elementary Mechanics of Fluids', John Wiley & Sons. Omc. 1946.
5. I.H.Shames, 'Mechanics of Fluids', McGraw Hill, Int. Student, Education, 1988.

HS***** Environment and Ecology

Designation	:	Compulsory
Pre-requisites	:	Nil
Credit and Contact hrs	:	2(L) - 0(T) – 0(P) – 2(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment: (Scheme)** 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise Tests, Term paper etc)
Course Outcomes	:	**The successful student will learn:** 2. Understand environmental problems arising due to developmental activities 3. Identify the natural resources and suitable methods for conservation and sustainable development 4. Realize the importance of ecosystem and biodiversity for maintaining ecological balance. 5. Identify the environmental pollutants and abatement devices
Modes of Delivery	:	Talk and chalk, Power point presentations, and practical etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	√			√	√		√			
CO2						√		√		
CO3										

Syllabus

Introduction- Introduction and scope, Indian Scenerio of Natural Resources, Conservation of natural resources.
Ecosystem- Ecosystem and its basic concept, Structure and function of an ecosystem, Food chains, food webs and ecological pyramids, Ecological succession.
Biodiversity- Biodiversity and its conservation, types of biodiversity, Hot spots and threats to biodiversity, National and global scenario, Biodiversity conservation.
Environmental Pollution- Environmental Pollution: Air pollution, Water pollution, Soil pollution, Marine pollution, Noise pollution, Thermal pollution and Nuclear hazards.
Social Issue- Sustainable development, Environmental ethics: Issues and possible solutions, Climate change, global warming, acid rain, ozone layer depletion, nuclear accidents, Wasteland reclamation.
Environmental Laws- Environmental laws/Acts, EPA Act 1986, Water Act. etc. 2(L)

References books

1. A Basic Course in Environmental Studies. Deswal & Deswal. Pub. Dhanpat Rai & Sons
2. Environmental Studies. Bharucha. Pub. University of Press
3. Ecology. Odum. Pub. Oxford & IBH
4. Environmental Engineering. Peavy et.al. Pub. McGraw Hill

5.	A Text Book of Environmental Engg. Venugopal Rao. Pub. PHI

Semester-III

AM***** Structure of Materials		
Designation	:	Compulsory
Pre-requisites	:	None
Credit and Contact hrs	:	3(L) - 0(T) - 2(P) - 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment: (Scheme)** 20 marks (5 marks for attendance + 15 marks for assigement submission, Surprise Tests, Term paper etc)
Course Outcomes	:	**The successful student will learn:** 1. Primary objective is to present the basic fundamentals of materials science and engineering. 2. Expose the reader community to different classes of materials, their properties, structures and imperfections present in them. 3. Help understand the subject with ease by presenting the content in a simplified and logical sequence at a level appropriate for students/teachers/researchers. 4. Aid the teaching learning process through relevant illustrations, animations, web content and practical examples. 5. Highlight important concepts for each topic covered in the subject.
Modes of Delivery	:	Talk and chalk, Power point presentations, and practical etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1			√				√			
CO2		√		√				√	√	
CO3				√			√	√		

Syllabus

Introduction- Historical perspective of Materials Science, Structure and properties relationship of Engineering Materials, Classification of materials, Advanced Materials, Nano-materials.

Structure of Solids and Characterization of Materials- Introduction to crystal structures and systems, Metallic structures, Ceramic crystal structures, Crystallographic directions and planes, Miller indices, Density computations, Crystallography, Diffraction methods, Electron microscopy, Metallography, Thermal characterization techniques.

Imperfections in Solids- Point defects, Dislocations, Interfacial Defects, Bulk defects.

Diffusion- Diffusion mechanisms, steady and non-steady state diffusion, Factors that influence diffusion, Law's of diffusion, Applications of Diffusion.

Mechanical Behaviour of Materials- Elastic and plastic properties, Creep, Fatigue, Fracture.

Ceramic Materials- Ceramic types, Properties, Processing Application, Advanced ceramics.

Composites- Introduction, Applications, Particle reinforced composites, Fiber reinforced composites, Structural composites.

Economic, Environmental and Social issues of Material Usage- Economic considerations, Environmental and societal considerations, Recycling issues, Life cycle analysis and its use in design.

References books

1. Raghavan V, "Materials Science and Engineering".
2. Callister W. D. Jr., "Materials Science and Engineering: An Introduction".
3. George E. Dieter, "Mechanical Metallurgy".
4. Van Vlack, "Elements of Material Science and Engineering"
5. K. M. Gupta, "Material Science in Engineering".

AM***** Phase Diagrams		
Designation	:	Compulsory

Pre-requisites	:	Chemistry
Credit and Contact hrs	:	4(L) - 0(T) - 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment: (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise Tests, Term paper etc.)
Course Outcomes	:	**The successful student will learn:** Phase diagrams are important for materials science and engineering applications encompassing from structural materials to functional materials, including electronic, magnetic applications. The course is intended to make the students and research familiarize with binary and ternary phase diagrams and microstructure of different materials. It is to be noted that microstructure plays a vital role in deciding the properties of the materials. Thus, it is important to connect the phase diagram information for microstructural evolution.
Modes of Delivery	:	Talk and chalk, Power point presentations, and practical etc.

Mapping of course outcomes with program outcomes

Course outcome	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10
CO1	√						√			
CO2	√	√	√			√			√	
CO3			√	√		√	√	√		
CO4			√		√			√	√	√
CO5		√			√			√		

Syllabus

Phase rule, Hume-Rothery rules, lever rule, Free energy of phase mixture; Unary systems, Effect of pressure on phase diagrams

Binary Isomorophous Systems, Free energy-composition digrams; Equilibrium solidification, Non- Equilibrium solidification of alloys; Coring, examples from Cu-Ni alloys, Zone refining

Phase Diagrams of Binary Eutectic systems; Solidification of eutectic, hypo-eutectic, and hyper-eutectic alloys and their morphologies with examples from Al-Si, Fe-C,Ag-Cu,Pb-Sn system

Phase diagrams of binary peritectic System, evolution of these phase diagrams; Solidification of peritectic alloys, hypo and hyper-peritectic alloys;

Concept of Liquid Phase immiscibility Binary Monotectic and Systectic Systems, Evolution of monotectic and syntactic phase diagrams, free –energy composition diagrams, Development of microstructures in systems Cu-Pb, Na-Zn,KZn, Effect of gravity on solidification of these alloys

Concept of solid state immicibility and spinodal decompositions, Phase diagrams showing spinodal decomposition, microstrucural evolution, Thermodynamics of phase equilibria: Regular and irregular solutions, Models for regular and irregular solutions, Quasichemical theory : detailed descriptions; Stability of regular solution and miscibility gap, Application of Quaichemical to eutectic, peritectic and Monotectic systems, intrinsic stability of solution and spinodal.

Important systems with intermediate phases: Ni-Al, Ti-Al and Fe-Al systems

Iron-carbon phase diagram and microstructures of plain carbon steel and cast iron: non-equilibrium structures

Some binary ceramics systems:SiO2-Al2O3, NiO-MnO, etc and their microstructure.

Ternary phase diagrams: Gibbs triangle, isothermal and vertical sections, Polythermal projections, two-phase equilibrium Concept of the lines, rules for construction of tie lines, three phase equilibrium, concept of tie-triangle, four phase equilibria.

Multi-component alloy systems:Stainless steels, high speed steels, super alloys, light metal alloys, refractory systems (Al2O3 - SiO2 - MgO)

References books

1. Phase Transformations in Metals and Alloys, Porter, Easterling; 3rd ed, CRC Press, 1991
2. F. C. Campbell, Phase Diagrams: Understanding the Basics, ASM International, 2012.
3. D R F West, N Saunders, Ternary Phase Diagrams In Materials Science, Anebooks – Woodhead 2006

AM*** Mechanics of Solids**

Designation	:	Compulsory
Pre-requisites	:	Engineering Mechanics
Credit and Contact hrs	:	3(L) - 0(T) – 2(P) – 4(Cr)
Assessment	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks

Methods		Mid Semester Exam: 20 marks Internal Assessment: (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise Tests, Term paper etc)
Course Outcomes	:	**The successful student will learn:** 1. To draw the SF and BM diagrams for various beams under different loading conditions. 2. To be able to determine strength and deformation of members under various loading conditions. 3. To determine the stability of the columns under different end conditions and understand the design principles. 4. Learn the two dimensional stress transformation and apply it for analysis of members with combined loading.
Modes of Delivery	:	Talk and chalk, Power point presentations, and practical etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	√			√			√			
CO2	√	√	√	√			√		√	
CO3							√			
CO4					√				√	

Syllabus

Concept of stress and strain, Normal and direct shear stresses and strains, Stresses on inclined planes, Cauchy's stress theorem, Stress at a point, Strain-displacement relations, Small displacement theory, Compatibility conditions, Stress and Strain transformation, Principal stresses and strains, Mohr's circle, Constitutive equations, Strain Measurements, Pure bending - Bending and shear stresses in beams, Deflection of beams, Thin walled Shells, Torsion of circular shafts, Springs, Failure theories.

References books

1. Popov,E.P., Engineering Mechanics of Solids, 2 nd ed., Prentice Hall of India, New Delhi, 2000.
2. Beer, F.P.,Johnston, E.R. and DeWolf, J.T.,Mechanics of Materials, 3rd ed., Tata McGraw-Hill.
3. Timoshenko, S.P. and Young, D.H.,Elements of Strength of Materials, McGraw-Hill.
4. Irving H. Shames, Introduction to Solid Mechanics, 2 nd ed., Prentice Hall of India.
5. Crandall, S.H., Dahl, N.C. and Lardner, T.J.,Introduction to Mechanics of Solids, McGraw-Hill

AM*** Transport Phenomena**

Designation	:	Compulsory
Pre-requisites	:	None
Credit and Contact hrs	:	3(L) - 0(T) – 0(P) – 3(Cr)
Assessment Methods	:	**Theory Examination:** (Scheme) End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment:** (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise Tests, Term paper etc)
Course Outcomes	:	**The successful student will learn:** 1. To select appropriate damage measures and to model damage using suitable variables 2. To understand and derive thermodynamically consistent dissipation potentials, constitutive equations and evolution equations 3. To classify and describe different kinetic laws of damage evolution 4. To implement the damage theories for analysis of damage in structures
Modes of Delivery	:	Talk and chalk, Power point presentations, and practical etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1		√					√			

CO2		√	√	√		√		√	√	
CO3				√		√	√			
CO4					√		√		√	

Syllabus

Laminar Flow: Velocity distribution in Laminar flow - Shell momentum balances - Flow through tubes, surfaces, Flow of non - Newtonian fluids.

Equation of Motion: Equation of change for isothermal process - One dimensional equation of motion and continuity - Euler and Navier - Stokes's equation. Dimensional analysis of equation of change.

Turbulent Flow: Velocity distribution in turbulent flow - Semi empirical expressions for Reynold's stress. Interphase transport in isothermal system - Ergun's equation.

Heat Transfer Analysis: Temperature distribution in solids and fluids in laminar flow - Equations of change for multi component systems.

Mass Transfer Analysis: Concentration distribution in solids and in fluids laminar flow - Equations of change for multi component systems.

References books

1. Jagdish Lal, Fluid Mechanics, Metropolitan Book Company Ltd., Delhi. Vijay Gupta and S.K.Gupta, 'Fluid Mechanics and its Applications', Wiley Eastern Ltd, 1984.
2. Modi, P.N., and Seth, S.H., 'Hydrualics and Fluid Machines', Standard Book House, 1989 J.L. Stuart., 'Transport Phenomena", John Wiley, New York, 1982.
3. R. B. Bird, W. Stewart and E. N. Lightfoot, "Transport Phenomena", Wiley, New York, 1960.
4. C. J. Geankopolis, "Transport Processes in Chemical Operations", 3rd Edn., Prentice Hall of India, New Delhi, 1996.

AM***** Applied Computational Methods

Designation	:	Compulsory
Pre-requisites	:	Engineering Mathematics and computer programming
Credit and Contact hrs	:	3(L) - 0(T) - 2(P) - 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment: (Scheme)** 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise Tests, Term paper etc)
Course Outcomes	:	**The successful student will learn:** 1. To identify the differences between "Exact methods & Computational Methods" and applications of these methods. 2. To develop knowledge of expressing a real-life problem in terms of mathematics i.e to develop the skill of Mathematical Modeling. 3. To identify and develop the skill to solve real life engineering problems e.g., Nonlinear Problems, Initial Value & Boundary Value Problems, Numerical Differentiation & Integration problems. 4. To develop skill of writing Flow Charts of real-life engineering problems and transform those into computer programming
Modes of Delivery	:	Talk and chalk, Power point presentations, and practical etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	√			√					√	
CO2			√		√	√		√	√	
CO3			√		√	√		√		
CO4				√					√	

Syllabus

Review: Error and its propagation, Eigenvalues and Eigenvectors - Direct and Iterative solvers. Partial Differential Equations (PDEs) - Hyperbolic, Parabolic and Elliptic PDEs, nonlinear PDEs.

Nonlinear Equations: Motivation, Open and bracketing method, Bisection, Fixed point, Newton's method, Secant and False position method, Rate of convergence, Merits and demerits of methods.

Interpolation: Lagrange, Newton divided difference formula, Newton's interpolations, and errors in interpolation.

Approximation: least square and uniform approximations.

Differentiation: differentiation using interpolation formulas. Integration using interpolation: Newton-Cotes formulas, Gauss quadrature rules. Ordinary differential equations: Taylor, Euler and Runge-Kutta methods.

Numerical Integration: Motivation, Newton-Kotes method, Trapezoidal rule, Simpson's rule, Rhomberg integration, Gauss Quadrature. Initial Value Problem: Motivation, Euler's method, Modified Euler method, Runge-Kutta methods, Adaptive integrations and multistep methods. Boundary-value and Eigen-value Problem: Methods and Applications in Mechanics.

Statistical Computations-Frequency Chart, Regression Analysis, Least Square fit, Polynomial fit, Linear and Nonlinear Regression, Multiple Regression, Statistical Quality Control Methods.

References books

1. "Numerical Methods in Engineering", M. Salvadori, Prentice Hall International, 1961.
2. "Applied Numerical Methods", B. Carnahan, Krieger Pub, 1990.
3. "Applied Numerical Analysis", C.F. Gerald and P.O. Wheatley, 5th edition, Addison-Wesley, 1998.
4. "Numerical Mathematics & Computing", W. Cheney and D. Kincaid, 5th edition, Brooks/Cole, 2004.
5. "Applied Partial Differential Equations", Paul DuChateau and David Zachmann.
6. "Partial Differential Equations for Scientists and Engineers", Stanley J. Farlow.
7. "Numerical Methods for Partial Differential Equations", William F. Ames.
8. "Numerical Methods for Elliptic and Parabolic Partial Differential Equations", John R. Levison, Peter Knabner, Lutz Angermann

US***** Economics for Engineers

Designation	:	Compulsory
Pre-requisites	:	None
Credit and Contact hrs	:	3(L) - 0(T) - 0(P) - 3(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment: (Scheme)** 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise Tests, Term paper etc)
Course Outcomes	:	**The successful student will learn:** 1. Prepare accounting records and summarize and interpret the accounting data for managerial decisions 2. Understand the macro-economic environment of the business and its impact on enterprise 3. Understand cost elements of the product and its effect on decision making 4. Understand the concepts of financial management and smart investment.
Modes of Delivery	:	Talk and chalk, Power point presentations, and practical etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1		√					√			
CO2		√	√	√		√		√	√	
CO3				√		√	√			
CO4					√		√		√	

Syllabus

Engineering Economics: Introduction to Engineering Economics – Fundamental concepts – Time value of money – Cash flow and Time Diagrams – Choosing between alternative investment proposals – Methods of Economic analysis. The effect of borrowing on investment- Various concepts of National Income – Significance of National Income estimation and its limitations, Inflation –Definition – Process and Theories of Inflation and measures to control, New Economic Policy 1991 Impact on industry. Accountancy: Accounting Principles, Procedure – Double entry system – Journal – Ledger, Trail Balance – Cash Book - Preparation of Trading, Profit and Loss Account – Balance sheet. Cost Accounting Introduction – Classification of costs – Methods of costing Techniques of costing Cost sheet and preparation of cost sheet- Breakeven Analysis – Meaning and its application, Limitations.

References books

1. Henry Malcom Stenar, Engineering Economic Principles, McGraw Hill, 2005.
2. K K Dewett, Modern Economic Theory, Siltan Chand & Co., 2005.
3. Agrawal AN, Indian Economy, Wiley Eastern Ltd, New Delhi, 2012.
4. Jain and Narang, Accounting Part-I, Kalyani Publishers, 2012.
5. Arora, M.N., Cost Accounting, Vikas Publications, 2013

Semester-IV

AM***** Metallurgical Thermodynamics and Kinetics

Designation	:	Compulsory
Pre-requisites	:	Phase diagrams
Credit and Contact hrs	:	3(L) - 0(T) – 0(P) - 3(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment: (Scheme)** 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise Tests, Term paper etc.)
Course Outcomes	:	**The successful student will learn:** 1. To identify thermally activated processes in materials and metallurgy. 2. To demonstrate thermodynamics of crystal growth and phase transformation, defects, etc. 3. To design and develop thermodynamics of Ceramics, Polymers and Composites during synthesis
Modes of Delivery	:	Talk and chalk, Power point presentations, and practical etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	√		√	√				√		
CO2			√					√	√	
CO3			√		√	√		√	√	

Syllabus

Introduction: Review of thermodynamic functions, laws of thermodynamics, enthalpy, heat capacity, internal entropy, configurational entropy, free energy functions and their relationships, Gibbs-Helmholtz relations, Maxwell relations, Clausius-Clapeyron equation, importance of thermodynamics in materials science-illustrations and examples; applications in areas of materials technology, industrial and process metallurgy, related calculation.

Thermodynamic Reactions and Rate of Processes: Thermally activated processes in materials, stability of materials, activation energy, potential barrier, Arrhenius equation, rate of reactions- first order, second order etc, introduction to solutions, mixing functions, ideal and non-ideal solutions, related calculations, thermodynamics involved with rate of loading (anelastic behaviour / adiabatic loading)

Thermal Properties of Materials: Specific heat - Debye and other models, heat capacity, thermal expansion, thermal conduction, thermal stress and shock, melting point.

Crystal Growth: Formation of crystals, theories of crystal growth, homogeneous and heterogeneous nucleation/crystal growth; criteria for equilibria in crystal growth; solid solubility; kinetics of growth - nucleation, diffusion and surface migration, dislocation; motion of dislocation, dislocation density; super-cooling; growth of single crystal of high perfection, whiskers and whiskers growth.

Phase Transformations: Classification of phase transformations, order of transformation , Gibbs rule and applications, rapid solidification and its methods, glass transformation, alloy solidification – cellular, dendritic, eutectic; peritectic, eutectoid; boundary transformations; recrystallization, grain growth; effect of alloying elements; strengthening mechanisms, shape memory effects/alloys, thermodynamics and metallography / polymorphism.

Thermodynamics of Multi-Component System: Gibbs-Duhem equation for ternary and multi-components systems, kinetics of solidification and melting, thermodynamics of melts.

Thermodynamics of Defects / Dislocations: Thermodynamics of lattice defects, enthalpy of formation of vacancy, interstitial and substitutional impurity, Frenkel's defects, calculations on all these topics, thermal energy required to minimize the dislocations.

Thermodynamics of Ceramics, Polymers and Composites: Phase changes in Ceramics, glass transition, glasses, phase changes in polymers and amorphous materials, phase changes in composites, metallic glasses.

Thermodynamics of Surfaces and Interfaces: Surface energy, surface tension, absorption kinetics of diffusion in solids, Rate controlling mechanism of interface reactions, energy, shape, segregation at external and internal interfaces, theory of interface stability

Term Paper: On recent advances based on literature survey and/or lab/industry visit

References books

1. Gaskell David R, 'Introduction to Metallurgical Thermodynamics', McGraw Hill, latest edition.
2. Jere H. Brophy, Robert M. Rose and John Wulff, 'The Structure and Properties of Materials, Vol II; Thermodynamics of structure', Wiley Eastern Pvt. Ltd., N.Delhi, latest edition.
3. Tupkary R. H., 'Introduction to Metallurgical Thermodynamics', Latest edition., Tu Publishers, Nagpur, 1995 onwards edition.
4. Upadhyaya G. S. and R. K. Dube, 'Problems in Metallurgical Thermodynamics and kinetics', Latest edition Pergamon Press, 1977 onwards.
5. Kenneth M. Ralls, Thomas H. Courtney and John Wulff, ' Introduction to Materials Science and Engineering', Wiley Eastern Ltd., latest edition.
6. W. Kurz and D. J. Fisher, 'Fundamentals of Solidification', Trans. Tech. Publication, Switzerland.
7. R. W. Balluffi, S. M. Allen and W. C. Carter, Kinetics of Materials', John Wiley.
8. G. Khachaturyan, 'Theory of Structural Transformation in Solids', Wiley Interscience Publishers.
9. M. Alper, 'Phase Diagrams: Material Science and Technology', Vol 6, Academic Press.
10. Alok Gupta and Chatterjee, 'Thermodynamics and Phase Equilibrium'

AM*** Non-Ferrous Metals and Alloys**

Designation	:	Compulsory
Pre-requisites	:	None
Credit and Contact hrs	:	3(L) - 1(T) - 0(P) - 3(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment: (Scheme)** 20 marks (5 marks for attendance + 15 marks for assigument submission, Surprise Tests, Term paper etc)
Course Outcomes	:	**The successful student will learn:** To comprehend the basic principles of non-ferrous materials and apply those principles to demanding engineering applications. CO1 Understand the structure and properties of nonferrous metals and alloys CO2 Identify the phases present in different alloy systems by analyzing the phase diagrams CO3 Apply the basic principles of non-ferrous physical metallurgy for recommending materials for specific applications
Modes of Delivery	:	Talk and chalk, Power point presentations, and practical etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1		√					√			
CO2		√	√	√		√		√	√	
CO3				√		√	√			
CO4					√		√		√	

Syllabus

Brief introduction to extraction of aluminium; Aluminium and its alloys; physical, chemical and mechanical properties, classifications, heat treatable and non-heat-treatable types – structural features corrosion behaviour; cladding and other methods of corrosion protection.

Brief introduction to extraction of titanium; Titanium and its alloys; physical, chemical and mechanical properties of titanium, effect of other elements on its properties, types of titanium alloys, microstructural features, properties and applications.

Brief introduction to extraction of magnesium; Magnesium and its alloys; structure, properties and applications of magnesium and some its alloys; metallurgy of magnesium castings; Brief introduction to extraction of copper; copper and its alloys, electrical conductivity as influenced by other elements, alloys for high conductivity.

Lead, tin, zinc, zirconium, other non-ferrous alloys, relevant phase diagrams and microstructural features, properties and applications

Creep resistant materials, structure-property relationship, high temperature applications, superalloys, applications based on structure and properties, Intermetallics.

References books

1. Polmear I. J., Light Alloys: From Traditional Alloys to Nanocrystals, 4th Edition, ButterworthHeinemann, 2006
2. Alan Russell and, Kok Loong Lee ., Structure-Property Relations in Nonferrous Metals, WileyInterscience, 2005.
3. ASM Handbook: Properties and Selection: Nonferrous Alloys and Special-Purpose Material, 10th edition, ASM International, 1990
4. Joseph R. Davis, Alloying: Understanding the Basics, ASM International, 2001
5. Angelo P C and Ravisankar B"Non Ferrous Alloys: Structures, Properties and Engineering Applications", Cengage publishers, 2018

AM*** Materials Characterization**

Designation	:	Compulsory
Pre-requisites	:	Structure of materials
Credit and Contact hrs	:	3(L) - 0(T) – 2(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment: (Scheme)** 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise Tests, Term paper etc)
Course Outcomes	:	**The successful student will learn:** 1. Descriptions of a range of common characterization methods for the determination of the structure and composition of solids. 2. Theory and practice of x-ray and electron diffraction. 3. Basic elements of electron microscopy. 4. Basic aspects of optical and thermal characterization methods including probe microscopy and spectroscopy.
Modes of Delivery	:	Talk and chalk, Power point presentations, and practical etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	√			√			√	√		
CO2			√				√	√		√
CO3			√			√		√		
CO4	√		√			√		√		

Syllabus

Crystallography: Overviews in bonding, Bravais lattices, Miller indices, imperfections in crystals, crystal structures of common metal, ceramics, polymers. symmetries in crystals, point groups, space groups, reciprocal lattice, morphology

X-ray Diffraction Techniques: Production of X-rays, its properties and hazards, photon scattering, X-ray diffraction and Bragg's law, intensities calculations, Laue techniques, Debye-Scherrer techniques. modern diffractometers, diffractometer measurements, determination of crystal structure of powder sample, small angle scattering, line broadening, particle size, crystallite size, residual stress measurement, plane indexing, precise parameter measurement, phase identification, phase quantification.

Optical Microscopy: Principles and operations of microscopy, resolution, magnification, numerical aperture, depth of field, viewing area, contrast, geometry of optical microscopes, application of microscopy in metallurgical studies (qualitative and quantitative), morphology and symmetry, grain boundaries and dislocations, phase contrast microscop.

Electron Microscopy: Electron sources, electron diffraction, principles and operation of scanning electron microscope, geometry of electron microscopes, specimen handling and preparation, secondary electron image, backscattered electron image, image processing, analysis of electron micro-graphs and fractography studies, transmission electron microscopy (TEM).

Scanning Probe Microscopy: Principles and operation of scanning probe microscopes, scanning tunnelling microscope, atomic force microscope, magnetic force microscopy, topography studies, nanoindentation and its probing.

Thermal Analysis: Thermo gravimetric analysis, differential thermal analysis, differential scanning calorimetery, thermo-mechanical analysis and their applications.

Term Paper: On recent advances based on literature survey and/or lab/industry visit

References books

1. Crystals and Crystal structures, R.J.D. Tilley, John Wiley and Sons, 2006
2. Elements of X-ray Diffraction, Cullity B. D., Addison-Wesley Publishing Co.
3. Electron Microscopy and Analysis, P.J. Goodhew, F.J. Humphreys, Taylor & francis, Second edition.
4. Solid state chemistry and its Applications, Antony R. West, Wiley Student Edition.
5. Fundamentals of Molecular spectroscopy, Colin N. Banwell and Elaine M. McCash, Tat McGraw-Hill Publishing Co. Ltd., Fourth edition.
6. Materials Characterization: Introduction to Microscopic and Spectroscopic, Yang Leng, John Wiley&Sons.

AM***** Polymer Science and Composites

Designation	:	Compulsory
Pre-requisites	:	Chemistry
Credit and Contact hrs	:	3(L) - 0(T) - 2(P) 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment: (Scheme)** 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise Tests, Term paper etc)
Course Outcomes	:	**After completion of the course, students will be able to:** 1. Understand polymerization process and techniques 2. Explain the structure-property relations and flow behaviour of polymers 3. Demonstrate characterization and testing of polymers and composites 4. Understand the manufacturing process of composites 5. Choose an appropriate polymer material for various applications.
Modes of Delivery	:	Talk and chalk, Power point presentations, and practical etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	√			√	√		√			
CO2						√		√		
CO3										

Syllabus

Chemistry of Polymers: Polymerization methods and kinetics, copolymerization, different copolymers, polymerization techniques, molecular weight of polymers, glass transition temperature and crystallinity in polymers. Synthesis and properties of thermoplastics, Thermosetting polymers, Natural and synthetic rubbers, Thermoplastic Elastomer.

Polymer Characterization: Solubility and swelling, determination of molecular weights, polydispersity, analysis of polymers using IR, XRD, thermal (DSC, DMTA, TGA), microscopic (optical and electronic) techniques.

Polymer Rheology: Flow of Newtonian and non-Newtonian fluids, parameters influencing the polymer rheology, types of rheometer, viscoelasticity mechanical models, rubber curing.

Polymer Blends: blend miscibility-miscible and immiscible blends, thermodynamics and phase morphology. Compounding ingredients, cross-linking and vulcanization.

Polymer Processing: Compression molding, transfer molding, injection molding, blow molding, reaction injection molding, extrusion, calendaring, rotational molding, thermoforming, two-roll mill and internal mixer.

Polymer Testing: Mechanical tests, Conductivity-thermal and electrical, dielectric constant, electric resistance, surface and volume resistivity, swelling, ageing resistance, environmental stress cracking resistance. ASTM codes for polymer testing.

Polymer composites: Fiber and matrix materials, fiber architecture. Manufacturing techniques- Hand layup, bag moulding process, compression molding, liquid composite moulding, Filament winding, Pultrusion, reactive polymer composites, Thermal and mechanical properties, Testing of composites, advantages and applications.

List of Experiments:

1. Identification of various polymers.
2. Bulk photo-polymerization of Methyl Methacrylate
3. Preparation of Polystyrene by the free radical polymerization process
4. Preparation of Nylon by interfacial polymerization
5. Preparation of cured epoxy resin by room temperature reaction
6. Molecular weight determination by viscometry and end-group analysis
7. Mechanical testing of plastic and rubbers

8. Preparation and mechanical testing of fiber reinforced plastics.

References books

1. Polymer Science, Vasant R. Gowariker, N. V. Viswanathan & Jayadev Sreedhar.
2. Encyclopedia of Polymer Science and Technology, Herman F. Mark.
3. Essentials of Polymer Science and Engineering, Paul C. Painter and Michael M. Coleman.
4. Physical Properties of Polymers, James Mark, Kia Ngai, William Graessley, Leo Mandelkern, Edward Samulski, Jack Koenig, George Wignall.
5. Plastics Engineering, R. J. Crawford, Pergamon Press.
6. Text Book of Polymer Science, Billmeyer, John Wiley & Sons.
7. Principles of Polymerization, Odian G, 4th ed., John Wiley & Sons.
8. Processing of Polymer Matrix Composites, P.K. Mallick, CRC Press.

AM***** Iron and Steel making

Designation	:	Compulsory
Pre-requisites	:	None
Credit and Contact hrs	:	3(L) - 0(T) – 0(P) – 3(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment: (Scheme)** 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise Tests, Term paper etc)
Course Outcomes	:	**After the completion of this course, students will be able to** 1. Understand the traditional and modern steel making process. 2. Demonstrate different kinds of furnaces, operations and remedial measures 3. Apply the knowledge to enhance the productivity and to improve the quality.
Modes of Delivery	:	Talk and chalk, Power point presentations, and practical etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	√	√					√		√	√
CO2		√	√	√	√			√	√	√
CO3			√		√	√		√	√	

Syllabus

PRODUCTION OF IRON AND FERRO ALLOYS: History of Iron Making, Traditional Iron Making, Evolution of Blast Furnace, Iron Making in India. Iron ores of the world: Distribution; Indian iron ores, limestones and coking coal deposits, problems associated with Indian raw materials. Iron ore beneficiation and agglomeration, theory and practice of sintering and pelletising, Testing of burden materials, Blast Furnace Reactions, Thermodynamics and Kinetics, Fundamental studies, Blast furnace design, other auxiliary units, plant layout, recent developments in the design & operation of blast furnace, irregularities in operation and their remedies, Blast furnace refractories and instrumentation; Blast furnace slag & gas: importance, formation and use. Direct reduction methods, Details of some commercial processes like Rotary Kiln, Electric Pig Iron Furnace, HYL, Midrex, Fluilised Bed, Corex Process, Pyrophoricity of DRI, Ferroalloy Furnaces, Production of FeSi, FeMn and FeCr, Nitrided Ferroalloys.

References books

1. Making, Shopping and Treating of Steel, 10 th Edition, Edited by United States Steel, 1985.
2. Ghosh and A. Chatterjee, Ironmaking and Steelmaking: Theory and Practice, PHI Learning (P) Ltd., New Delhi, 2008.
3. A. K. Biswas, Principle of Blast Furnace iron making, SBA Publications, Calcutta, 1981.
4. Kurt Meyer, Pelletizing of Iron Ores Springer Verlag, Berlin, Heidelberg, Newyork, 1980.
5. Strasburger, Brown, Stephenson & Dancy, B.F. Theory and Practice, Vol.I & II, 1969, Gordon & Reach, New York.
6. K.K.Prasad & H.S. Ray, Advances in Rotary Kiln Sponge Iron Plant.
7. Robert L. Stephenson, Direct reduced iron – Technology & Economics of production and use, 1980, Iron & Steel Society of AMIE.
8. C.K.Gupta and A.K.Suri, Ferroalloys Technology in India, C.K. 1982, Milind Pub., New Delhi.
9. Thupkary R.H, 'Introduction to Modern Iron Making', Khanna Publications, Delhi, 2004.
10. J.G. Peacey and W.G. Davenport, Blast Furnace: Theory and Practice, Pergamon Press, Oxford, 1979.

HS***** Engineering Ethics, IPR and Entrepreneurship

Designation	:	Compulsory
Pre-requisites	:	
Credit and Contact hrs	:	3(L) - 0(T) – 0(P) – 3(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment: (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise Tests, Term paper etc).
Course Outcomes	:	The successful student will learn: 1. Identify the core values that shape the ethical behavior of an engineer. 2. To create an awareness on professional ethics and Human Values 3. To appreciate the rights of others
Modes of Delivery	:	Talk and chalk, Power point presentations, and practical etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1		√					√			
CO2		√	√	√		√		√	√	
CO3				√		√	√			
CO4					√		√		√	

Syllabus

Values: Concept, Types, Rokeach Value Survey. Different Kinds of Values: Individual, Societal, Material, Psychological, Cultural, Moral and Ethical, Spiritual; The Burgeoning Crises at Each of these levels. Modern Approach to the Study of Values: Analyzing Individual Human Values such as Creativity, Freedom, Wisdom and Love; Value Spectrum for a Good Life; The Indian Concept of Values, Comparison of eastern and western concept of values. Ethics: Values, Morals and Ethics; Need for Ethics in Professional Life; Kohlberg's Theory of Moral Development and Its Applicability to Engineers. Professional Ethics: Values in Work Life; Professional Ethics and Ethos; Codes of Conduct, Whistle-Blowing, Corporate Social Responsibility, Case Studies on Ethics in Business.

Introduction to IPR: Nature and Enforcement, International Character of IPRs, Role of IPRs in Economic Development. Patents: Introduction to Patents, Object of Patent Law, Inventions not Patentable, Obtaining Patents, Rights and Obligations of a Patentee. Copyrights: Introduction to Copyrights, Subject-Matters of Copyright, Rights Conferred by Copyright, Infringement, Assignment and Licensing of Copyrights, Copyright Societies, International Copyright, Performer's Rights. Trademarks: Functions, Significance and types of Trademarks, Distinctiveness and Deceptive Similarity, Registration Procedure, Trademark Registry, Grounds for Refusal of Registration of Trademarks, Concurrent Use, Character Merchandising. Trade Secrets: Meaning, Types of Trade Secrets, Statutory Position of Trade Secrets in India, Proofs Required in Trade Secret Litigation Case.

Entrepreneurship: Concept, Functions, Need and Importance, Types of Entrepreneurs, Entrepreneurship Journey, Innovation and Problem Solving, Market Understanding, Resource Mobilization

References books

1. Mika Martin and Roland Scinger, 'Ethics in Engineering', Pearson Education/Prentice Hall, New York 1996.
2. Govindarajan M., Natarajan S., Senthil Kumar V. S., 'Engineering Ethics' Prentice Hall of India, New Delhi, 2004.
3. Charles D. Fleddermann, 'Ethics in Engineering', Pearson Education/Prentice Hall, New Jersey, 2004 (Indian Reprint).
4. Charles E. Harris, Michael S. Protchard and Michael J. Rabins, 'Engineering Ethics – Concept and Cases', Wadsworth Thompson Learning, United States, 2000 (Indian Reprint now available).
5. 'Concepts and Cases', Thompson Learning (2000).
6. John R. Boatright, 'Ethics and Conduct of Business', Pearson Education, New Delhi, 2003.
7. Edmund G. Seebauer and Robert L. Barry, 'Fundamentals of Ethics for Scientists and Engineers', Oxford University of Press, Oxford, 2001.

Semester-V

AM***** Mechanical Metallurgy

Designation	:	Compulsory
Pre-requisites	:	Structure of Materials
Credit and Contact hrs	:	3(L) - 0(T) – 2(P) - 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment: (Scheme)** 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise Tests, Term paper etc)
Course Outcomes	:	The successful student will learn: This course is primarily designed to develop the fundamental aspects of mechanics of deformation and fracture of materials by destructive testing. At the end of the course, the student will be able to identify and analyze the deformation mechanisms that occur in metals and alloys so that the metal forming operations can be easily understood.
Modes of Delivery	:	Talk and chalk, Power point presentations, and practical etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1		√					√			
CO2		√	√	√		√		√	√	
CO3				√		√	√			
CO4					√		√		√	

Syllabus

Plastic Deformation in Metals and Alloys: Critical resolved shear stress. Defects in crystalline materials Point defects and line defects. The concept of dislocation – Edge dislocation and screw dislocation. Interaction between dislocations, sessile dislocation, glissile dislocation, dislocation climb, Jogs, Forces on dislocations Energy of a dislocation. Frank Reed source, slip and twinning.

Fracture: Elementary theories of fracture, Griffith's theory of brittle fracture, Ductile Fracture, Notch sensitivity.

Hardness Test: Methods of hardness testing Brinells, Vickers, Rockwell, Rockwell superficial, Shore and Poldi methods, Microhardness test, relationship between hardness and other mechanical properties.

Tension Test: Mechanism of elastic action, linear elastic properties. Engineering stress and Engineering strain, True stress-strain curve. Tension Test and tensile properties, conditions for necking, effect of temperature and strain rate on tensile properties. Compression Test: Elastic and in elastic action in compression, compression Test. Impact Test: Notched bar impact test and its significance, Charpy and Izod Tests, significance of transition temperature curve, Metallurgical factors affecting the transition temperature, temper embrittlement. DBTT curve and its importance.

Fracture toughness testing – COD and CTOD tests.

Mechanical testing for materials, Measurement techniques in experimental solid mechanics, Non-destructive testing

References books

1. Mechanical Metallurgy – GE Dieter
2. Mechanical Behavior of Material – A. H. Courtney
3. Engineering Materials Science – CW Richards
4. Mechanical Metallurgy – White & Le May

AM***** Nanomaterials and Nano Technology

Designation	:	Compulsory
Pre-requisites	:	Engineering Mathematics and computer programming
Credit and Contact hrs	:	3(L) - 0(T) – 0(P) - 3(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks. Mid Semester Exam: 20 marks. **Internal Assessment: (Scheme)** 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise Tests, Term paper, etc.)
Course Outcomes	:	**The successful student will learn:** 1. Can identify potential of nanomaterial properties and nanotechnology. 2. Can understand and interpret TEM and SEM micrographs of nanomaterials and

		nanostructures. 3. Can able to demonstrate uses of nanomaterial. 4. Can able to identify the scope of nanomaterial and nanotechnology.
Modes of Delivery	:	Talk and chalk, Power point presentations, practical, etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	√		√		√	√		√		
CO2		√		√	√	√		√		
CO3			√		√	√		√		
CO4.	√	√	√			√				

Syllabus

Introduction to Nanomaterial and Nanotechnology: Nano technology, Nano-science, MEMS, CNT, Fullerene, Nano-machines, Semiconductor technology, etc.

Solid State Physics: Introduction, Structure (physics of solid state), FCC nanoparticle, Semiconductor structures, Lattice vibration, Energy band, Reciprocal space, Fermi surfaces, Localized particles, Mobility, Exciton, etc.

Methods of Measuring Properties: Review of measurement methods, Particle size, Spectroscopy, LEED, RHEED, surface structures, microscopy – TEM, SEM, FIM, AFM, etc.

Properties of Nanoparticles: Properties of nano-particles, Metal nano-clusters, Semi conducting nano-particles, and Molecular clusters.

Carbon Nanostructures: Carbon nanostructures, Carbon-molecule, Carbon clusters, C60, C20H20, C8H8, CNT, Applications.

Nano Composites:

Bulk Nanostructured Materials: Solid disordered nanostructures: Synthesis, Failure, Mechanical properties, Electrical properties, Composite glasses, Porous silicon, Nanostructured crystals, and Photonic crystals.

Nanostructured Ferromagnetism: Basic, Para-, Ferro-, Ferri-, Antiferro-magnetism, Effect of bulk nano-structuring on magnetic properties, Dynamics of nano-magnets, Nanopore containment, Nanocarbon ferromagnets, Giant and colossal magnetoresistance, and Ferrofluids.

Quantum Nanostructure, Self-Assembly and Deposition: Quantum wells, Quantum wires, Quantum dots, Preparation, Monolayer, Multiplayer, LB film deposition, CVD, PVD, Sputtering, etc.

References books

1. Introduction to Nanotechnology, C. P. Poole Jr. and F. J. Owens, Wiley Interscience, New York.
2. Nano Structures and Nano Materials: Synthesis, Properties and Applications, Guozhong Cao- Imperial College Press.
3. Nanomaterials, A. K. Bandyopadhyay, New Age International (p) Limited.
4. Nanostructured Materials Processing, Properties and Applications, C. C Koch, Jaico Publishing House.
5. Nanotechnology, W. I. Atkinson, Jaico Publishing House.

AM*** Heat Treatment and Phase Transformation**

Designation	:	Compulsory
Pre-requisites	:	Structure of Materials
Credit and Contact hrs	:	3(L) - 0(T) - 2(P) - 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment: (Scheme)** 20 marks (5 marks for attendance + 15 marks for assigument submission, Surprise Tests, Term paper etc)
Course Outcomes	:	**The successful student will learn:** Understanding the thermodynamic and kinetics for phase transformations Understanding of homogeneous and heterogeneous nucleation as well as growth processes leading to a particular microstructure Understanding of different types of solid state phase transformations Study of different heat treatment cycles and their obtained property
Modes of Delivery	:	Talk and chalk, Power point presentations, and practical etc.

Mapping of course outcomes with program outcomes

Course	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10

outcome										
CO1		√					√			
CO2		√	√	√		√		√	√	
CO3				√		√	√			
CO4					√		√		√	

Syllabus

Introduction and classification of phase transformations. Diffusion in solids: phenomenological approach and atomistic approach. Nucleation and growth theories of vapour to liquid, liquid to solid, and solid to solid transformations; homogeneous and heterogeneous strain energy effect during nucleation; interface-controlled growth and diffusion controlled growth; overall transformation kinetics. Principles of solidification, evolution of microstructures in pure metals and alloys. Precipitation from solid solution: types of precipitation reactions, crystallographic description of precipitates, precipitation sequence and age hardening, spinoidal decomposition. Iron-carbon alloy system: iron-carbon diagram, nucleation and growth of pearlite, cooling of hypo-eutectoid, eutectoid, and hyper-eutectoid steels, development of microstructures in cast irons. Heat treatment of steels: TTT and CCT diagrams, bainitic transformation, martensitic transformation, hardenability, role of alloying elements in steels, conventional heat treatment of steels. Massive transformation. Order-disorder transformation. Phase transformations in and heat treatment of some common non-ferrous metals and alloys.

References books

1. A. Porter and K. Easterling: Phase Transformation in Metals and Alloys, CRC Press, 2000.
2. George Krauss: Steels-Heat Treatment and Processing Principles, ASM International, Materials Park, Ohio, 1990

HS***** Organizational Behavior and Psychology

Designation	:	Compulsory
Pre-requisites	:	Nil
Credit and Contact hrs	:	3(L) - 0(T) 0(P) – 3(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment: (Scheme)** 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise Tests, Term paper etc)
Course Outcomes	:	**The successful student will learn:** Introduction to organizational behaviour, Historical development of the field and some challenges in contemporary times, Learning and perceptual processes in organizations and their implications for work-life,Work related attitudes- job satisfaction, organizational commitment, organizational justice, organizational citizenship behaviour, Individual differences related to personality, emotions and abilities and functioning in organization, Group processes in organizations, Formation of groups and teams, Effective teams, Communication in organizations, Social influence processes in organizations, influencing people, power dynamics and politics and impact on organizational functioning, Theories and styles of leadership in organization and their impact on organizational functioning, Organizational ethos and culture and its impact on productivity and well- being, Various kinds of organizational structures and their effectiveness, managing organizations in times of change.
Modes of Delivery	:	Talk and chalk, Power point presentations, and practical etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1		√					√			
CO2		√	√	√		√		√	√	
CO3				√		√	√			
CO4					√		√		√	

Syllabus

Introduction: Historical development; concept of organization; elements of organizational structure; scope of organizational behaviour. Motivation and job satisfaction: Major theories; content and process; (Adams, Maslow, Vroom, Herzberg). Intrinsic and extrinsic motivation; incentive systems: Job satisfaction; concept and determinants. Leadership: Functions and approaches; trait, behavioural and contingency models; characteristics of successful leaders; role of power in leadership. Communication: Communication process: types of communication; communication channels and networks; barriers to communication. Group behaviour and conflict: Defining and classifying groups;

stages of group development; concept, causes and consequences of conflicts; methods of conflict-resolution. Definition of Industrial and Organisational Psychology, Major Fields of Industrial/Organisational Psychology; Personnel Psychology, Ergonomics, Vocational and Career Counselling, Organisation Development, Industrial Relations

References books

Aamodt, M. G. (2001). Industrial/organizational psychology. New Delhi: Cengage.

Luthans, F. (2005). Organizational behavior(12th Ed.). New York: McGraw Hill.

Muchinsky (2009). Psychology applied to work. New Delhi: Cengage.

Robbins , S., Judge, T.A., &Sanghi, S.. (2009). Organizational behavior 13th Ed.). New Delhi:Pearson Education.

Riggio, R.E..(2003) Introduction to Industrial/Organizational Psychology (4th Ed.)New Jersey : Prentice-Hall .

Semester-VI

AM*** Introduction to Computational Materials Science**

Designation	:	Compulsory
Pre-requisites	:	Applied Mathematics and computation
Credit and Contact hrs	:	3(L) - 0(T) – 2(P) – 4(Cr)
Assessment Methods	:	**Theory Examination:** (Scheme) End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment:** (Scheme) 20 marks (5 marks for attendance + 15 marks for assigement submission, Surprise Tests, Term paper etc)
Course Outcomes	:	**The successful student will learn:** 1. To understand basic of material modelling. 2. Different multi-scale modelling technique and their correlation. 3. To use open source and commercial software for solving simple problems.
Modes of Delivery	:	Talk and chalk, Power point presentations etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	√			√	√		√		√	
CO2			√		√		√			√
CO3			√			√		√		

Syllabus

Introduction and Fundamentals: Introduction to various regimes, multiscale modelling & simulation of materials, System size vs computation time, Parallel processing

Ab Initio Methods: Density functional theory, quantum mechanics, schrodinger wave equation, many particle system, car parrinello method, born openheimer approximation, hohenberg-kohn theorem, kohn sham formulation, local density approximation, bloch's theorem, pseudo potential, energy minimisation techniques, examples of crystals and non-crystals.

Lattice Mesoscale methods: Lattice gas automata, lattice director model.

Coarse graining: Particle based models-Lattice gas model, connolly williams approximation, spatial models, dynamic (temporal) models, application to polymer and polar materials. grain continuum modelling, computational micro-mechanics, multiscale coupling.

Term Paper on application of Multiscale Modelling to Composite damage, Dislocation behavior, Phase field modeling, Modelling of grain growth and microstructure in polycrystalline materials, Modelling of structural materials And other recent advances based on literature survey

Term paper on material modeling.

References books

1. Introduction to Materials Modelling, Ed Zoe H. Barber, Maney Publishing.
2. Computational Material Science From Ab Initio to Monte Carlo Methods, K. Ohno, K.Esfarjani, Y. Kawazoe, Springer.
3. Multiscale Materials Modelling: Fundamentals and Applications, Ed Z Xiao Guo, Woodhead Publishing Limited, Cambridge.
4. Computational Meso-mechanics of Composites, Leon Mishnaevsky, Jr., John Wiley & Sons.
5. Multi-scale modelling of Composite Material Systems, C. Soutis & P. W. R. Beaumont Woodhead Publishing Ltd.

6. Continuum Scale Simulation of Engineering Materials-Fundamentals, Microstructures, Process Applications. Dierk Rabbe, Barlat, Wiley.
7. Annual Review of Materials Research on Computational Materials Research, Vol 32.
8. Understanding Molecular Simulation- from Algorithm to Application, Frenkel Daan, Smit Berend. Academic Press.
9. Notes of Workshop on Computational Materials Science, Indian Institute of Sciences, Bangalore, 06-08 Mar 2009.
10. Computational Material Science, Dierk Raabe, Wiley-VCH Verlag GmbH
11. Multiscale Modelling & Simulation, Attringer & Coumoutsakos, Springer
12. Computational Materials Design, Tetsuya, Springer
13. Combinatorial Material Science, Balaji narasimhan, Surya K Mallaprajada, Wiley
14. Materials Informatics, Data-Driven Discovery in Material Sc, Krishana Rajan, Wiley.

AM*** Fatigue and Fracture of Materials**

Designation	:	Compulsory
Pre-requisites	:	Strength of Materials, linear Algebra
Credit and Contact hrs	:	3(L) - 0(T) – 0(P) · 3(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment: (Scheme)** 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise Tests, Term paper etc)
Course Outcomes	:	**The successful student will learn:** 1. Different types of deformation and mechanical properties. 2. Role of mechanical properties in designing. 3. Different testing technique of mechanical characterization.
Modes of Delivery	:	Talk and chalk, Power point presentations, and practical etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	√			√	√		√	√		
CO2	√			√	√		√			
CO3				√		√		√		

Syllabus

Overview: Different responses of material to loading, material properties, macroscopic experiments and its relevance, physical mechanisms controlling the behavior.

Elasticity: Atomic structure and bonding, Atomic interaction, physical origin of elastic modulus, Generalized Hooke's law, orientation dependence of elastic modulus.

Plasticity: Theoretical shear strength of crystals, Point, line and volume defects, edge and screw dislocations, Burgers circuit and Burgers vector, force between dislocations, movement and interactions of dislocations, slip planes, twinning, strengthening mechanisms, work hardening, grain boundary strengthening and solid solution strengthening, true stress-strain curve, necking pheonomenon, yield criteria, plastic stress- strain relationships.

Viscoelasticity and viscoplasticity: Responses of viscoelastic materials under different loading, creep and relaxation, Maxwell and Kelvin models.

Creep and Fracture: Primary, secondary and tertiary creep, creep mechanisms, dislocation creep, diffusion creep and grain boundary creep, creep laws, Analysis and Applications in Design. Brittle, ductile and fatigue fracture, fracture surfaces, Griffith's theory, modes of fracture, energy release rate, stress intensity factor, crack tip plasticity, J-integral and Crack Tip Opening Displacement

Fatigue: Cyclic loads, constant amplitude and variable amplitude loads, cycle counting techniques, infinite life, safe-life, fail-safe, damage-tolerant design philosophies, Low cycle and high cycle fatigue, Stress-Life approach, Strain-Life approach and Fracture mechanics approach, Cumulative damage theories.

Term Paper: On recent advances based on literature survey and/or lab/industry visit

References books

1. Norman E. Dowling, Mechanical behavior of materials: Engineering Methods for Deformation, Fracture and Fatigue, Prentice Hall.
2. Marc Meyers and Krishnan K. Chawla, Mechanical behavior of materials, Cambridge University Press.
3. William F. Hosford, Mechanical behavior of materials, Cambridge University Press.
4. Thomas H. Courtney, Mechanical behavior of materials, Overseas Press.

5. Joachim Roesler, Harald Harders, and Martin Baeker, Mechanical Behavior of Engineering Materials, Springer.
6. Prashant Kumar, Elements of fracture mechanics, Tata McGraw Hill.
7. S. Suresh, Fatigue of Materials, Cambridge University Press
8. RW Hertzberg, Deformation and Fracture Mechanics of Engineering Materials, John Wiley & Sons.
9. D. Hull, DA Bacon, Introduction to dislocations, Pergamon.
10. G. E. Dieter, Mechanical Metallurgy, McGraw Hill.

AM*** Corrosion Science and Engineering**

Designation	:	Compulsory
Pre-requisites	:	Chemistry
Credit and Contact hrs	:	3(L) - 0(T) - 2(P) - 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid.Semester Exam: 20 marks **Internal Assessment: (Scheme)** 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise Tests, Term paper etc)
Course Outcomes	:	**The successful student will learn:**
Modes of Delivery	:	Talk and chalk, Power point presentations, and practical etc.
		Mapping of course outcomes with program outcomes

Course outcome	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10
C01										
C02										
C03										
C04										

Thermodynamics of Corrosion: Free energy change, EMF and galvanic series, Pourbaix diagrams, Nernst equation.
Electrochemical Theory: Corrosion rate, activation polarization, concentration polarization, anodic, cathodic, mixed control. Passivation, Tafel equation.
Types of Corrosion: Different forms of corrosions-uniform, galvanic, crevice, pitting, intergranular, erosion-corrosion, scc, hydrogen cracking, corrosion fatigue, fretting corrosion, effect of metallurgical variables and environments on different forms of corrosion.
Corrosion Protection: Corrosion prevention methods-anodic protection, cathodic protection, inhibitors.
Corrosion Testing: Electrochemical techniques-potentiostat, Tafel extrapolation, linear polarization, galvanostat, impedance spectroscopy. Thermogravimetric technique, salt spray test, weight change measurements, corrosion and oxidation resisting materials.
Hot Corrosion: High temperature oxidation of metals and alloys, laws governing oxidation, molten salt corrosion, liquid metal corrosion.
Radiation Damage: Introduction and nature, types of radiation damage in different materials

Reference books:

1. Principles and Prevention of Corrosion, Denny A. Jones, 2nd ed., Prentice-Hall, Inc.
2. Corrosion Engineering, Fontana M. G., and Greene N. D., McGraw Hill.
3. Corrosion and Corrosion Control, Uhlig H. H. and Revie R. W., 3rd Ed., John Wiley & Sons.
4. Corrosion, Metals Handbook, Vol.13 A & B, 9th ed., ASM.
5. The Fundamental of Corrosion, J. C. Scully, 2nd ed., Pergamon Press.
6. Fundamentals of Electrochemical Corrosion, E. E. Stansbury and R. A. Buchanan, ASM International.

HSS*** Indian Art and Culture**

Designation	:	Compulsory
Pre-requisites	:	Nil
Credit and Contact hrs	:	3(L) - 0(T) - 0(P) - 3(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks

		Internal Assessment: (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise Tests, Term paper etc)
Course Outcomes	:	**The successful student will learn:**
Modes of Delivery	:	Talk and chalk, Power point presentations, and practical etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1		√					√			
CO2		√	√	√		√		√	√	
CO3				√		√	√			
CO4					√		√		√	

Syllabus

An Introduction to Indian Culture- History and Culture through ages: Ancient India, Medieval India, Modern India, Languages and Literature: Indian Languages and Literature-I, Indian Languages and Literature-II, Religion and Philosophy: Religion and Philosophy in ancient India, Religion and Philosophy in Medieval India, Religious Reform Movements in Modern India, Painting, Performing Arts and Architecture: Indian Painting, Performing Arts: Music. Dance and Drama, Indian Architecture SCIENCE AND TECHNOLOGY: Science and Technology in India, Scientists of Ancient India, Science and Scientists of Medieval India, Scientists of Modern India EDUCATION: Education in India, SOCIAL STRUCTURE: Indian Social Structure, Socio-Cultural Issues in Contemporary India SPREAD OF INDIAN CULTURE ABROAD: Spread of Indian Culture Abroad.

References books

Semester-VII

AM*** Modelling and Simulation in Materials Processes**

Designation	:	Compulsory
Pre-requisites	:	Mechanics of materials, Heat treatment, Mechanical Processing of Materials.
Credit and Contact hrs	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination:** (Scheme) End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment:** (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise Tests, Term paper etc).
Course Outcomes	:	**After the completion of this course, students will be able to** 1. Understand principles, methods, and approaches of simulation and modeling. 2. Identify, formulate, and solve engineering problems. 3. Choose modeling and simulation techniques to computationally solve any metal processing operations.
Modes of Delivery	:	Talk and chalk, Power point presentations, and practical etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	√			√	√		√			
CO2						√		√		
CO3										

Syllabus

Introduction to modeling- simulation models.

Casting process: Modelling of heat transfer, direct heat conduction modelling, one- dimensional and multidimensional inverse modelling, fluid flow and heat transfer model, thermodynamics of solidification, metal/mold interfacial heat transfer, deformation and stresses in castings, thermomechanical modelling in casting, determination of heat-transfer coefficient and air gap width in permanent mould castings, continuous casting and DC casting process,

Welding process: weld heat -source models, thermal analysis with-microstructure, transient fluid flow, residual stresses in welds,

Heat treatment: Metal quenchant, interfacial heat transfer, diffusion model, microstructure model, carburization model, quench crack simulation, creep simulation,

Modeling of material processing: Rolling, forming and extrusion processes. Artificial Neural Networks in materials processing, Phase-field modeling and Monte-Carlo simulations. Introduction to commercial softwares.

References books

1. Modeling in Welding, Hot Powder Forming and Casting (Eds. L. Karlsson), ASM, MaterialsPark,OH, 1997.
2. Szekely,J.,Evans, J.E.and Brimacombe, J.K., The Mathematical and Physical Modelling of Primary Metal processing Operations, Wiley, 1988.
3. Numerical Recipes: The Art of Scientific Computing, Cambridge Univ. Press, N.Y., 1988.
4. D.R. Poirier and G.H. Geiger: Transport Phenomena in Materials Processing, TMS, warrendale.
5. R.I. L. Guthrie: Engineering in Process Metallurgy, Oxford Science Publications (1989).
6. Barber Z.H., 2005, "Introduction of Materials Modeling", Maney Publishing.
7. King P.R., 2012, "Modeling and Simulation of Mineral Processing Systems", Society for Mining, Metallurgy & Exploration (SME).

AM*** Machine Learning in Material Science**

Designation	:	Compulsory
Pre-requisites	:	Engineering Mathematics
Credit and Contact hrs	:	3(L) - 0(T) – 2(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment: (Scheme)** 20 marks (5 marks for attendence + 15 marks for assignment submission, Surprise Tests, Term paper etc).
Course Outcomes	:	**After the completion of this course, students will be able to** 1. Understand the basic concepts and techniques of Machine Learning. 2. Identify and solve the problem using a suitable machine learning technique. 3. Able to design application using machine learning techniques.
Modes of Delivery	:	Talk and chalk, Power point presentations, and practical etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	√			√	√		√			
CO2						√		√		
CO3										

Syllabus

Introduction to machine learning: Types of learning, Inductive classification, Linear regression, Decision trees, Probability and Bayes learning, Experimental evaluation of learning algorithms, Logistic regression, Support vector machine, Kernel function and Kernel SVM.

Artificial neural networks -Perceptrons, Multilayer neural networks, Back propagation algorithm, Different activation functions), Computational learning theory, Clustering and unsupervised learning.

Implementation of various Machine Learning algorithms-Coding with software tools. Introducing machine learning tools to design solutions for various problems related to material science.

References books

1. Tom M Mitchell, "Machine Learning", McGraw Hill Education, 2017.
2. Alpaydin, E. "Introduction to machine learning", MIT press, 2014. Marsland, S. "Machine learning: an algorithmic perspective", CRC press, 2015.
3. Christopher M Bishop, "Pattern recognition and machine learning" Springer Science Business Media,2006.
4. Richard O. Duda, Peter E. Hart, David G. Stork, "Pattern Classification" Second edition John Wiley, 2001.
5. Tom M Mitchell, "Machine Learning", McGraw Hill Education, 2017.
6. Christopher M Bishop, "Pattern recognition and machine learning", Springer New York, 2016.
7. Goodfellow, I., Bengio, Y., Courville, A., &Bengio, Y, "Deep learning" (Vol. 1). Cambridge: MIT press, 2016.
8. Richard O. Duda, Peter E. Hart, David G. Stork, "Pattern Classification" Second edition John Wiley,2001.

AM***** Ceramics and Refractories

Designation	:	Compulsory
Pre-requisites	:	Engineering Materials, Structure of Materials, Phase Diagrams, etc.
Credit and Contact hrs	:	3(L) - 0(T) - 0(P) – 3(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks. Mid Semester Exam: 20 marks. **Internal Assessment: (Scheme)** 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise Tests, Term paper, etc.)
Course Outcomes	:	**The successful student will learn:** 5. To identify Ceramics and Refractories. 6. To know and understand common Ceramics and Refractories. 7. To develop knowledge of expressing and applying Ceramics and Refractories in a real life problem. 8. To know Ceramics for medical and scientific products.
Modes of Delivery	:	Talk and chalk, Power point presentations, practical, etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	√			√					√	
CO2		√				√		√		
CO3	√		√		√	√		√		
CO4	√			√					√	√

Syllabus

General Introduction: Concepts of materials science, Definition and scope of ceramics and ceramic materials, Classification of ceramic materials, Conventional ceramics, Advanced ceramics, and Areas of applications.

Ceramic Structures: Basic structures, Silicates, Silica, Glass, Ceramic oxides, etc.

Properties of Ceramics: Mechanical properties, Thermal properties, Electrical properties, etc.

Engineering Ceramics: Carbide: Boron carbide, Silicon carbide, Titanium carbide, Zirconium carbide, Hafnium carbide, Uranium carbide, etc., Nitride: Boron nitride, Silicon nitride, Aluminium nitride, etc., Silicide: Molybdenum disilicide, Borides, Sialon, Graphites, etc.

Refractories: Classification of Refractories, Modern trends and developments, Basic raw materials, Elementary idea of manufacturing process technology, Flow diagram of steps necessary for manufacture, and Basic properties and areas of application.

Fundamentals of Refractory Science and Engineering: Brief review of raw materials, Gap grading, Continuous grading, Fabrication and firing, etc.

Ceramics for Medical and Scientific Products: Tissue attachment mechanism, Bio-active materials, Nearly inert crystalline ceramics, Porous ceramics, Bioactive glass and glass ceramics, Calcium phosphate based ceramics, Carbon based implant materials, and Dental ceramics.

Ceramics Environmental Impact: Life cycle assessment of ceramics, and Case studies.

References books

1. Elements of Ceramics, F. H. Norton, Addison-Wesley.
2. Fundamentals of Ceramics, M. W. Barsoum, Institute of Physics Publishing, Bristol and Philadelphia.
3. Introduction to ceramics, W. D. Kingery, Harvey Kent Bowen, Donald Robert Uhlmann.
4. An Introduction to Ceramics and Refractories, A. O. Surendranathan, CRC Press.
5. Ceramic Materials Processes, Properties and Applications, edited by Philippe Boch Jean-Claude Niepce, ISTE.

Core Electives

AM*** Finite Element Method**

Designation	:	Elective
Pre-requisites	:	Mechanics of Materials
Credit and Contact hrs	:	3(L) - 0(T) – 2(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment: (Scheme)** 20 marks (5 marks for attendance + 15 marks for assigement submission, Surprise Tests, Term paper etc).
Course Outcomes	:	**After the completion of this course, students will be able to** 1. Understand the basic concept of FEM and able to solve manually. 2. Apply FEM to various structural problems 3. Impart knowledge on commercial FEA software.
Modes of Delivery	:	Talk and chalk, Power point presentations, and practical etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	√	√					√		√	√
CO2		√	√	√	√			√	√	√
CO3			√		√	√		√	√	

Syllabus

Introduction: History of FEM, Application, Concept of Discretization and Interpolation, Different Steps in Finite Element Analysis, Demonstration through FE Analysis of Axially Loaded Bar.

Variational Methods & Energy Principles: Introduction to Variational Calculus, Energy Principles – Principle of Virtual Work and Complementary Virtual Work, Principle of Minimum Potential Energy and Complementary Potential Energy, Mixed Principles.

Classical Finite Element Methods: Ritz Method, Method of Weighted Residuals, Galerkin method, Strong & Weak formulation. One & Two dimensional structural & non-structural boundary value.

FEM for Solid Mechanics: Finite element discretization – Piecewise Interpolation & Shape Functions, C^0 and C^1 Interpolation, Conventional 1D, 2D & 3D Elements, Special Elements, Sub Parametric, Super Parametric & Isoparametric elements. FE Formulation using Variational Methods & Energy Principles. Coordinate transformation & Jacobian, Numerical Integration & Calculation of Element Matrices.

Introduction to Material and Geometric Non-linearity: Procedures for non-linear problems, one-dimensional plasticity problem. Finite Element analysis using commercial software and MATLAB coding.

References books

1. Energy and Finite Element Methods in Structural Mechanics: I. H. Shames and C. L. Dym.
2. Concepts and Applications of Finite Element Analysis: R. D. Cook, D. S. Malkus and M. E. Plesha.
3. The Finite Element Method Vol. I-II: O.C. Zienkiwicz and R.L. Taylor.
4. Finite Element Procedures: K. J. Bathe.
5. An Introduction to Finite Element Methods: J.N. Reddy.
6. Finite Element Methods in Engineering: S.S. Rao.
7. Advanced Topics in Finite Element Analysis of Structures: with Mathematica and MATLAB Computations, M. Asghar Bhatti.

AM*** Powder Metallurgy**

Designation	:	Elective
Pre-requisites	:	Nil
Credit and Contact hrs	:	3(L) - 0(T) - 2(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks

		Internal Assessment: (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise Tests, Term paper etc)
Course Outcomes	:	The successful student will learn: 1. Understanding of different metal/alloy powder fabrication techniques 2. Ability to characterize powder particles 3. To study basics of powder compaction and different powder compaction techniques 4. Understanding of fundamentals of sintering and applications of different sintering techniques to fabricate P/M products
Modes of Delivery	:	Talk and chalk, Power point presentations, and practical etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1		√					√			
CO2		√	√	√		√		√	√	
CO3				√		√	√			
CO4					√		√		√	

1:Slightly 2:Moderately 3:Substantially

Syllabus

Introduction: scope of powder metallurgy, characterization of metal powders, physical properties-particle size and shape determination, technological properties-apparent density, tap density, green density, sintered density, flow rate etc.

Powder manufacturing: reduction, electrolysis, and atomization processes. Compaction and consolidation: Die compaction and other advanced consolidation techniques like hot pressing (HP), hot iso-static pressing (HIP), spark plasma sintering (SPS) etc.

Sintering: solid and liquid state sintering, sintering mechanisms. Sintering furnaces and sintering atmospheres. Sintering theory and the influence of different processing conditions, wetting and surface diffusion...

Powder metallurgy products: bearing, filters, friction parts, hard metals, refractory metals, contact materials, magnetic materials, structural parts, and dispersion strengthened materials.

References books

1. R.M. German, Powder Metallurgy Science, Metal Powder Industries Federation, Princeton, New Jersey
2. M.N. Rahaman, Ceramic Processing and Sintering, Marcel Dekker, New York
3. G.S. Upadhyaya, Powder Metallurgy Technology, Cambridge International Science Publishing
4. A.K. Sinha, Powder Metallurgy, Dhanpat Rai Publication

AM*** Mechanical Processing of Materials**

Designation	:	Elective
Pre-requisites	:	Structure of materials
Credit and Contact hrs	:	3(L) - 0(T) – 2(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment: (Scheme)** 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise Tests, Term paper etc).
Course Outcomes	:	**After the completion of this course, students will be able to** 1. Understand the fundamentals of material processing. 2. Impart knowledge on various material processing techniques. 3. Able to choose a processing method for given material and application.
Modes of Delivery	:	Talk and chalk, Power point presentations, and practical etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	√			√	√		√			
CO2						√		√		
CO3										

Minor: Materials Engineering

S No	Course No.	Title	L	T	P	C
1	AM*****	Metallurgical Thermodynamics and Kinetics	3	0	0	3
2	AM*****	Structure of Materials	3	0	2	4
3	AM*****	Phase Diagrams	3	0	0	3
4	AM*****	Elective*	3	0	0	3
5	AM*****	Elective*	3	0	0	3
6	AM*****	Elective*	3	0	0	3

S No	*List of electives:		L	T	P	C
1	AM*****	Characterization of Materials	3	0	0	3
2	AM*****	Ceramic Materials	3	0	0	3
3	AM*****	Mechanical Behaviour of Materials	3	0	0	3
4	AM*****	Powder Metallurgy	3	0	0	3
5	AM*****	Mechanical Processing of Materials	3	0	0	3
6	AM*****	Iron and Steel Making	3	0	0	3
7	AM*****	Polymers Science and Composites	3	0	0	3
8	AM*****	Corrosion Science and Engineering	3	0	0	3
9	AM*****	Electrical and Electronic Materials	3	0	0	3
10	AM*****	Non-destructive Testing	3	0	0	3
11	AM*****	Electronic Ceramics	3	0	0	3
12	AM*****	Thin Films and Devices	3	0	0	3
13	AM*****	Biomaterials	3	0	0	3
14	AM*****	Fatigue and Fracture of Materials	3	0	0	3
15	AM*****	Nanomaterial	3	0	0	3
16	AM*****	Tribology	3	0	0	3
17	AM*****	Materials in Services	3	0	0	3
18	AM*****	Energy Materials	3	0	0	3
19	AM*****	High Temperature Materials	3	0	0	3
20	AM*****	Nuclear Materials	3	0	0	3
21	AM*****	Smart Materials and Structures	3	0	0	3
22	AM*****	Introduction to Computational Materials Science	3	0	0	3
23	AM*****	Carbon and Nanostructures	3	0	0	3

CO2		√		√	√	√		√	√	
CO3		√	√	√	√				-	
CO4	√	√	√	√	√					√

Syllabus

Introduction: Brief outline of the essential requirements of materials for automotive and aerospace applications.

Battery vehicles: Battery materials and battery vehicle technology

Light Metals and Alloys: Processing, properties and applications: Aluminium alloys e.g. AlCu, Al-Si, Al-Cu-Mg, Al-Zn- Mg-Cu, Al-Li; titanium alloys e.g. alpha, near alpha, alpha beta and titanium aluminides; magnesium alloys with Cu, Zn, Zr and rare earth elements.

Superalloys: Classification and development of superalloys. Physical and mechanical properties; heat treatment, microstructures and strengthening mechanisms. Creep resistance. Oxidation and hot corrosion. Coatings. Processing developments and applications.

Steels: Heat treatment, microstructure, mechanical properties and typical applications of HSLA, dual phase, ultra low carbon, interstitial free, ultra high strength, cryogenic and maraging steels.

Composites and Metal Foams: Typical Composites and Their properties, metal-matrix, fibre reinforcement composites, carbon-carbon composites, Metal forms and their applications

References books

1. I. J. Polmear, Light Alloys: From Traditional Alloys to Nanocrystals, Fifth Edition
2. Chunwen Sun, Advanced Battery Materials
3. Chester T. Sims, The superalloys
4. Frederick Brian Pickering, Physical Metallurgy and the Design of Steels

Contact hrs		
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks. Mid Semester Exam: 20 marks. **Internal Assessment: (Scheme)** 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise Tests, Term paper, etc.)
Course Outcomes	:	**The successful student will learn:** 1. To identify the applications of thin films. 2. To understand and know about the various techniques of nano-thin films. 3. To know about the growth mechanism of nanostructured thin films. 4. To have knowledge about synthesis and characterization of nanostructured thin films for futuristic applications.
Modes of Delivery	:	Talk and chalk, Power point presentations, practical, etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1			√			√		√		
CO2		√		√	√	√		√	√	
CO3		√	√	√	√					
CO4	√	√	√	√	√					√

Syllabus

Introduction: Basic of Thin films and Nanostructures, Role of thin films in Devices, and Recent changes in the Semiconductor Industry.

Fabrication of Thin Films: Sol-gel synthesis, Spin coating, Chemical vapor deposition, Physical vapor deposition, Sputtering deposition, Ion implantation, Cathodic arc deposition, Pulsed laser deposition, Molecular beam epitaxy, etc.

Characterization of Thin Films: X-ray diffraction, UV-vis spectroscopy, Squid, Four probe resistivity, Atomic probe microscopy, Profilometer, etc.

Properties of Thin Films: Structural, Electrical, Magnetic, Optical, Thermal, etc.

Application of Thin Films: Application of thin films in different areas such as - Electronics, Medical, Defense, Sports, Automobiles, etc.

Silicon and Silicon based Thin Film: Epitaxy by CVD - Process, Reactor, Equipment, Theory of CVD, Defects, Safety, and Key technical issues, CVD of silicon dioxide - Overview of atmospheric pressure CVD, Plasma enhanced CVD, Properties of dielectric films, New deposition technologies, and Future directions.

Feature Scale Modeling: Introduction, Components of etch and deposition modeling, Etch modeling, Etch examples, Deposition modeling, and Deposition examples.

References books

1. Materials Science of Thin Films, M. Ohring, Academic Press.
2. Handbook of Thin-Film Deposition - Processes and Techniques Principles, Methods, Equipment and Applications, edited by K. Seshan, Noyes Publications.
3. Thin Film Phenomena, K. L. Chopra, McGraw Hill.
4. Nanostructures and Nanomaterials: Synthesis, Properties and Applications, G. Cao, Imperial College Press.

AM*** Automotive and Aerospace Materials**

Designation	:	Elective
Pre-requisites	:	Structure of Materials
Credit and Contact hrs	:	3(L) - 0(T) – 0(P) – 3(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks. Mid Semester Exam: 20 marks. **Internal Assessment: (Scheme)** 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise Tests, Term paper, etc.)
Course Outcomes	:	The course is intended to familiarize the student with different automotive and aerospace materials and the recent developments
Modes of Delivery	:	Talk and chalk, Power point presentations, practical, etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1			√			√		√		

1. R .Stephenson, Introduction to Nuclear Engineering, McGraw-Hill.
2. H.S. Ray, R. Sridhar and K.P. Abraham: Extraction of Non ferrous Metals, Affiliated East-West Press Private Limited.
3.S. Glasstone and A.Sesonke: Nuclear Reactor Engineering, Van Nostrand

AM***** Tribology

Designation	:	Elective
Pre-requisites	:	Structure of Materials
Credit and Contact hrs	:	3(L) - 0(T) – 0(P) - 3(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks. Mid Semester Exam: 20 marks. **Internal Assessment: (Scheme)** 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise Tests, Term paper, etc.)
Course Outcomes	:	**The successful student will learn:** To impart knowledge on friction, wear and lubrication To acquire knowledge on surface coatings and measurements. 1.Apply the knowledge of tribology in industries 2. Identify the types of wear 3. Know the working of surface measuring instruments
Modes of Delivery	:	Talk and chalk, Power point presentations, practical, etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	√		√			√			√	
CO2	√	√	√					√		
CO3			√			√		√		√
CO4			√							√

Syllabus

Tribology -- definition, Industrial significance, economic aspects, trends. Factors influencing Tribological phenomena. Engineering surfaces - Surface characterization, Computation of surface parameters. Genesis of friction, friction in contacting rough surfaces, sliding and rolling friction, various laws and theory of friction. Stick-slip friction behavior, frictional heating and temperature rise. Friction measurement techniques.
Wear and wear types. Mechanisms of wear - Adhesive, abrasive, corrosive, erosion, fatigue, fretting, etc., Wear of metals and non-metals. Wear models - asperity contact, constant and variable wear rate, geometrical influence in wear models, wear damage. Wear in various mechanical components, wear controlling techniques.
Introduction to lubrication. Lubrication regimes. Introduction to micro and nano tribology. Coating characteristics, Coating performance evaluation, Powder coatings and types, application methods.
Surface topography measurements - Electron microscope and friction and wear measurements - Laser method. Sliding friction and wear abrasion test, rolling contact and fatigue test, solid particle and erosion test, Use of transducers and instruments in Tribology

References books

1. Hulling , J. (Editor) --"Principles of Tribology", MacMillan, 1984.
2. Williams J.A . "Engineering Tribology" ,Oxford Univ. Press,1994.
3. Neale M.J , "Tribology Hand Book ", Butterworth Heinemann, 1995.
4. I.M. Hutchings, "Tribology: Friction and Wear of Engineering Materials", Elsevier Limited, 1992.
5. G. W. Stachowiak, A. W. Batchelor, "Engineering Tribology", Elsevier Limited, 2005.
6. K.C. Ludema, "Friction, wear, lubrication: A text book in tribology", CRC Press, 1996.
7. Bharat Bhushan, "Nanotribology and Nanomechanics: An Introduction", Springer, 2008.

AM***** Thin Films/Coatings and Applications

Designation	:	Elective
Pre-requisites	:	Engineering Mathematics and computer programming
Credit and	:	3(L) - 0(T) – 0(P) - 3(Cr)

Introduction to Carbon Nanostructure: Carbon molecule, carbon small clusters, carbon big clusters, fullerenes, discovery of C_{60}, synthesis of C_{60}, properties of C_{60}, other buckeyballs, CNT.

CNT Morphology: From a graphene sheet to a nanotube, structure - achiral and chiral nanotubes, singlewall, multiwall and bundled nanotubes, zigzag and armchair nanotubes, Euler's Theorem in cylindrical and defective nanotubes.

Production Techniques of Nanotubes: Growth of single-wall/multiwall nanotubes, carbon arc bulk synthesis in presence and absence of catalysis, high purity material (bucky paper) production using pulsed laser vaporization (PLV) of pure and doped graphite, high-pressure co-conversion (HIPCO), nanotube synthesis based on Boudoir reaction-chemical vapor deposition (CVD), laser ablation, synthesis of aligned nanotube films.

Structural, Electronic Properties: Structural changes in free standing and interacting nanotubes – librations, rotations, twistons, effect of inter tube interactions on the electronic structure, electronic structure of graphite as building block of nanotubes, effect of chirality and discrete atoms, conducting versus insulating nanotubes, band structure of metallic carbon nanotubes, effect of doping on conductivity, electrical properties, vibrational properties, chemical properties, mechanical properties, physical properties, optical properties.

Applications of Nanotubes Harnessing field enhancement, flat panel displays, Hydrogen storage, carbon nanotubes & drug delivery, structural application of CNTs, CNT nanocomposites.

Term Paper: On recent advances based on literature survey and/or lab/industry visit

References books

1. Carbon Nanotubes, M. Endo, S. Iijima, M. S. Dresselhaus, Pergamon.
2. Carbon Nanotubes: Advanced Topics in the Synthesis, Structure, Properties and Applications, Ado Jorio, Mildred S. Dresselhaus, and Gene Dresselhaus, Springer.
3. Carbon Nanostructures, Springer.
4. Physics of Carbon Nanostructures, Stefano Bellucci, Alexander Malesevic, Springer.
5. Fullerenes, Nanotubes, and Carbon Nanostructures, F. D'Souza, P. Kamat, N. Martin, R. Weisman, S. Rotkin, H. Shinohara, Z. Slanina, Y. Iwasa, L. Wilson, N. Solladie: ECS Transactions: Vol 6, Issue 16.
6. Carbon Nanotube and Graphene Device Physics, H.-S. Philip Wong and Deji Akinwande, Cambridge University Press, 2011.

AM***** Nuclear Materials

Designation	:	Elective
Pre-requisites	:	Structure of Materials
Credit and Contact hrs	:	3(L) - 0(T) – 0(P) – 3(Cr)
Assessment Methods	:	**Theory Examination:** (Scheme) End Semester Exam: 60 marks. Mid Semester Exam: 20 marks.
		Internal Assessment: (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise Tests, Term paper, etc.)
Course Outcomes	:	**The successful student will learn:**
Modes of Delivery	:	Talk and chalk, Power point presentations, practical, etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	√		√			√			√	
CO2	√	√	√					√		
CO3			√			√		√		√
CO4			√							√

Syllabus

Nuclear Structure: Structure of nucleus, binding energy, fission reaction, neutron cross sections, moderation of neutrons, multiplication factor. ; Fusion reaction, Reactors and Materials: Classification of nuclear reactors, Materials for nuclear reactors, Fuels, Moderators, Control rods, Coolant, Reflectors and Structural materials. Fabrication of fuel and cladding materials. ; Radiation Effects: Effect of radiation on reactor materials, Radiation hazards, safety and shielding, disposal of radioactive wastes. ; Production of Nuclear Materials: Atomic minerals, their occurrence in India, General methods of their processing, Production metallurgy of nuclear grade uranium, Thorium beryllium and zirconium, Production of enriched uranium. ; Processing of spent fuel: Indian reactors and atomic energy programme in India. Use of nanomaterials for nuclear application

References books

CO3			√		√	√		√	√	

Syllabus

Introduction: Need for high temperature materials, equipment for material testing at high temperatures, requirements of high temperature materials (mechanical properties and preferred microstructure, environmental resistance, erosion and wear)

Principles for high temperature strengthening: Metallic materials (solid solution strengthening, precipitation strengthening, dispersion strengthening grain size and grain boundary effects) Ceramic materials (phase control, defect tolerance, thermal shock resistance), composite materials.

Creep and stress rupture: Creep test, stress rupture test, structural changes during creep, mechanism of creep deformation, and fracture at elevated temperatures.

Creep-fatigue interaction: Modes of high temperature fracture and fatigue fracture, creep-fatigue interaction (creep accelerated by fatigue), fatigue-creep interaction (fatigue accelerated by creep), micro-mechanism of damage, fracture criterion for creep fatigue, creep-fatigue failure mapping, creep-fatigue testing, influence of environment.

Oxidation and Hot Corrosion: Pilling-Bedworth ratio, kinetic laws of oxidation - defect structure and control of oxidation by alloy additions - sulphation, hot gas corrosion deposit, modified hot gas corrosion, effect of alloying elements on hot corrosion.

Materials for high temperature: Metals / alloys, superalloys, steels, titanium and its alloys, ceramics (Alumina, Zirconia, Silicon carbide, Silicon nitride, Glass ceramics) composites (Metal matrix composites, ceramic matrix composites) carbon – carbon composites.

Coatings for protection against high temperature corrosion and erosion: Corrosion / oxidation resistant coatings (metallic, ceramic, rare and reactive metal reinforced coatings), high temperature erosion and wear, thermal barrier coats.

References books

1. Meetham, G. W., Van de Voorde, M. H., "Materials for High Temperature Engineering Applications (Engineering Materials)", 1 st Ed., Springer
2. Chan R. W., "High temperature structural materials", Chapman & Hall
3. Reed R. C., "The Super-alloys: Fundamentals and Applications", Cambridge University Press.
4. Birks, N., Meier, G. H., and Pettit, F. S., "Introduction to the High Temperature Oxidation of Metals", Cambridge University Press.
5. Bose, S., "High Temperature Coatings", Butterworth-Heinemann.
6. Hertzberg R. W, 'Deformation and Fracture Mechanics of Engineering Materials', 4th Edition, John Wiley, 1996.
7. Courtney T.H, "Mechanical Behavior of Materials", McGraw-Hill, USA, 1990.
8. Raj, R., "Flow and Fracture at Elevated Temperatures", American Society For Metals, USA, 1985

AM***** Carbon Nanotube and Carbon Nanostructures

Designation	:	Elective
Pre-requisites	:	None
Credit and Contact hrs	:	3(L) - 0(T) - 0(P) – 3(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment: (Scheme)** 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise Tests, Term paper etc)
Course Outcomes	:	**The successful student will learn:** 1. To identify significance of carbon nanomaterials and nanostructures. 2. To understand and interpret structure property relationship of carbon nanomaterials and nanostructures. 3. To demonstrate uses of nanomaterials.
Modes of Delivery	:	Talk and chalk, Power point presentations, and practical etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	√						√			
CO2	√	√	√			√			√	
CO3			√	√		√	√	√		

Syllabus

Contact hrs		
Assessment Methods	:	**Theory Examination:** (Scheme) End Semester Exam: 60 marks. Mid Semester Exam: 20 marks. **Internal Assessment:** (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise Tests, Term paper, etc.)
Course Outcomes	:	The course would be a basic course in plasma physics with focus on techniques of plasma production and measurements, waves and instabilities, single particle motion in electric and magnetic fields, plasma confinement, and applications to medium and short wave communication, plasma processing of materials, laser driven fusion and magnetic fusion.
Modes of Delivery	:	Talk and chalk, Power point presentations, practical, etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1										
CO2										
CO3										
CO4										

Syllabus

Basics of plasmas: Plasma as a state of matter, Debye length, plasma frequency, collisions, dc conductivity, ac conductivity.

Plasma production and measurements: dc discharge, rf discharge, photo-ionization, tunnel ionization, avalanche breakdown, laser produced plasmas, Langmuir probe.

Waves and instabilities: Electromagnetic waves, Langmuir wave, ion acoustic wave, surface plasma wave, ionosphere propagation, two stream instability, Weibel instability.

Plasma confinement : Single particle motion in a magnetic field, motion in magnetic and electric fields, motion in inhomogeneous and curved magnetic fields, magnetic moment invariance, mirror confinement, tokamak confinement.

Applications: Medium and short wave communication, plasma processing of materials, laser ablation, laser driven fusion, magnetic fusion.

References books

1. Introduction to plasma physics and controlled fusion, F.F. Chen, Plenum Press (1084).
2. Interaction of electromagnetic waves with electron beams and plasmas, C.S. Liu and V.K. Tripathi, World Scientific (1994).
3. Principles of Plasma Physics, N.A. Krall and A.W. Trivelpiece, Mc Graw Hill (1973).

AM*** High Temperature materials**

Designation	:	Elective
Pre-requisites	:	Structure of Materials
Credit and Contact hrs	:	3(L) - 0(T) – 0(P) – 3(Cr)
Assessment Methods	:	**Theory Examination:** (Scheme) End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment:** (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise Tests, Term paper etc)
Course Outcomes	:	**After the completion of this course, students will be able to** 1. Understand the microstructure of structural materials and high temperature strengthening process. 2. Explain the creep, fracture, fatigue, and oxidation and corrosion mechanism at elevated temperatures. 3. Impart knowledge on production coating for materials at high temperature.
Modes of Delivery	:	Talk and chalk, Power point presentations, and practical etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	√	√					√		√	√
CO2		√	√	√	√			√	√	√

process. Electric arc furnace steel making for high alloy steels.
De-oxidation, degasification and decarburization-different techniques of vacuum degassing, AOD, VOD, CLU and MRP processes.

References books
1. Physical Chemistry of Iron and Steel Manufacture, Author- C. Bodsworth
2. Making ,Shaping and Treating of Steel.
3. Ferrous Process Metallurgy, Author- J.L. Bray
4. An Introduction to Physical Chemistry of Iron and Steel Making, Author- R.G.Ward
5. The Physical Chemistry of Liquid Steel in Electric Furnace Steelmaking, Author- J.F Elliot
6. Iron Making And Steel Making- Theory and Practice, Author – A. Ghosh and A. Chattrjee..

AM***** Alternate Route to Steel Manufacturing

Designation	:	Elective
Pre-requisites	:	Structure of Materials
Credit and Contact hrs	:	3(L) - 0(T) – 0(P) – 3(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks. Mid Semester Exam: 20 marks.
		Internal Assessment: (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise Tests, Term paper, etc.)
Course Outcomes	:	**The successful student will learn:** This course is intended to elucidate the alternative routes of iron and steel making.
Modes of Delivery	:	Talk and chalk, Power point presentations, practical, etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	√		√			√			√	
CO2	√	√	√					√		
CO3			√			√		√		√
CO4			√							√

Syllabus
Introduction: Need for the development of alternative routes, approaches towards new techniques. Classification of processes.
Principles: Thermodynamic and kinetic aspects of iron ore reduction in solid and liquid state using solid/gaseous reductants.
Methods : Sponge iron production using shaft, kiln, retort and rotary hearth reactors. Raw materials preparation. Selection of reductants. Heat and mass transfer. Energy consumption and operating problems. Storage, transportation and utilization of sponge iron in India.
Pre-Reduced Pellets and Powders: Pre-reduced iron ore pellets for blast furnace applications, concept of composite pellets and its feasibility. Iron powder and iron carbide preparation from fluidised bed reactor and other processes. Operating/storage problems.
Smelting-Reduction Processes: Principles, classification, merits and limitations. 69 COREX process and electric smelting processes.
Steel Making: Continuous and direct steel making.

References books
1. L.Von Bogdandy and H.J. Engell: Reduction of Iron Ores, Springer.
2. R.R. Rogers (ed.): Proc. of Symp. Iron Ore Reduction, Pergamon.
3. A Chatterjee: Sponge iron production by direct reduction of iron oxide,PHI,New Delhi,2010
4. A Chatterjee: hot metal production by smelting reduction of iron oxide, PHI,New Delhi,2010
5. RH Tupkary : Modern iron making, Khanna publishers, New delhi
6. Proc. of Int. Conf. on Alternative Routes to Iron & Steel under Indian Conditions, IIM Jamshedpur 1988.
7. A. Chatterjee, R. Singh and B. Pandey: Metallics for Steel making Production and Use, Allied Publisher

AM***** Plasma Technology

Designation	:	Elective
Pre-requisites	:	Physics
Credit and	:	3(L) - 0(T) – 0(P) 3(Cr)

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	√		√			√			√	
CO2	√	√	√					√		
CO3			√			√		√		√
CO4			√							√

Syllabus

General Introduction: Concepts of Electronic Ceramics, Scope of ceramics, Brief information about applications, and Advanced ceramics.

Ferro and Piezo Electric Ceramics: Ferro-electricity, Piezo-electricity, Symmetry and other criteria of ferro-electricity, ferroelectric transitions in $BaTiO_3$, $PbTiO_3$ and other related, Effect of compositional modifications and grain size, PZT, PZT film, etc.

Conducting Ceramics: Introduction, Broad band and narrow band conduction, Mott's transition. Effect of partial pressure of oxygen and doping in oxide conductors, Grain boundary effects on electrical conduction, Grain Boundary Barrier, Layer capacitors, and Ceramic superconductors.

Ceramic Magnets: Ferrites - Ni-Zn ferrites, Mn-Zn ferrites, Garnets and Hexagonal Ferrites, Processing of ferrites, Effect of composition on processing, microstructure, and properties, and Applications of magnetic ceramics.

Varisters and their Applications: Varistor Characteristics, ZnO Varistor materials systems and their processing, microstructure and applications, and Varistor models.

Thick film and Multilayer Ceramics: Formulation of conductive, resistive and dielectric inks, Screen printing and firing of hybride devices, Fabricatious of multilayer devices and their applications.

Ceramics for Green Energy: Solid oxide fuel cells (SOFC) Cells, Solid electrolytesbased on stabilized zirconia, Co-doped ceria, Cathode, Anode and Interconnect materials, and Batteries and solar cells.

Sensors and Actuators: Types of sensors and actuators, Thermal NTC and PTC sensors, Electrochemical sensors, Gas and humidity sensors, Piezoelectric and electro-optic sensors and actuators, Thermoelectric effect in ceramic systems, Magnetoresistance, and Colossal Magnetoresistance (CMR).

Ceramics Environmental Impact: Life cycle assessment of electro-ceramics, and Case studies.

References books

1. Ceramic Materials for Electronic Application, edited by R. C. Buchanon, CRC Press.
2. Electronic Ceramics, edited by B. C. H. Steele, Kluwer Academics Group.
3. Introduction to ceramics, W. D. Kingery, Harvey Kent Bowen, Donald Robert Uhlmann.
4. Ceramic Materials Processes, Properties and Applications, edited by Philippe Boch Jean-Claude Niepce, ISTE.
5. Modern Magnetic materials: Principles and Applications, R. C. O'Handiy, John Willy & Sons, Inc.

AM*** Physical Chemistry of Steels**

Designation	:	Elective
Pre-requisites	:	Chemistry
Credit and Contact hrs	:	3(L) - 0(T) - 0(P) – 3(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks. Mid Semester Exam: 20 marks.
		Internal Assessment: (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise Tests, Term paper, etc.)
Course Outcomes	:	**The successful student will learn:**
Modes of Delivery	:	Talk and chalk, Power point presentations, practical, etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	√		√			√			√	
CO2	√	√	√					√		
CO3			√			√		√		√
CO4			√							√

Syllabus

Physico-chemical principles of steel making; slag metal equilibrium involved in steel making.

Ionic slag theory as applied to slag-metal reaction in hearth steel making; role of slag --metal and gas metal reaction in pneumatic steel melting processes.

Genesis of modern combine blowing technique of steel production. Refining mechanism in oxygen steel making

Contact hrs		
Assessment Methods	:	**Theory Examination:** (Scheme) End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment:** (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise Tests, Term paper etc)
Course Outcomes	:	**After the completion of this course, students will be able to** 1. Understand the multi-domain mechanism in smart materials. 2. Impart knowledge on various smart materials and their use as sensors and actuators in various configurations. 3. Knowledge of smart systems with application examples.
Modes of Delivery	:	Talk and chalk, Power point presentations, and practical etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	√	√					√		√	√
CO2		√	√	√	√			√	√	√
CO3			√		√	√		√	√	

Syllabus

Introduction to Smart Material Systems; Overview of smart materials, Modeling mechanical, thermal and electrical systems (thermo mechanics and electrostatics);Piezoelectric materials: constitutive modelling, piezoelectric beam static and vibration analysis Shape memory alloys (SMA): constitutive modelling, actuation models for SMA, electrical actuation Brief overview of Electroactive Polymers, Magnetostrictive materials, Electro and Magneto Rheological Fluids Mechanics of smart composite structures Transducer applications: Vibration control and damping using piezoelectric materials. Case study: Sensing and control of Smart beams and plates.

References books

1. Ferroelectric devices- Kenji Uchino, Marcell Decker Inc., 2000.
2. Adaptronics and Smart Structures- Basics, Design and Applications- Janocha Harmut (Ed.), Springer-Verlag Berlin Heidelberg, 1999.
3. Smart Materials and Structures- M.V. Gandhi, B.S. Thompson, Chapman and Hall, London1992.
4. Electromechanical Sensors and Actuators, Ilene J. Busch-Vishniac, Springer-Verlag NY, 1999.
5. Fundamentals of Piezoelectricity- Takuro Ikeda, Oxford University Press, 1990.
6. Piezoelectric Senorics, G. Gautschi, Springer-Verlag Berlin Heidelberg, 2002.
7. Actuators: Basics and Applications Harmut Janocha (Ed), Springer-Verlog Berlin Heidelberg, 2004.
8. Smart materials, structures and mathematical issues, Rogers A Craig, Technomic Publishing Company, Inc, 1991.
9. Smart Material Systems: Model Developments, Ralph C. Smith, Cambridge University Press, Series: Frontiers in Applied Mathematics (No. 32), 2005.
10. Smart Material Structures: modeling, estimation and control, H.T. Banks, R.C. Smith and Y. Wang, John Wiley & Sons Inc. NY, 1996.

AM***** Electronic Ceramics

Designation	:	Elective
Pre-requisites	:	Ceramic Materials, Structure of Materials, Phase Diagrams, etc.
Credit and Contact hrs	:	3(L) - 0(T) - 0(P) – 3(Cr)
Assessment Methods	:	**Theory Examination:** (Scheme) End Semester Exam: 60 marks. Mid Semester Exam: 20 marks. **Internal Assessment:** (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise Tests, Term paper, etc.)
Course Outcomes	:	**The successful student will learn:** 1. To know and identify Electronic Ceramics. 2. To understand piezoelectricity and piezoelectric ceramics. 3. To develop knowledge and understanding of Sensors and Actuators. 4. To apply concepts of Electro-ceramics for products.
Modes of Delivery	:	Talk and chalk, Power point presentations, practical, etc.

Mapping of course outcomes with program outcomes

9.	Nuclear Engineering Materials, V.Gerasimov & A. Monakhov, Mir Publishers, Moskow, 1983.

AM***** Smart Materials and Systems

Designation	:	Elective
Pre-requisites	:	Structure of materials
Credit and Contact hrs	:	3(L) - 0(T) - 0(P) – 3(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment: (Scheme)** 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise Tests, Term paper etc)
Course Outcomes	:	**After the completion of this course, students will be able to** . 1. Understand the multi-domain mechanism in smart materials. 2. Impart knowledge on various smart materials and their use as sensors and actuators in various configurations. 3. Knowledge of smart systems with application examples.
Modes of Delivery	:	Talk and chalk, Power point presentations, and practical etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	√	√					√		√	√
CO2		√	√	√	√			√	√	√
CO3			√		√	√		√	√	

Syllabus

Introduction: Definition and characteristics of smart materials.

Smart Materials and Properties: Piezoelectric, electrostrictive, magnetostrictive, pyroelectric, electrooptic, Piezomagnetism, Pyromagnetism, Piezoresitivity, Thermoelectricity, shape memory alloy, Superelastic, Viscoelastic, Elastorestrictive, electrorheological and magnetorheological fluids, Thermochromic materials. Phenomenology and constitutive relations.

Material design and Engineering: Crystal structure, phase diagram and effect of various parameters.

Smart composites: Introduction, working, application.

Material Synthesis: Solid state reaction, sol-gel process.

Measurement of properties: Testing and characterization of materials.

Applications: Design and fabrication of devices and structures and their integration with system: Biomorphs/Moonies, Chip capacitor, Memory devices (FRAM), Sensor, actuator and transducers, Accelerometer, Gyroscopes, Ultrasonic Motor, Liquid Crystal display, Photonics, Structural Health Monitoring.

References books

1. Ferroelectric devices- Kenji Uchino, Marcell Decker Inc., 2000.
2. Adaptronics and Smart Structures- Basics, Design and Applications- Janocha Harmut (Ed.), Springer-Verlag Berlin Heidelberg, 1999.
3. Smart Materials and Structures- M.V. Gandhi, B.S. Thompson, Chapman and Hall, London1992.
4. Electromechanical Sensors and Actuators, Ilene J. Busch-Vishniac, Springer-Verlag NY, 1999.
5. Fundamentals of Piezoelectricity- Takuro Ikeda, Oxford University Press, 1990.
6. Piezoelectric Sensorics, G. Gautschi, Springer-Verlag Berlin Heidelberg, 2002.
7. Actuators: Basics and Applications H.armut Janocha (Ed), Springer-Verlag Berlin Heidelberg, 2004.
8. Smart materials, structures and mathematical issues, Rogers A. Craig, Technomic Publishing Company, Inc, 1991.
9. Smart Material Systems: Model Developments, Ralph C. Smith, Cambridge University Press, Series: Frontiers in Applied Mathematics (No. 32), 2005.
10. Smart Material Structures: modeling, estimation and control, H.T. Banks, R.C. Smith and Y. Wang, John Wiley & Sons Inc. NY, 1996.

AM***** Smart Materials and Structure

Designation	:	Elective
Pre-requisites	:	Structure of materials
Credit and	:	3(L) – 0(T) – 0(P) – 3(Cr)

References books

1. Acoustics, L. L. Beranek, Acoustical Society of America.
2. Introduction to Electro acoustics and Amplifier Design, W. M. Leach, Kendall Hunt Publishing Company.
3. Acoustics-An Introduction, H. Kuttruff, Taylor & Francis.
4. Fundamentals of Acoustics, Kinsler, Frey, Coppens, and Sanders. John Wiley and Sons.
5. Audio Engineer's Reference Book, Edited by Michael Talbot-Smith, Focal Press.

AM***** Energy Materials

Designation	:	Elective
Pre-requisites	:	Structure of materials
Credit and Contact hrs	:	3(L) - 0(T) – 0(P) 3(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment: (Scheme)** 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise Tests, Term paper etc)
Course Outcomes	:	**After completion of the course, students will be able to:** 1. Understand the process of energy storage and conversion. 2. Understand the need of sustainable energy and materials. 3. Impart knowledge on materials used in nuclear, fuel cell, solar cells.
Modes of Delivery	:	Talk and chalk, Power point presentations, and practical etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	√			√	√		√			
CO2						√		√		
CO3										

Syllabus

Nuclear Materials: Structures and properties of materials for nuclear power generation: uranium and other actinides, beryllium, zirconium, rare-earth elements, graphite. Materials of nuclear fuels and nuclear fuel element fabrication. Reprocessing of nuclear fuel elements.

Nuclear Power Plant Materials: Nuclear reactor, pressurised reactor, breeder reactor. Materials for fuel, control rods, coolant, moderator, shielding.

Effects of Radiation on Materials Properties: Effects of α,β, γ rays on creep, fatigue, tensile, and other properties of metals, alloys, ceramics, polymers, rubbers etc. Effects on electrical, electronic and magnetic behaviour of materials, Effects on crystal structure, grain size etc.

Materials in Fuel cells and Solar Cells: Electrocatalyst materials for low temperature fuel cells, Conductive membranes for low-temperature fuel cells, Materials for high temperature fuel cells, silicon, quantum dots for solar energy, nanomaterials for solar thermal energy and photovoltaic.

Materials in Thermal Power Generation: Superalloys, steels, ceramics, TBC, hydrogen membrane materials, sensor and sensor materials, biomass, coal, flyash, etc.

Materials in Hydro Power Generation: Materials for power plant components, steel, stainless steel, ceramics, etc.

Energy storage: Artificial photosynthesis/solar to fuels, CO_2 separation and utilization, Safer nuclear waste disposal, biofuels production, biological fuel cell technologies, reduction of energy use in manufacturing processes, Improved grid technologies, sustainable energy economic.

References books

1. Introduction to Nuclear Science, Bryan, J. C., CRC Press.
2. Fundamentals of Radiation Materials Science, G.S. Was, Springer
3. Nuclear Reactor Materials and Applications, B.M. Ma, Van Nostrand Reinhold Company.
4. Nuclear Reactor Materials, C.O. Smith, Addison-Wesley Publishing Company.
5. Fundamentals Aspects of Nuclear Fuel Elements, D.R. Olander,
6. Structural Materials in Nuclear Power Systems, J. T. A. Roberts, Plenum Press.
7. Handbook of Fuel Cells, Wolf Vielstich, Arnold Lamm, Hubert A. Gasteiger, and Harumi Yokokawa, John Wiley and Sons, Inc.
8. Advanced power plant materials, design and technology, Edited by D Roddy, Woodhead Publishing Series in Energy No. 5 and CRC Press.

engineering, tissue scaffolds, optical biosensors, etc.
Fabrication of MEMS: Bulk micromachining, surface micromachining, lithography, LIGA, SLIGA, etc.
MEMS Packaging: MEMS metrology, Overview of packaging of microelectronics, packaging design, technique, material, etc.
MEMS Design and Software: Design methodologies for MEMS, study of following softwares based on availability: Ansys multiphysics, COMSOL multiphysics, MatLab, Intellisuite, AutoCAD, SolidWorks, Spice, Ledit etc.
Term Paper: On recent advances based on literature survey and/or lab/industry visit

References books

1. Foundations of MEMS, Chang Liu, Pearson Education International.
2. MEMS and MICROSYSTEM Design and Manufacture, Tai-Ran Hsu, Tata Mcgraw-Hill Publishing Company Ltd., New Delhi.
3. Microsystem Design, S. D. Senturia, Kluwer Academic Publishers.
4. Fundamentals of Microfabrication, Marc Madou, CRC Press, NY.
5. Microsystem Technology in Chemistry and Life Sciences, A. Manz and H. Becker, Eds.Springer-Verlag, New York.
6. Fundamentals of Micro Fabrication, the Science of Miniaturization, M. Madou, Nanogen Corporation, USA, CRC Press.

AM***** Electroacoustic Transducers

Designation	:	Elective
Pre-requisites	:	None
Credit and Contact hrs	:	3(L) - 0(T) - 0(P) – 3(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment: (Scheme)** 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise Tests, Term paper etc)
Course Outcomes	:	**The successful student will learn:** 1. Can identify the significance of acoustics in human life. 2. Can apply electro-mechano-acoustical analogy (equivalent circuit method) for electroacoustic transducer. 3. Can design and simulate microphone and loudspeaker.
Modes of Delivery	:	Talk and chalk, Power point presentations, and practical etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1			√				√			
CO2		√		√				√	√	
CO3				√			√	√		

Syllabus

Introduction to Acoustics: Acoustic variables & basic relations, plane & spherical waves, reflection & transmission, radiation & reception of acoustic waves, absorption and attenuation of sound.
Electro-Mechano-Acoustical Analogy: Introduction, basic equations and impedances, transformer and gyrator, simple harmonic oscillator, Helmholtz resonator, loop analysis, circuit elements, Lagrange equation.
Acoustical Elements: Basic acoustic elements, specific acoustic impedance, mechanical impedance, electrical impedance, acoustic radiation impedance, duct impedance, equivalent circuit model, various acoustical examples, frequency and wavelength, dB scale, sound pressure level.
Basic Theory and Modeling of Microphone: Introduction, types, response, sensitivity, specifications, directivity pattern, microphone array, microphone equation, electret condenser microphone (ECM), ECM model for various types of microphone.
Basic Theory and Modeling of Moving Coil Transducer: Introduction, types, reciprocal and anti-reciprocal system, TS parameters, speaker non-linearities, equivalent circuit representation, loudspeaker enclosure, types of loudspeaker enclosure and corresponding circuits, total harmonic distortion, intermodulation distortion, miniature loudspeaker.
Theory and Analysis of Piezoelectric Transducer: Brief introduction to piezoelectricity, piezoelectric materials, piezoelectric devices, polarization, equivalent circuit, piezoelectric accelerometer, piezoelectric speaker, piezoelectric microphone.
Term Paper: On recent advances based on literature survey and/or lab/industry visit

CO2		√	√	√	√			√	√	√
CO3			√		√	√		√	√	

Syllabus

Classes of biomaterials, Bulk Properties of Materials, Surface properties and surface characterization of materials, Biocompatibility, Bio-functionality, Mechanical and Biological Testing of Biomaterials.

Metallic Implant Materials: Stainless steels, Co-based alloys, Ti and Ti-based alloys and Other metals. Corrosion of metallic implants.

Ceramic Implant Materials: Aluminum oxides, Calcium Phosphate, Glass Ceramics and Carbons. Medical applications of Ceramic Materials.

Polymeric implant: Polymerization, Polymeric implant materials, Degradable Polymers used for Biomedical Applications. Silicones, Hydrogels, Smart Polymers as biomaterials, Polymers used for drug delivery and Tissue Engineering Applications. Natural polymers found in human body, Composites as Biomaterials.

Applications: Cardiovascular, Orthopedic, Ophthalmological, soft and hard tissue.

Text books and References

1. Buddy D. Ratner, Allan S. Hoffman, Frederick J. Schoen, Jack E. Lemons Biomaterials Science, Second Edition: Wiley Science.
2. Jef A., Helsen H., Jürgen Breme, Metals as Biomaterials Wiley.
3. Kinam Park and Randall J. Mrsny Controlled Drug Delivery Designing Technology for the future American chemical society Publication.
4. Park J.B. & Lakes R.S, Biomaterials: An Introduction, Plenum Press, New York.
5. Silver F.H, Biomaterials, Medical Devices &Tissue Engineering: An Integrated approach, Chapman & Hall.

AM***** MEMS & Bio-MEMS

Designation	:	Elective
Pre-requisites	:	None
Credit and Contact hrs	:	3(L) - 0(T) – 0(P) – 3(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment: (Scheme)** 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise Tests, Term paper etc)
Course Outcomes	:	The successful student will learn: 1. To identify potential MEMS products and compare it with conventional products. 2. To demonstrate and explain MEMS micro-manufacturing. 3. To design and simulate MEMS product based on conventional FEM software.
Modes of Delivery	:	Talk and chalk, Power point presentations, and practical etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1		√			√		√			
CO2		√	√		√	√				
CO3				√		√	√	√		

Syllabus

Introduction: MEMS, microsystem, sensor, actuator, history, market, applications etc.

Review of Essential Mechanical, Electrical Concepts: Mechanical: stress, strain, beam, cantilever, plates, bending, thermal stress, torsion of beam, fracture, vibration etc, Electrical: Conductor, insulator, semiconductor.

Scaling Laws in Miniaturization: Scaling in geometry, force, electricity, fluid, heat transfer, etc.

Material for MEMS: Review of crystal structure, miller indices, material for MEMS, substrate, device, packaging, silicon, silicon compound, gallium arsenide, piezoelectric martial, quartz, polymer, biomaterials and biocompatibility issues etc.

Micro Total Analysis System (µTAS): Fluid control components, µ-TAS: sample handling, µ-TAS: separation components, µ-TAS: detection, cell handling and characterization systems, systems for biotechnology and PCR, polynucleotide arrays and genetic screening.

Sensing and Actuation: Electrostatic sensing and actuation, thermal sensing and actuation, piezoelectric and piezoresistive sensing and actuation, magnetic sensing and actuation, miniature biosensors, biosensors arrays and implantable devices, neural interfaces, microsurgical tools, micro needles, and drug delivery, Microsystems for tissue

Outcomes		To know the principle methods, areas of usage, possibilities and limitations as well as environmental effects of the Additive Manufacturing technologies. CO1 Describe the need and applications of additive manufacturing CO2 Prepare CAD model, model slicing, tool path using different software CO3 Classify and evaluate the relative merits and demerits of liquid and solid based additive manufacturing system CO4 Understand the laser based additive manufacturing techniques CO5 Fabricate the 3D printed bio products
Modes of Delivery	:	Talk and chalk, Power point presentations, and practical etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	√	√					√		√	√
CO2		√	√	√	√			√	√	√
CO3			√		√	√		√	√	

Syllabus

Overview – History – Need-Classification -Additive Manufacturing Technology in product development-Materials for Additive Manufacturing Technology – Tooling – Applications.

Reverse Engineering: Basic Concept – Digitization techniques – Model Reconstruction – Data Processing for Additive Manufacturing Technology: CAD model preparation – Part Orientation and support generation – Model Slicing –Tool path Generation – Softwares for Additive Manufacturing Technology: MIMICS, MAGICS.

Classification – Liquid based system – Stereo lithography Apparatus (SLA)- Principle, process, advantages and applications - Solid based system -Fused Deposition Modeling - Principle, process, advantages and applications, Laminated Object Manufacturing

Selective Laser Sintering – Principles of SLS process - Process, advantages and applications, Three Dimensional Printing - Principle, process, advantages and applications- Laser Engineered Net Shaping (LENS), Electron Beam Melting.

Customized implants and prosthesis: Design and production. Bio-Additive Manufacturing- Computer Aided Tissue Engineering (CATE) – Case studies

References books

1. Brent Stucker,DavidRosen, and Ian Gibso, Additive Manufacturing Technologies, Springer, 2010
2. Chua C.K., Leong K.F., and Lim C.S., Rapid prototyping: Principles and applications, Third Edition, World Scientific Publishers, 2010
3. Gebhardt A., Rapid prototyping, Hanser Gardener Publications, 2003.
4. Kamrani A.K. and Nasr E.A., Rapid Prototyping: Theory and practice, Springer, 2006.

AM*** Biomaterials**

Designation	:	Elective	
Pre-requisites	:	Structure of Materials	
Credit and Contact hours	:	3(L) - 0(T) – 2(P) – 4(Cr)	
Assessment Methods	:	**Theory Examination:** (Scheme)	End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment: (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission Surprise Tests, Quizzes, Assignments and Tutorials, etc.).	
Course Outcomes	:	**After completion of the course, students will be able to:** 1. Understand the need of Biomaterials and Biocompatibility. 2. Impart knowledge on different classes of biomaterials, characterization and biological testing. 3. Choose a material for implant applications.	
Modes of Delivery	:	Talk and chalk, Power point presentations, and practical etc.	

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	√	√					√		√	√

Outcomes		1. Understand the electrical, electronic, magnetic and dielectric properties of materials. 2. Explain the mechanism of conduction, superconduction, polarization, magnetization, photoconductivity in materials. 3. Choose an appropriate material for specific electrical and electronic devices.
Modes of Delivery	:	Talk and chalk, Power point presentations, and practical etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	√	√					√		√	√
CO2		√	√	√	√			√	√	√
CO3			√		√	√		√	√	

Syllabus

Introduction: Classification of materials on the basis of energy gap, conductors, semiconductors, dielectrics.

Electrical Properties and Conducting Materials: Mechanism of electrical conduction, electron theories of solids, free electron theory, factors affecting electrical conductivity, Wiedemann-franz law, Lorentz number, thermoelectric properties, high voltage conducting materials, high and low resistance materials, fuse materials, conductors, cables, wire materials, solder, sheathing, and sealing materials.

Electronic Properties and Semiconducting Materials: Energy band theory, Brillouin zone theory, Fermi energy level, effective mass, concept of doping, types of semiconductors, semiconductor compounds and alloys, structures of semiconductors, amorphous semiconductor, materials for different devices. Methods of crystal growth, zone refining.

Dielectric Properties and Insulating Materials: Dielectric constant, dielectric strength and dielectric loss, mechanism of polarization, factors affecting polarization, polarization curve and hysteresis loop, Clausius -Mosotti equation, types of dielectric materials-solid, liquid and gaseous types; ferroelectrics, piezoelectric, pyroelectrics, electrostriction effect.

Magnetic Properties and Magnetic Materials: Origin of magnetism, types of magnetic materials-dia, para, ferro, antiferro and ferrimagnetic materials. Curie temperature, laws of magnetic materials, domain theory, domain growth and domain wall rotation, magnetic anisotropy, magnetostriction, ferrites, spinels & garnets, ferromagnetic domains, magnetic hystersis. magnetoplumbite, hard and soft magnetic materials, magnetic tape, magnetic bubble, magnetic glasses, commercial magnetic materials.

Superconductivity and Superconducting Materials: Concept and properties of superconductors, Meissner effect, critical magnetic field & critical temperature, Type I & II superconductors, Silsbee rule, BCS theory, Debye temperature. London's & Glag theories, superconductors materials, NMR, maglev, MHD.

References books

1. Electrical Properties of Materials, L. Solymar, D. Walsh, Oxford University Press, USA.
2. Introduction to the Electronic Properties of Materials, David C. Jiles, Taylor and Francis.
3. Introduction to Magnetism and Magnetic Materials, D.C. Jiles, Springer.
4. Structure and Properties of Materials Volume IV, Rose R. M., Shepard L. A., Wulff J, John Wiley & Sons.
5. Advanced Electrical and Electronics Materials, K.M. Gupta and Nishu Gupta, Wiley.
6. Introduction to Magnetic Materials, B. D. Cullity, Addison-Wesley Publishing Company, California, London, 1972.
7. Magnetism and Magnetic Materials, J. P. Jakubovics, Institute of Materials, London, 1994.
8. Physics of Dielectric Materials, Tareev B.,MIR, 1975.
9. Electronic Properties of Materials, Rolf E. Hummel, Springer, 2004.
10. Principles of Electronic Materials and Devices, Safa O. Kasap, McGraw-Hill, 2005.
11. Electronic Materials Science, Irene, Wiley-Interscience, 2006.
12. Smart Electronic Materials: Fundamentals and Applications, Jasprit Singh, Cambridge University Press, 2005.
13. Solid State Physics, Dekker A. J. Macmillan India, 1995.
14. Modern Magnetic Materials: Principles and Applications, Robert C., O' Handley, Wiley-Interscience. 1999.

AM***** Additive Manufacturing		
Designation	:	Elective
Pre-requisites	:	Nil
Credit and Contact hrs	:	3(L) - 0(T) – 2(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment: (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise Tests, Term paper etc)
Course	:	**After the completion of this course, students will be able to**

Radiography, Computed Radiography, Computed Tomography.

References books

1. Baldev Raj, T.Jayakumar, M.Thavasimuthu, 'Practical Non-Destructive Testing', Narosa Publishing House, 2009.
2. Ravi Prakash, 'Non-Destructive Testing Techniques', 1st revised edition, New Age International Publishers, 2010.
3. ASM Metals Handbook, Non-Destructive Evaluation and Quality Control, American Society of Metals, Metals Park, Ohio, USA, 200, Volume-17.
4. Paul E Mix, 'Introduction to Non-destructive testing: a training guide', Wiley, 2nd Edition New Jersey, 2005.
5. Charles, J. Hellier, 'Handbook of Nondestructive evaluation', McGraw Hill, New York 2001.
6. ASNT, American Society for Non Destructive Testing, Columbus, Ohio, 'NDT Handbook Vol. 1, Leak Testing, Vol. 2, Liquid Penetrant Testing, Vol. 3, Infrared and Thermal Testing Vol. 4, Radiographic Testing, Vol. 5, Electromagnetic Testing, Vol. 6, Acoustic Emission Testing, Vol. 7, Ultrasonic Testing'.

AM***** Materials Selection and Design

Designation	:	Elective
Pre-requisites	:	Structure of Materials
Credit and Contact hrs	:	3(L) - 0(T) - 2(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment: (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise Tests, Term paper etc)
Course Outcomes	:	**After the completion of this course, students will be able to** to familiarize with alloy design principles, methodology of materials selection and design for different applications
Modes of Delivery	:	Talk and chalk, Power point presentations, and practical etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	√	√					√		√	√
CO2		√	√	√	√			√	√	√
CO3			√		√	√		√	√	

Syllabus

Alloy Design: Brief history. Factors affecting alloy design. Methodology for alloy design for strength, toughness, and improved resistance to fatigue, creep, environment assisted fracture, corrosion, oxidation, wear and friction.

Materials Selection: Methodology of materials selection. Identification of required properties and materials index parameters based on elastic, yield, fracture, fatigue and creep limited design. Selection of materials based on available property data and optimisation to select the best material.

Illustrative Case Studies of Components and Materials: Pressure vessels, turbine blades, boiler tubes, oil/gas pipe lines, bearings, gears, springs and prosthetic materials.

References books

1. M.F. Ashby and R.H. Jones: Engineering Materials, Vol. 1&2, Pergamon.
2. J.K. Tien and G.S. Ansell (eds.): Alloy and Microstructural Design, Academic Press.
3. S. Ranganathan, V.S. Arunachalam and R.W. Cahn: Alloy Design, Indian Academy of Sciences.
4. F.B. Pickering: Physical Metallurgy and Design of Steels, Applied Sciences.
5. Materials Selection and Design, ASM Handbook, Vol. 20.

AM***** Electrical, Electronic and Magnetic Materials

Designation	:	Elective
Pre-requisites	:	Structure of Materials
Credit and Contact hrs	:	3(L) - 0(T) – 2(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment: (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise Tests, Term paper etc)
Course	:	**After the completion of this course, students will be able to**

Syllabus

Introduction: Microstructure and properties, plasticity, work hardening, softening mechanism, deformation mechanism and phase transformation.

Forming Techniques: Rolling, Extrusion, Wire drawing, Forging, Pilgering, Sheet metal forming, Hydroforming, Superplastic forming.

Other Processes: Casting Process and Techniques, Rolling, Extrusion and Drawing process.

Joining Process: Fusion, Welding, Solid State Welding, Brazing, Soldering, Adhesive-Bonding, Mechanical fastening.

Defects in Thermo-mechanical processing: Form defects, surface defects, fracture related defects, strain Localizations and surface defects.

Physical simulation of properties: Tensile and compression testing, hot torsion tests, mixed strain path tests, typical formability tests.

Case studies: Thermo-mechanical process of Aluminium Alloy, Steel and Titanium forging. Fabrications of microchannels and micro-devices.

References books

1. G. Dieter, Mechanical Metallurgy, McGraw-Hill, 1976.
2. B. Verlinden, J. Driver, I. Samajdar, R.D. Doherty, Thermo-Mechanical Processing of Metallic Materials, Pergamon Materials Series, Ed. R.W. Cahn, Elsevier, Amsterdam, 2007.
3. Metals Handbook 302226 Forming and Forging, Vol. 14, Ninth Edition, (1988), ASM, Ohio, USA.S. Kalpakjian, Manufacturing engineering and technology, Addison-Wesley, 1995.

AM***** Non-Destructive Testing

Designation	:	Elective
Pre-requisites	:	Physics
Credit and Contact hrs	:	3(L) - 0(T) - 2(P) - 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment: (Scheme)** 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise Tests, Term paper etc).
Course Outcomes	:	**After the completion of this course, students will be able to** 1. Understand the basic principles and limitations of Non-Destructive Testing 2. Demonstrate various methods of Non-Destructive Testing. 3. Choose right technique for evaluating structural components.
Modes of Delivery	:	Talk and chalk, Power point presentations, and practical etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	√	√					√		√	√
CO2		√	√	√	√			√	√	√
CO3			√		√	√		√	√	

Syllabus

Overview of NDT: Non-Destructive Testing Methods for the detection of manufacturing defects as well as material characterization, merits and limitations, Various physical characteristics of materials and their applications in NDT, Visual inspection Unaided and aided.

Surface NDE methods: Liquid Penetrant Testing, Magnetic Particle Testing -- Principles, Types and properties of Inspection materials, Testing Procedure, Interpretation of results, Advantages and limitations.

Thermography and eddy current testing (ET): Thermography- Principles, Contact and non-contact inspection methods, Techniques for applying liquid crystals, Advantages and limitation. Eddy Current Testing- generation of eddy currents, properties of eddy currents, eddy current sensing elements, probes, instrumentation, types of arrangement, applications, advantages, limitations, interpretation/evaluation.

Ultrasonic testing (UT) and acoustic emission (AE): Ultrasonic Testing-Principle, Transducers, Transmission and pulse-echo method, Straight beam and angle beam, Instrumentation, Data representation, A/Scan, B-scan, C-scan. Phased Array Ultrasound, Time of Flight Diffraction. Acoustic Emission Technique, AE parameters, Applications

Radiography (RT): Principle, interaction of X-Ray with matter, Imaging, film and film less techniques, Types and use of filters and screens, Geometric factors, Inverse square law, Characteristics of films – graininess, density, speed, contrast, characteristic curves, Penetrameters, Exposure charts, Radiographic equivalence. Fluoroscopy- Xero-

ANNEXURE–III

डॉ० रमेश पाण्डेय
विभागाध्यक्ष

प्रयुक्त यांत्रिकी विभाग
मोतीलाल नेहरू राष्ट्रीय प्रौद्योगिकी संस्थान इलाहाबाद
प्रयागराज–211004 (उ0प्र0), भारत
Department of Applied Mechanics
Motilal Nehru National Institute of Technology Allahabad
Prayagraj-211004 (U.P.) India

02/07/2021

पत्रांक सं0 636/प्र0यां0वि0/संचिका सं0 190/2021–22 दिनांक: 01 जुलाई, 2021

श्रीमान अध्यक्ष,
विद्या परिषद परास्नातक समिति (एस0एम0पी0सी0)

विषय: विभाग में मौजूदा चारो परास्नातक कार्यक्रम के संशोधित पाठ्यक्रम के संदर्भ में।

महोदय,

आपको यह अवगत कराना है कि दिनांक 01 जुलाई 2021 को विभागीय परास्नातक कार्यक्रम समिति की एक संगोष्ठी अपराह्न 1:15 बजे आनलाइन एम0एस0 टीम प्लेटफार्म पर आहूत की गयी। जिसमें विभागीय अकादमिक बोर्ड से अनुमोदित मौजूदा चारो परास्नातक कार्यक्रमो के संशोधित पाठ्यक्रमो के बारे में विचार विमर्श किया गया। इस संगोष्ठी का कार्यवृत्त तथा मौजूदा चारो परास्नातक कार्यक्रमो के संशोधित पाठ्यक्रम इस पत्र के साथ संलग्नित करके आपके अवलोकनार्थ एवम् अनुमोदनार्थ हेतु आपको प्रेषित है।

रमेश पाण्डेय
01/07/2021
(रमेश पाण्डेय)
विभागाध्यक्ष

संलग्नक:
1. विभागीय परास्नातक कार्यक्रम समिति संगोष्ठी की सूचना।
2. दिनांक 06 मार्च 2021 को संपन्न विभागीय अकादमिक बोर्ड संगोष्ठी का अनुमोदित कार्यवृत्त।
3. विभागीय परास्नातक कार्यक्रम समिति का कार्यवृत्त।
4. आपके द्वारा अनुमोदित विभागीय परास्नातक कार्यक्रम समिति की छायाप्रति।
5. विभागीय परास्नातक कार्यक्रम समिति संगोष्ठी के दौरान उपस्थित संकाय सदस्यों की उपस्थिती।

Put up in the SMPC Meeting
05.07.2021

MNNIT WEBMAIL

Head Applied Mechanics Department <hamd@mnnit.ac.in>

Fwd: Gentle Memory Recall: DUGC and DMPC meetings_ scheduled on July 01, 2021at 12.45 pm and 01.15 pm

1 message

Head AMD <hamd@mnnit.ac.in>
To: amdf <amdf@mnnit.ac.in>

Thu, Jul 1, 2021 at 12:09 AM

---------- Forwarded message ---------
From: Head AMD <hamd@mnnit.ac.in>
Date: Mon, Jun 28, 2021, 2:51 PM
Subject: DUGC and DMPC meetings_ scheduled on July 01, 2021at 12.45 pm and 01.15 pm
To: amdf <amdf@mnnit.ac.in>

Dear Colleagues,

As per suggestion of Chairman Board of Academics (BoAc) and Dean (Academic), a DUGC meeting is called on July 01, 2021 at 12.45 pm to discuss about the two new proposed UG programmes based on NEP-2020, followed by a DMPC meeting on the same day at 01.15 pm to discuss about the revision of course curriculum of running four PG programmes of the department in accordance with resolutions made in Board of Academics (BoAc) meeting held in March 2021. All the Programme coordinators are requested to incorporate the resolutions in the course content of the programmes and complete all other requirements as per NEP-2020 and send me the final Doc as well as PDF files latest by June 30, 2021.

Thanks and Regards

Minutes of BoA meeting of Board of Academics held on March 06, 2021

A meeting of Board of Academics (BoAc) was convened on March 06, 2021 at 10.00 a.m. through MS Teams online platform by the Head, Applied Mechanics Department in the Chairmanship of Prof. R. K. Singh, Dean (Academic Affairs). All the members of BoAc attended the meeting along with other faculty members of the department as special invitee. The agenda items of the meeting were as follows:

1. Revision and Approval of two UG Programme based on NEP-2020;

i) B.Tech. in Materials Science and Engineering.

ii) B.Tech. in Engineering and Computational Mechanics.

2. Revision of Course curriculum of running four PG Programmes of the department.

Programme of B.Tech. in Materials Science and Engineering was presented by Dr. Abhishek Kumar and B.Tech. in Engineering and Computational Mechanics was presented by Dr. Ashutosh Kumar Upadhyay. Revision of course curriculum of PG programmes were presented by Programme Coordinators Dr. V. Murari (M.Tech.- Engineering Mechanics and Design), Dr. A. R. Paul (M.Tech.- Fluids Engineering), Prof. S. J. Pawar (M.Tech.- Material Science and Engineering) & Prof. R. P. Tewari (M.Tech.- Biomedical Engineering) respectively. Minutes of proposed UG programmes were compiled and presented by Dr. R. Sujithra, Convener DUGC and minutes of revision of course curriculum of running PG programmes were compiled and presented by Dr. Ashutosh Mishra, Convener DMPC immediately after the commencements of respective programme presentations to incorporate each and every remark of distinguished expert members in totality in the same spirit in which it was expressed. Swapping of courses from one semester to another, proposing some more vibrant and demand driven courses as electives, changes in course contents, change in name of the Programmes etc. were suggested by the distinguished expert members. All the programmes updated after incorporating the expert suggestions have been attached herewith for your kind perusal and further necessary direction. Resolutions needs to be taken into account in due course of time are as follows:

(i) Industrial exposure needs to be enhanced as compared to allocated only in 6th semester at present. Industrial exposure/summer training may be incorporated after IVth semester also.

(ii) Lab component needs to be enhanced to meet the mandate of NEP-2020 which will enhance the skill development and hands on experience of the students.

(iii) Elective courses on Patent, IPR, Entrepreneurship needs to be included at the Institute level.

(iv) MOU can be signed between the Department of Applied Mechanics at IIT Madras, Chennai and MNNIT Allahabad, Prayagraj to promote final year UG and PG students for attending courses and research activities. Furthermore, the students may be extended facility of direct admission in Ph. D programme without separate entrance examinations.

(v) Courses needs to be designed and placed based on the current employability scenario and industrial needs of the country.

(vi) NITs and IITs have to plan on the proposal for the change in GATE syllabus to account for the new introduced interdisciplinary courses.

(vii) Institute needs to think on promoting the students for higher studies in Institute itself based on their CGPA.

As per the suggestions B.Tech Materials Science & Engg name changed to B.Tech Materials Engineering.

(viii) Students needs to be exposed to Biomechanics open software like Open-Sim to understand various protocols.

R K Singh	C. Lakshmana Rao	Sunil Mohan	S. Vengadesan	Neelesh Kumar
Chairman	Ext. Member	Ext. Member	Ext. Member	Ext. Member
Anil Jain	B. P. Tewari	S. J. Pawar	Abhishek Kumar	Vivek Kumar Patel
Member	Member	Member	Member	Member

Ramesh Pandey
Convener & Head

Through mail

Head Applied Mechanics Department <[illegible]>

Gentle Memory Recall: Minutes of the Board of Academics (BoAc) meeting _ March 06, 2021

6 messages

Head AMD <[illegible]> Fri, Mar 26, 2021 at 6:05 AM

To: Lakshmana Rao C <[illegible]>, Dr S Mohan <[illegible]>, [illegible], Venugopal S <[illegible]>, NEELESH KUMAR <[illegible]>, [illegible]

---------- Forwarded message ---------
From: Head AMD <[illegible]>
Date: Sun 21 Mar, 2021, 10:29 PM
Subject: Minutes of the Board of Academics (BoAc) meeting _ March 06, 2021
To: Dean Academic default <[illegible]>, Dean Academic default <[illegible]>, Venugopal S <[illegible]>, Dr S Mohan <[illegible]>, Lakshmana Rao C <[illegible]>, [illegible], Anuj Jain Asst. Prof. AMD FACULTY <[illegible]>, NEELESH KUMAR <[illegible]>, [illegible], Abhishek Kumar FACULTY <[illegible]>, R.P. Tewari <[illegible]>, S.S. Pawar FACULTY, [illegible] FACULTY <[illegible]>, [illegible] FACULTY <[illegible]>, Rajeev Tripathi FACULTY <[illegible]>

Respected Sir,

Wishing you a Happy Holi in advance and convey my heartiest greetings for the same.

I wish to convey my heartiest thanks for your kind participation and remarkable observations in introducing two new UG programmes and industry-oriented need-based revision of course curriculum of four running PG programmes of the department. Your valuable inputs have enriched the academic programmes of the department. I extend my warm welcome for strengthening the bond between us and our Institutions/Organizations in near future in the same spirit as was expressed by you all in meeting of Board of Academics (BoAc). Your valuable suggestions and observations immediately implementable have already been incorporated by the programme coordinators to the best possible. Your suggestions and observations requiring involvement of other academic/constitutional bodies of the Institute are presented in the form of "*Minutes of the BoAc meeting held on March 06, 2021*" and may be implemented sooner or later. Kindly find attached herewith modified and updated programmes of the department with detailed course curriculum for your kind perusal and suggestions (if any).

You are kindly requested to convey your consent for "Minutes of the BoAc meeting agreed in principle", with or without your valuable observations through your reply mail at your earliest possible.

Waiting and Anticipating for your green signal and remarks (if any).

Please feel free to enquire your query, if any.

Thanks and Extreme Regards

रमेश पाण्डेय || Ramesh Pandey
विभागाध्यक्ष || Head
प्रयुक्त यांत्रिकी विभाग || Department of Applied Mechanics
मोतीलाल नेहरू राष्ट्रीय प्रौद्योगिकी संस्थान इलाहाबाद
Motilal Nehru National Institute of Technology Allahabad

प्रयागराज-२११००४, (उत्तर प्रदेश), भारत || Prayagraj - 211004 (Uttar Pradesh), INDIA
दूरभाष नंबर: [illegible] || Phone No. 0532-2271100
इलेक्ट्रॉनिक पता: [illegible] || Email ID: [illegible]

7 attachments

- Course Curriculum_B.Tech.(Honours)_ECM.pdf
  125K
- Course Curriculum_B.Tech._Materials Engineering.pdf
  1450K
- Updated Curriculum_EMD.pdf
  [illegible]K
- Updated Curriculum_FE.pdf
  [illegible]K
- Updated Curriculum_MSD.pdf
  1507K
- Updated Curriculum_BME.pdf
  1264K
- Minutes of the BoAc meeting_March 06, 2021.pdf
  [illegible]K

Dr S Mohan <[illegible]> Fri, Mar 26, 2021 at 8:04 AM
To: Head AMD <[illegible]>

Agreed

NEELESH KUMAR <[illegible]> Fri, Mar 26, 2021 at 9:24 AM
To: [illegible]

Dear Sir

Congratulations on conducting a detailed BoAc meeting and thank you for sharing the minutes of the meeting.
I confirm my consent to the attached minutes of the BoAc meeting.
I have also seen the updated course curriculum for M.Tech Biomedical Engineering. The highlighted modifications are accepted to me.

With Best Regards
Neelesh

Lakshmana Rao C [illegible] Sun, Mar 26, 201[illegible]
To: Head MKD [illegible]

Dear Prof. Ramesh Pandey,
Greetings.
I have gone through the minutes of the meeting. I am happy to note that almost all the points that were discussed in the meeting are reflected in the minutes.

I give my full consent to the minutes of the meeting as stated.

Wishing you all a Happy HOLI,
With best regards,
Lakshmana Rao

Minutes of the DMPC Meeting held on July 01, 2021 at 12.45 pm through MS Team online platform

A DMPC meeting was called on July 01, 2021 at 01.15 pm through MS Team on-line platform to freeze the revision of course curriculum of four running PG programmes of the department. All the DMPC faculty members attended the meeting.

Head apprised the members about revision of four running PG programmes of the department, "M.Tech.- Engineering Mechanics and Design, M.Tech.- Fluids Engineering, M.Tech.- Material Science and Engineering & M.Tech.- Biomedical Engineering, respectively which are brought in the DMPC meeting after incorporating the valuable suggestions of Board of Academics (BoAc) meeting of the department (Approved Minutes of BoAc attached herewith for ready reference) held on March 06, 2021 through MS Teams on-line platform. DMPC members appreciated the efforts of Programme Coordinators, Dr. V. Murari, Dr. A. R. Paul, Prof. S. J. Pawar and Prof. R. P. Tewari, respectively and contributions of all other faculty members of the department in this hectic and marvelous work. DMPC members found the documents in order and recommended for further processing with their well wishes for its earliest implementation at Institute.

01/07/2021

Ashutosh Mishra
(Convener, DMPC)

F- प्रेषित / Concern

डॉ० रमेश पाण्डेय
विभागाध्यक्ष

प्रयुक्त यांत्रिकी विभाग
मोतीलाल नेहरू राष्ट्रीय प्रौद्योगिकी संस्थान इलाहाबाद
प्रयागराज–211004 (उ०प्र०), भारत
Department of Applied Mechanics
Motilal Nehru National Institute of Technology Allahabad
Prayagraj-211004 (U.P.) India

पत्रांक सं० /प्रया०वि०/संचिका सं० 190/2020–21 दिनांक: 02 सितम्बर, 2020

प्र०यां०वि०/AMD
डायरी नं०/Diary No. 157
दिनांक/Date: 16-9-20
समय/Time: 12:10

श्रीमान् अध्यक्ष
विद्या–परिषद परास्नातक कार्यक्रम समिति (एस०एम०पी०सी०)

महोदय, विभाग की संशोधित परास्नातक कार्यक्रम समिति के सदस्यों की सूची आपके अवलोकनार्थ, रिकार्ड एवम् अनुमोदनार्थ नीचे वर्णित है:

विभागीय परास्नातक कार्यक्रम समिति (Departmental Master Programme Committee)

- विभागाध्यक्ष — पदेन सदस्य
- डॉ० आशुतोष मिश्रा — समन्वयक
- डॉ० आर० सुजीथ्रा — सदस्य एवम् समन्वयक (विभागीय स्नातक समिति)
- डॉ० नरेश कुमार — वाह्य सदस्य (भौतिकी विभाग)
- प्रो० रवि प्रकाश तिवारी — सदस्य
- प्रो० एस० जे० पवार — सदस्य
- डॉ० आशुतोष कुमार उपाध्याय — सदस्य
- डॉ० सतीश कुमार — सदस्य
- डॉ० तन्मय मंडल — सदस्य
- सुश्री ऋषिका तिवारी (2019FE10) — छात्र प्रतिनिधि प्रथम (फ्लूड इंजीनियरिंग)
- श्री चन्द्र प्रकाश पाण्डेय (2019BM01) — छात्र प्रतिनिधि द्वितीय (बायोमेडिकल इंजीनियरिंग)

अनुमोदित
विनोद कुमार
तिवारी
4.09.2020

Chairman (SMPC)

Please find herewith the revised list of the members of the Departmental Master Programme Committee for your kind information, record and necessary approval please,

Departmental Master Programme Committee (DMPC)

Head	Ex. Officio (Chairman)
Dr. Ashutosh Mishra	Convener
Dr. R. Sujithra	Member & Convener (DUGC)
Dr. Naresh Kumar	External Member (Physics Department)
Prof. Ravi Prakash Tewari	Member
Prof. S. J. Pawar	Member
Dr. Ashutosh Kumar Upadhyay	Member
Dr. Satish Kumar	Member
Dr. Tanmoy Mondal	Member
Mrs. Rishika Tiwari (2019FE10)	Students Representative I (Fluid Engineering)
Mr. Chandra Prakash Pandey (2019BM01)	Students Representative II (Biomedical Engineering)

Approved

रमेश पाण्डेय
03/09/2020

(रमेश पाण्डेय / Ramesh Pandey)
विभागाध्यक्ष / Head

Full Name	User Action	Timestamp
Ramesh Pandey	Joined	7/1/2021, 1:10:22 PM
Abhishek Kumar	Joined	7/1/2021, 1:10:26 PM
Ashutosh Mishra	Joined	7/1/2021, 1:15:01 PM
R. Sujithra	Joined	7/1/2021, 1:15:29 PM
S.J.Pawar	Joined	7/1/2021, 1:16:08 PM
Satish Kumar	Joined	7/1/2021, 1:16:55 PM
Tanmoy Mondal	Joined	7/1/2021, 1:17:07 PM
R.P. Tiwari	Joined	7/1/2021, 1:17:26 PM
R.P. Tiwari	Left	7/1/2021, 1:18:27 PM
R.P. Tiwari	Joined	7/1/2021, 1:18:40 PM
Ashutosh Kumar Up	Joined	7/1/2021, 12:51:47 PM
R.P. Tiwari	Left	7/1/2021, 1:19:41 PM
R.P. Tiwari	Joined	7/1/2021, 1:21:06 PM
NareshKumar	Joined	7/1/2021, 1:20:13 PM
NareshKumar	Left	7/1/2021, 1:20:47 PM
NareshKumar	Joined	7/1/2021, 1:20:58 PM

AMxxxxx Corrosion Science and Engineering

Designation	:	Elective
Pre-requisites	:	Chemistry and Fundamental Material Science.
Credit and Contact hours	:	L+T+P=4
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks. Mid Semester Exam: 20 marks. **Internal Assessment: (Scheme)** 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise tests, Term paper, etc.)
Course Outcomes	:	**The successful student will learn:** 1. Can identify potential of corrosion and its effects. 2. Can understand the causes of and the mechanisms of various types of corrosion. 3. Can able to demonstrate economics associated with corrosion. 4. Can able to design and quantify protection against corrosion.
Modes of Delivery	:	Talk and chalk, Power point presentations, Practical, etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	√					√	√			√
CO2		√							√	
CO3						√				√
CO4						√		√		√

Syllabus

Basics of Corrosion: Introduction, Classification, Economics, EMF series, Galvanic series, Corrosion theories, Derivation of potential – current relationships of activation controlled and diffusion controlled corrosion processes, Potential – pH diagrams, Fe-H_2O system, Application and limitations.

Type of Corrosion: Broad forms of corrosion – uniform, uneven, pitting, cracking, etc. Various types of corrosion along with case studies - Galvanic, Thermogalvanic, High temperature corrosion, Intergranular, Pitting, Selective attack (leaching), Fretting corrosion – erosion, Cavitation, Stress corrosion cracking, Hydrogen embrittlement, etc.

Atmospheric Corrosion and Protective Coatings: Atmospheric corrosion, Factors influencing atmospheric corrosion, Temporary corrosion preventive methods - organic coating, surface preparation, natural, synthetic resin, paint formulation and applications, Paint testing and evaluation, Selection of material, Fabrication process for corrosion control, Role of residual stress, Changes in operating conditions

Immersion Corrosion and Electrochemical Protection: Corrosion in immersed condition - Effect of dissolved gases, salts, pH, temperature and flow rates on corrosion; marine corrosion, Underground corrosion - Corrosion process in the soil, factors influencing soil corrosion, Biological corrosion - Definition, mechanism of biological corrosion control of bio corrosion, Electrochemical methods of protection - Theory of cathodic protection, design of cathodic protection, sacrificial anodes, impressed current anodes, Anodic protection, Corrosion inhibitors for acidic, neutral and alkaline media.

Advances in Corrosion: Corrosion resistant coatings, Alloying for corrosion resistance, Case studies, etc.

References books

1. Fundamentals of Electrochemical Corrosion, E. E. Stansbury and R. A. Buchanan, ASM International.
2. Corrosion Engineering, M. G. Fontana and N. D. Greene, McGraw-Hill.
3. Corrosion and Corrosion Control: An Introduction to corrosion Science and Engineering, R. W. Revie and H. H. Uhlig, John Wiley & Sons.
4. Corrosion - For Students of Science and Engineers, R. Trethewey and J. Chaberlain, Longman Sc & Tech.
5. Principles and Prevention of Corrosion, D. A. Jones, Longman Scientific & Technical, John Wiley, Macmillan Pub Co.

AMxxxxx Ceramic Technology		
Designation	:	Elective
Pre-requisites	:	Basic Material Science and Engineering.
Credit and Contact hours	:	L+T+P=4
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks. Mid Semester Exam: 20 marks.
		Internal Assessment: (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise tests, Term paper, etc.)
Course Outcomes	:	**The successful student will learn:** 1. To identify ceramics and their application. 2. To narrate properties of ceramics, and fabrication and processing of ceramics. 3. To explain ceramic phase diagrams.
Modes of Delivery	:	Talk and chalk, Power point presentations, Practical, etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	√	√		√	√		√			
CO2		√	√				√		√	
CO3			√			√			√	

Syllabus

Introduction: Introduction, History, Types and nature, Conventional ceramics, Applications, Bonding, Crystallography, etc.

Structure of Ceramics: Lattice points, Directions and planes, Basic structures, Silicates, Silica, Glass, Ceramic oxides, Perovskite structure, etc.

Defects in Ceramics: Point defects, Linear defects, Planar (surface) defects, Interfaces, and Non-equilibrium structure.

Properties of Ceramics: Mechanical properties, Thermal properties, Electrical properties, Optical properties, Magnetic properties, Failure modes in ceramics, and Property structure relationship.

Ceramic Phase Diagrams and Phase Equilibrium: Law of partial pressures, Determination of phase diagrams, Uniary (carbon, SiO_2), Binary (NiO/CoO, MgO/CaO, $MgO/MgAl_2O_4/Al_2O_3$, BeO/Al_2O_3, MgO/TiO_2), Ternary ($MgO/Al_2O_3/SiO_2$, $CaO/Al_2O_3/SiO_2$, $Na_2O/CaO/SiO_2$), and Quaternary (SiO_2–Al_2O_3–AlN–Si_3N_4) systems.

Processing: Powder synthesis and sintering, Glass forming processes, Drawing, Hot and cold pressing, Fibre forming, Blowing, Powder crushing, Slip casting, Hydro plastic forming, Extrusion, Centring, Jiggering, Sol-gel processing, Anvil technologies, Ceramic coating, Fusion casting, Dyeing and firing, Gas phase, Liquid phase, Solid phase ceramic fabrication processes, CVD, Directed metal oxidation, Reaction bonding, Polymerisation, Metal casting, Ceramic-composite processing, etc.

Bioceramics: Introduction, History and uses, Biological properties, Processing of bioceramics, etc.

Ceramics Environmental Impact: Life cycle assessment of ceramics, Emissions and consumptions, and Case studies.

Advanced Ceramics and their Applications: Toughened ceramics, Cermets, Functionally graded materials, Piezoelectric ceramics, Ceramic magnets, High temperature super-conducting magnets, Glass ceramic composites, chemically bonded ceramics, Ceramics in electrical applications, Electro ceramics, etc.

Term Paper: On recent advances based on literature survey and/or laboratory/industry visit.

References books

1. Introduction to ceramics, W. D. Kingery, H. K. Bowen, and D. R. Uhlmann, Wiley Series on the Science and Technology of Materials.
2. Ceramic Materials: Science and Engineering, C. B. Carter and M. G. Norton, Springer.
3. Handbook of Advanced Ceramics Vol II, Processing and their Applications, S. Somiya, Elsevier Academic Press.
4. Mechanical Properties of Ceramics, J. B. Watchman, W. R. Cannon, and J. Matthewson, Wiley.
5. Series in Materials Science and Engineering - Fundamentals of Ceramics, M. W. Barsoum, Institute of Physics Series in Materials.
6. Phase Equilibria and Crystallography of Ceramic Oxides, W. Wong-Ng, R. S. Roth, T. A. Vanderah, and H. F. McMurdie, Volume 106, Number 6, Journal of Research of the National Institute of Standards and Technology.
7. Electronic Ceramics, IEEE transactions.
8. Ceramic Processing and Sintering, M. N. Rahman, Marcel Dekker, Inc./CRC Press.

AMxxxxx Non-Destructive Testing		
Designation	:	Elective
Pre-requisites	:	Physics.
Credit and Contact hours	:	L+T+P=4
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks. Mid Semester Exam: 20 marks. **Internal Assessment: (Scheme)** 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise tests, Term paper, etc.)
Course Outcomes	:	**The successful student will learn:** 1. To use various Non Destructive Evaluation and Testing methods, theory and their industrial applications. 2. To use testing methods for defects and characterization of industrial component
Modes of Delivery	:	Talk and chalk, Power point presentations, Practical, etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	√			√		√	√			
CO2			√	√	√		√			√

Syllabus

Overview of NDT: NDT versus Mechanical testing, Overview of the Non Destructive Testing Methods for the detection of manufacturing defects as well as material characterization, Relative merits and limitations, Various physical characteristics of materials and their applications in NDT, and Visual inspection Unaided and aided.

Surface NDE methods: Liquid Penetrant Testing - Principles, Types and properties of liquid penetrants, Developers, Advantages and limitations of various methods, Testing Procedure, Interpretation of results, Magnetic Particle Testing-Theory of magnetism, Inspection materials, Magnetisation methods, Interpretation and evaluation of test indications, Principles and methods of demagnetization, and Residual magnetism.

Thermography and eddy current testing (ET): Thermography- Principles, Contact and non-contact inspection methods, Techniques for applying liquid crystals, Advantages and limitation - infrared radiation and infrared detectors, Instrumentations and methods, Applications, Eddy Current Testing - generation of eddy currents, Properties of eddy currents, Eddy current sensing elements, Probes, Instrumentation, Types of arrangement, Applications, Advantages, Limitations, Interpretation/evaluation.

Ultrasonic testing (UT) and acoustic emission (AE): Ultrasonic Testing-Principle, Transducers, Transmission and pulse-echo method, Straight beam and angle beam, Instrumentation, Data representation, A/Scan, B-scan, C-scan, Phased Array Ultrasound, Time of Flight Diffraction, Acoustic Emission Technique, AE parameters, and Applications.

Radiography (RT): Principle, Interaction of X-Ray with matter, Imaging, film and film less techniques, Types and use of filters and screens, Geometric factors, Inverse square law, Characteristics of films - graininess, density, speed, contrast, characteristic curves, Penetrameters, Exposure charts, Radiographic equivalence, Fluoroscopy - Xero-Radiography, Computed Radiography, Computed Tomography.

Term Paper: On recent advances based on literature survey and/or laboratory/industry visit.

References books

1. Practical Non-Destructive Testing, B. Raj, T. Jayakumar, and M. Thavasimuthu, Narosa Publishing House.
2. Non-Destructive Testing Techniques, R. Prakash, New Age International Publishers.
3. ASM Metals Handbook, Non-Destructive Evaluation and Quality Control, American Society of Metals, Metals Park, Ohio, USA, 200, Volume-17.
4. Introduction to Non-destructive Testing: A Training Guide, P. E. Mix, Wiley, New Jersey.
5. Handbook of Nondestructive Evaluation, C. J. Hellier, McGraw-Hill, New York.
6. NDT Handbook, Columbus, Ohio, Vol. 1 - Leak Testing, Vol. 2 - Liquid Penetrant Testing, Vol. 3 - Infrared and Thermal Testing, Vol. 4 - Radiographic Testing, Vol. 5 - Electromagnetic Testing, Vol. 6 - Acoustic Emission Testing, Vol. 7 - Ultrasonic Testing, American Society for Non Destructive Testing (ASNT).

AMxxxxx Nanomaterials		
Designation	:	Elective
Pre-requisites	:	Chemistry and Fundamental Material Science.
Credit and Contact hours	:	L+T+P=4
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks. Mid Semester Exam: 20 marks. **Internal Assessment: (Scheme)** 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise tests, Term paper, etc.)
Course Outcomes	:	**The successful student will learn:** 1. To identify significance of nanomaterials. 2. To identify potential of nanomaterials properties and nanotechnology. 3. To understand and interpret TEM and SEM micrographs of nanomaterials and nanostructures. 4. To demonstrate uses of nanomaterials.
Modes of Delivery	:	Talk and chalk, Power point presentations, Practical, etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	√					√	√			√
CO2		√							√	
CO3			√			√				
CO4						√		√		√

Syllabus

Introduction to Nanotechnology: Nano technology, Nano science, MEMS, CNT, Fullerene, Nano machines, Semiconductor technology, etc.

Solid State Physics: Introduction, Structure (physics of solid state), FCC nanoparticle, Semiconductor structures, Lattice vibration, Energy band, Reciprocal space, Fermi surfaces, Localized particles, Mobility, Exciton, etc.

Methods of Measuring Properties: Measurement methods, structure – atomic, crystallography, particle size, mass spectroscopy, LEED, RHEED, surface structures, microscopy – TEM, SEM, FIM, AFM etc.

Properties of Nanoparticles: Properties of nano-particles, metal nano-clusters, semi conducting nano-particles, semi conducting nano-particles, rare gas & molecular clusters, methods of synthesis.

Carbon Nanostructures: Carbon nano-structures, Carbon molecule, Carbon clusters, C_{60}, $C_{20}H_{20}$, C_8H_8, CNT, and, Applications.

Bulk Nanostructured Materials: Solid disordered nanostructures - synthesis, failure, Mechanical properties, Multilayers, Electrical properties, Other properties, Composite glasses, Porous silicon, Nanostructured crystals - natural crystals, Array in zeolites, Metal nanoparticles, and Photonic crystals.

Nanostructured Ferromagnetism: Basic, para-, ferro-, ferri-, antiferro-magnetism, Effect of bulk nanostructuring on magnetic properties, Dynamics of nanomagnets, Nanopore containment, Nanocarbon ferromagnets, Giant and colossal magnetoresistance, and Ferrofluids.

Quantum Nanostructure, Self Assembly and Deposition: Quantum wells, Quantum wires, Quantum dots, Preparation, Size effect, Single electron tunneling, Monolayer, Multiplayer, LB film deposition, CVD, PVD, Sputtering etc.

Homework: Report on history & current status of Nanotechnology, Nanomanufacuring, Nanomachines, etc.

Project: Small research project summarized in a four-page write-up on the nano-fabrication, nanodevice (abstract style). One presentation based on the research work of any paper of your choice in the field of nanoscience and nanotechnology, visits to various labs.

Term Paper: On recent advances based on literature survey and/or laboratory/industry visit.

References books

1. Introduction to Nanotechnology, C. P. Poole Jr. and F. J. Owens, Wiley Inter Science.
2. Nano Structures and Nano Materials: Synthesis, Properties and Applications, G. Cao, Imperial College Press.
3. Nanomaterials, A. K. Bandyopadhyay, Newage International (p) Limited.
4. Nanostructured Materials Processing, Properties and Applications, edited by C. C Koch, William Andrew Inc.
5. Nanotechnology, W. I. Atkinson, Jaico Publishing House.

AMxxxxx Phase Equilibrium and Phase Diagrams		
Designation	:	Elective
Pre-requisites	:	Material Science.
Credit and Contact hours	:	L+T+P: 4
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks. Mid Semester Exam: 20 marks. **Internal Assessment: (Scheme)** 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise tests, Term paper, etc.)
Course Outcomes	:	**The successful student will learn:** 1. Can identify basics of phases, phase diagrams, and lever rule. 2. Can understand and concept of material development. 3. Can able to demonstrate phase equilibria in materials. 4. Can understand invariant reactions and phase diagrams.
Modes of Delivery	:	Talk and chalk, Power point presentations, Practical, etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1		√		√		√				√
CO2	√				√	√			√	√
CO3		√						√		
CO4			√						√	

Syllabus

Introduction and Review: Phase rule, Hume-Rothery rules, Lever rule, Free energy of phase mixture; Unary systems, Effect of pressure on phase diagrams.

Binary Phase Diagrams: Binary Isomorphous Systems, Free energy-composition diagrams, Equilibrium solidification, Non-equilibrium solidification of alloys, Coring, Examples from Cu-Ni alloys, Zone refining, Binary eutectic systems, Solidification of eutectic, hypo-eutectic, and hyper-eutectic alloys and their morphologies with examples from Al-Si, Fe-C, Ag-Cu, and Pb-Sn system, Binary peritectic System, evolution of these phase diagrams, Solidification of peritectic alloys, hypo and hyper-peritectic alloys, Concept of liquid phase immiscibility, Binary monotectic and syntectic systems, Evolution of monotectic and syntactic phase diagrams, Free – energy composition diagrams, Development of microstructures in systems Cu-Pb, Na-Zn, Effect of gravity on solidification of these alloys, Concept of solid state immiscibility and spinodal decompositions, Phase diagrams showing spinodal decomposition and microstructural evolution, Important systems with intermediate phases - Ni-Al, Ti-Al and Fe-Al systems.

Thermodynamics of Phase Equilibria: Regular and irregular solutions, Models for regular and irregular solutions, Quasichemical theory, Detailed descriptions, Stability of regular solution and miscibility gap, Application of Quasichemical to eutectic, peritectic and monotectic systems, Intrinsic stability of solution and spinodal.

Iron-carbon Phase Diagram: Iron-carbon phase diagram and microstructures of plain carbon steel and cast iron, Non-equilibrium structures.

Binary Ceramics Phase Equilibria: Some binary ceramics systems - SiO_2-Al_2O_3, NiO-MnO, etc and their microstructure.

Ternary Phase Diagrams: Gibbs triangle, Isothermal and vertical sections, Polythermal projections, Two-phase equilibrium, Concept of the lines, Rules for construction of tie lines, Three phase equilibrium, and Concept of tie-triangle.

Multi-component Alloy Systems: Stainless steels, High speed steels, Super alloys, Light metal alloys, Refractory systems (Al_2O_3 - SiO_2 - MgO), and Four phase equilibria.

References books

1. Phase Diagrams: Understanding the Basics, F. C. Campbell, ASM International.
2. Phase Transformations in Metals and Alloys (Revised Reprint), D. A. Porter, K. E. Easterling, and M. Y. A. Sherif, CRC Press.
3. Phase Diagrams, Materials Science and Technology. Vol. I: Theory, Principles, and Techniques of Phase Diagrams, Von A. M. Alper, Academic Press.
4. Principles of Phase Diagrams in Materials Systems, G. Paul, McGraw-Hill.
5. Ternary Phase Diagrams in Materials Science, D. R. F. West and N. Saunders, CRC Press.
6. Modern Physical Metallurgy and Materials Engineering Science, process, applications, R. E. Smallman and R. J. Bishop, Butterworth-Heinemann.

AMxxxxx Powder Technology

Designation	:	Elective
Pre-requisites	:	Material Science.
Credit and Contact hours	:	L+T+P=4
Assessment Methods	:	**Theory Examination:** (Scheme) End Semester Exam: 60 marks. Mid Semester Exam: 20 marks. **Internal Assessment:** (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise tests, Term paper, etc.)
Course Outcomes	:	**The successful student will learn:** 1. Can identify potential of nanomaterials properties and nanotechnology. 2. Can understand and interpret TEM and SEM micrographs of nanomaterials and nanostructures. 3. Can able to demonstrate uses of nanomaterials. 4. Can able to
Modes of Delivery	:	Talk and chalk, Power point presentations, Practical, etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	√		√			√				
CO2	√	√	√	√	√	√	√	√		
CO3		√					√	√	√	
CO4		√	√	√						

Syllabus

Introduction: Scope of powder metallurgy, Brief applications of powder metallurgy, Characterization of metal powders, Physical properties-particle size and shape determination, Technological properties, Apparent density, Tap density, Green density, Sintered density, Flow rate, etc.

Powder Manufacturing: Classification, Mechanical method (machine milling, ball milling, atomization, shotting, etc.), Physical method, Chemical method, Reduction, Electrolysis, Atomization processes. Powder conditioning, Compaction and consolidation, Die compaction, Other advanced consolidation techniques like hot pressing (HP), hot iso-static pressing (HIP), spark plasma sintering (SPS), etc.

Powder Sintering: Fundamental, Types of sintering (solid and liquid state), Sintering mechanisms, Sintering furnaces and sintering atmospheres, Sintering theory and the influence of different processing conditions, Wetting and surface diffusion, etc.

Characteristics and Testing of Metal Powders: Sampling, Chemical composition purity, Surface contamination, Particle size and its measurement, Principle and procedure of sieve analysis, Microscopic analysis, Adsorption methods and resistivity methods, Particle shape - classifications, microstructure, specific surface area, apparent and tap density, green density, green strength, sintered compact density, porosity, shrinkage, etc.

Powder Metallurgy Applications: Bearing, Filters, Friction parts, Hard metals, Refractory metals, Contact materials, Magnetic materials, Structural parts, and Dispersion strengthened materials.

References books

1. Powder Metallurgy Science, R. M. German, Metal Powder Industries Federation, Princeton.
2. Ceramic Processing and Sintering, M. N. Rahaman, Marcel Dekker.
3. ASM Handbook, Volume 7: Powder Metallurgy, edited by P. K. Samal and J. W. Newkirk, ASM International.
4. Powder Metallurgy Applications, Advantages and Limitations, E. Klar, ASM International, Metals Park.
5. Powder Metallurgy, R. L. Sands and C. R. Shakespeare, Newnes International Monographs on Material Science and Technology, Cambridge University Press.

AM21310 Applied Elasticity

Designation	:	Elective
Pre-requisites	:	Mechanics of Materials
Credit and Contact hours	:	4(L) - 0(T) - 0(P) - 4(Cr)
Assessment Methods	:	Theory Examination: (Scheme) End Semester Exam: 60 marks Mid Semester Exam: 20 marks Internal Assessment (Scheme):20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).
Modes of Delivery	:	Talk and chalk (main), Power point presentations (sometimes), Self-study (as assigned), Hands on training through Computer Programming.

Course Outcomes:

Sl. No.	On successful completion of the course, student is expected to be able to:	Mapping into POs
1.	Analyze the stress/strain behavior of materials and the stress-strain relations.	1, 4
2.	Analyze solid mechanics problems using classical and energy methods.	4, 7
3.	Apply different failure criteria for general state of stress states at points.	4, 7, 8
4.	Understand the time dependent behavior of materials.	4, 7

Topics to be Covered:

Units	Details
1.	**Analysis of Stress:** Concept of Stress, Stress Components, Equilibrium Equations, Stress on a General Plane (Direction Cosines, Axis Transformation, Stress on Oblique Plane through a point, Stress Transformation), Principal Stresses, Stress Invariants, Deviatoric Stresses, Octahedral Stresses, Plane Stress, Stress Boundary Condition Problem.
2.	**Analysis of Strain:** Deformations (Lagrangian Description, Eulerian Description), Concept of Strain, Strain Components (Geometrical Interpretation), Compatibility Equations, Strain transformation, Principal Strains, Strain Invariants, Deviatoric Strains, Octahedral Strains, Plane Strain, Strain Rates.
3.	**Stress-Strain Relations:** Introduction, One-Dimensional Stress-Strain Relations (Idealized Time independent and Time-dependent stress-strain laws), Linear Elasticity (Generalized Hooke's Law), Stress-Strain Relationships for Isotropic and Anisotropic Materials (Plane stress and Plane Strain)
4.	**Basic Equations of Elasticity for Solids:** Introduction, Stresses in Terms of displacements, Equilibrium Equations in terms of displacements, Compatibility equations in Terms of Stresses, Special cases of Elasticity equations (Plane Stress, Plane strain, Polar Co-ordinates), Principle of Superposition, Uniqueness of Solution, Principle of virtual work, Potential and Complementary energy, Variational Principles, St. Venant's Principle, Methods of analysis for Elastic Solutions, Elastic solutions by Displacement and stress Functions, Airy's Stress Function (Plane stress, Plane strain, Polar Co-ordinates).
5.	**Torsion:** Introduction, Circular shaft, Torsion of non-circular cross-section, St. Venant's theory, Warping function, Prandtl's stress function, Shafts of other cross-sections, Torsion of bars with thin walled sections.
6.	**Viscoelasticity:** Introduction, Viscoelastic models (Maxwell, Kelvin-Voigt, Generalized Maxwell and Kelvin models), Viscoelastic stress-strain relationships.

Text books, References:

1. Mathematical Theory of Elasticity: I. S. Sokolnikoff
2. Advanced Mechanics of Materials: Boresi
3. Theoretical Elasticity: A. E. Green and W. Zerna
4. Theory of Elasticity: Timoshenko and Gere
5. Advanced Strength and Applied Elasticity: A. C. Ugural and S. K. Fenster
6. Applied Elasticity: R.T.Fenner
7. Advanced Strength of Materials: L. S. Srinath

AM21311 Finite Element Methods				
Designation	:	Elective		
Pre-requisites	:	Linear Algebra with Matrix Operations, Differential Equations, Mechanics of Materials, Theory of Elasticity.		
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)		
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks		
		Internal Assessment (Scheme):20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).		
Course Outcomes	:	**Sl. No.**	**On successful completion of the course, student is expected to be able to:**	**Mapping into POs**
		1.	Identify the primary and derived dependent variables involved, kinematic and natural constrains to be imposed and other required detail for a general initial-boundary value problem, primarily related to solid mechanics.	4, 8, 9
		2.	Formulate, through use of energy principles and Variational methods, relevant finite element equations, implement the same into computer program and solve a solid mechanics problem, using the Finite Element Method.	4
		3.	Analyze, interpret and communicate results obtained from developed computer program as well as from commercial finite element Software.	4, 5
		4.	Be prepared for extending the complete knowledge of solving a solid mechanics problem using FEM, to a more general type of initial-boundary value problem related to other areas of engineering / science.	3, 4, 7, 8
		5.	Pursue higher / self-study and research, involving Finite Element Analysis in the domain of solid mechanics, in general.	9, 10
Modes of Delivery	:	Talk and chalk (main), Power point presentations (sometimes), Self-study (as assigned), Hands on training through Computer Programming.		
Topics to be Covered	:	**Units**	**Details**	
		1.	**Introduction:** Course objectives, History of FEM, Application Areas, Concept of Discretization and Interpolation, Different Steps in Finite Element Analysis, Demonstration through FE Analysis of Axially Loaded Bar.	
		2.	**Variational Methods & Energy Principles:** Brief Introduction to Variational Calculus, Energy Principles – Principle of Virtual Work and Complementary Virtual Work, Principle of Minimum Potential Energy and Complementary Potential Energy, Mixed Principles.	
		3.	**Detailed FE Formulation for Solid Mechanics:** Finite element discretization – Piecewise Interpolation & Shape Functions, C0 and C1 Interpolation, Conventional 1D, 2D & 3D Elements, Special Elements, Sub Parametric, Super Parametric & Isoparametric elements. FE Formulation Using Variational Methods & Energy Principles. Coordinate transformation & Jacobian, Numerical Integration & Calculation of Element Matrices.	
		4.	**Classical Finite Element Methods:** Ritz Method, Method of Weighted Residuals, Galerkin method, Strong & Weak formulation. One & Two dimensional structural & non-structural boundary value problems involving scalar and vector valued dependent variables.	
		5.	**Dynamic Problems and Other Topics (in brief):** Dynamic Equations from Hamilton's Principle, Mass (Consistent & Diagonal) and Damping Matrices, Free Vibration Analysis – Eigen value problem, Time-History analysis in Forced Vibration – Direct (Explicit & Implicit) Integration Methods. Nonlinear & Stability problems, Error & Error estimation, Conforming & Non-conforming Elements, Patch test.	
		6.	**Application through Computer Programming:** ➢ Input for Geometric & Material Configuration, Loading and Boundary	

			Conditions. ➢ Automatic Mesh Generation, Nodal Coordinate and Nodal Connectivity. ➢ Calculation of Element Matrices (Stiffness & Mass Matrices, Load Vector). ➢ Assembly of Element Matrices to Global Matrices, Imposing Boundary Conditions. ➢ Solution (Gauss Elimination & other methods), Post Processing.
Text books, References	:	1. Energy and Finite Element Methods in Structural Mechanics: I. H. Shames and C. L. Dym. 2. Concepts and Applications of Finite Element Analysis: R. D. Cook, D. S. Malkus and M. E. Plesha. 3. The Finite Element Method Vol. I-II: O.C. Zienkiwicz and R.L. Taylor. 4. Finite Element Procedures: K. J. Bathe. 5. An Introduction to Finite Element Methods: J.N. Reddy. 6. Finite Element Methods in Engineering: S.S. Rao.	

AM21102 Continuum Mechanics		
Designation	:	Compulsory
Pre-requisites	:	*Basic Engineering Mathematics, Linear Algebra*
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment (Scheme)**:20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).
Course Outcomes	:	see table below
Modes of Delivery	:	Talk and chalk (main), Power point presentations (sometimes), Self-study (as assigned), Hands on training through Computer Programming.
Topics to be Covered	:	see table below
Text books, References	:	1. Introduction to the Mechanics of a Continuous Medium: Lawrence E. Malvern. 2. An Introduction to Continuum Mechanics: Morton M. Gurtin. 3. Introduction to Continuum Mechanics for Engineers: Ray M. Bowen. 4. Continuum mechanics for engineers: G. Thomas Mase and George E. Mase. 5. Theory and Problems of Continuum Mechanics: George E. Mase.

Course Outcomes

Sl. No.	On successful completion of the course, student is expected to be able to:	Mapping into POs
1.	To read and comprehend journals and texts written in tensorial notations by applying the knowledge of tensors.	1, 8
2.	To describe the motion and deformation of body.	1, 4
3.	To apply the suitable stress and strain measures depending on the need.	1, 5
4.	To formulate the constitutive equations obeying the general principles of mechanics and thermodynamics.	1, 3, 7

Topics to be Covered

Units	Details
1.	**Mathematical Preliminaries and Introduction:** Index notation, range and summation convention, free and dummy indices, Kronecker delta, Levi-Civita symbol, co-ordinate transformations, Cartesian tensor, properties of tensors, tensors as linear operators, invariants of tensor, eigen values and Eigen vectors, polar decomposition, scalar, vector and tensor functions, comma notation, gradient of a scalar, gradient of a vector, divergence and curl of a tensor, integral theorems of vectors and tensors. Notion of a continuum, configuration, mass and density, descriptions of motion, material and spatial coordinates.
2.	**Kinematics of Deformation and Motion:** Deformation gradient tensor, stretch and rotation, right and left Cauchy-Green deformation tensors, Eulerian and Lagrangian strain tensors, strain-displacement relations, infinitesimal strain tensor, infinitesimal stretch and rotation, compatibility conditions, principal strains and strain deviator, material and local time derivatives, stretching and vorticity, path lines, stream lines, vortex lines, Reynolds transport theorem, circulation and vorticity.
3.	**Forces and Stresses:** Body and surface forces, Cauchy Stress Tensor, First and Second Piola-Kirchhoff Stress Tensor, Deviatoric and Pressure Components, Principal Stress.
4.	**Fundamental Balance Laws of Continuum Mechanics:** Balance of Mass – Continuity Equation; Balance of Linear Momentum – Equations of Motion / Equilibrium Equations; Moments of Momentum (Angular Momentum); Balance of Energy - First Law of Thermodynamics, Energy Equation; Equations of State – Entropy, Second Law of Thermodynamics; Clausius-Duhem Inequality, Dissipation Functions
5.	**Constitutive Relations and Material Models:** Constitutive Assumptions; Ideal Fluids; Elastic Fluids, Hyperelastic Material; Notion of isotropy; Isothermal Elasticity - Thermodynamic Restrictions, Material Frame Indifference, Material Symmetry; Hooke's law, Stokes problem and Newtonian fluids.

		6. Nonlinear Continuum Mechanics for Finite Element Analysis: J. Bonet and R. D. Wood. 7. Continuum mechanics and plasticity: Han Chin Wu.

AM24312 Optimization Techniques

Designation	:	Elective
Pre-requisites	:	*Differential Calculus & Computer Programming*
Credit and Contact hours	:	4(L) - 0(T) - 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment (Scheme)**:20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).

Course Outcomes:

Sl. No.	On successful completion of the course, student is expected to be able to:	Mapping into POs
1.	Development of the skill of finding optimum value of desired variable in a real life engineering problem.	9, 10
2.	Development of knowledge of expressing a real life problem in terms of mathematics i.e to develop the skill of Mathematical Modeling.	8, 4
3.	To Identify and develop the skill to solve real life engineering problems e.g. Linear & Non-linear Programming, Gradient Methods & Artificial Neural Networks.	5, 10
4.	To develop skill of writing Flow Charts of real life engineering problems and transform those into computer programming.	9, 10

Modes of Delivery: Talk and chalk (main), Power point presentations (sometimes), Self-study (as assigned), Hands on training through Computer Programming.

Topics to be Covered:

Units	Details
1.	**Introduction to Optimization:** Design variables, Design constraints, Objective function Design space, Feasible region, Problem statement, Local and Global optima, Classification of optimization problems, Solution by calculus and numerical methods.
2.	**Linear Programming:** Simplex method, Geometric Programming: Application to simple problems.
3.	**Non-Linear Programming:** Method of approximation programming, Kelly's Cutting Plane method.
4.	**Gradient Methods:** Steepest descent and Side step method, Conjugate Gradient method, Rosin's Gradient Projection Method, Zotendik's method of feasible directions, Unconstrained minimization, and penalty function technique search procedures.
5.	**Genetic Algorithm:** Artificial Neural Network, Dynamic programming
6.	**Application to problems of Process Equipment, Development of computer programmes.**

Text books, References:

1. Engineering Optimization, Theory and Practice: S. S. Rao
2. Optimization of Structural and Mechanical Systems: J. S. Arora
3. Elements of Structural Optimization: R. T. Haftka and Z. Gürdal
4. Cost Optimization of Structures: Fuzzy Logic, Genetic Algorithm and Parallel Computing: H. Adeli and K. C. Sarma
5. An Introduction to Optimization: Edwin K. P. Chong and Stanislaw H. Zak
6. Nonlinear Optimization- Theory and Algorithms: L.C.W. Dixon
7. Linear Programming Vol.I: G. Hadley
8. Nonlinear and Dynamic Programming, Vol.II: G. Hadley

Semester-II

AMxxxxx Mechanical Behavior of Materials		
Designation	:	Compulsory
Pre-requisites	:	Strength of Materials and Linear Algebra.
Credit and Contact hours	:	L+T+P=4
Assessment Methods	:	**Theory Examination:** (Scheme) End Semester Exam: 60 marks. Mid Semester Exam: 20 marks. **Internal Assessment:** (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise tests, Term paper, etc.)
Course Outcomes	:	**The successful student will learn:** 1. Different types of deformation and mechanical properties. 2. Role of mechanical properties in designing. 3. Different testing technique of mechanical characterization.
Modes of Delivery	:	Talk and chalk, Power point presentations, Practical, etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	√			√	√		√	√		
CO2	√			√	√		√			
CO3				√		√		√		

Syllabus

Overview: Different responses of material to loading, Material properties, Macroscopic experiments and its relevance, and Physical mechanisms controlling the behavior.

Elasticity: Atomic structure and bonding, Atomic interaction, Physical origin of elastic modulus, Generalized Hooke's law and orientation dependence of elastic modulus.

Plasticity: Theoretical shear strength of crystals, Point, Line and Volume defects, Edge and Screw dislocations, Burgers circuit and Burgers vector, Force between dislocations, Movement and interactions of dislocations, Slip planes, Twinning, Strengthening mechanisms, Work hardening, Grain boundary strengthening and solid solution strengthening, True stress-strain curve, Necking phenomenon, Yield criteria and plastic stress- strain relationships.

Viscoelasticity and viscoplasticity: Responses of viscoelastic materials under different loading, Creep and relaxation, and Maxwell and Kelvin models.

Creep and Fracture: Primary, Secondary and Tertiary creep, Creep mechanisms, Dislocation creep, Diffusion creep and grain boundary creep, Creep laws, Analysis and Applications in Design. Brittle, Ductile and Fatigue fracture, Fracture surfaces, Griffith's theory, Modes of fracture, Energy release rate, Stress intensity factor, Crack tip plasticity, J-integral and Crack Tip Opening Displacement.

Fatigue: Cyclic loads, Constant amplitude and variable amplitude loads, Cycle counting techniques, Infinite life, Safe-life, Fail-safe, Damage-tolerant design philosophies, Low cycle and high cycle fatigue, Stress-Life approach, Strain-Life approach and Fracture mechanics approach and Cumulative damage theories.

Mechanical Characterization of Materials: Mechanical testing for material Characterization, Measurement techniques in experimental solid mechanics and non-destructive testing.

Term Paper: On recent advances based on literature survey and/or laboratory/industry visit.

References books

1. Mechanical Behavior of Materials: Engineering Methods for Deformation, Fracture and Fatigue, N. E. Dowling, Prentice Hall.
2. Mechanical Behavior of Materials, M. Meyers and K. K. Chawla, Cambridge University Press.
3. Mechanical Behavior of Materials, W. F. Hosford, Cambridge University Press.
4. Mechanical Behavior of Materials, T. H. Courtney, Overseas Press.
5. Mechanical Behavior of Engineering Materials, J. Roesler, H. Harders, and M. Baeker, Springer.
6. Elements of Fracture Mechanics, P. Kumar, Tata McGraw-Hill.
7. Fatigue of Materials, S. Suresh, Cambridge University Press.
8. Deformation and Fracture Mechanics of Engineering Materials, R. W. Hertzberg, John Wiley & Sons.
9. Introduction to Dislocations, D. Hull and D. A. Bacon, Pergamon.
10. Mechanical Metallurgy, G. E. Dieter, McGraw-Hill.

AMxxxxx Material Synthesis and Characterization Laboratory		
Designation	:	Compulsory
Pre-requisites	:	None.
Credit and Contact hours	:	L+T+P=6
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 50 marks. **Internal Assessment: (Scheme)** 50 marks (10 marks for attendance + 40 marks shall be for the day-to-day assessment of performance in the all the laboratory sessions evaluated through daily preparedness for conducting Experiments, participation in conduct of Experiments, Report Writing and submission, Interaction, Sincerity, Attendance and Quizzes.
Course Outcomes	:	**The successful student will learn:** 1. The importance of literature survey. 2. To design, simulation, synthesis of any composition and will understand importance phase diagrams. 3. To characterization using XRD, SEM and other relevant techniques. 4. Report preparation, writing technical thesis/reports and also about writing research articles.
Modes of Delivery	:	Demonstration in laboratory and Power point presentations.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	√	√	√	√				√		√
CO2	√	√	√	√	√	√		√	√	√
CO3		√	√		√			√		
CO4		√			√	√	√	√	√	√

Project	Details
Any 4 projects from the followings.	
1.	Synthesis and characterization of given composition by sol-gel, hydrothermal, and solid state route.
2.	Role of the metallurgical process (e.g. heat treatment processes) on micro-structural and mechanical properties of a given alloy.
3.	Fabrication and mechanical behavior of any composite.
4.	Fabrication and simulation of acoustic material.
5.	Design and simulation of material using any commercial software.
6.	Study of geometry and material non-linearity using Finite Element Analysis.
7.	Finite element analysis of simple metal forming process.
8.	Preparation and characterization of bulk materials using the Powder metallurgy Technique.
9.	Development of Ultrafine/nanostructured metals and alloys using severe deformation methods.
Reference	1. Books and research article through referred journals.

AM22103 Bio-Materials

Designation	:	Elective
Pre-requisites	:	None.
Credit and Contact hours	:	L+T+P=4
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks. Mid Semester Exam: 20 marks. **Internal Assessment: (Scheme)** 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise tests, Term paper, etc.)
Course Outcomes	:	**The successful student will learn:** 1. To demonstrate a broad knowledge of materials science and engineering in biomedical applications. 2. Use the biomaterials surface modification methods and characterizations to improve biomaterial properties. 3. Analyze biocompatibility and tissue material interaction for different kinds of biomaterials. 4. Compare the mainstream biomaterials currently used for medical applications including tissue engineering, biosensors, and rehabilitation fields.
Modes of Delivery	:	Talk and chalk, Power point presentations, Practical, etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1				√						
CO2	√	√		√		√			√	
CO3		√								
CO4					√	√	√		√	√

Syllabus

Classes of biomaterials, Bulk Properties of Materials, Surface properties and surface characterization of materials, Properties of biomaterials: Physical, thermal, electrical and optical properties of bio-materials. Biocompatibility, Bio-functionality, Mechanical and Biological Testing of Biomaterials, Regulatory issues and medical ethics.

Metallic Implant Materials: Stainless steels, Co-based alloys, Ti and Ti-based alloys and Other metals. Corrosion of metallic implants.

Ceramic Implant Materials: Aluminum oxides, Calcium Phosphate, Glass Ceramics and Carbons. Medical applications of Ceramic Materials.

Polymeric implant: Polymerization, Polymeric implant materials, Degradable. Polymers used for Biomedical Applications. Silicone used for Biomaterials, Hydrogels, Smart Polymers as biomaterials, Polymers used for drug delivery and Tissue Engineering Applications. Natural polymers found in human body, Composites as Biomaterials.

Applications in Cardiovascular, Orthopedic, and Ophthalmological implants and devices, Biomaterials used for artificial skin and dental implant applications.

Recent advances in the field of Biomaterials.

Term Paper: On recent advances based on literature survey and/or lab/industry visit.

Text books and References

1. Buddy D. Ratner, Allan S. Hoffman, Frederick J. Schoen, Jack E. Lemons Biomaterials Science, Second Edition: Wiley Science.
2. Jef A., Helsen H., Jürgen Breme, Metals as Biomaterials Wiley.
3. Kinam Park and Randall J. Mrsny Controlled Drug Delivery Designing Technology for the future American chemical society Publication.
4. Park J.B. & Lakes R.S, Biomaterials: An Introduction, Plenum Press, New York.
5. Silver F.H, Biomaterials, Medical Devices &Tissue Engineering: An Integrated approach, Chapman & Hall.

AMxxxxx Computational Materials Science

Designation	:	Elective
Pre-requisites	:	Applied Mathematics and Computation.
Credit and Contact hours	:	L+T+P=4
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks. Mid Semester Exam: 20 marks. **Internal Assessment: (Scheme)** 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise tests, Term paper, etc.)
Course Outcomes	:	**The successful student will learn:** 1. To understand basic of matcrial modelling. 2. Different multi-scale modelling technique and their correlation. 3. To use open source and commercial software for solving simple problems.
Modes of Delivery	:	Talk and chalk, Power point presentations, etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	√			√	√		√		√	
CO2			√		√		√			√
CO3			√			√		√		

Syllabus

Introduction and Fundamentals: Introduction to various regimes, Multi-scale modelling and simulation of materials, System size vs computation time, and Parallel processing.
Ab Initio Methods: Density functional theory, Quantum mechanics, Schrodinger wave equation, Many particle system, Car parrinello method, Born openheimer approximation, Hohenberg-kohn theorem, Kohn sham formulation, Local density approximation, Bloch's theorem, Pseudo potential, Energy minimisation techniques, and Examples of crystals and non-crystals.
Lattice Meso-scale methods: Lattice gas automata, and Lattice director model.
Coarse graining: Particle based models-Lattice gas model, Connolly Williams approximation, Spatial models, Dynamic (temporal) models, Application to polymer and polar materials, Grain continuum modelling, Computational micro-mechanics, and Multi-scale coupling.
Term Paper: On application of Multi-scale Modelling to Composite damage, Dislocation behavior, Phase field modeling, Modelling of grain growth and microstructure in polycrystalline materials, Modelling of structural materials, and Other recent advances based on literature survey.
Term paper: On Material modeling.

References books

1. Introduction to Materials Modelling, Z. H. Barber, Maney Publishing.
2. Computational Materials Science from Ab Initio to Monte Carlo Methods, K. Ohno, K. Esfarjani, and Y. Kawazoe, Springer.
3. Multiscale Materials Modelling: Fundamentals and Applications, Z. X. Guo, Woodhead Publishing Limited, Cambridge.
4. Computational Meso-mechanics of Composites, L. Mishnaevsky Jr., John Wiley & Sons.
5. Multi-scale modelling of Composite Material Systems, C. Soutis and P. W. R. Beaumont, Woodhead Publishing Ltd.
6. Continuum Scale Simulation of Engineering Materials-Fundamentals, Microstructures, Process Applications, D. Rabbe, F. Roters, F. Barlat, and L. Chen, Wiley.
7. Annual Review of Materials Research on Computational Materials Research, Vol 32.
8. Understanding Molecular Simulation- from Algorithm to Application, F. Daan and S. Berend, Academic Press.
9. Notes of Workshop on Computational Materials Science, Indian Institute of Sciences, Bangalore, 06-08 Mar 2009.
10. Computational Material Science, D. Raabe, Wiley-VCH Verlag GmbH.
11. Multiscale Modelling and Simulation, Editors: Attinger, Sabine, Koumoutsakos, and Petros, Springer.
12. Computational Materials Design, edited by T. Saito, Springer.
13. Combinatorial Material Science, B. Narasimhan, S. K. Mallapragada, Wiley.
14. Materials Informatics, Data-Driven Discovery in Material Science, K. Rajan, Wiley.

AMxxxxx Energy Materials

Designation	:	Elective
Pre-requisites	:	None.
Credit and Contact hours	:	L-T-P: P=4
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks. Mid Semester Exam: 20 marks. **Internal Assessment: (Scheme)** 20 marks (5 marks for attendance + 15 marks for assigument submission, Surprise tests, Term paper, etc.)
Course Outcomes	:	**The successful student will learn:** 1. To understand the use of materials in advanced application. 2. To understand hazardous conditions for health and related issues. 3. Coating for hazardous conditions.
Modes of Delivery	:	Talk and chalk, Power point presentations, Practical, etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1					√	√	√		√	
CO2			√		√		√			√
CO3			√			√		√		

Syllabus

Nuclear Metallurgy: Structures and properties of materials with special relevance for nuclear power generation: uranium and other actinides, Beryllium, Zirconium, Rare-earth elements, graphite, The materials of nuclear fuels and nuclear fuel element fabrication, and Reprocessing of nuclear fuel elements.

Nuclear Power Plant and Their Materials: Nuclear reactor, Pressurised reactor, Breeder reactor, Materials for fuel, Control rods, Coolant, Moderator, and Shielding.

Effects of Radiation on Materials Properties: Effects of α,β, γ rays on creep, fatigue, tensile, and other properties of metals, alloys, ceramics, polymers, rubbers etc., Effects on electrical, electronic and magnetic behaviour of materials, and Effects on crystal structure, grain size etc.

Materials in Fuel cells and Solar Cells: Electrocatalyst materials for low temperature fuel cells, Conductive membranes for low-temperature fuel cells, Materials for high temperature fuel cells, Silicon, Quantum dots for solar energy, Nanomaterials for solar thermal energy and Photovoltaic.

Materials in Thermal Power Generation: Superalloys, Steels, Ceramics, TBC, Hydrogen membrane materials, Sensor and Sensor materials, Biomass, Coal, Fly ash, etc.

Materials in Hydro Power Generation: Materials for power plant components, Steel, Stainless steel, Ceramics, etc.

Energy storage: Artificial photosynthesis/solar to fuels, CO2 separation and utilization, Safer nuclear waste disposal, Biofuels production, Biological fuel cell technologies, Reduction of energy use in manufacturing processes, Improved grid technologies, and Sustainable energy economic.

Term Paper: On recent advances based on literature survey and/or laboratory/industry visit.

References books

1. Introduction to Nuclear Science, J. C. Bryan, CRC Press.
2. Fundamentals of Radiation Materials Science, G. S. Was, Springer.
3. Nuclear Reactor Materials and Applications, B. M. Ma, Van Nostrand Reinhold Company.
4. Nuclear Reactor Materials, C. O. Smith, Addison-Wesley Publishing Company.
5. Fundamentals Aspects of Nuclear Fuel Elements, D.R. Olander, Technical Information Center, Office of Public Affairs Energy Research and Development Administration.
6. Structural Materials in Nuclear Power Systems, J. T. A. Roberts, Springer.
7. Handbook of Fuel Cells, W. Vielstich, A. Lamm, H. A. Gasteiger, and H. Yokokawa, John Wiley and Sons, Inc.
8. Advanced power plant materials, design and technology, D. Roddy, Woodhead Publishing Series in Energy No. 5 and CRC Press.

AMxxxxx Carbon Nanotube and Carbon Nanostructures		
Designation	:	Elective
Pre-requisites	:	None.
Credit and Contact hours	:	L-T+P=4
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks. Mid Semester Exam: 20 marks. **Internal Assessment: (Scheme)** 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise Tests, Term paper, etc.)
Course Outcomes	:	**The successful student will learn:** 1. To identify significance of carbon nanomaterials and nanostructures. 2. To understand and interpret structure property relationship of carbon nanomaterials and nanostructures. 3. To demonstrate uses of nanomaterials.
Modes of Delivery	:	Talk and chalk, Power point presentations, Practical, etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	√						√			
CO2	√	√	√			√			√	
CO3			√	√		√	√	√		

Syllabus

Introduction to Carbon Nanostructure: Carbon molecule, Carbon small clusters, Carbon big clusters, Fullerenes, Discovery of C_{60}, Synthesis of C_{60}, Properties of C_{60}, Other buckeyballs, and CNT.

CNT Morphology: From a graphene sheet to a nanotube, Structure - chiral nanotubes, single wall, multiwall and bundled nanotubes, Zigzag and armchair nanotubes, and Euler's Theorem in cylindrical and defective nanotubes.

Production Techniques of Nanotubes: Growth of single-wall/multiwall nanotubes, Carbon arc bulk synthesis in presence and absence of catalysts, High purity material (bucky paper) production using pulsed laser vaporization (PLV) of pure and doped graphite, High-pressure co-conversion (HIPCO), Nanotube synthesis based on Boudoir reaction-chemical vapor deposition (CVD), Laser ablation, and Synthesis of aligned nanotube films.

Structural, Electronic Properties: Structural changes in free standing and interacting nanotubes – librations, rotations, twistons, Effect of inter tube interactions on the electronic structure, Electronic structure of graphite as building block of nanotubes, Effect of chirality and discrete atoms, Conducting versus insulating nanotubes, Band structure of metallic carbon nanotubes, Effect of doping on conductivity, Electrical properties, Vibrational properties, Chemical properties, Mechanical properties, Physical properties, and Optical properties.

Applications of Nanotubes: Harnessing field enhancement, Flat panel displays, Hydrogen storage, Carbon nanotubes and drug delivery, Structural application of CNTs, and CNT nanocomposites.

Term Paper: On recent advances based on literature survey and/or laboratory/industry visit.

References books

1. Carbon Nanotubes, M. Endo, S. Iijima, M. S. Dresselhaus, Pergamon.
2. Carbon Nanotubes: Advanced Topics in the Synthesis, Structure, Properties and Applications, A. Jorio, M. S. Dresselhaus, and G. Dresselhaus, Springer.
3. Carbon Nanostructures, Series Ed.: P. Araujo, Springer.
4. Physics of Carbon Nanostructures, S. Bellucci and A. Malesevic, Springer.
5. Fullerenes, Nanotubes, and Carbon Nanostructures, F. D'Souza, P. Kamat, N. Martin, R. Weisman, S. Rotkin, H. Shinohara, Z. Slanina, Y. Iwasa, L. Wilson, and N. Solladie: ECS Transactions: Vol 6, Issue 16.
6. Carbon Nanotube and Graphene Device Physics, H. S. P. Wong and D. Akinwande, Cambridge University Press.

AMxxxxx Glass Science and Engineering

Designation	:	Elective
Pre-requisites	:	None.
Credit and Contact hours	:	L+T+P=4
Assessment Methods	:	**Theory Examination:** (Scheme) End Semester Exam: 60 marks. Mid Semester Exam: 20 marks. **Internal Assessment:** (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise tests, Term paper, etc.)
Course Outcomes	:	**The successful student will learn:** 1. To expose himself to the fundamental knowledge of glass. 2. To understand composition of different types of glasses and their physical and chemical properties and uses. 3. To design glass for various application. 4. To understand manufacturing of glass.
Modes of Delivery	:	Talk and chalk, Power point presentations, Practical, etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	√			√			√		√	
CO2	√	√		√				√		
CO3				√	√				√	√
CO4		√	√							

Syllabus

Introduction: History of glass and glass making, Composition, Applications, et.

Glass Making: Raw materials, Criteria for selection of raw materials, Batch house operations, Glass melting and homogenization, Addition of cullet to the batch, Reactions amongst the constituents of glass, Defects in glass - bubbles and seeds, cords, stresses and colour inhomogeneity and their remedies, and annealing of glasses.

Glass Fundamentals: Kinetic and thermodynamic criteria for glass formation, Use of Na_2O-SiO_2 and Na_2O-$CaOSiO_2$ phase diagrams in glass manufacture, Physical properties of glasses, Density, Refractive index and dispersion, Thermal expansion and thermal stresses, Thermal endurance of glass, Toughening of glasses, Strength and fracture behavior of glass and its articles.

Manufacture of Glasses: Glass forming machines, Manufacture of glass objects - bottles, rods, tubes, bulbs and bangles, glass blocks and laboratory glass wares, sheet, plate and rolled glass, toughened safety glass, laminated safety glass, glass fiber and wool, foam glass, optical and ophthalmic glasses, Semi-automatic and fully automatic machines.

Absorption and Colours in Glasses: Role of transition metal ions in glass, Sulphur and selenium in glass, Oxidation-reduction equilibria in glass, Effect of temperature, Composition and partial pressure of oxygen on redox equilibria in glass, Application of redox reactions in glass industry for coloration, Decolorization and refining of glasses.

Non-conventional Processing of Glasses: Sol-Gel method, Chemical vapor deposition method, Acid-base concept in glass, Technology of making radiation shielding glasses, Heat absorbing glasses, Solder glasses, Chalcogenide and Halide glasses, and Low durability glasses.

References books

1. Introduction to Glass Science, edited by L. D. Pye, H. J. Stevens, and W. C. LaCourse, Plenum Press, Springer.
2. Hand book of Glass Manufacture Vol. I and II, F. V. Tooley, Ogden Publishing Company, Ashlee Publishing Company.
3. Properties of Glass, J. W. Moorey, Reinhold Publishing Corporation.
4. Colour Glasses, W. A. Weyl, Society of Glass Technology.
5. Glass-Ceramic Technology, W. Höland and G. H. Beall,
6. Glass Ceramic Technology, W. Höland and G. H. Beall, John Wiley & Sons.
7. Ceramic Materials: Science and Engineering, C. B. Carter and M. G. Norton, Springer.

AMxxxxx Materials in Service		
Designation	:	Elective
Pre-requisites	:	Material Science and Chemistry.
Credit and Contact hours	:	L+T+P=4
Assessment Methods	:	**Theory Examination:** (Scheme) End Semester Exam: 60 marks. Mid Semester Exam: 20 marks. **Internal Assessment:** (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise tests, Term paper, etc.)
Course Outcomes	:	**The successful student will learn:** 1. To learn to alter the properties of material due to change in the microstructure of materials. 2. To understand the mechanism and degradation of material under wear. 3. To apply preventive measures against wear. 4. To identify the cause of corrosion and protection methods against the corrosion. 5. To monitor and quantify the damage in the material using different techniques.
Modes of Delivery	:	Talk and chalk, Power point presentations, Practical, etc.

Mapping of course outcomes with program outcomes

Course outcome	P01	P02	P03	P04	P05	P06	P07	P08	P09	P10
CO1	√						√			
CO2	√	√	√			√			√	
CO3			√	√		√	√	√		
CO4			√		√			√	√	√
CO5		√			√			√		

Syllabus

Tribology: Components of tribology, Wear, Friction and lubrication, Laws of friction, Measurement of Friction, Effect of viscosity, Effect of Temperature, Types of wear, Mechanism of wear, Degradation and strength loss of materials due to wear, Surface morphology, Advantage and disadvantage of lubrication in various application, Preventive measures of wear loss, and Methods of surface improvement.

Corrosion: Thermodynamics of Corrosion, Free energy change, EMF and galvanic series, Pourbaix diagrams, Nernst equation. Electrochemical theory; Corrosion rate, Activation polarization, Concentration polarization, Anodic, cathodic and mixed control, Passivation, Tafel equation, Types of Corrosion; Different forms of corrosions-uniform, Galvanic, Crevice, Pitting, Intergranular, Erosion-corrosion, SCC, Hydrogen cracking, Corrosion fatigue, Fretting corrosion, Effect of metallurgical variables and environments on different forms of corrosion. Corrosion Protection; Corrosion prevention methods-anodic protection, cathodic protection, inhibitors, Corrosion Testing, Electrochemical techniques, Potentiostat, Tafel extrapolation, Linear polarization, Galvanostat, Impedance spectroscopy, Thermogravimetric technique, Salt spray test, Weight change measurements, Corrosion and oxidation resisting materials, Hot Corrosion, High temperature oxidation of metals and alloys, Laws governing oxidation, Molten salt corrosion, and Liquid metal corrosion.

Structural Health Monitoring: Introduction, Motivation of SHM, SHM and Non Destructive technique, Passive and Active SHM, Vibration based Techniques for SHM, Damage localization and quantification, Fibre optic sensors, Electrical resistance based SHM, Low frequency Electromagnetic Techniques, and Capacitive methods for SHM.

Term Paper: On recent advances based on literature survey and/or laboratory/industry visit.

References books

1. Material Science for Engineers: An Introduction, W. D. Callister, Jr, John Wily and Sons, Inc.
2. Mechanical Metallurgy, G. E. Dieter, McGraw-Hill.
3. Introduction to Tribology, B. Bhushan, Wiley.
4. Wear: Materials, Mechanism and Practice, edited by G. W. Stachowiak, Wiley.
5. Principles and Prevention of Corrosion, D. A. Jones, Prentice-Hall, Inc.
6. Corrosion Engineering, M. G. Fontana, McGraw-Hill.
7. Corrosion and Corrosion Control, R. W. Revie, John Wiley & Sons.
8. Corrosion, Metals Handbook, Vol.13 A & B, edited by S. D. Cramer and B. S. Covino Jr., ASM International.
9. The Fundamental of Corrosion, J. C. Scully, Pergamon Press.
10. Fundamentals of Electrochemical Corrosion, E. E. Stansbury and R. A. Buchanan, ASM International.
11. Structural Health Monitoring, edited by D. Balageas, C. P. Fritzen, and A. Güemes, Wiley-ISTE.

AMxxxxx Thin Films		
Designation	:	Elective
Pre-requisites	:	None.
Credit and Contact hours	:	L+T+P=4
Assessment Methods	:	Theory Examination: (Scheme) End Semester Exam: 60 marks. Mid Semester Exam: 20 marks. Internal Assessment: (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise tests, Term paper, etc.)
Course Outcomes	:	**The successful student will learn:** 1. To understand about nano-thin films. 2. To know about the growth mechanism of nanostructured thin films. 3. To have knowledge about synthesis and characterization of nanostructured thin films for futuristic applications. 4. To identify the applications of thin films.
Modes of Delivery	:	Talk and chalk, Power point presentations, Practical, etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	√								√	√
CO2		√	√		√					
CO3		√	√	√		√				
CO4				√				√	√	√

Syllabus

Introduction: Basic of Thin films and Nanostructures, Difference between thin and thick film, Role of thin films in Devices, and Recent changes in the Semiconductor Industry.

Defects in Thin Film: Concepts, Nature of defect, Microscopic defect and dislocation, Boundary defects, Energy states - donar acceptor levels, trap and recombination centers, excitons, phonons, etc.

Fabrication of Thin Films: Sol-gel synthesis, Spin coating, Chemical vapor deposition, Physical vapor deposition, Sputtering deposition, Ion implantation, Cathodic arc deposition, Pulsed laser deposition, Molecular beam epitaxy, etc.

Characterization of Thin Films: X-ray diffraction, UV-vis spectroscopy, Squid, Four probe resistivity, Atomic probe microscopy, Profilometer, etc.

Properties of Thin Films: Structural, Electrical, Magnetic, Optical, Thermal, etc.

Silicon and Silicon based Thin Film: Epitaxy by CVD - Process, Reactor, Equipment, Theory of CVD, Defects, Safety, and Key technical issues, CVD of silicon dioxide - Overview of atmospheric pressure CVD, Plasma enhanced CVD, Properties of dielectric films, New deposition technologies, and Future directions.

Feature Scale Modeling: Introduction, Components of etch and deposition modeling, Etch modeling, Etch examples, Deposition modeling, and Deposition examples.

Application of Thin Films: Application of thin films in different areas such as - Electronics, Medical, Defense, Sports, Automobiles, etc.

References books

1. Materials Science of Thin Films, M. Ohring, Academic Press.
2. Handbook of Thin-Film Deposition - Processes and Techniques Principles, Methods, Equipment and Applications, edited by K. Seshan, Noyes Publications.
3. Thin Film Phenomena, K. L. Chopra, McGraw-Hill.
4. Nanostructures and Nanomaterials: Synthesis, Properties and Applications, G. Cao, Imperial College Press.
5. Hand Book of Thin Film Technology, L. T. Meissel and R. Glang, McGraw-Hill.
6. Handbook of Thin-Film Deposition Processes and Techniques Principles, Methods, Equipment and Applications, edited by K. Seshan, Noyes Publications.

AMxxxxx Smart Materials

Designation	:	Elective
Pre-requisites	:	Materials Science, Ceramics.
Credit and Contact hours	:	L+T+P=4
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks. Mid Semester Exam: 20 marks. **Internal Assessment: (Scheme)** 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise tests, Term paper, etc.)
Course Outcomes	:	**The successful student** will learn: 1. Can identify various smart materials. 2. Can understand and interpret piezoelectric materials, Shape Memory Alloys, Electrorheological and Magnetorheological fluids. 3. Can know and infer smart sensors. 4. Can investigate and design smart materials for futuristic applications.
Modes of Delivery	:	Talk and chalk, Power point presentations, Practical, etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1				√			√		√	
CO2	√		√			√				
CO3				√					√	√
CO4				√	√			√		

Syllabus

Introduction: Overview of Smart Materials, Smart structures and products, Piezoelectric materials, Elecrostrictive materials, Magnetostrictive materials, Magneto electric materials. Magnetorheological fluids, Electroheological fluids, Shape memory materials, and Fiber optic sensors.

Piezoelectric Materials: Principles of Piezoelectricity, Perovskite structure, Zirconate, Titanate, Piezo ceramic materials, PZT, Single crystals vs polycrystalline Systems, Piezoelectric polymers, and Properties.

Shape Memory Alloys: Introduction, Phenomenology, Influence of stress on characteristic temperatures, Modelling of shape memory effect, Vibration control through shape memory alloys, Design considerations, Multiplexing embedded NiTiNOL actuators, etc.

Electrorheological and Magnetorheological Fluids: Mechanisms and Properties, Characteristics, Fluid composition and behaviour, Discovery and Early developments, Summary of material properties, and Applications of ER and MR fluids (Clutches, Dampers, others).

Fibre Optics: Introduction, Physical Phenomenon, Characteristics, Fibre optic strain sensors, Twisted and Braided Fibre Optic sensors, Optical fibres as load bearing elements, Crack detection applications, Integration of Fibre optic sensors and shape memory elements.

Smart Sensor, Actuator and Transducer Technologies: Smart sensors – Accelerometers, Force sensors, Load cells, Torque sensors, Pressure sensors, Microphones, Impact hammers, MEMS sensors, Sensor arrays, Smart actuators - Displacement actuators, Force actuators, Power actuators - Vibration dampers, Shakers, Fluidic pumps, Motors, and Smart Transducers - Ultrasonic transducers, Sonic transducers.

References books

1. Smart Materials and Structures, M. V. Gandhi and B. S. Thompson, Chapman & Hall.
2. Smart Materials, edited by M. Schwartz, CRC Press.
3. Smart Material Systems and MEMS: Design and Development Methodologies, V. K. Varadan, K. J. Vinoy, and
4. S. Gopalakrishnan, John Wiley & Sons.
5. Encyclopedia of Smart Materials Volume 1 and Volume 2, M. Schwartz, John Wiley & Sons, Inc.
6. Smart Structures –Analysis and Design, A. V. Srinivasan, D. M. McFarland Cambridge University Press.

AMxxxxx MEMS and Bio-MEMS

Designation	:	Elective
Pre-requisites	:	None.
Credit and Contact hours	:	L+T+P=4
Assessment Methods	:	Theory Examination: (Scheme) End Semester Exam: 60 marks. Mid Semester Exam: 20 marks. Internal Assessment: (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise tests, Term paper, etc.)
Course Outcomes	:	**The successful student will learn:** 1. To identify potential MEMS products and compare it with conventional products. 2. To demonstrate and explain MEMS micro-manufacturing. 3. To design and simulate MEMS product based on conventional FEM software.
Modes of Delivery	:	Talk and chalk, Power point presentations, Practical, etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1		√			√		√			
CO2		√	√		√	√				
CO3				√		√	√	√		

Syllabus

Introduction: MEMS, Microsystem, Sensor, Actuator, History, Market, Applications, etc.
Review of Essential Mechanical, Electrical Concepts: Mechanical: Stress, Strain, Beam, Cantilever, Plates, Bending, Thermal stress, Torsion of beam, Fracture, Vibration, etc., Electrical: Conductor, Insulator, and Semiconductor.
Scaling Laws in Miniaturization: Scaling in geometry, Force, Electricity, Fluid, Heat transfer, etc.
Material for MEMS: Review of crystal structure, Miller indices, Material for MEMS, Substrate, Device, Packaging, Silicon, Silicon compound, Gallium arsenide, Piezoelectric martial, Quartz, Polymer, Biomaterials and biocompatibility issues, etc.
Micro Total Analysis System (μTAS): Fluid control components, μ-TAS: Sample handling, μ-TAS: Separation components, μ-TAS: Detection, Cell handling and Characterization systems, Systems for biotechnology and PCR, Polynucleotide arrays, and Genetic screening.
Sensing and Actuation: Electrostatic sensing and actuation, Thermal sensing and actuation, Piezoelectric and piezoresistive sensing and actuation, Magnetic sensing and actuation, Miniature biosensors, Biosensors arrays and implantable devices, Neural interfaces, Microsurgical tools, Micro needles, Drug delivery, Microsystems for tissue engineering, Tissue scaffolds, Optical biosensors, etc.
Fabrication of MEMS: Bulk micromachining, Surface micromachining, Lithography, LIGA, SLIGA, etc.
MEMS Packaging: MEMS metrology, Overview of packaging of microelectronics, and Packaging design - technique, material, etc.
MEMS Design and Software: Design methodologies for MEMS, Study of following softwares based on availability: Ansys multiphysics, COMSOL multiphysics, MatLab, Intellisuite, AutoCAD, SolidWorks, Spice, Ledit, etc.
Term Paper: On recent advances based on literature survey and/or laboratory/industry visit.

References books

9. MEMS and MICROSYSTEM Design and Manufacture, T. R. Hsu, Tata Mcgraw-Hill Publishing Company Ltd.
10. Foundations of MEMS, C. Liu, Pearson Education International.
11. Microsystem Design, S. D. Senturia, Springer.
12. Fundamentals of Microfabrication, M. Madou, CRC Press.
13. Microsystem Technology in Chemistry and Life Sciences, A. Manz and H. Becker, Springer.
14. Fundamentals of Micro Fabrication, the Science of Miniaturization, M. Madou, Nanogen Corporation, CRC Press.

AMxxxxx Machine Learning in Materials Science		
Designation	:	Elective.
Pre-requisites	:	None.
Credit and Contact hours	:	L+T+P=4
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks. Mid Semester Exam: 20 marks. **Internal Assessment: (Scheme)** 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise tests, Term paper, etc.)
Course Outcomes	:	**The successful student will learn:** 1. To understand the basic concepts and techniques of machine learning. 2. To identify and solve the problem using a suitable machine learning technique. 3. To apply machine learning to material science. 4. To understand materials knowledge and materials data science.
Modes of Delivery	:	Talk and chalk, Power point presentations, Practical, etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1									√	√
CO2				√					√	√
CO3		√		√					√	√
CO4		√			√		√			√

Syllabus

Introduction to machine learning: Types of learning, Inductive classification, Linear regression, Decision trees, Probability and Bayes learning, Experimental evaluation of learning algorithms, Logistic regression, Support vector machine, Kernel function and Kernel SVM.

Artificial neural networks -Perceptrons, Multilayer neural networks, Back propagation algorithm, Different activation functions), Computational learning theory, Clustering and unsupervised learning.

Implementation of various Machine Learning algorithms: Coding with software tools. Introducing machine learning tools to design solutions for various problems related to material science.

Machine Learning for Materials Science (MS): Neural Networks in MS, Genetic/Evolution Algorithms in MS, Cluster Expansion in MS, Kernel Ridge Regression in MS, Gaussian Processes in MS, Bayesian Optimisation in MS, Support Vector Machines in MS, and Particle Swarm Optimisation in MS.

Materials Knowledge and Materials Data Science: Property, structure and process spaces, Process-structure-property linkages, Materials knowledge, Role of data science in materials knowledge system, Overview approaches and main components of data science, Material structure and its digital representation, 2-point statistics, Principal component analysis to reduce dimensionality and Homogenization and localization concepts.

References books

1. Machine Learning, T. M. Mitchell, McGraw-Hill Education.
2. Introduction to Machine Learning, E. Alpaydin, MIT press.
3. Pattern Recognition and Machine Learning, C. M. Bishop, Springer.
4. Machine Learning in Materials Science: Recent Progress and Emerging Applications, T. Mueller, A. G. Kusne, and R. Ramprasad, Reviews in Computational Chemistry, Volume 29, edited by A. L. Parrill and K. B. Lipkowitz. 2016, John Wiley & Sons, Inc.
5. Perspective: Machine Learning Potentials for Atomistic Simulations, Journal of Chemical Physics. Vol. 145, pp. 170901, 2016.
6. Stability and Metastability of Clusters in a Reactive Atmosphere: Theoretical Evidence for Unexpected Stoichiometries of Mg_MO_x, S. Bhattacharya, S. V. Levchenko, L. M. Ghiringhelli, and M. Scheffler, Physical Review Letter, Vol. 111, pp. 135501, 2013.
7. Cluster Expansion Method and Its Application in Computational Materials Science, Q. Wu, B. He, T. Song, J. Gao, and S. Shik, Computational Materials Science, Vol. 125, pp. 243-254, 2016.
8. Fast and Accurate Modeling of Molecular Atomization Energies with Machine Learning, M. Rupp, A. Tkatchenko, K. R. Müller and O. A. Lilienfeld, Physical Review Letter, Vol. 108, pp. 058301, 2012.
9. Molecular Dynamics with On-the-Fly Machine Learning of Quantum-Mechanical Forces, Z. Li, J. R. Kermode, and A. D. Vita, Physical Review Letter, 114, 096405, March 2015.
10. Accelerated Search for Materials with Targeted Properties by Adaptive Design, D. Xue, P. V. Balachandran, J. Hogden, J. Theiler, D. Xue, and T. Lookman, Nature Communications, Vol. 7, article number: 11241, 2016.
11. Identifying Cysteines and Histidines in Transition-Metal-Binding Sites Using Support Vector Machines and Neural Networks, A. Passerini, M. Punta, A. Ceroni, B. Rost, and P. Frasconi, PROTEINS: Structure, Function, and Bioinformatics, Vol. 65, pp. 305–316, 2006.

12. CALYPSO Structure Prediction Method and its Wide Application, H. Wang, Y. Wang, J. Lv, Q. Li, L. Zhang, and Y. Ma, Computational Materials Science, Vol. 112, Part B, pp. 406-415, 2016.

AM22313 Mechanics of Composite Materials		
Designation	:	Elective
Pre-requisites	:	*Continuum Mechanics / Solid Mechanics, Basic Engineering Mathematics, Linear Algebra, Differential Equations*
Credit and Contact hours	:	4(L) - 0(T) - 0(P) 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment (Scheme):**20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).
Course Outcomes	:	see below
Modes of Delivery	:	Talk and chalk (main), Power point presentations (sometimes), Self-study (as assigned), Hands on training through Computer Programming.
Topics to be Covered	:	see below
Text books, References	:	1. Mechanics of fibrous composites: Carl T. Herakovich 2. Principles of Composite Material Mechanics: R. F. Gibson 3. Mechanics of Composite Materials: R. M. Jones 4. Introduction to Composite Material: Stephen W.Tsai and H. Thomas Hahn 5. Composite Materials and their use in Structures: J. R. Vinson and T.W. Chou

Course Outcomes

Sl. No.	On successful completion of the course, student is expected to be able to:	Mapping into POs
1.	Predict effective properties of composite lamina from the constituent properties by applying the micromechanical theories	1, 4, 5
2.	Predict the effective properties and response of the laminate from the fiber orientation details of the lamina and the stacking sequence by applying the macro mechanical theories.	5, 6, 8
3.	Understand the behavior of laminate in different environmental conditions	5, 9
4.	To predict the failure conditions by applying the basic aspects of damage mechanics	5, 9, 10

Topics to be Covered

Units	Details
1.	**Introduction:** Classification and characteristics of composites, Conventional vs. Composite materials, Advantages and limitations, Salient applications in various fields, Fabrication technologies, Properties of matrix and reinforcement materials.
2.	**Micromechanics:** Fiber volume fraction, micro-mechanical relations, determination of strength and stiffness, Environmental effects-Hygro-thermal behavior.
3.	**Macromechanics:** Basic stress-strain relationships for anisotropic materials, engineering constants for orthotropic materials, stress-strain relations for a lamina of arbitrary orientation, effective moduli, invariant properties of anorthotropic lamina, special cases of laminate stiffness, laminate strength analysis, concept of inter-laminar stresses and delamination.
4.	**Failure theories and Damage mechanics:** Failure mechanisms, maximum stress theory, maximum strain theory, Tsai-Hill theory, Tensor polynomial failure criterion, first ply failure theory, Introduction to damage theory based on continuum damage mechanics.

AM22318 Continuum Damage Mechanics

Designation	:	Elective
Pre-requisites	:	*Continuum Mechanics, Linear Algebra, Differential Equations*
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment (Scheme):**20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).

Course Outcomes:

Sl. No.	On successful completion of the course, student is expected to be able to:	Mapping into POs
1.	To select appropriate damage measures and to model damage using suitable variables	2, 7
2.	To understand and derive thermodynamically consistent dissipation potentials, constitutive equations and evolution equations	2, 3, 4, 6, 8, 9
3.	To classify and describe different kinetic laws of damage evolution	4, 6, 7
4.	To implement the damage theories for analysis of damage in structures	5, 7, 9

Modes of Delivery: Talk and chalk (main), Power point presentations (sometimes), Self-study (as assigned), Hands on training through Computer Programming.

Topics to be Covered:

Units	Details
1.	**Essentials of Continuum mechanics:** Tensorial notation, stress, strain, invariants, equilibrium equations, Domain and validity of continuum damage mechanics, concept of representative volume element.
2.	**Phenomenological aspects of damage:**Damage, measurement of damage, modeling of damage through effective area reduction, void volume fraction and stiffness reduction, representation of damage through different orders of tensors, concept of effective stress, hypothesis of strain equivalence, strain energy equivalence, and complementary strain energy equivalence.
3.	**Thermodynamics of damage:**State variables, damage as state variables, first and second law of thermodynamics, thermodynamics potentials, dissipation potentials, constitutive equations, evolution equations.
4.	**Kinetic Laws of Damage Evolution:**Unified formulation of damage laws, damage laws for brittle, quasi-brittle, ductile, creep, low cycle and high cycle fatigue.
5.	**Damage Analysis of Structures:**Implementation of isotropic damage theory, case studies from literature.

Text books, References:

1. A Course on damage mechanics: Jean Lemaitre
2. Continuum damage mechanics: S. Murakami
3. Mechanics of solid materials: Jean Lemaitre and J. L. Chaboche
4. An Introduction to damage mechanics: L. M. Kachanov
5. Damage mechanics with finite elements: P. I. Kattan and G. Z. Voyiadjis
6. Damage mechanics: Dusan Krajcinovic
7. Damage mechanics: George Z. Voyiadjis and Peter I. Kattan

AM22315 Multiscale Modeling of Advanced Materials

Designation	:	Elective
Pre-requisites	:	Engineering Mathematics, Basic Materials Science, Advanced Solid Mechanics.
Credit and Contact hours	:	4(L) - 0(T) - 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment (Scheme):** 20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).

Course Outcomes:

Sl. No.	On successful completion of the course, student is expected to be able to:	Mapping into POs
1.	Demonstrate understanding on the fundamental principles of molecular dynamics, including equations of motion for atoms, atomic interactions etc.	1
2.	Develop awareness on available commercial software for molecular dynamic simulation and skill for designing molecular dynamics simulations using such software.	4, 5
3.	Acquire knowledge on the connection between information available on small (i.e., atomistic) and large (i.e., macroscopic / continuum) scales.	4, 5, 8, 9
4.	Use molecular dynamic simulation data in a finite element simulation, and be able to analyze, interpret / explain and communicate the results, commensurate to the scientific community.	4, 5, 8

Modes of Delivery: Talk and chalk / Power point presentations (as required), Self-study (as assigned).

Topics to be Covered:

Units	Details
1.	**Introduction:** Examples and motivation for exploring multiscale behaviour of materials, Relevant material properties at different scales.
2.	**Review of Preliminaries:** Prerequisite mathematics, Fundamentals of Thermodynamics and statistical mechanics.
3.	**Molecular Dynamics and Related Issues:** Particle-based methods, EAM/MEAM potentials: bridging from QM, Atomistic Plasticity, Damage & Fatigue, Molecular Dynamic Simulation Methods.
4.	**Meso-scale methods:** Overview and need, Quasi-continuum methods, Density Functional method.
5.	**Homogenization and Bridging:** Multi-scale homogenization and stochastic homogenization, Inter-scale exchange and Scale bridging.
6.	**Computational Application:** Variational multiscale methods, Numerical resolution and asymptotic behaviour of stochastic PDEs, Enriched continuum models and design.

Text books, References:

1. Nano Mechanics and Materials: Theory, Multiscale Methods and Applications: Liu, Wing Kam, Karpov, Eduard G., and Park, Harold S.
2. An Introduction to Thermal Physics: Schroeder, Daniel V.
3. A First Course in Finite Elements: Fish, Jacob and Belytschko, Ted
4. Nonlinear Finite Elements for Continua and Structures: Belytschko, Ted, Liu, Wing Kam, and Moran, Brian

AM22317 Fracture Mechanics				
Designation	:	Elective		
Pre-requisites	:	*Continuum Mechanics/Applied Elasticity*		
Credit and Contact hours	:	4(L) - 0(T) - 0(P) - 4(Cr)		
Assessment Methods	:	Theory Examination: (Scheme)	End Semester Exam: 60 marks Mid Semester Exam: 20 marks	
		Internal Assessment (Scheme):20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).		
Course Outcomes	:	**Sl. No.**	**On successful completion of the course, student is expected to be able to:**	**Mapping into POs**
		1.	Understand the principles, application and limitations of fracture mechanics	4, 8
		2.	Calculate the fracture toughness of a material of standard specimen geometry	4, 7
		3.	Understand the micro-mechanisms of fracture failure in metals	4, 9, 10
		4.	Formulate problems in terms of fracture mechanics	9, 10
Modes of Delivery	:	Talk and chalk (main), Power point presentations (sometimes), Self-study (as assigned), Hands on training through Computer Programming.		
Topics to be Covered	:	**Units**	**Details**	
		1.	**Introduction:** Modes of loading, Crack growth and fracture mechanisms, Need for fracture mechanics, Linear elastic fracture mechanics and elastic plastic fracture mechanics.	
		2.	**Energy Release Rate:** Surface Energy, Resistance, Griffith Theory of fracture, Extension of Griffith Theory by Irwin and Orowan, R-Curve, Pop-in phenomena, Crack branching, Necessary and sufficient conditions for fracture.	
		3.	**Crack-Tip Stress and Displacement Fields:** Airy's stress function, Westergaard's approach, Generalized Westergaard's approach, William's Eigen function approach, Multi-parameter stress field equations, Influence of the T-stress and higher order terms, Role of photoelasticity on the development of stress field equations in fracture mechanics.	
		4.	**Stress Intensity Factor:** Equivalence between SIF and *G*, Various methods for evaluating Stress Intensity Factors.	
		5.	**Crack Tip Plastic Zone:** Modeling plastic zone at the crack-tip, Irwin and Dugdale models.	
		6.	**Fracture Toughness Testing:** Qualitative toughness testing, K_{IC} testing, K-R curve testing, J_{IC} measurements, J-R curve testing, CTOD testing.	
		7.	**Micromechanics of Fracture:** Cohesive strength of solids, Cleavage fracture, Intergranular fracture, Ductile fracture, Crack detection methods.	
Text books, References		1. Elementary Engineering Fracture Mechanics: D. Broek 2. Elements of Fracture Mechanics: Prashant Kumar 3. Fracture Mechanics - Fundamentals and Applications: T. L. Anderson 4. Introduction to Fracture Mechanics: Kare Hellan 5. Fracture Mechanics- With an Introduction to Micromechanics: Dietmar Gross and Thomas Seelig 6. Fracture Mechanics- An Introduction: E.E. Gdoutos		

AM22316 Applied Plasticity		
Designation	:	Elective
Pre-requisites	:	*Continuum Mechanics/Applied Elasticity*
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	Theory Examination: (Scheme) End Semester Exam: 60 marks Mid Semester Exam: 20 marks Internal Assessment (Scheme):20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).
Course Outcomes	:	

Sl. No.	On successful completion of the course, student is expected to be able to:	Mapping into POs
1.	Understand the elastic and plastic behavior from stress-strain curves for materialsat normal temperatures as related to questions of strength of structures	1, 4
2.	Understand the physical interpretation of material constants in mathematical formulation of constitutive relationship	4, 5, 7
3.	Use plasticity theory to design beams, plates and shells and the system consisting of these structural element	7, 8, 9
4.	Develop constitutive models based on experimental results on material behavior	4, 8, 10

Modes of Delivery	:	Talk and chalk (main), Power point presentations (sometimes), Self-study (as assigned), Hands on training through Computer Programming.
Topics to be Covered	:	

Units	Details
1.	**Crystal plasticity:** Resolved shear stress & strain, Lattice slip systems, Hardening, Yield surface, Flow rule, Micro to Macro plasticity.
2.	**Stresses and Strains:** The Stress–Strain Behaviour, Analysis of Stress, Mohr's Representation of Stress, Velocity gradient and rate of deformation, Kinematics of large deformation, The Criterion of Yielding, Yielding of materials under complex stress state, Choice of yield function.
3.	**Non-Hardening & Elastic-Perfect Plasticity:** Classical theories and its application to uniform & non uniform stress states, Hencky vs. Prandtl-Reuss, Elastic-Plastic Torsion and Bending of Beams, Thick walled cylinders.
4.	**Theory of the Slipline Field:** Formulation of the Plane Strain Problem, Properties of Slipline Fields and Hodographs, Stress Discontinuities in Plane Strain, Construction of Slipline Fields and Hodographs, Analytical and Matrix Methods of Solution, Explicit Solutions for Direct Problems, Some Mixed Boundary-Value Problems, Superposition of Slipline Fields.
5.	**Limit Analysis:** Collapse of Beams & Structures, Transverse loading of circular plates.
6.	**The Flow Curve:** Uniaxial tests, Torsion tests, Compression tests, Bulge test, Equations to flow curve, Strain & work hardening hypothesis.
7.	**Plasticity with Hardening:** Isotropic hardening, Non associated flow rules, Prandtl-Reuss flow theory, Kinematic hardening.
8.	**Plastic Instability:** Inelastic buckling of struts, Buckling of plates, Tensile instability, Circular bulge instability, Plate stretching.

Text books, References		1. Theory of Plasticity: J. Chakrabarty 2. Plasticity Theory: Jacob Lubliner. 3. Basic Engineering Plasticity: DWA Rees

4. The Mathematical theory of plasticity: R.Hill
5. Finite Elements in Plasticity- Theory & Practice: D. R. J. Owen and E. Hinton
6. Continuum Theory of Plasticity: S. Huang
7. Fundamentals of the Theory of Plasticity: L.M. Kachanov
8. Plasticity for Engineers: Theory and Applications: C. R. Calladine

AMxxxxx Electroacoustic Transducers		
Designation	:	Elective
Pre-requisites	:	None.
Credit and Contact hours	:	L+T+P :4
Assessment Methods	:	**Theory Examination:** (Scheme) End Semester Exam: 60 marks. Mid Semester Exam: 20 marks.
		Internal Assessment: (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise tests, Term paper, etc.)
Course Outcomes	:	**The successful student will learn:** 1. To identify the significance of acoustics in human life. 2. To apply electro-mechano-acoustical analogy (equivalent circuit method) for electroacoustic transducer. 3. To design and simulate microphone and loudspeaker.
Modes of Delivery	:	Talk and chalk, Power point presentations, Practical, etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1			√				√			
CO2		√		√				√	√	
CO3				√			√	√		

Syllabus

Introduction to Acoustics: Acoustic variables and basic relations, Plane and spherical waves, Reflection and transmission, Radiation and reception of acoustic waves, and Absorption and attenuation of sound.

Electro-Mechano-Acoustical Analogy: Introduction, Basic equations and impedances, Transformer and gyrator, Simple harmonic oscillator, Helmholtz resonator, Loop analysis, Circuit elements, and Lagrange equation.

Acoustical Elements: Basic acoustic elements, Specific acoustic impedance, Mechanical impedance, Electrical impedance, Acoustic radiation impedance, Duct impedance, Equivalent circuit model, Various acoustical examples, Frequency and wavelength, dB scale, and Sound pressure level.

Basic Theory and Modeling of Microphone: Introduction, Types, Response, Sensitivity, Specifications, Directivity pattern, Microphone array, Microphone equation, Electret condenser microphone (ECM), and ECM model for various types of microphone.

Basic Theory and Modeling of Moving Coil Transducer: Introduction, Types, Reciprocal and anti-reciprocal system, TS parameters, Speaker non-linearities, Equivalent circuit representation, Loudspeaker enclosure, Types of loudspeaker enclosure and corresponding circuits, Total harmonic distortion, Intermodulation distortion, and Miniature loudspeaker.

Theory and Analysis of Piezoelectric Transducer: Brief introduction to piezoelectricity, Piezoelectric materials, Piezoelectric devices, Polarization, Equivalent circuit, Piezoelectric accelerometer, Piezoelectric speaker, and Piezoelectric microphone.

Term Paper: On recent advances based on literature survey and/or laboratory/industry visit.

References books

1. Acoustics, L. L. Beranek, Acoustical Society of America.
2. Introduction to Electro acoustics and Amplifier Design, W. M. Leach, Kendall Hunt Publishing Company.
3. Acoustics-An Introduction, H. Kuttruff, Taylor & Francis.
4. Fundamentals of Acoustics, L. E. Kinsler, A. R. Frey, A. B. Coppens, and J. V. Sanders, John Wiley and Sons.
5. Audio Engineer's Reference Book, edited by M. T. Smith, Focal Press.

Master of Technology

in

BIOMEDICAL ENGINEERING

Course Structure,
Scheme of Evaluation
&
Syllabi

(*Proposed to be Effective from July 2021*)

Department of Applied Mechanics

Motilal Nehru National Institute of Technology Allahabad
Allahabad, U.P. -211004, INDIA

VISION AND MISSION OF THE INSTITUTE

VISION

To establish a unique identity for the institute amongst national and international academic and research organizations through knowledge creation, acquisition and dissemination for the benefit of society and humanity.

MISSION

- To generate high quality human and knowledge resources in our core areas of competence and emerging areas to make valuable contribution in technology for social and economic development of the nation. Focused efforts to be undertaken for identification, monitoring and control of objective attributes of quality and for continuous enhancement of academic processes, infrastructure and ambience.
- To efficaciously enhance and expand, even beyond national boundaries, its contribution to the betterment of technical education and offer international programmes of teaching, consultancy and research.

VISION AND MISSION OF THE DEPARTMENT

VISION

To establish itself as a department recognized for its quality post graduate education and research in the broad field of Applied Mechanics and Materials.

MISSION

VISION

To establish itself as a department recognized for its quality post graduate education and research in the broad field of Applied Mechanics and Materials.

MISSION

- To produce high quality human resource in the area of Applied Mechanics and Materials Engineering by way of continuous up gradation of curriculum, improvement in academic processes & ambience, and faculty & infrastructure development.
- To create knowledge resource through research in emerging areas of Applied Mechanics and Materials in collaboration with national & international academic, research and industrial organizations and disseminate the same by contributing and conducting STTP, Workshops, Symposiums and Conferences.

PROGRAM EDUCATIONAL OBJECTIVES (PEOs):

PEO-1	Mathematics, science, and engineering fundamentals expertise at the interface of engineering and the life sciences which enables them to take leadership roles in the field of biomedical engineering
PEO-2	An ability to use their multidisciplinary background to foster communication across professional and disciplinary boundaries with the highest professional and ethical standards .
PEO-3	The ability to recognize the limits of their knowledge and initiate self-directed learning opportunities to be able to continue to identify and create professional opportunities for themselves in the field of biomedical engineering
PEO-4	To build a character in student to pursue life-long learning by enhancing knowledge and skills for professional advancement.

Graduate Attributes (GAs):

1. **Scholarship of Knowledge:** Acquire in-depth knowledge of specific discipline or professional area, including wider and global perspective, with an ability to discriminate, evaluate, analyze and synthesize existing and new knowledge, and integration of the same for enhancement of knowledge.
2. **Critical Thinking:** Analyze complex engineering problems critically, apply independent judgment for synthesizing information to make intellectual and/or creative advances for conducting research in a wider theoretical, practical and policy context.
3. **Problem Solving:** Think laterally and originally, conceptualize and solve engineering problems, evaluate a wide range of potential solutions for those problems and arrive at feasible, optimal solutions after considering public health and safety, cultural, societal and environmental factors in the core areas of expertise.
4. **Research Skill:** Extract information pertinent to unfamiliar problems through literature survey and experiments, apply appropriate research methodologies, techniques and tools, design, conduct experiments, analyze and interpret data, demonstrate higher order skill and view things in a broader perspective, contribute individually/in group(s) to the development of scientific/technological knowledge in one or more domains of engineering.
5. **Usage of modern tools:** Create, select, learn and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modeling, to complex engineering activities with an understanding of the limitations.
6. **Collaborative and Multidisciplinary work:** Possess knowledge and understanding of group dynamics, recognize opportunities and contribute positively to collaborative-multidisciplinary scientific research, demonstrate a capacity for self-management and teamwork, decision-making based on open-mindedness, objectivity and rational analysis in order to achieve common goals and further the learning of themselves as well as others.
7. **Project Management and Finance:** Demonstrate knowledge and understanding of engineering and management principles and apply the same to one's own work, as a member and leader in a team, manage projects efficiently in respective disciplines and multidisciplinary environments after consideration of economic and financial factors.
8. **Communication:** Communicate with the engineering community, and with society at large, regarding complex engineering activities confidently and effectively, such as, being able to comprehend and write effective reports and design documentation by adhering to appropriate standards, make effective presentations, and give and receive clear instructions.
9. **Life-long Learning:** Recognize the need for, and have the preparation and ability to engage in life-long learning independently, with a high level of enthusiasm and commitment to improve knowledge and competence continuously.
10. **Ethical Practices and Social Responsibility:** Acquire professional and intellectual integrity, professional code of conduct, ethics of research and scholarship, consideration of the impact of research outcomes on professional practices and an understanding of responsibility to contribute to the community for sustainable development of society.
11. **Independent and Reflective Learning:** Observe and examine critically the outcomes of one's actions and make corrective measures subsequently, and learn from mistakes without depending on external feedback.

Mapping of Mission statements with program educational objectives Mission Statement

Mission statements	PEO-1	PEO-2	PEO-3	PEO-4
MS1	√	√	√	
MS2			√	√
MS3		√	√	√
MS4	√	√	√	√

Mapping of program educational objectives with graduate attributes

PEO	GA1	GA2	GA3	GA4	GA5	GA6	GA7	GA8	GA9	GA10	GA11
PEO-1	√	√	√	√		√			√		
PEO-2	√	√	√		√		√				√
PEO-3	√	√	√		√					√	
PEO-4			√	√	√	√	√	√	√	√	√

PROGRAM OUTCOMES: At the end of the program the student will be able to:

PO1	apply knowledge of engineering and science in real life challenges of Biomedical Engineering.
PO2	design and realize a biomedical device, component, or process to meet desired need.
PO3	function as biomedical engineer in a multi-disciplinary team.
PO4	identify, formulate and solved biomedical engineering problems.
PO5	understand of professional and ethical responsibilities.
PO6	understand the impact of real-life problems and their engineering solutions in a global and societal context.
PO7	recognize a need for, and ability to engage in lifelong learning.
PO8	gain knowledge on contemporary technologies.
PO9	use the techniques, skills and modern engineering tools necessary for biomedical engineering practice.
PO10	design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability

Mapping of program outcomes with program educational objectives

PO	PEO1	PEO2	PEO3	PEO4
1.	3	3	2	2
2.	3	3	2	2
3.	1	2	3	1
4.	3	2	2	1
5.	3	2	3	3
6.	2	3	2	1
7.	3	3	2	2
8.	2	2	3	1
9.	2	1	2	3
10.	1	1	1	3

1: Slightly 2: Moderately 3: Substantially

Course Structure

I Semester (Total credit = 20)

Course code	Subject Name	Credits (L+T+P)	Distribution of Marks out of 100		
			TA	Mid Sem. Exam	End Sem. Exam
AM21104	Biomechanics	4	20	20	60
AM21101	Applied Mathematics & Computation	4	20	20	60
AM21XXX	Elective-I	4	20	20	60
AM21XXX	Elective-II	4	20	20	60
AM21XXX	Elective-III	4	20	20	60

List of Electives (Semester I):

AM21330	Anatomy & Physiology for Biomedical Engineers	AM21332	Biomedical Instrumentation
AM21331	Radiology for Engineers	AM22332	Biomedical Signal Processing and Analysis
ME21318	Ergonomics	AM21335	Design, Innovation, and Entrepreneurship in Biomedical Engineering
AM21311	Finite Element Methods for Biomedical Engineering		
AM21325	Non-Destructive Testing		
AM21341	Bio-fluid Dynamics		
ME21325	Computer Aided Design		

II Semester (Total credit= 20)

Course code	Subject Name	Credits (L+T+P)	Distribution of Marks out of 100		
			TA	Mid Sem. Exam	End Sem. Exam
AM22203	Biomedical Engineering Laboratory	4	0	50	50
AM22103	Biomaterials	4	20	20	60
AM22XXX	Elective-I	4	20	20	60
AM22XXX	Elective-II	4	20	20	60
AM22XXX	Elective-III	4	20	20	60

List of Electives (Semester II):

AM22330	Advanced Biomechanics	AM22337	Artificial Intelligence in Biomedical Engineering (Modular Course)
AM22333	Tissue Engineering	AMXXXX	Biological Materials and Characterization
AM22336	Medical Imaging and Diagnostics	AMXXXX	Medical Robotics
AM22334	Electro Diagnostics, Therapy and Electrical Safety	AMXXXX	Poroelasticity
AM22323	MEMS and Bio-MEMS	AMXXXX	Telemedicine
AM22335	Rehabilitation Engineering and Assistive Technology	AMXXXX	Healthcare Management (Modular Course)
AMXXXX	Cell Mechanics and Mechanobiology	BT2234	Bioethics, Biosafety and IPR
AMXXXX	Sports Biomechanics	AM21334	Biological System Analysis and Control

III Semester (Total credit= 20)

Course code	Subject Name	Credits
AM23653	Special Study/State of the Art/Colloquium/ Project/Industrial Training/ Research	4
AM23603	Thesis/ Project	16

IV Semester (Total credit= 20)

Course code	Subject Name	Credits
AM24603	Thesis/ Project	20

Note: The distribution of thesis evaluation marks will be as follows:

1. Supervisor(s) evaluation component: 60%
2. Oral Board evaluation component: 40%

Semester-I

AM21104 Biomechanics		
Designation	:	Compulsory
Pre-requisites	:	Basics of engineering mechanics, and Anatomy of human body
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment: (Scheme)** 20 marks (5 marks for attendance + 15 marks for assignment submission Surprise Tests, Quizzes, Assignments and Tutorials etc.)
Course Outcomes	:	The students will be able: 1. to add, multiple forces and compute moments and determine internal forces in a structure. 2. to design experiments involving single molecule statics. 3. to compute forces within anatomical joint and describe motion with precise, well-defined mechanical and anatomical terminology. 4. to understand the mechanics of connective tissue and injury and able to understand the kinetic and kinematic assessment of posture(s).
Modes of Delivery	:	Talk and chalk, Power point presentations, project work etc.

Mapping of course outcomes with program outcomes

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	√	√	√	√					√	
CO2		√	√			√		√	√	
CO3			√	√		√		√	√	
CO4	√	√	√	√		√		√	√	√

Syllabus

Introduction to Deformable Body Mechanics: Basics concepts of Force Moments and Torque Equilibrium, analysis of systems in equilibrium, internal forces and moments, Stress and Strain, Uniaxial tension test, Stress-strain diagram Hooke's Law, Mechanical Properties based on Stress-strain Diagrams, Poisson's ratio, Biaxial and tri axial stresses, Failure theories, Torsion, Bending and combined loading.

Application of Statics to Biomechanics: Skeletal joints, Skeletal muscle. Mechanics of the elbow, shoulder, Spinal column, Hip, Knee and ankle. Basic assumptions and limitations.

Mechanical Properties of Bone and Soft Tissues: Mechanics of bone, Composition of bone, Mechanical properties of bone, Bone fractures and Bone Adaptation and Remodeling, Biomechanics of Tendon and Ligaments, Biomechanics of Skeletal Muscles. Biomechanics of Articular cartilage.

Term Paper: On recent advances based on literature survey and/or lab/industry visit

Text books and References:

1. Fung Y.C., Biomechanics, Springer Verlag
2. Winter.D.A., Biomechanics and Motor Control of Human Movement.
3. Frankel V.H.& Nordin Margareta, Basic Biomechanics of the Skeletal System, LEA & FEBIGER
4. Nihat Ozkaya and Margareta Nordin Fundamentals of Biomechanics, 3rd Edition. VNR, New York

AM21101 Applied Mathematics and Computation

Designation	:	Compulsory
Pre-requisites	:	Engineering Mathematics and computer programming
Credit and Contact hrs	:	4(L) - 0(T) - 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment: (Scheme)** 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise Tests, Term paper etc)
Course Outcomes	:	The students will be able: 1. to identify the differences between "exact methods & computational methods" and applications of these methods. 2. to develop knowledge of expressing a real-life problem in terms of mathematics i.e to develop the skill of mathematical modeling. 3. to identify and develop the skill to solve real life engineering problems e.g., nonlinear problems, initial value & boundary value problems, numerical differentiation & integration problems. 4. to develop skill of writing flow charts of real-life engineering problems and transform those into computer programming
Modes of Delivery	:	Talk and chalk, Power point presentations, and practical etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1				√					√	
CO2			√			√		√	√	
CO3			√			√		√		
CO4				√						

Syllabus

Review of Elementary Engineering Mathematics: Solution of homogeneous and non-homogeneous equations; Power series; Laplace transform and its applications; Fourier series and Fourier transform

Linear Algebra: Matrices and Linear Transformations, Operational Fundamentals of Linear Algebra, Systems of Linear Equations, Gauss Elimination Family of Methods, Special Systems and Special Methods, Numerical Aspects in Linear Systems, Eigen values and Eigenvectors, Diagonalization and Similarity Transformations, Jacobi and Givens Rotation Methods, Tri-diagonal Matrices, QR Decomposition Method, Eigen value Problem of General Matrices, Singular Value Decomposition, Direct and Iterative solvers.

Ordinary Differential Equations: Introduction to ordinary differential equations, homogeneous linear equations of second order, non-homogeneous linear equations of second order, free and forced oscillation problems, problems with variable coefficients, system of equations.

Partial Differential Equations (PDEs): Existence and uniqueness of differential equations, nature of solution, Hyperbolic, Parabolic and Elliptic PDEs, nonlinear PDEs.

Nonlinear Equations: Motivation, Open and bracketing method, Bisection, Fixed point, Newton's method, Secant and False position method, Rate of convergence, Merits and demerits of methods.

Numerical Integration: Motivation, Newton-Kotes method, Trapezoidal rule, Simpson's rule, Rhomberg integration, Gauss Quadrature.

Initial Value Problem: Motivation, Euler's method, Modified Euler method, Runge-Kutta methods, Adaptive integrations and multistep methods.

Boundary-value and Eigen-value Problem: Methods and Applications in Mechanics.

Text books and References

1. "Numerical Methods in Engineering", M. Salvadori, Prentice Hall International, 1961.
2. "Applied Numerical Methods", B. Carnahan, Krieger Pub, 1990.
3. "Applied Numerical Analysis", C.F. Gerald and P.O. Wheatley, 5th edition, Addison-Wesley, 1998.

4. "Numerical Mathematics & Computing", W. Cheney and D. Kincaid, 5th edition, Brooks/Cole, 2004.
5. "Applied Partial Differential Equations", Paul DuChateau and David Zachmann.
6. "Partial Differential Equations for Scientists and Engineers", Stanley J. Farlow.
7. Numerical Methods for Partial Differential Equations: William F. Ames.
8. Numerical Methods for Elliptic and Parabolic Partial Differential Equations: John R Levison, Peter Knabner, Lutz Angermann.

AM21330 Anatomy & Physiology for Biomedical Engineers

Designation	:	Elective
Pre-requisites	:	
Credit and Contact hours	:	4(L) - 0(T) - 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination:** (Scheme) End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment:** (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission Surprise Tests, Quizzes, Assignments and Tutorials etc.)
Course Outcomes	:	**The successful student will learn:** 1.Describe and identity basic anatomical features of the different human organ systems 2. Describe both qualitatively and quantitatively the fundamental physiological functions of the different human organ systems. 3. Formulate strategies in multidisciplinary teams to address current biomedical problems using information and resources from outside of the classroom environment.
Modes of Delivery	:	Talk and chalk, Power point presentations, project work etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	√								√	
CO2		√				√		√	√	
CO3			√			√		√		

Syllabus

Introduction to Human Body: Human as Biological Organism, levels of the organization of human body, homeostasis, Anatomical position and terminology, Body regions and Body cavities.
Cell Structure and Function: Cells and Their Structure, Replication, Transcription and Translation, Mitosis and meiosis, Cellular Communication. Nature of cancer cells, Transport of ions through cell membrane, Resting and action potentials.
Tissues: Epithelial tissue, Connective Tissue, Muscle Tissue, Nervous Tissue
Integumentary System: Function of the Integumentary System, Structure of the Skin, Physiology of the Skin.
Skeletal System: Structure and Function of Bone, Bone formation, Bones of the axial skeleton, Bone of the appendicular skeleton, Articulations.
Muscle Tissues mode of contraction: Microscopic and macroscopic structure of muscle, mode of muscle contraction.
Muscular System: Muscle terminology, muscle of axial and appendicular skeleton.
Nervous System: Anatomy of Central Nervous System, Peripheral and Autonomic Nervous system, Neuron, Physiology of Nerve conduction, Synapse and Synaptic Transmission. Brain, Blood brain barrier, neurotransmitter and Spinal cord. Cranial nerves, spinal nerves and Reflex arc.
Sensory Organs: Taste, smell, Structure and Function of Eye, structure and Function of ear.
Endocrine System: Hormones, Negative and Positive Feedback Endocrine gland and their secretions.
Cardiovascular System: Function and Composition of Blood, structure of Heart, blood flow thorough heart, Fetal circulation, coronary circulation, conduction system and innervation, cardiac cycle and electrocardiogram, Vessels, arteries, capillaries and veins, Principle systemic arteries and veins, Blood pressure.
Lymphatic System: Lymphatic structure, Nonspecific defense, antibody and cell mediated immunity, transfusion and rejection reactions.
Respiratory System: Respiration, Components of respiratory system, Mechanics of Breathing, Lung Volumes, Gas transport, Regulation of respiration.
Digestive System: digestive processes, Peritoneum, structure and Function of GI track.

Urinary System: Components of urinary system, Structure of nephron and its function, Urine concentration, Acid base balance.
Metabolism and temperature regulatory System, Water balance and electrolyte.
Term Paper: On recent advances based on literature survey and/or lab/industry visit

Text books and References:

1. Elaine.N. Marieb, 'Essentials of Human Anatomy and Physiology', 8th edition, Pearson Education, New Delhi
2. Richard S Snell, *Clinical Anatomy by Regions*: Lippincott Williams & Wilkins, 8th edition
3. Charles E. Tobin, Basic human Anatomy
4. Guyton and Hall, "Textbook of Medical Physiology", Elsevier
5. William F. Ganong, 'Review of Medical Physiology', 22nd edition, McGraw Hill, New Delhi

AM21331 Radiology for Engineers		
Designation	:	Elective
Pre-requisites	:	
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment: (Scheme)** 20 marks (5 marks for attendance + 15 marks for assignment submission Surprise Tests, Quizzes, Assignments and Tutorials, etc.).
Course Outcomes	:	The students will be able: 1. to interpret the imaging outputs. 2. to identify the suitable medical imaging techniques for specific pathology. 3. to devise new ideas to solve certain issues in medical imaging. 4. to justify the impact of medical imaging system for diagnosis.
Modes of Delivery	:	Talk and chalk, Power point presentations, project work etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	√		√	√						
CO2	√	√	√	√					√	
CO3	√		√	√					√	√
CO4	√		√	√					√	

Syllabus

Life, Health and Radiation: Atomic interactions, Long wave radiation, Short Wave radiation, Light as radiation, Ionizing radiation, Radiation in health, Radiation and atom, Electromagnetic radiation, Structure of atom, Atomic nucleus, Radioactivity, ionization and excitation, Nuclear fission and fusion.

Interaction of radiation with matter: Particle interaction, photon interaction, coherent scattering, photoelectric effect, Compton scattering, pair production and their relative importance and effect to human body.

Physics of Diagnostic Radiology: Basic concepts of power, work, force, energy, electricity, magnetism and their units and measurements, Einstein's formula, electromagnetic induction — X-rays production and properties – X-ray tube - quality of x-rays – factors affecting quality and intensity of X-rays, interaction of X and gamma rays - X-radiation measurements etc. Principles of Radiation detection and measurements - TLD, Pocket Dosimeter, Radiation Survey meter and radiation zone monitor.

Radio Diagnostic Technologies: Old and new Imaging systems: Ultrasound – Basic principles – production of ultrasound – Interaction of Ultrasound with matter – images acquisition – image quality – Artifacts – Doppler ultrasound – Biological safety Magnetic Resonance Imaging – Basic principles – Image acquisition – Reconstruction techniques – image characteristics – Artifacts – MRI instrumentation – Biological safety.

Radiation protection and nuclear medicine technology: Occupational exposures, Protective barrier specification– Workload, use factor, Occupancy factor, Nuclear Medicine technology and Guidelines for safe work practice: Principles of Radiation Detection and Measurements; normal and abnormal appearances of images, normal variants and common artefacts in bones and infection images, Regulatory agencies – Atomic energy regulatory agencies, Radiation protection rules in India, ICRP Recommendations, Dose equivalent limits.

Text books and References:

1. Ramesh Chandra and Arman Rahmim (1998) Nuclear Medicine Physics: The Basics; Wolters Kluwer.
2. Thormod Henriksen, David H. Maillie, Radiation and Health (2002). Taylor & Francis.
3. Diagnostic Radiology Physics. International Atomic Energy Agency.
4. Jerrold T. Bushberg, J. Anthony Seibert, John M. Boone, Edwin Marion Leidholdt. The Essential Physics of Medical Imaging (2012). Wolters Kluwer Health.

ME21318 Ergonomics

Designation	:	Elective
Pre-requisites	:	Solid mechanics, Linear Algebra, Differential Equations, etc.
Credit and Contact hours	:	4(L) - 0(T) - 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment: (Scheme)** 20 marks (5 marks for attendance + 15 marks for assignment submission Surprise Tests, Quizzes, Assignments and Tutorials, etc.).
Course Outcomes	:	The students will be able: 1. to apply basic knowledge of physical ergonomics such as physical load, anthropometry, biological variation and biomechanics. 2. to present a completed ergonomic analysis of product and workplace orally and in writing. 3. to demonstrate knowledge of employee recognition and compensation, health related issues, office design and ergonomic issues, and health and safety issues. 4. to prepare a basis for a production ergonomic analysis.
Modes of Delivery	:	Talk and chalk, Power point presentations, practical, video lectures, project work etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	√	√	√	√	√	√			√	√
CO2			√	√		√	√		√	
CO3		√	√			√		√	√	√
CO4	√								√	

Syllabus

Introduction to Ergonomics; Elements of Anthropometry; Physiology, Anatomy; Biomechanics, Kinesiology; Workspace Design, Seating Design; Cumulative Trauma Disorders (CTDs); Manual Material Handling; Hand Tool Design; Human Information Processing; Cognitive ergonomics; Man machine system interface, Displays and Controls, Principles of graphic user interface design; Compatibility environmental factors; Human errors, product safety, product liability.

The Elemental Resource Model for Human Performance, Measurement of Neuromuscular Performance Capacities, Measurement of Sensory-Motor Control Performance Capacities: Tracking Tasks, Measurement of Information-Processing Subsystem Performance Capacities, High-Level Task Analysis: Cognitive Components, Task Analysis and Decomposition: Physical Components, Human–Computer Interaction

Design, Applications of Human Performance Measurements to Clinical Trials to Determine Therapy Effectiveness and Safety, Applications of Quantitative Assessment of Human Performance in Occupational Medicine, Human Performance Engineering Design and Analysis Tools, Human Performance Engineering:

Challenges and Prospects for the Future.

Term Paper: On recent advances based on literature survey and/or lab/industry visit.

Text books and References:

1. J. D. Branzino, Handbook of Biomedical Engineering: Fundamentals of Biomedical Engineering, CRC Press.
2. Shrawan Kumar, Biomechanics in Ergonomics, CRC Press.

AM21311 Finite Element Methods for Biomedical Engineering

Designation	:	Elective
Pre-requisites	:	Linear Algebra with Matrix Operations, Differential Equations, Engineering Mechanics.
Credit and Contact hours	:	3(L) - 0(T) – 2(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks. Mid Semester Exam: 20 marks **Internal Assessment: (Scheme)** 20 marks (5 marks for attendance + 15 marks for assignment submission Surprise Tests, Quizzes, Assignments and Tutorials, etc.).
Course Outcomes	:	The students will be able: 1. to identify the dimension, variables involved, constrains to be imposed and type of element(s) to be used for fe analysis of different biomechanics problems. 2. to formulate, program and solve a solid mechanics problem application in biomedical engineering. 3. to analyze, interpret and communicate results obtained from developed computer program as well as from commercial finite element software. 4. to pursue higher / self-study and research, involving finite element analysis in the domain of solid mechanics application in biomedical engineering.
Modes of Delivery	:	Talk and chalk, Power point presentations, practical, video lectures, project work etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1				√					√	
CO2			√			√		√	√	
CO3			√			√		√		
CO4				√						

Syllabus

The finite element and finite difference methods, Gallerkin, weighted residuals, discretization, mechanical analysis of structures, trusses, beams, solids and shells, DoFs, hand calculations of simple FE problems, underlying PDEs, flow in porous media, computational biofluid dynamics, Newtonian vs. non-Newtonian fluid, potential flow,

Application to Biomedical Engineering: Mechanical analysis of structures (truss, beams), 2D solids, meshing, organ level analysis of bones, voxel models, solver limitations, contact analysis, Friction, bonding, rough contact, implants, bone-cement composites Confined and unconfined compression of cartilage, sequentially-coupled poroelastic and transport models for solute transport, Computational Biofluid Dynamics, Flow between micro-rough parallel plates

Application through Computer Programming& Commercial Software: Input for Geometric & Material Configuration, Loading and Boundary Conditions, Automatic Mesh Generation, Nodal Coordinate and Nodal Connectivity, Calculation of Element Matrices (Stiffness & Mass Matrices, Load Vector), Assembly of Element Matrices to Global Matrices, Imposing Boundary Conditions, Solution (Gauss Elimination & other methods), and Post Processing.

Text books and References:

1. Energy and Finite Element Methods in Structural Mechanics: I. H. Shames and C. L. Dym.
2. Concepts and Applications of Finite Element Analysis: R. D. Cook, D. S. Malkus and M. E. Plesha.
3. The Finite Element Method Vol. I-II: O.C. Zienkiwiczand R.L. Taylor.
4. Finite Element Procedures: K. J. Bathe.
5. An Introduction to Finite Element Methods: J.N. Reddy.
6. Finite Element Methods in Engineering: S.S. Rao.
7. Yang, Z. C. (2019). Finite Element Analysis for Biomedical Engineering Applications, CRC Press.

AM21325 Non-Destructive Testing (AM)

Designation	:	Elective
Pre-requisites	:	Basic Material Science and Engineering
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment: (Scheme)** 20 marks (5 marks for attendance + 15 marks for assignment submission Surprise Tests, Quizzes, Assignments and Tutorials, etc.).
Course Outcomes	:	The students will be able: 1. to use various non-destructive evaluation and testing methods, theory and their biomedical application in biomedical industries. 2. to use testing methods for defects and characterization of industrial biomedical components and devices. 3. in-depth knowledge and hands-on experience in conventional and advanced techniques in the field of non-destructive testing at the national and global levels. 4. to investigate and find solutions for complex engineering components and structures using theoretical and practical knowledge acquired in NDT
Modes of Delivery	:	Talk and chalk, Power point presentations, practical, video lectures, project work etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1				√					√	
CO2			√			√		√	√	
CO3			√			√		√		
CO4				√						

Syllabus

Overview of NDT: NDT Versus Mechanical testing, Overview of the Non-Destructive Testing Methods for the detection of manufacturing defects as well as material characterization. Relative merits and limitations, Various physical characteristics of materials and their applications in NDT, Visual inspection Unaided and aided.

Surface NDE Techniques: Liquid Penetrant Testing – Principles, Types and properties of liquid penetrants, Developers, Advantages and limitations of various methods, Testing Procedure, Interpretation of results. Magnetic Particle Testing- Theory of magnetism, Inspection materials Magnetization methods, Interpretation and evaluation of test indications, Principles and methods of demagnetization, Residual magnetism.

Thermography and eddy current testing (ET): Thermography- Principles, Contact and non-contact inspection methods, Techniques for applying liquid crystals, Advantages and limitation – infrared radiation and infrared detectors, Instrumentations and methods, applications. Eddy Current Testing- generation of eddy currents, properties of eddy currents, eddy current sensing elements, probes, instrumentation, types of arrangement, applications, advantages, limitations, interpretation/evaluation.

Ultrasonic testing (UT) and acoustic emission (AE): Ultrasonic Testing-Principle, Transducers, Transmission and pulse-echo method, Straight beam and angle beam, Instrumentation, Data representation, A/Scan, B-scan, C-scan. Phased

Array Ultrasound, Time of Flight Diffraction. Acoustic Emission Technique, AE parameters, Applications

Radiography (RT): Principle, Interaction of X-Ray with matter, Imaging, film and film less techniques, Types and use of filters and screens, Geometric factors, Inverse square law, Characteristics of films – graininess, density, speed, contrast, characteristic curves, Penetrometers, Exposure charts, Radiographic equivalence. Fluoroscopy- Xeroradiography, Computed Radiography, Computed Tomography.

Term Paper: On recent advances based on literature survey and/or lab/industry visit.

Text books and References:

1. Practical Non-Destructive Testing: Baldev Raj, T. Jayakumar, M. Thavasimuthu
2. Non-Destructive Testing Techniques: Ravi Prakash
3. ASM Metals Handbook, Non-Destructive Evaluation and Quality Control, American Society of Metals, Metals Park, Ohio, USA, 200, Volume-17.
4. Introduction to Non-destructive testing: a training guide: Paul E Mix
5. Handbook of Nondestructive evaluation: Charles J. Hellier
6. ASNT, American Society for Non-Destructive Testing, Columbus, Ohio, NDT Handbook, 1, Leak Testing, Vol.
7. Liquid Penetrant Testing, Vol. 3, Infrared and Thermal Testing Vol. 4, Radiographic Testing, Vol. 5, Electromagnetic Testing, Vol. 6, Acoustic Emission Testing, Vol. 7, Ultrasonic Testing

AM21341 Bio-fluid Dynamics

Designation	:	Elective
Pre-requisites	:	Engineering Fluid Mechanics, Elementary Biology
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment: (Scheme)** 20 marks (5 marks for attendance + 15 marks for assignment submission Surprise Tests, Quizzes, Assignments and Tutorials, etc.).
Course Outcomes	:	The students will be able: 1. to formulate the problems related to fluid mechanics in human body system and solve by engineering concepts. 2. fundamental understanding of the governing physics behind the pulsatile flow and cardiovascular system. 3. about artificial organs and devices that are exposed or work based the flow inside human body. 4. to work in teams for tackling problems in biofluid mechanics.
Modes of Delivery	:	Talk and chalk, Power point presentations, practical, video lectures, project work etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1				√					√	
CO2			√			√		√	√	
CO3			√			√		√		
CO4				√						

Syllabus

Introduction to Fluid Mechanics: Fluid properties, basic laws governing conservation of mass momentum and energy; laminar flow, couette flow and Hagen Poiseuille equation.

Blood Rheology: Blood system network and physiology, blood rheology, Vessel structure and mechanical properties, Large artery hemodynamics, Blood flow in small vessels, Flow of Newtonian and non-Newtonian fluids in rigid tubes, flexible tubes and collapsible tubes.

Circulatory system: Anatomy of the vasculature, Heart and pumping process, Cardiac cycle; Qualitative description of cardiac pumping, Arterial pulse propagation, Systolic and diastolic pressure, Windkessel model, Arterial wall structure and elasticity, Pressure–flow relationships: purely oscillatory flow, Osmotic pressure the capillaries, The veins, Cardiac valve dysfunctions and heart failure, Components and functions of arterial and venous systems, pressure-flow relations in vascular beds.

Respiratory system: Gross anatomy and Physiology, Biofluid dynamics of breathing, Lung elasticity and surface tension effects, Flow behavior in upper and lower human respiratory system during different breathing conditions, studies of wall shear stress and its implications, Mass transfer in lungs, Particle transport in the lung, Dispersion and deposition of aerosols/inhaled particles in respiratory system, critical airways, tumorous airways.

Text books and References:

1. "Bio-fluid Mechanics", J.N. Mazumdar, World Scientific, 1992.
2. Ethier, C. R., & Simmons, C. A. (2007). Introductory biomechanics: from cells to organisms. Cambridge University Press.
3. "Biomechanics: Motion", Flow, Stress, and Growth", Y.C. Fung; Springer-Verlag, 1990.
4. "Cardiovascular Physiology", R.M. Berne, M.N. Levy, 8th Edition, Mosby, 2001.
5. "Bio-fluid Dynamics", C. Klienstreuer, Taylor & Francis.

ME21325 Computer Aided Design		
Designation	:	Elective
Pre-requisites	:	
Credit and Contact hours	:	3(L) - 0(T) – 2(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment: (Scheme)** 20 marks (5 marks for attendance + 15 marks for assignment submission Surprise Tests, Quizzes, Assignments and Tutorials, etc.).
Course Outcomes	:	The students will be able: 1. to understand and manipulate coordinate systems, views, and transformations. 2. to construct sketches and place geometric and topologic constraints on them. construct parametric and feature models solid models. 3. to perform construction, analysis, and interrogation of cad models. 4. to have hands on simulation using different software.
Modes of Delivery	:	Talk and chalk, Power point presentations, practical, video lectures, project work etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1				√					√	
CO2			√			√		√	√	
CO3			√			√		√		
CO4				√						

Syllabus

Introduction: Historical Development, Explicit and Implicit Equations, Intrinsic Equations, Parametric Equations, Coordinate Systems.

Curves: Fundamental of Curve Design, Parametric Space of a Curve, Reparameterization, Space Curves: Spline Curves, Bezier Curves, B-Spline Curve, Rational Polynomials, Rational curves, NURBS.

Surfaces: Fundamental of Surface Design, Parametric Space of a Surface, Reparameterization of a Surface patch, Sixteen-point form, Four Curve Form, Plane, Cylindrical and Ruled Surfaces, Surfaces of Revolutions, Bezier Surface, B-Spline Surface.

Solids: Fundamental of Solid Design, Parametric Space of a Solids, Continuity and composite Solids.

Solid Modeling: Topology and Geometry, set theory, Euler Operators, Regularized Boolean Operators, Construction Criteria, Graph Based Models, Instances and Parameterized Shapes, Cell-decomposition and Spatial Occupancy Enumeration, Sweep representation, Applications in Biomedical Engineering Design: Bone and organ 3D model construction, 3D-scaffold modeling.

Laboratory: Students will be introduced to basic design elements in making 2D sketches, leading-up to more complex features with 3D parts and assemblies. Students will also gain practical experience in engineering design and 3D printing fabrication using the Pro/ENGINEER and other available Softwares.

Term Paper: On recent advances based on literature survey and/or lab/industry visit.

Text books and References:

1. Posinasetti Nageswara Rao CAD/CAM: Principles and Applications, Tata McGraw-Hill Education.
2. Groover, CAD/CAM: Computer-Aided Design and Manufacturing, Pearson Education India.

AM21332 Biomedical Instrumentation

Designation	:	Elective
Pre-requisites	:	
Credit and Contact hours	:	4(L) - 0(T) - 0(P) - 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment:** (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission Surprise Tests, Quizzes, Assignments and Tutorials, etc.).
Course Outcomes	:	The students will be able: 1. to do Measurements on and interpretation of data from living systems. 2. to have a basic understanding of medical terminology, relevant for biomedical instrumentation. Understand and describe the physical and medical principles used as a basis for biomedical instrumentation. 3. to understand the elements of risk for different instrumentation methods and basic electrical safety. Understand the position of biomedical instrumentation in modern hospital care. 4. to design a system, component or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health & safety, manufacturability & sustainability.
Modes of Delivery	:	Talk and chalk, Power point presentations, practical, video lectures, project work etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	√	√							√	
CO2	√	√	√						√	
CO3	√	√	√	√			√	√	√	
CO4				√	√	√			√	√

Syllabus

Basic concepts of Medical Instrumentation: Generalized medical Instrumentation System, Medical Measurement constraints, Classification of Biomedical Instruments, Generalized static and dynamic characteristics, Design criteria, Commercial Medical Instrumentation Development process, Regulation of Medical Devices.

Theory, Analysis and design of biomedical transducers: optical, photo-electric, electrochemical, electrical, mechanical, electromechanical and thermoelectric, Applications to biomedical systems, Transducer characteristics sensors for physical measurands, sensors for measurement of chemicals. Medical measurands sensor characteristics and design for measurement of medical parameters like ECG, arterial blood pressure heart sounds, bio-potential amplifiers, Various types of electrodes used in ECG, EEG and EMG, Measurement of EEG, EMG and their diagnostic applications in Medicine, Flow and pressure measuring instruments in biomedical engineering, Development of non-invasive diagnostic instruments for tissue abnormalities, Medical Ultrasonography, Latest biomedical Instruments, Electro surgical unit, Pulse Oximeter, Defibrillators, Foetal ECG.

Term Paper: On recent advances based on literature survey and/or lab/industry visit.

Text books and References:

1. Khandpur R.S., Hand book of Biomedical instrumentation, TMH.
2. Tompkins, Biomedical Digital Signal Processing.
3. Cormwell L. et al., Bio medical Instrumentation & Measurements, PHI.
4. Carr & Brown, Introduction to Biomedical Equipment, PHI.
5. Webster JG, *Medical Instrumentation: Application and Design*, 4th ed., John Wiley & Sons: New York.

AM22332 Biomedical Signal Processing and Analysis

Designation	:	Elective
Pre-requisites	:	
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment: (Scheme)** 20 marks (5 marks for attendance + 15 marks for assignment submission Surprise Tests, Quizzes, Assignments and Tutorials, etc.).
Course Outcomes	:	The students will be able: 1. to understand the nature of common biomedical signals and images from different modalities. 2. to apply classical and modern signal processing techniques for analyzing analog and digital biomedical signals. 3. to apply the basic methods of digital image and video processing, statistical pattern recognition, and machine vision to solve problems in medical image processing and put in practice mathematical modeling and analysis algorithms for processing physiological signals 4. to develop computing skills by using matlab for signal and image analysis and system modeling
Modes of Delivery	:	Talk and chalk, Power point presentations, practical, video lectures, project work etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	√			√						
CO2	√		√	√		√				
CO3	√	√	√	√		√			√	√
CO4		√		√		√	√		√	

Syllabus

Introduction to bioelectric phenomenon, generation, transmission and interaction of signals in nervous systems. Discussion of initiation and propagation of action potential along the nerve fibers. Voltage clamp experiments, synaptic transmission and transduction process and receptors. Frequency modulation of the electrical signals. Use of mathematical models particularly electrical circuits models and describing behavior of cell membrane. Neural control mechanism, genesis and characteristics of EEG, ECG, EMG and Evoked potentials.

Term Paper: On recent advances based on literature survey and/or lab/industry visit.

Text books and References:

1. Cynthia Furse, Douglas A. Christensen, Carl H. Durney Basic Introduction to Bioelectromagnetic, Second Edition, CRC Press.
2. J. Malvino & R. Plonsey Bioelectromagnatism.
3. Webster J G, *Medical Instrumentation: Application and Design*, 4th ed., John Wiley & Sons: New York.

AM21335 Design, Innovation, and Entrepreneurship in Biomedical Engineering

Designation	:	Elective
Pre-requisites	:	
Credit and Contact hours	:	3(L) - 0(T) – 2(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment: (Scheme)** 20 marks (5 marks for attendance + 15 marks for assignment submission Surprise Tests, Quizzes, Assignments and Tutorials, etc.).
Course Outcomes	:	The students will be able: 1. to design and develop devices for biomedical application. 2. to provide innovative solutions for healthcare problems 3. to inculcate Entrepreneurship abilities in the area of healthcare. 4. to develop leadership skill in the area of biomedical engineering entrepreneurship.
Modes of Delivery	:	Talk and chalk, Power point presentations, practical, video lectures, project work etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	√			√	√			√		
CO2	√		√	√		√				
CO3	√	√		√		√			√	
CO4	√			√	√	√	√			√

Syllabus

Design Process: Creative and Design Thinking, Minimum Viable Product, Business Model Development, Business Plan and Access to Funding. Elements of design process including need identification, concept generation, concept selection and implementation with specific applications in HealthCare. System Synthesis, Design analyses, optimization, impact on patient health and comfort, healthcare costs, clinical trials and regulatory issues and medical ethics.

Orthopedic Implant Design: Design Concepts, Clinical Problems Requiring Orthopedic Implants for Solution, Principles of Orthopedic Implant Design, Design Parameters.

Tissue Engineering: Scaffolds, Cells and Regulators, Case Study of Organ Regeneration, Design Parameters, Design Specifications: Biomaterials, Biocompatibility: Local and Systemic Effects, Design Specifications, Biocompatibility: Scar Formation and Contraction, Degradation of Devices: Corrosion and Wear, Regulation of medical Devices,

Cardiovascular Prostheses Design: Heart Valves and Stents, Devices for Nerve Regeneration, Musculoskeletal Soft Tissues: Meniscus, Intervertebral Disk, Dental and Ear Implants,

Design and application of electromechanical biomedical devices, Concept of prototype development and testing of medical instrument.

Innovations in Healthcare: Idea generation, market research, product development and financing, Team development and business model for commercialization of healthcare innovations.

Introduction to entrepreneurship: Healthcare start- ups. Recent Innovations in Healthcare.

Mini Project: Design and analysis of any innovative healthcare product

Text books and References:

1. E. J. Mccormick, Human factors in Engineering and Design, TMH.
2. O. P. Astrand and R. Kaarc, Textbook of Work Physiology, McGraw Hill.
3. Yannas, I. V. *Tissue and Organ Regeneration in Adults.* New York, NY: Springer-Verlag, 2001.
4. Ayyana M. Chakravartula, Lisa A. Pruitt Mechanics of Biomaterials: Fundamental Principles for Implant Design (Cambridge Texts in Biomedical Engineering).
5. Webster J. G., *Medical Instrumentation: Application and Design,* 4th ed., John Wiley & Sons: New York.
6. J. D. Branzino, Handbook of Biomedical Engineering: Fundamentals of Biomedical Engineering, CRC Press.
7. Measuring the Gains from Medical Research by Kevin Murphy and Robert Topel, Published by the University of Chicago Press
8. Medical Care Output and Productivity by Ernst Berndt and David Cutler, National Bureau of Economic Research, Studies in Income and Wealth Volume 62
9. Craig R. Davis "Calculated Risk: A Framework for Evaluating Product Development.

Semester-II

AM22203 Biomedical Engineering Laboratory		
Designation	:	Compulsory
Pre-requisites	:	Biomechanics, Biomaterials and Biomedical Instrumentation.
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment: (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission Surprise Tests, Quizzes, Assignments and Tutorials, etc.).
Course Outcomes	:	The students will be able: 1. to acquire knowledge on designing simple medical equipment. 2. to acquire biosignals using the developed medical equipment. 3. to familiarize themselves with the digital signal processing, digital filter design, and data compression techniques. 4. to develop various healthcare problem solving skill through experiments
Modes of Delivery	:	Talk and chalk, Power point presentations, practical, video lectures, project work etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	√	√	√	√					√	
CO2			√			√		√	√	√
CO3		√	√	√	√	√	√		√	
CO4				√					√	

Syllabus

1. To perform the tensile test on biomedical implant using universal testing machine. To draw stress strain curve and to find out the followings: (1) Yield stress, (2) Ultimate Stress, (3) Breaking Stress, (4) Percentage Elongation, (5) Percent Reduction in Area, and (6) the Modulus of Elasticity.
2. To determine the impact strength of biomaterial using (a) Charpy test (b) Izod test for biomedical implants.
3. To determine the value of modulus of elasticity of an implant by measurement of slope and deflection of a beam using beam-bending apparatus. Draw load-deflection diagram.
4. To perform torsion test on the given biomedical implant. To draw toque -twist curve and to find out the following. To determine the hardness of the given material by (1) Brinell Method (2) Rockwell Method.
5. Measurement of Blood Pressure using different methods.
6. Recording and analysis of electrocardiogram.
7. Recording and analysis of electroencephalogram.
8. Recording and analysis of electromyogram.
9. Preparation of composite using Hand layup method.
10. 3-point bending test of composite.
11. Kinetic and Kinematic analysis of human locomotion using OpenSim/Anybody
12. Micro-CT image to model development and finite element analysis
13. Histological examination of tissues
14. Project-1.
15. Project-2.
16. Project-3.
17. Project-4.

Text books and References:

Lab Manuals.

AM22103 Biomaterials		
Designation	:	Compulsory
Pre-requisites	:	
Credit and Contact hours	:	4(L) - 0(T) – 0(P) - 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment: (Scheme)** 20 marks (5 marks for attendance + 15 marks for assignment submission Surprise Tests, Quizzes, Assignments and Tutorials, etc.).
Course Outcomes	:	The students will be able: 1. to demonstrate a broad knowledge of materials science and engineering in biomedical applications. 2. to use the biomaterials surface modification methods and characterizations to improve biomaterial properties. 3. to analyze biocompatibility and tissue material interaction for different kinds of biomaterials. 4. to compare the mainstream biomaterials currently used for medical applications including tissue engineering, biosensors, and rehabilitation fields.
Modes of Delivery	:	Talk and chalk, Power point presentations, practical, video lectures, project work etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	√	√	√	√	√	√		√	√	
CO2	√	√	√	√	√	√		√	√	
CO3					√			√		√
CO4		√	√	√						√

Syllabus

Classes of biomaterials, Bulk Properties of Materials, Surface properties and surface characterization of materials, Properties of biomaterials: Physical, thermal, electrical and optical properties of bio-materials, Biocompatibility, Bio-functionality, Mechanical and Biological Testing of Biomaterials, Regulatory issues and medical ethics

Metallic Implant Materials: Stainless steels, Co-based alloys, Ti and Ti-based alloys and Other metals. Corrosion of metallic implants.

Ceramic Implant Materials: Aluminum oxides, Calcium Phosphate, Glass Ceramics and Carbons. Medical applications of Ceramic Materials.

Polymeric implant: Polymerization, Polymeric implant materials, Degradable Polymers used for Biomedical Applications. Silicone used for Biomaterials, Hydrogels, Smart Polymers as biomaterials, Polymers used for drug delivery and Tissue Engineering Applications. Natural polymers found in human body, Composites as Biomaterials.

Applications in Cardiovascular, Orthopedic, and Ophthalmological implants and devices, Biomaterials used for artificial skin and dental implant applications.

Recent advances in the field of Biomaterials.

Term Paper: On recent advances based on literature survey and/or lab/industry visit.

Text books and References:

1. Buddy D. Ratner, Allan S. Hoffman, Frederick J. Schoen, Jack E. Lemons Biomaterials Science, Second Edition: Wiley Science.
2. Jef A., Helsen H., Jürgen Breme, Metals as Biomaterials Wiley.
3. Kinam Park and Randall J. Mrsny Controlled Drug Delivery Designing Technology for the future American chemical society Publication.
4. Park.J.B. & Lakes R.S, Biomaterials: An Introduction, Plenum Press, New York.
5. Silver F .H, Biomaterials, Medical Devices &Tissue Engineering: An Integrated approach, Chapman & Hall.

AM22330 Advanced Biomechanics

Designation	:	Elective
Pre-requisites	:	
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment: (Scheme)** 20 marks (5 marks for attendance + 15 marks for assignment submission Surprise Tests, Quizzes, Assignments and Tutorials, etc.).
Course Outcomes	:	The students will be able: 1. to understand the biomechanics principles and gait analysis of human locomotion. 2. to derive the joint force and muscle force for various biomechanical systems in human. 3. to derive the equation of motion for bodies in constrained plane motions. 4. to student will able to develop engineering muscle models student will able to discuss viscoelastic behavior of biological tissues.
Modes of Delivery	:	Talk and chalk, Power point presentations, practical, video lectures, project work etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	√			√					√	
CO2				√		√			√	
CO3	√	√				√			√	
CO4	√								√	

Syllabus

Applications of Principles of Biomechanics in Two- and three-dimensional kinematics.

Kinematics: Body segment parameters: Method of measuring and estimating body segment parameters, two dimensional and three-dimensional computational methods.

Two dimensional inverse dynamics: Planar motion analysis, numerical formulations, Human joint kinetics.

Three-dimensional Kinetics: Data required for Three-dimensional analysis, anthropometry and three-dimensional kinetics calculations.

Electromyographic Kinesiology: Physiology of the EMG Signals, Acquisition, interpretation and Analysis of EMG Signals. Applications of EMG Techniques in Biomechanics related problems.

Computer simulation of Human Movement: Mathematical formulations, free body diagrams, Lagrange's equation of motion, numerical solution techniques, control theory, advantages and limitation of computer models.

Elastic Behavior of Biological Materials: Strain and stress relationship, Plastic deformation, Biological material properties based on strain and stress diagram.

Viscoelastic Behavior of Soft Tissues:

Viscoelasticity, Analogies based on Spring and dashpots, Empirical models of Viscoelasticity, Time- dependent material response, Bio viscoelastic solids, Structure of Skeletal Muscle, Sliding element theory of muscle action, Hill's Equation for skeletal muscle, Modified Hill equation, Hypothesis of Cross Bridge Theory. Other recent muscle models.

Term Paper: On recent advances based on literature survey and/or lab/industry visit.

Text books and References:

1. Nihat Ozkaya and Margareta Nordin Fundamentals of Biomechanics: 3rd Edition, VNR, New York.
2. David A. Winter Biomechanics and motor control of Human Movements: 3rd Edition, John Wiley & Sons, Inc.
3. D. Gordon, E. Robertson, Graham E. Caldwell, Joseph Hamill Research Methods in Biomechanics: Human Kinetics.
4. Mark L. Latash Neurophysiological Basis of Movement: Human Kinetics.
5. Fung, Y.C.: Biomechanics: Mechanical Properties of Living Tissues, Springer, 1993.

AM22333 Tissue Engineering

Designation	:	Elective
Pre-requisites	:	
Credit and Contact hours	:	4(L) - 0(T) - 0(P) - 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment: (Scheme)** 20 marks (5 marks for attendance + 15 marks for assignment submission Surprise Tests, Quizzes, Assignments and Tutorials, etc.).
Course Outcomes	:	The students will be able: 1. to describe and use the fundamental tools and techniques used in tissue engineering. 2. to compare and contrast various strategies for repairing tissues. 3. the basic concepts of cell culture. 4. to articulate the scientific vocabulary used in communicating information in tissue engineering.
Modes of Delivery	:	Talk and chalk, Power point presentations, practical, video lectures, project work etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1				√					√	
CO2			√			√		√	√	
CO3			√			√		√		
CO4				√						

Syllabus

Introduction to Tissue Engineering, Fundamentals of Stem Cell Tissue Engineering, Growth Factors and Morphogens: Signals for Tissue Engineering, Extracellular Matrix: Structure, Function, and Applications to Tissue Engineering, Mechanical Forces on Cells, Cell Adhesion, Cell Migration, Inflammatory and Immune Responses to Tissue Engineered Devices, Polymeric Scaffolds for Tissue Engineering Applications, Calcium Phosphate Ceramics for Bone Tissue Engineering, Biomimetic Materials, Nanocomposite Scaffolds for Tissue Engineering, Roles of Thermodynamic State and Molecular Mobility in Bio-preservation, Drug Delivery Gene Therapy, Tissue Engineering Bioreactors, Animal Models for Evaluation of Tissue-Engineered Orthopedic Implants, Bioengineering of Human Skin Substitutes, Gene Therapy and Tissue Engineering Based on Muscle-Derived Stem Cells: Potential for Musculoskeletal Tissue Regeneration and Repair, Tissue Engineering application in Bone, cartilage, Vascular graft, Heart valves, Tissue Engineering, Stem Cells and Cloning for the Regeneration of Urologic Organs, The Bioengineering of Dental Tissues and recent advances.

Term Paper: On recent advances based on literature survey and/or lab/industry visit.

Text books and References:

1. Patrick, Mikos and McIntire, Frontiers in Tissue Engineering, Pergamon Press.
2. Lanza, Labnger and Vacanti. Principles of Tissue Engineering, Academic Press.
3. Morgan and Yarmush, Tissue Engineering Methods and Protocols, Humana Press.

AM22336 Medical Imaging and Diagnostics

Designation	:	Elective
Pre-requisites	:	
Credit and Contact hours	:	4(L) - 0(T) - 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment: (Scheme)** 20 marks (5 marks for attendance + 15 marks for assignment submission Surprise Tests, Quizzes, Assignments and Tutorials, etc.).
Course Outcomes	:	The students will be able: 1. to describe the physics principles underlying the operation of medical imaging equipment; 2. to demonstrate an understanding of and apply mathematical methods of image construction and processing; 3. to demonstrate an understanding of aspects of clinical applications of imaging methods; 4. to discuss radiation safety issues in the operation of medical imaging equipment.
Modes of Delivery	:	Talk and chalk, Power point presentations, practical, video lectures, project work etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	√			√					√	
CO2	√	√	√	√					√	
CO3			√	√	√	√		√		√
CO4				√	√	√		√		√

Syllabus

Introduction to medical imaging and different medical Imaging modalities. Review of Signals and system, Fourier transform, Transfer functions, Hankel transform, Sampling theorem.

Image Quality: Contrast, Modulation transfer function, resolution, Noise, Signal to noise ratio, accuracy, etc.

Radiography: Atomic structure (review), Ionization, forms of Ionizing radiation and their properties, Radiation dosimetry.

Projection Radiography: X-Ray production, X-ray interaction with biological matters, Instrumentation for medical X-ray system, Filters, contrast agents, X- Films and intensifiers, Image formation, Noise and artifacts.

X-Ray Computed Tomography: CT Instrumentation, Different generations of CT Scanner, Imaging principle, Image formation, Redon transform, Back Projection Theorem, Helical CT Reconstruction, Cone Beam CT, Image quality in CT.

Application of Projection radiography: Mammography, Fluoroscopy, Angiography, etc.

Nuclear Medical Imaging: Radio Active Decay, Modes of decay, Radio traces, Instrumentation for planer scintigraphy, Image Formation and Image quality. Instrumentation for PET and SPECT, Image Quality in PET and SPECT.

Ultrasound Imaging: Physics of Ultrasound, interaction of ultrasound with biological matter, Ultrasound beam patterns and focusing. Instrumentation for ultrasound imaging system, ultrasound transducer and probes, pulse echo imaging, A Mode, B Mode and M Mode imaging. Doppler ultrasound imaging.

Magnetic Resonance Imaging:
Instrumentation for MRI System, Concept of MRI Imaging, Magnetization, RF excitation, relaxation, Pulse echo sequences and contrast mechanism. MRI data acquisition, Image Reconstruction and Image quality.

Term Paper: On recent advances based on literature survey and/or lab/industry visit.

Text books and References:

1. William R. Hendee, E. Russell Ritenour, Medical Imaging Physics.
2. Jerry L. Prince, Jonathan M., Medical Imaging Signals and Systems, Pearson Education.
3. Andrew G. Webb, Introduction to Biomedical Imaging, IEEE Press.

AM22334 Electro Diagnostics, Therapy and Electrical Safety		
Designation	:	Elective
Pre-requisites	:	
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment: (Scheme)** 20 marks (5 marks for attendance + 15 marks for assignment submission Surprise Tests, Quizzes, Assignments and Tutorials, etc.).
Course Outcomes	:	The students will be able: 1. to explain and describe different therapeutic methods of treatment where electrical medical equipment are a vital part of the method and their necessary instrumentation. 2. to analyze and evaluate the effect of different diagnostic and therapeutic methods, their risk potential, physical principles, opportunities and possibilities for different medical procedures. 3. to understand the elements of risk for different instrumentation methods and basic electrical safety. 4. to understand the position of biomedical instrumentation in modern hospital care.
Modes of Delivery	:	Talk and chalk, Power point presentations, practical, video lectures, project work etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	√	√	√	√					√	
CO2	√	√	√	√	√	√		√	√	√
CO3	√	√	√			√		√		√
CO4	√	√	√	√						√

Syllabus

Bio-potential Electrodes: Electrode- electrolyte interface, Polarizable and Non- Polarizable electrodes, Electrode behavior and circuit models, Body surface recording electrodes, internal electrodes, electrode array, microelectrodes and electrode for electric stimulation of Tissue. Practical considerations for optimum performance.

Diagnostic Equipment's: Recording of ECG, Different Lead Systems, Vector cardiography, Diagnostic Applications of ECG, Recording of EEG, different montage for EEG recording, Application of EEG for diagnosis of epilepsy, Surface EMG and its diagnostic applications.

Therapeutic Equipment: Cardiac Pacemakers, different types of pacemakers, pacing system analyzer, recent developments in implantable cardiac pacemaker. Cardiac defibrillators, Surgical Diathermy, Electro Surgical units and safety. Diagnostic application of LASERs, High frequency heat therapy, Short wave diathermy, microwave diathermy, Pain relief through electrical stimulation, Bladder Stimulator and cerebral stimulators. Hemodialysis, Ventilators, Anesthesia machines, Automatic Drug delivery Systems.

Electrical Safety: Physiological effect of electricity, Microshock and Macroshock Hazards, Electrical safety codes and standards, Basic approaches to protection against shock, grounding, Electrical safety analyzers, testing the electrical systems and electric appliances.

Text books and References:

1. Khandpur R. S., Hand book of Biomedical instrumentation, TMH.
2. Carr & Brown, Introduction to Biomedical Equipment, PHI.
3. Webester J. G., Medical Instrumentation, 3rd Edition, John Wiley.

AM22323 MEMS & Bio-MEMS		
Designation	:	Elective
Pre-requisites	:	
Credit and Contact hours	:	4(L) - 0(T) – 0(P) - 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment: (Scheme)** 20 marks (5 marks for attendance + 15 marks for assignment submission Surprise Tests, Quizzes, Assignments and Tutorials, etc.).
Course Outcomes	:	The students will be able: 1. to identify potential MEMS products and compare it with conventional products. 2. to demonstrate and explain MEMS micro-manufacturing. 3. to design and simulate MEMS product based on conventional FEM software. 4. to know the various applications of Bio MEMS.
Modes of Delivery	:	Talk and chalk, Power point presentations, practical, video lectures, project work etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1				√					√	
CO2			√			√		√	√	
CO3			√			√		√		√
CO4				√						√

Syllabus

Introduction: MEMS, microsystem, sensor, actuator, history, market, applications, etc.
Review of Essential Mechanical, Electrical Concepts: Mechanical: stress, strain, beam, cantilever, plates, bending, thermal stress, torsion of beam, fracture, vibration etc, Electrical: Conductor, insulator, semiconductor.
Scaling Laws in Miniaturization: Scaling in geometry, force, electricity, fluid, heat transfer, etc.
Material for MEMS: Review of crystal structure, miller indices, material for MEMS, substrate, device, packaging, silicon, silicon compound, gallium arsenide, piezoelectric martial, quartz, polymer, biomaterials and biocompatibility issues etc.
Micro Total Analysis System (μTAS): Fluid control components, μ-TAS: sample handling, μ-TAS: separation components, μ-TAS: detection, cell handling and characterization systems, systems for biotechnology and PCR, polynucleotide arrays and genetic screening.
Sensing and Actuation: Electrostatic sensing and actuation, thermal sensing and actuation, piezoelectric and piezoresistive sensing and actuation, magnetic sensing and actuation, miniature biosensors, biosensors arrays and implantable devices, neural interfaces, microsurgical tools, micro needles, and drug delivery, Microsystems for tissue engineering, tissue scaffolds, optical biosensors, etc.
Fabrication of MEMS: Bulk micromachining, surface micromachining, lithography, LIGA, SLIGA, etc.
MEMS Packaging: MEMS metrology, Overview of packaging of microelectronics, packaging design, technique, material, etc.
MEMS Design and Software: Design methodologies for MEMS, study of following softwares based on availability:
ANSYS Multiphysics, COMSOL Multiphysics, MATLAB, Intellisuite, AutoCAD, SolidWorks, Spice, Ledit, etc.
Term Paper: On recent advances based on literature survey and/or lab/industry visit.

Text books and References:

1. Foundations of MEMS, Chang Liu, Pearson Education International.
2. MEMS and MICROSYSTEM Design and Manufacture, Tai-Ran Hsu, Tata McGraw-Hill Publishing Company Ltd., New Delhi.
3. Microsystem Design, S. D. Senturia, Kluwer Academic Publishers.
4. Fundamentals of Microfabrication, Marc Madou, CRC Press, NY.
5. Microsystem Technology in Chemistry and Life Sciences, A. Manz and H. Becker, Eds. Springer-Verlag, New York. Fundamentals of Micro Fabrication, the Science of Miniaturization, M. Madou, Nanogen Corporation, USA, CRC Press.

AM22335 Rehabilitation Engineering and Assistive Technology

Designation	:	Elective
Pre-requisites	:	
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment: (Scheme)** 20 marks (5 marks for attendance + 15 marks for assignment submission Surprise Tests, Quizzes, Assignments and Tutorials, etc.).
Course Outcomes	:	The students will be able: 1. to develop a strong "system" understanding of the continuum of care for clinical rehabilitation, including from the context of optimizing outcomes. 2. to understand key terminology used by various medical rehabilitation professionals and within the disability community, the infrastructure that exists for clinical rehabilitation services, and roles for rehabilitation engineers. 3. to understand key aspects of sensorimotor systems as related to human performance and design/evaluation of human-technology interfaces. 4. to understand some basic principles and applications of biomechanics to rehab devices and interfaces.
Modes of Delivery	:	Talk and chalk, Power point presentations, practical, video lectures, project work etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	√			√		√	√	√		√
CO2	√		√	√		√	√	√		√
CO3	√	√	√	√	√	√	√	√	√	√
CO4	√	√	√	√	√	√	√	√	√	√

Syllabus

Introduction to Rehabilitation:

Definition, Concept of Rehabilitation, Concept of disability, Socio-vocational Rehabilitation, Medical, Psychological and social issues influencing the rehabilitation, Rehabilitation team, Therapeutic exercises and treatment techniques used in rehabilitation process, Socio-legal aspect of rehabilitation.

Orthotics & Prosthetics in Rehabilitation:

Concept of orthotics and prosthetics, material and fabrication for orthotics and prosthetics, Types of orthotics and prosthetics, Intelligent prosthetic Knee, Prosthetic Hand, Advance and automated prosthetics and orthosis, externally powered and Controlled orthotics & prosthetics, -FES system, Restoration of Hand function, Restoration of standing and walking, Myo-electric Hand. Engineering concepts in motor rehabilitation, applications. Computer Aided Engineering in Customized Component Design for orthotics and prosthetics.

Computer Application in Rehabilitation Engineering:

Interface in compensation for visual perception, Improvement of orientation and Mobility.

Engineering concepts in sensory rehabilitation Engineering; Sensory augmentation and substitution:

Visual system, Classification of Visual Impairments, Prevention and cure of visual impairments, Visual Augmentation, Tactile vision substitution, auditory substitution and augmentation, tactile auditory substitution, Assistive devices for the visual impaired, Hearing aids, cochlear implantation. Materials used for wheel chairs, Type of Wheel Chairs, design of wheel Chair, Tricycle, Walkers, Crutches, Robotics in Rehabilitation and Assistive Technologies.

Rehabilitation Aids for Mentally Impaired:

Walking Aids, Seating Aids and Postural Aids.

Applied Rehabilitative conditions:

Rehabilitation of people with spinal cord injury, stroke, cerebral palsy, traumatic brain injury, Hemiplegic, Spasticity, Myopathy, Cerebral injury and limb amputation. Rehabilitation engineering for the restoration of variety of human activities for disabilities that include sensory, motor of cognitive losses. **Artificial organs:** Kidney, heart, pancreas, liver, etc.

Burn injury Rehabilitation

Term Paper: On recent advances based on literature survey and/or lab/industry visit.

Text books and References:

1. Smith, Raymond V. & John H. Leslie, "Rehabilitation Engineering". CRC Press.
2. Mann, William C. and Joseph P. Pane, "Assistive Technology for Persons with Disabilities" The American Occupation Therapy Association Inc.
3. Webster, John G. et al, "Electronic Devices for Rehabilitation" John Wiley & Sons.
4. Cooper Rory A, OhnabeHisaichi, Hobson Douglas A. "An Introduction to Rehabilitation Engineering (Series in Medical Physics and Biomedical Engineering)", CRC Press.
5. Cooper Rory A, Rehabilitation Engineering Applied to Mobility and Manipulation (Series in Medical Physics and Biomedical Engineering), CRC Press.

AMXXXX Cell Mechanics and Mechanobiology

Designation	:	Elective
Pre-requisites	:	
Credit and Contact hours	:	4(L) - 0(T) – 0(P) - 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment:** (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission Surprise Tests, Quizzes, Assignments and Tutorials, etc.).
Course Outcomes		The students will be able: 1. to understand the basics of different cellular processes ranging from cell division to cell differentiation and death. 2. to have quantitative understanding of the way cells detects, modify, and respond to the physical properties within the cell environment. 3. to understand the role of models of cell mechanics, and the methods to measure mechanical properties of cells. 4. to understand the basic terminology and concepts of mechanics at the molecular and cellular level with an emphasis on quantitative analysis, modeling, and applications to clinical medicine.
Modes of Delivery	:	Talk and chalk, Power point presentations, practical, video lectures, project work etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1				√		√	√	√		
CO2	√		√			√		√		√
CO3	√	√	√	√	√		√	√	√	√
CO4		√			√		√		√	

Syllabus

Theory of cellular architecture, mechanical forces, deformations, and adhesions, leading up to force generation and interaction of cells with the external environment, measurement of cell mechanics using experimental techniques such as micropipette aspiration, single particle tracking and atomic force microscopy, cell shapes, biomaterials (soft filaments and sheets in cells), forces inside cells, random walks, movement in a viscous fluid, viscoelasticity (background, constitutive models and measurement in cells), complex filaments, rheology of cytoskeletal filaments, biomembranes (bilayers, micelles, vesicle formation), cell-cell and cell-matrix interactions, micropipette aspiration, single particle tracking, applications of cell mechanics viz. cell division, migration, morphogenesis, cancer metastasis

Text books and References:

1. David Boal, Mechanics of the Cell, Cambridge University Press (2012)
2. Christopher R. Jacobs, Hayden Huang, Ronald Y. Kwon, Introduction to Cell Mechanics and Mechanobiology, Garland Science (2013)
3. Ronald Kaunas, AssafZamal, Cell and Matrix Mechanics, CRC Press (2014)
4. Jonathon Howard, Mechanics of Motor Proteins and the Cytoskeleton, Sinauer Associates Inc. (2001)

AM22337 Artificial Intelligence in Biomedical Engineering

Designation	:	Elective
Pre-requisites	:	Basic knowledge of Computers, Linear algebra, etc.
Credit and Contact hours	:	4(L) - 0(T) – 0(P) - 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment: (Scheme)** 20 marks (5 marks for attendance + 15 marks for assignment submission Surprise Tests, Quizzes, Assignments and Tutorials, etc.).
Course Outcomes	:	The students will be able: 1. to describe features that can be used for a particular machine learning approach 2. to classify contrast pros and cons of various machine learning techniques. 3. to infer various machine learning approaches and paradigms. 4. to interrelate genetic algorithm concepts for the given problem.
Modes of Delivery	:	Talk and chalk, Power point presentations, practical, video lectures, project work etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1				√		√	√	√		
CO2	√		√			√		√		√
CO3	√	√	√	√	√		√	√	√	√
CO4		√			√		√		√	

Syllabus

Introduction to AI: Historical Evolution and AI today, Architecture of AI Systems, Theory (Knowledge, Logic, Search, Reasoning, Planning, Learning), Tools and Applications, Interface (Sensing, Actuation, Control), Domains and Scope of AI Applications, Inter-disciplinary Problem Solving, Intelligent/Expert Knowledge based Systems, Case-studies and Success Stories.

Knowledge Representation Methods: State space representation, graph representation, constraint oriented, symbolic representation, Examples: Timetable building, Puzzle solving (Sudoku), Path finding, Scheduling, Logical Representations, Propositional, First-order Logic Representations, Descriptive Logic Representations, Propositional Temporal Logic, Modelling Examples, Knowledge Graphs, Ontology Representation, Semantic Graphs, Representation and Access Mechanisms

AI and Machine Learning — Applications and Foundations: Heuristic Search, solving: Backtracking and CSP Search, Optimization: DFBB, Best-first Search / A* Search, IDA* search, Search over Large Knowledge Graphs, Examples: Puzzle solving, Airline Timetable/Scheduling,

Path finding, Reasoning & Deduction, Proof Techniques, Tools: Coq prover, solver Examples: Program analysis, State reachability analysis, Planning, Action, Control, Graph-plan, Hierarchical-plan, Case-study: Robot motion planning, Tools: Feed Forward-Feed Downward Planner.

Learning: Decision-tree learning, Supervised and Unsupervised learning, Classification and Regression, Support Vector Machines, Neural Networks (Basics), Reinforcement Learning, Tools: Tensor Flow, ML Flow etc.

AI for Healthcare: Disease Diagnosis and Patient Monitoring, Natural Language Processing, Data Analytics in Health Care

Mini Project: Practical approach to solve any innovative problem in healthcare using AI

Text books and References

1. D. L. Hudson and M. E. Cohen, "Neural Networks and Artificial Intelligence for Biomedical Engineering", Prentice Hall.
2. Vojislav Kecman, "Learning and soft computing", Pearson Education (Asia) Pte. Ltd.
3. Russell, Stuart, and Peter Norvig. "Artificial intelligence: a modern approach." (2002).
4. Heaton, Jeff. Artificial Intelligence for Humans, Volume 1: Fundamental Algorithms. CreateSpace Independent Publishing: North Charleston, SC, USA, 2013.

AMXXXX Biological Materials and Characterization		
Designation	:	Elective
Pre-requisites	:	
Credit and Contact hours	:	3(L) - 1(T) – 0(P) - 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment: (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission Surprise Tests, Quizzes, Assignments and Tutorials, etc.).
Course Outcomes		The students will be able: 1. to have knowledge of characterization methods for the determination of the structure and composition of biological materials. 2. to experience the various characterization techniques. 3. to understand the basics of optical and thermal characterization methods including probe microscopy and spectroscopy. 4. To apply the information gained in the development of new materials.
Modes of Delivery	:	Talk and chalk, Power point presentations, practical, video lectures, project work etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1									√	
CO2	√					√		√	√	
CO3	√					√		√		
CO4	√	√								

Syllabus

Nano and microstructure of biological materials, biominerals, proteins, biological ceramics, biological, polymer and polymer composite, biological elastomers, functional biological materials, bioinspired materials. scanning electron microscopy, atomic force microscopy, nanoindentation, x-ray diffraction, Raman spectroscopy, applications of techniques in biological material characterization

Text books and References:

1. Meyers, Marc André, and Po-Yu Chen. Biological Materials science: Biological materials, Bioinspired materials and biomaterials. Cambridge University Press, 2014.
2. Bandyopadhyay, Amit, and Susmita Bose, eds. Characterization of biomaterials. Newnes, 2013.

AMXXXX Medical Robotics

Designation	:	Elective
Pre-requisites	:	
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment: (Scheme)** 20 marks (5 marks for attendance + 15 marks for assignment submission Surprise Tests, Quizzes, Assignments and Tutorials, etc.).
Course Outcomes		**The successful student will learn:** 1. to use the software tools for designing and analyzing the robot motion. 2. to classify the performance to various sensors to its environment. 3. to recommend the suitable principles for specific conditions. 4. to create simple robots for surgical applications.
Modes of Delivery	:	Talk and chalk, Power point presentations, practical, video lectures, project work etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1			√				√		√	
CO2	√	√		√	√	√		√	√	√
CO3	√		√		√	√		√		
CO4	√	√		√						√

Syllabus

Introduction to Robotics: History, Overview of robot subsystems, Degrees of freedom, configurations and concept of workspace, Automation, Mechanisms and movements, Dynamic stabilization- Forward Kinematic Problems, Inverse Kinematic Problems, Solutions of Inverse Kinematic problems

Actuators, Grippers and Manipulators: Pneumatic and hydraulic actuators, Stepper motor control circuits, End effectors, Various types of Grippers, Design consideration in vacuum and other methods of gripping, actuator models, Construction of Manipulators, Manipulator Dynamic and Force Control.

Robotics In Medicine: Medical Robot (MR) History, Da Vinci Surgical System, Robotically Assisted Minimally Invasive Surgery (MIS), MR Visual Servoing, MR-MIS Navigation and Deformation Tracking, Haptic Feedback in MIS, Learning and Perceptual Docking in MIS Surgical Robotics (Laparoscopic and Endoscopic Manipulators), Oncology Robotics, Image guided robotic systems for focal ultrasound based surgical applications, System concept for robotic Tele-surgical system for off-pump CABG surgery, Urologic applications, Cardiac surgery, Neuro-surgery, Pediatric-, and General- Surgery, Gynecologic Surgery, General Surgery and Nano robotics.

Text books and References:

1. Nagrath and Mittal, "Robotics and Control", Tata McGraw-Hill, First edition, 2003.
2. Spong and Vidhyasagar, "Robot Dynamics and Control", John Wiley and Sons, First edition, 2008.
3. Jacob Rosen, Blake Hannaford & Richard M Satava, "Surgical Robotics: System Applications & Visions", Springer 2011.
4. Barbara Webb and Thomas Consi. R, "BioRobotics: Methods & Applications", AAAI Press/MIT Press, First Edition, 2001.

AMXXXX Poroelasticity		
Designation	:	Elective
Pre-requisites	:	
Credit and Contact hours	:	3(L) - 1(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme):** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment: (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission Surprise Tests, Quizzes, Assignments and Tutorials, etc.).
Course Outcomes		The students will be able: 1. to understand the concept of poroelastictiy in physiological systems. 2. to understand the solid deformation governed flow in biological tissues. 3. to incorporate the knowledge of poroelasticity in design of devices for physiological organs. 4. to include the concept of poroealsticity in device design.
Modes of Delivery	:	Talk and chalk, Power point presentations, practical, video lectures, project work etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1			√				√		√	
CO2	√	√		√	√	√		√	√	√
CO3	√		√		√	√		√		
CO4	√	√		√						√

Syllabus

The porous medium, the physical medium, relevant physical phenomena, pore scale vs. continuum scale, fluid and porous matrix properties, mathematical models of porous media, network models, statistical descriptors, fractal models, double porosity models, mass, momentum and energy conservation, equations of motion single phase flow in a porous medium, constitutive theory, Darcy's law, boundary value problems, Biot's thermodynamics, and constitutive equations, finite element formulation of fluid diffusion strong and weak forms; finite element formulation of coupled solid deformation-fluid flow mixture theory; the effective stress concept, variational principles; mixed formulation, elastic deformation of porous media, incompressibility constraint, advanced topics on modeling of porous media: bone, cartilage, and lung tissues.

Text books and References:

1. O. Coussy, Poromechanics, John Wiley & Sons, 2004.
2. J. Bear, Dynamics of Fluids in Porous Media, Dover Publications, 1972.
3. R.I. Borja, Plasticity - Modeling and Computation, Springer, 2013.
4. J. Rudnicki, Fundamentals of Continuum Mechanics, Wiley, 2014.
5. T. Belytschko, W.K. Liu and B. Moran, Nonlinear Finite Elements for Continua and Structures, Wiley, 2000.

AMXXXX Telemedicine		
Designation	:	Elective
Pre-requisites	:	
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment: (Scheme)** 20 marks (5 marks for attendance + 15 marks for assignment submission Surprise Tests, Quizzes, Assignments and Tutorials, etc.).
Course Outcomes	:	**The successful student will learn:** 1. to interpret the legal aspects of telemedicine. 2. to illustrate multimedia technologies in telemedicine. 3. to use protocols behind encryption techniques for secure transmission of data. 4. to apply telehealth in healthcare
Modes of Delivery	:	Talk and chalk, Power point presentations, practical, video lectures, project work etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1				√	√		√			
CO2	√	√			√			√		
CO3	√		√	√					√	√
CO4	√	√	√	√	√	√	√		√	√

Syllabus

Introduction to Telemedicine: History and Evolution of telemedicine, Functional diagram of telemedicine system, Essential Parameters for Telemedicine, Delivery Modes in Telemedicine, Benefits and Limitations of Telemedicine.

Ethical, Security and Legal Aspects of Telemedicine: Confidentiality, patient rights and consent: confidentiality and the law, the patient-doctor relationship, access to medical records, consent treatment - data protection & security, jurisdictional issues, intellectual property rights, Security in Telemedicine systems – Access control, Fire wall, Encryption, Authentication, Digital certificate, Digital Timestamp

Telemedical Technology: Principles of Multimedia - Text, Audio, Video, data, PSTN, POTS, ANT, ISDN, Internet, Wireless Communication - GSM satellite, and Micro wave, Modulation techniques, Types of Antenna, Satellite communication, Mobile hand-held devices and mobile communication. Internet technology and telemedicine using worldwide, Video and audio conferencing

Data Acquisition and Storage System: Acquisition System – Camera, Scanners, Display Systems – Analogue Devices, LCD, Laser Displays, Holographic Representation, Virtual Screen devices, Storage System – Magnetic System, Optical System, Solid State Disk

Data Security and Standards: Encryption, Cryptography, Mechanisms of encryption, phases of Encryption, Protocols: TCP/IP, ISO-OSI, Standards to followed DICOM, HL7, H. 320 series (Video phone-based ISBN) T. 120, H.324 (Video phone based PSTN)

Applications: Telemedicine access to health care services – health education and self-care. • Introduction to robotics surgery, Telesurgery, Teleradiology, Telepathology.

Text books and References:

1. Olga Ferrer Roca, M.Sosalndicissa , "Hand book of Telemedicine", IOS press, 2002.
2. Norris.A.C, "Essentials of Telemedicine and Telecare", John Sons & Ltd, 2002.
3. R.S.Khandpur "Telemedicine Technology and Applications (mhealth, Telehealth and ehealth)", PHI Learning Pvt.Ltd, Delhi 2017.
4. Wootton, R., Craig, J., Patterson, V., "Introduction to Telemedicine, Royal Society of Medicine" Press Ltd, Taylor & Francis 2006.

5. Latifi, R. "Current Principles and Practices of Telemedicine and e-Health" IOHS Press, Washington DC, 2008.
6. Bashshur, R.L., Shannon G.W. "History of Telemedicine", New Rochelle NY: Mary Ann Liebert Publishers, 2009.

AM*****		
AM*****		Elective
AM*****		
AM*****		4(L) - 0(T) - 0(P) – 4(Cr)
AM*****		**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment: (Scheme)** 20 marks (5 marks for attendance + 15 marks for assignment submission Surprise Tests, Quizzes, Assignments and Tutorials, etc.).
AM*****	:	The students will be able: 1. to develop skills in using materials tools and/or technology central to health care management. 2. to understand perspectives and values of health care management. 3. to develop the basic management skills and ability to work productively with others. 4. to integrate health care management theory with real world situations.
AM*****	:	Talk and chalk, Power point presentations, practical, video lectures, project work etc.
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BT-2234: Bioethics, Biosafety and IPR		
Designation	:	Elective
Pre-requisites	:	
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment: (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission Surprise Tests, Quizzes, Assignments and Tutorials etc.)
Course Outcomes	:	The students will be able: 1. to develop fundamental understanding intellectual properties and ipr. 2. to understand the applications and advantages of ipr. 3. to understand the biosafety and its relation to biomedical engineering. 4. interpret the basics of biosafety and bioethics and its impact on all the biological sciences and the quality of human life.
Modes of Delivery	:	Talk and chalk, Power point presentations, practical, video lectures, project work etc

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	√				√	√		√		√
CO2					√	√		√		√
CO3					√	√		√		√
CO4					√	√		√		√

Syllabus

Different ethical issues related to biomedical engineering, Importance and application of bioethics. International guidelines on bio-safety and bioethics and current legal issues.

Different standard practices (GLP, GMP, GCP etc.). Social and international challenges for modern medicine, GM food, stem cell therapy.

Types of IP: Patents, Trademarks, Copyright & Related Rights, Industrial Design, Traditional Knowledge, trade secrets, Geographical Indications. Precautions while patenting disclosure/non-disclosure. Patent infringement-meaning, scope, litigation, case studies.

Applications, international guidelines, and importance of biosafety, biosafety guidelines of biotechnology laboratories, important factors and safety guidelines to start-up of a biomedical-based company.

Role of different organizational level in bio-business set-up. Transition of an idea from biomedical-based R&D to business units, fund generation and resource creation for bio business startup.

Different bio-product based industries, their history, products and establishments. Different national and international organizations their functioning.

Text books and References:

1. Eric Grace Biotechnology unzipped: Promises and realities. Wash. DC: Joseph Henry Press. 1997.
2. Arthur Kornberg. Sausalito, CA The golden helix: University Science Books. 1995.
3. Richard Oliver the coming biotech age: The business of biomaterials. NY: McGraw Hill. 2000.
4. Ruth Ellen Bulger et al., The ethical dimensions of the biological sciences. NY: Cambridge University Press. 1993.
5. David F. Betsch, Principles of Biotechnology

AMXXXX Sports Biomechanics

Designation		Elective
Pre-requisites		
Credit and Contact hours		4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods		**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment: (Scheme)** 20 marks (5 marks for attendance + 15 marks for assignment submission Surprise Tests, Quizzes, Assignments and Tutorials, etc.).
Course Outcomes	:	The students will be able: 1. to define the importance of biomechanics in sport. 2. to adapt the biomechanical analysis for different sport branches. 3. the kinetic analysis of the high jump. 4. to recognize the movements in skeleto-muscle system.
Modes of Delivery	:	Talk and chalk, Power point presentations, practical, video lectures, project work etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	√		√	√		√			√	
CO2	√		√	√	√					
CO3	√			√	√	√				
CO4	√	√	√	√		√				

Syllabus

Muscle Action in Sport and Exercise - Biomechanical view:
Mechanical Properties and Performance in Skeletal Muscles, Muscle-Tendon Architecture and Athletic Performance - Eccentric Muscle Action in Sport and Exercise - Stretch-Shortening Cycle of Muscle Function - Biomechanical Foundations of Strength and Power Training.

Jumping and Aerial Movement: Aerial Movement - The High Jump - Jumping in Figure Skating, Throwing and Hitting, Principles of Throwing, The Flight of Sports Projectiles - Javelin Throwing: An Approach to Performance Development - Shot Putting - Hammer Throwing: Problems and Prospects.

Injury Prevention and Rehabilitation: Mechanisms of Musculoskeletal Injury - Musculoskeletal Loading During Landing - Sport-Related Spinal Injuries and their Prevention - Impact Propagation and its Effects on the Human Body - Neuromechanics of the Initial Phase of Eccentric Contraction-Induced Muscle Injury.

Special Olympic Sports: Manual Wheelchair Propulsion, Sports after Amputation. Biomechanics of Dance, Biomechanics of Martial arts.

Biomechanics of YOGA: Introduction, Definition of Yoga, Origin of the word Yoga, Meaning of the word Hatha, Stages of Yoga, Types of Yoga, Karma yoga, Gnana Yoga, Bhakti Yoga, Kriya Yoga, Buddhism and Yoga, Yoga as a Universally accepted term

Text books and References:

1. Vladimir Zatsiorsky, Wiley, 2008, "Biomechanics in Sport: Performance Enhancement and Injury Prevention"
2. Roger Bartlett, Melanie Bussey, Taylor & Francis , 2013, "Sports Biomechanics: Reducing Injury Risk and Improving Sports Performance"
3. Roger Bartlett , Taylor & Francis, 2007, "Introduction to Sports Biomechanics: Analyzing Human Movement Patterns"

AM21334 Biological System Analysis and Control		
Designation	:	Elective
Pre-requisites	:	
Credit and Contact hours	:	4(l) - 0(t) – 0(p) – 4(cr)
Assessment Methods	:	**Theory examination: (scheme)** end semester exam: 60 marks mid semester exam: 20 marks **Internal assessment: (scheme)** 20 marks (5 marks for attendance + 15 marks for assignment submission surprise tests, quizzes, assignments and tutorials etc.)
Course Outcomes	:	The students will be able: 1. to recast a range of biological problems (involving biochemistry, fluid mechanics, mechanics, electricity and physiology) into linear or nonlinear quantitative ordinary differential equation models. 2. to choose and apply appropriate analytical and numerical tools to solve ordinary differential equation models of biological problems. 3. to understand, predict and interpret the biological significance of linear and nonlinear control systems. 4. to identify systems models that fit experimental data. (performs systems identification and parameter estimation.)
Modes of Delivery	:	Talk and chalk, power point presentations, project work etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10

CO1	√									
CO2	√			√		√				
CO3	√	√		√		√			√	√
CO4		√		√					√	

Syllabus

Introduction to linear control system, mathematical modeling, transfer functions, signal flow graphs, feedback control and its characteristics, time domain and frequency domain analysis, stability analysis, routh hurwitz criteria, root locus plot, bode plot, nyquist plot and nichols plot, introduction to digital control, optimal, adaptive and non-linear control.

Introduction mathematical modeling and control. Biological receptors, thermoregulatory systems, human limbs, semicircular canal, musculoskeletal system, respiratory system, pupil control system, neuromuscular reflex motion.

Application of control theory to physiological systems, time domain and frequency domain analysis, stability analysis, biological performance criteria and adaptive control, simulation and implementation.

Term paper: on recent advances based on literature survey and/or lab/industry visit

Text Books and References:

1. Michael C. K. Khoo, Physiological Control Systems: Analysis, Simulation, and Estimation (Ieee Press Series On Biomedical Engineering)
2. John H. Milsum, Biological Control Systems Analysis, Mcgraw-Hill

Master of Technology

In

ENGINEERING MECHANICS AND DESIGN

Course Structure, Scheme of Evaluation and Syllabi

(Effective from July 2021)

Department of Applied Mechanics

Motilal Nehru National Institute of Technology Allahabad

Allahabad, U.P. -211004, INDIA

VISION AND MISSION OF THE INSTITUTE

VISION

To establish a unique identity for the institute amongst national and international academic and research organizations through knowledge creation, acquisition and dissemination for the benefit of society and humanity.

MISSION

- To generate high quality human and knowledge resources in our core areas of competence and emerging areas to make valuable contribution in technology for social and economic development of the nation. Focused efforts to be undertaken for identification, monitoring and control of objective attributes of quality and for continuous enhancement of academic processes, infrastructure and ambience.
- To efficaciously enhance and expand, even beyond national boundaries, its contribution to the betterment of technical education and offer international programs of teaching, consultancy and research.

VISION AND MISSION OF THE DEPARTMENT

VISION

To establish itself as a department recognized for its quality post graduate education and research in the broad field of Applied Mechanics and Materials.

MISSION

- To produce high quality human resource in the area of Applied Mechanics and Materials Engineering by way of continuous up gradation of curriculum, improvement in academic processes & ambience, and faculty & infrastructure development.
- To create knowledge resource through research in emerging areas of Applied Mechanics and Materials in collaboration with national & international academic, research and industrial organizations and disseminate the same by contributing and conducting STTP, Workshops, Symposiums and Conferences.

Program Educational Objectives (PEOs)

The *Program Educational Objectives* (PEOs) embody the expected accomplishments of students, who successfully graduate from the program, during their first few years (about 3-5) following their graduation. The PEOs for the present program are as follows.

PEO-1	To enable students to excel in their career in related industry / research / teaching involving solid mechanics, meeting the needs of global standards in the field, by means of successfully applying their knowledge on solid mechanics and its engineering applications, acquired during their graduation.
PEO-2	To develop overall ability and confidence among the students for successful product design, relevant to their career / professional growth in solid mechanics or related areas.
PEO-3	To make students have the required professional attitude and effective communication skills enabling them to work as effective collaborators on multidisciplinary projects, as well as leadership skills to lead teams from multidisciplinary background.
PEO-4	To make students become aware on the importance of life-long and self-learning and make them confident and enthusiastic enough for the same for their professional growth. This would also enable them to successfully pursue advanced studies / research, if they so desire.
PEO-5	To inculcate into students the qualities required to ignite thought process necessary for critical thinking and innovation in their work / research / teaching and to make them aware on issues of professional ethics, environmental and social responsibility.

Mapping of *Program Educational Objectives* (PEOs) to *Mission Statements* (MS)

Mission Statements	PEO-1	PEO-2	PEO-3	PEO-4	PEO-5
MS-1	√	√	√	√	√
MS-2	√		√		√

Graduate Attributes (GAs):

The following *Graduate Attributes* (GAs), attained through the *Program Outcomes* mentioned later, would help the successful students passing through the program to achieve the aforementioned PEOs.

1. **Scholarship of Knowledge**: Acquire in-depth knowledge of specific discipline or professional area, including wider and global perspective, with an ability to discriminate, evaluate, analyze and synthesize existing and new knowledge, and integration of the same for enhancement of knowledge.
2. **Critical Thinking**: Analyze complex engineering problems critically, apply independent judgment for synthesizing information to make intellectual and/or creative advances for conducting research in a wider theoretical, practical and policy context.
3. **Problem Solving**: Think laterally and originally, conceptualize and solve engineering problems, evaluate a wide range of potential solutions for those problems and arrive at feasible, optimal solutions after considering public health and safety, cultural, societal and environmental factors in the core areas of expertise.
4. **Research Skill**: Extract information pertinent to unfamiliar problems through literature survey and experiments, apply appropriate research methodologies, techniques and tools, design, conduct experiments, analyze and interpret data, demonstrate higher order skill and view things in a broader perspective, contribute individually/in group(s) to the development of scientific/technological knowledge in one or more domains of engineering.
5. **Usage of modern tools**: Create, select, learn and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modeling, to complex engineering activities with an understanding of the limitations.
6. **Collaborative and Multidisciplinary work**: Possess knowledge and understanding of group dynamics, recognize opportunities and contribute positively to collaborative-multidisciplinary scientific research, demonstrate a capacity for self-management and teamwork, decision-making based on open-mindedness, objectivity and rational analysis in order to achieve common goals and further the learning of themselves as well as others.
7. **Project Management and Finance**: Demonstrate knowledge and understanding of engineering and management principles and apply the same to one's own work, as a member and leader in a team, manage projects efficiently in respective disciplines and multidisciplinary environments after consideration of economic and financial factors.
8. **Communication Skill**: Communicate with the engineering community, and with society at large, regarding complex engineering activities confidently and effectively, such as, being able to comprehend and write effective reports and design documentation by adhering to appropriate standards, make effective presentations, and give and receive clear instructions.
9. **Life-long Learning**: Recognize the need for, and have the preparation and ability to engage in life-long learning independently, with a high level of enthusiasm and commitment to improve knowledge and competence continuously.
10. **Ethical Practices, Environment and Social Responsibility**: Acquire professional and intellectual integrity, professional code of conduct, ethics of research and scholarship, consideration of the impact of research outcomes on professional practices and an understanding of responsibility to contribute to the community for sustainable development of society.
11. **Independent and Reflective Learning**: Observe and examine critically the outcomes of one's actions and make corrective measures subsequently, and learn from mistakes without depending on external feedback.

These aforementioned GAs represent the required linkage between the *Program Outcomes* and the *Program Educational Objectives*.

Mapping of *Graduate Attributes* (GAs) to *Program Educational Objectives* (PEOs)

PEOs	GA-1	GA-2	GA-3	GA-4	GA-5	GA-6	GA-7	GA-8	GA-9	GA-10	GA-11
PEO-1	√		√		√					√	
PEO-2	√	√	√		√	√	√		√	√	
PEO-3		√				√	√	√		√	√
PEO-4	√		√	√	√			√	√		√
PEO-5		√	√	√		√	√			√	

PROGRAM OUTCOMES (POs):

(*Numbers inside parentheses indicate related GAs*)

On successfully graduating from the M.Tech Program in Engineering Mechanics and Design students are expected to be able to

1. Further improve their fundamental Mathematical, Scientific & Engineering Knowledge, acquired from their undergraduate level, to develop thorough understanding / knowledge, analytical and problem solving skills in the area of solid mechanics. (1, 2, 3)
2. Inculcate the necessary background for being acquainted with state-of-the-art tools and software and to work with them for related engineering application in the area of solid mechanics. (4, 5)
3. Develop skill and become confident for performing practical / virtual experimentation as well as develop skill for management and retrieval of scientific / engineering information / data and their interpretation. (3, 4, 5)
4. Critically apply the scientific and engineering principles for obtaining innovative solutions for engineering problems involving real-life engineering analysis and design in the area of solid mechanics. (1, 2, 3, 4)
5. Communicate effectively through oral and writing skills, helping their personality development for team work and leadership qualities as well as ability to work in a multidisciplinary environment, thereby enabling their preparedness for a successful career, including in industry. (6, 7, 8)

6. Understand the importance of and develop confidence for attaining self and life-long learning abilities. (4, 5, 9, 11)
7. Develop creative and optimal solution for engineering problems considering different aspects for design, like cost, environmental and societal effects, professional ethics and other constraints. (6, 7, 8, 10)
8. Get motivated and feel confident for pursuing higher studies and research in areas of complex solid mechanics problems of engineering relevance as well as for teaching profession. (1, 2, 4, 9, 11)

Mapping of *Program Outcomes* (POs) to *Program Educational Objectives* (PEOs)

POs	PEO-1	PEO-2	PEO-3	PEO-4	PEO-5
PO-1	√	√		√	
PO-2		√		√	
PO-3	√		√		
PO-4	√	√		√	√
PO-5			√		√
PO-6	√			√	
PO-7	√	√		√	√
PO-8	√			√	√

Course Structure and Evaluation Scheme

(Program: M.Tech in *Engineering Mechanics and Design*)

I Semester (Total Credits = 20):

Course Code	Subject Name	L	T	P	Credits	Distribution of Marks out of 100		
						TA	Mid Sem. Exam	End. Sem. Exam
AM21101	Applied Mathematics and Computation	4	0	0	4	20	20	60
AM21102	Continuum Mechanics	4	0	0	4	20	20	60
AM21XXX	Elective-I	4	0	0	4	20	20	60
AM21XXX	Elective-II	4	0	0	4	20	20	60
AM21XXX	Elective-III	4	0	0	4	20	20	60

List of Electives (Semester I):

Course Code	Subject Name
AM21310	Applied Elasticity
AM21311	Finite Element Methods
AM21312	Optimization Techniques
AM21313	Computational Solid Mechanic
AM21314	Dynamics of Structures
AM21315	Structural Reliability
AM21316	Design of Thin Walled Structures
AMXXXXX	Non-Destructive Testing
AMXXXXX	Biomechanics
AMXXXXX	Advanced Fluid Mechanics
MEXXXXX	Computer Aided Design

II Semester (Total Credits = 20):

Course Code	Subject Name	L	T	P	Credits	Distribution of Marks out of 100		
						TA	Mid Sem. Exam	End Sem. Exam
AM22101	Analysis and Design of Plates and Shells	4	0	0	4	20	20	60
AM22201	Experiments and Computations in Solid Mechanics	0	0	6	4	50	-	50
AM22XXX	Elective-IV	4	0	0	4	20	20	60
AM22XXX	Elective-V	4	0	0	4	20	20	60
AM22XXX	Elective-VI	4	0	0	4	20	20	60

List of Electives (Semester II):

Course Code	Subject Name
AM22310	Wave Propagation in Solids

AM22312	Theory of Stability
AM22313	Mechanics of Composite Materials
AM22314	Multi-Functional Materials and Structures
AM22315	Multiscale Modeling of Advanced Materials
AM22316	Applied Plasticity
AM22317	Fracture Mechanics
AM22318	Continuum Damage Mechanics
AM22319	Analysis and Design of Composite Structures
AM22320	Micromechanics
AMXXXXX	Electro-acoustic Transducers

III Semester (Total Credits = 20):

Course Code	Subject Name	Credits
AM23651	Special Study/Term Project/State of the Art/Colloquium/Industrial/ Research Training (Proposed)	4
AM23601	Thesis/Project	16

IV Semester (Total Credits = 20):

Course Code	Subject Name	Credits
AM24601	Thesis/Project	20

Note: The distribution of thesis evaluation marks will be as follows:

1. Supervisor(s) evaluation component: 60%
2. Oral Board evaluation component: 40%

AM21101 Applied Mathematics and Computation		
Designation	:	Compulsory
Pre-requisites	:	*Engineering Mathematics &Computer Programming*
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment (Scheme):**20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).
Course Outcomes	:	see table below
Modes of Delivery	:	Talk and chalk (main), Power point presentations (sometimes), Self-study (as assigned), Hands on training through Computer Programming.
Topics to be Covered	:	see table below
Text books, References		1. Numerical Methods in Engineering: M. Salvadori. 2. Applied Numerical Methods: B. Carnahan. 3. Applied Numerical Analysis: C.F. Gerald and P.O. Wheatley.

Course Outcomes

Sl. No.	On successful completion of the course, student is expected to be able to:	Mapping into POs
1.	To Identify the differences between "Exact methods & Computational Methods" and applications of these methods.	1, 2
2.	To Develop knowledge of expressing a real life problem in terms of mathematics i.e. to develop the skill of Mathematical Modelling.	3.4
3.	To Identify and develop the skill to solve real life engineering problems e.g. Nonlinear Problems, Initial Value & Boundary Value Problems, Numerical Differentiation & Integration problems.	4, 5, 6
4.	To develop skill of writing Flow Charts of real life engineering problems and transform those into computer programming	6, 7, 8

Topics to be Covered

Units	Details
1.	**Review of Elementary Engineering Mathematics:** Solution of homogeneous and non-homogeneous equations; Power series; Laplace transform and its applications; Fourier series and Fourier transform
2.	**Linear Algebra:** Matrices and Linear Transformations, Operational Fundamentals of Linear Algebra, Systems of Linear Equations, Gauss Elimination Family of Methods, Special Systems and Special Methods, Numerical Aspects in Linear Systems, Eigenvalues and Eigenvectors, Diagonalization and Similarity Transformations, Jacobi and Givens Rotation Methods, Tri-diagonal Matrices, QR Decomposition Method, Eigenvalue Problem of General Matrices, Singular Value Decomposition, Direct and Iterative solvers.
3.	**Ordinary Differential Equations:** Introduction to ordinary differential equations, homogeneous linear equations of second order, non-homogeneous linear equations of second order, free and forced oscillation problems, problems with variable coefficients, system of equations.
4.	**Partial Differential Equations (PDEs):** Existence and uniqueness of differential equations, nature of solution, Hyperbolic, Parabolic and Elliptic PDEs, nonlinear PDEs.
5.	**Nonlinear Equations:** Motivation, Open and braketing method, Bisection, Fixed point, Newton's method, Secant and False position method, Rate of convergence, Merits and demerits of methods.
6.	**Numerical Integration:** Motivation, Newton-Kotes method, Trapezoidal rule, Simpson's rule, Rhomberg integration, Gauss Quadrature.
7.	**Initial Value Problem:** Motivation, Euler's method, Modified Euler method, Runge-Kutta methods, Adaptive integrations and multistep methods.
8.	**Boundary-value and Eigen-value Problem:** Methods and Applications in Mechanics.

		4. Numerical Mathematics & Computing: W. Cheney and D. Kincaid. 5. Applied Partial Differential Equations: Paul DuChateau and David Zachmann. 6. Partial Differential Equations for Scientists and Engineers: Stanley J. Farlow. 7. Numerical Methods for Partial Differential Equations: William F. Ames. 8. Numerical Methods for Elliptic and Parabolic Partial Differential Equations: John R Levison, Peter Knabner, Lutz Angermann.

AM21102 Continuum Mechanics		
Designation	:	Compulsory
Pre-requisites	:	*Basic Engineering Mathematics, Linear Algebra*
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks; Mid Semester Exam: 20 marks **Internal Assessment (Scheme):** 20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).
Modes of Delivery	:	Talk and chalk (main), Power point presentations (sometimes), Self-study (as assigned), Hands on training through Computer Programming.

Course Outcomes:

Sl. No.	On successful completion of the course, student is expected to be able to:	Mapping into POs
1.	To read and comprehend journals and texts written in tensorial notations by applying the knowledge of tensors.	1, 8
2.	To describe the motion and deformation of body.	1, 4
3.	To apply the suitable stress and strain measures depending on the need.	1, 5
4.	To formulate the constitutive equations obeying the general principles of mechanics and thermodynamics.	1, 3, 7

Topics to be Covered:

Units	Details
1.	**Mathematical Preliminaries and Introduction:** Index notation, range and summation convention, free and dummy indices, Kronecker delta, Levi-Civita symbol, co-ordinate transformations, Cartesian tensor, properties of tensors, tensors as linear operators, invariants of tensor, eigen values and Eigen vectors, polar decomposition, scalar, vector and tensor functions, comma notation, gradient of a scalar, gradient of a vector, divergence and curl of a tensor, integral theorems of vectors and tensors. Notion of a continuum, configuration, mass and density, descriptions of motion, material and spatial coordinates.
2.	**Kinematics of Deformation and Motion:** Deformation gradient tensor, stretch and rotation, right and left Cauchy-Green deformation tensors, Eulerian and Lagrangian strain tensors, strain-displacement relations, infinitesimal strain tensor, infinitesimal stretch and rotation, compatibility conditions, principal strains and strain deviator, material and local time derivatives, stretching and vorticity, path lines, stream lines, vortex lines, Reynolds transport theorem, circulation and vorticity.
3.	**Forces and Stresses:** Body and surface forces, Cauchy Stress Tensor, First and Second Piola-Kirchhoff Stress Tensor, Deviatoric and Pressure Components, Principal Stress.
4.	**Fundamental Balance Laws of Continuum Mechanics:** Balance of Mass – Continuity Equation; Balance of Linear Momentum – Equations of Motion / Equilibrium Equations; Moments of Momentum (Angular Momentum); Balance of Energy - First Law of Thermodynamics, Energy Equation; Equations of State – Entropy, Second Law of Thermodynamics; Clausius-Duhem Inequality, Dissipation Functions
5.	**Constitutive Relations and Material Models:** Constitutive Assumptions; Ideal Fluids; Elastic Fluids, Hyperelastic Material; Notion of Isotropy; Isothermal Elasticity - Thermodynamic Restrictions, Material Frame Indifference, Material Symmetry; Hooke's law, Stokes problem and Newtonian fluids.

Text books, References:

1. Introduction to the Mechanics of a Continuous Medium: Lawrence E. Malvern.
2. An Introduction to Continuum Mechanics: Morton M. Gurtin.
3. Introduction to Continuum Mechanics for Engineers: Ray M. Bowen.

		4. Continuum mechanics for engineers: G. Thomas Mase and George E. Mase. 5. Theory and Problems of Continuum Mechanics: George E. Mase. 6. Nonlinear Continuum Mechanics for Finite Element Analysis: J. Bonet and R. D. Wood. 7. Continuum mechanics and plasticity: Han Chin Wu.

AM21310 Applied Elasticity			
Designation	:	Elective	
Pre-requisites	:	Mechanics of Materials	
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)	
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment (Scheme):**20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).	

Course Outcomes:

Sl. No.	On successful completion of the course, student is expected to be able to:	Mapping into POs
1.	Analyze the stress/strain behavior of materials and the stress-strain relations.	1,2,3
2.	Analyze solid mechanics problems using classical and energy methods.	4,6,7
3.	Apply different failure criteria for general state of stress states at points.	5
4.	Understand the time dependent behavior of materials.	1,2

Modes of Delivery: Talk and chalk (main), Power point presentations (sometimes), Self-study (as assigned), Hands on training through Computer Programming.

Topics to be Covered:

Units	Details
1.	**Analysis of Stress:** Concept of Stress, Stress Components, Equilibrium Equations, Stress on a General Plane (Direction Cosines, Axis Transformation, Stress on Oblique Plane through a point, Stress Transformation), Principal Stresses, Stress Invariants, Deviatoric Stresses, Octahedral Stresses, Plane Stress, Stress Boundary Condition Problem.
2.	**Analysis of Strain:** Deformations (Lagrangian Description, Eulerian Description), Concept of Strain, Strain Components (Geometrical Interpretation), Compatibility Equations, Strain transformation, Principal Strains, Strain Invariants, Deviatoric Strains, Octahedral Strains, Plane Strain, Strain Rates.
3.	**Stress-Strain Relations:** Introduction, One-Dimensional Stress-Strain Relations (Idealized Time independent and Time–dependent stress-strain laws), Linear Elasticity (Generalized Hooke's Law), Stress-Strain Relationships for Isotropic and Anisotropic Materials (Plane stress and Plane Strain)
4.	**Basic Equations of Elasticity for Solids:** Introduction, Stresses in Terms of displacements, Equilibrium Equations in terms of displacements, Compatibility equations in Terms of Stresses, Special cases of Elasticity equations (Plane Stress, Plane strain, Polar Co-ordinates), Principle of Superposition, Uniqueness of Solution, Principle of virtual work, Potential and Complementary energy, Variational Principles, St. Venant's Principle, Methods of analysis for Elastic Solutions, Elastic solutions by Displacement and stress Functions, Airy's Stress Function (Plane stress, Plane strain, Polar Co-ordinates).
5.	**Torsion:** Introduction, Circular shaft, Torsion of non-circular cross-section, St. Venant's theory, Warping function, Prandtl's stress function, Shafts of other cross-sections, Torsion of bars with thin walled sections.
6.	**Viscoelasticity:** Introduction, Viscoelastic models (Maxwell, Kelvin-Voigt, Generalized Maxwell and Kelvin models), Viscoelastic stress-strain relationships.

Text books, References:

1. Mathematical Theory of Elasticity: I. S. Sokolnikoff
2. Advanced Mechanics of Materials: Boresi
3. Theoretical Elasticity: A. E. Green and W. Zerna
4. Theory of Elasticity: Timoshenko and Gere
5. Advanced Strength and Applied Elasticity: A. C. Ugural and S. K. Fenster

		6. Applied Elasticity: R.T.Fenner 7. Advanced Strength of Materials: L. S. Srinath

AM21311 Finite Element Methods

Designation	:	Elective
Pre-requisites	:	Linear Algebra with Matrix Operations, Differential Equations, Mechanics of Materials, Theory of Elasticity.
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment (Scheme):** 20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).

Course Outcomes :

Sl. No.	On successful completion of the course, student is expected to be able to:	Mapping into POs
1.	Identify the primary and derived dependent variables involved, kinematic and natural constrains to be imposed and other required detail for a general initial-boundary value problem, primarily related to solid mechanics.	1
2.	Formulate, through use of energy principles and Variational methods, relevant finite element equations, implement the same into computer program and solve a solid mechanics problem, using the Finite Element Method.	1, 2, 7
3.	Analyze, interpret and communicate results obtained from developed computer program as well as from commercial finite element Software.	2, 3, 4, 5
4.	Be prepared for extending the complete knowledge of solving a solid mechanics problem using FEM, to a more general type of initial-boundary value problem related to other areas of engineering / science.	1, 6, 7, 8
5.	Pursue higher / self-study and research, involving Finite Element Analysis in the domain of solid mechanics, in general.	6, 8

Modes of Delivery : Talk and chalk (main), Power point presentations (sometimes), Self-study (as assigned), Hands on training through Computer Programming.

Topics to be Covered :

Units	Details
1.	**Introduction:** Course objectives, History of FEM, Application Areas, Concept of Discretization and Interpolation, Different Steps in Finite Element Analysis, Demonstration through FE Analysis of Axially Loaded Bar.
2.	**Variational Methods & Energy Principles:** Brief Introduction to Variational Calculus, Energy Principles – Principle of Virtual Work and Complementary Virtual Work, Principle of Minimum Potential Energy and Complementary Potential Energy, Mixed Principles.
3.	**Detailed FE Formulation for Solid Mechanics:** Finite element discretization – Piecewise Interpolation & Shape Functions, C0 and C1 Interpolation, Conventional 1D, 2D & 3D Elements, Special Elements, Sub Parametric, Super Parametric & Isoparametric elements. FE Formulation Using Variational Methods & Energy Principles. Coordinate transformation & Jacobian, Numerical Integration & Calculation of Element Matrices.
4.	**Classical Finite Element Methods:** Ritz Method, Method of Weighted Residuals, Galerkin method, Strong & Weak formulation. One & Two dimensional structural & non-structural boundary value problems involving scalar and vector valued dependent variables.
5.	**Dynamic Problems and Other Topics (in brief):** Dynamic Equations from Hamilton's Principle, Mass (Consistent & Diagonal) and Damping Matrices, Free Vibration Analysis – Eigen value problem, Time-History analysis in Forced Vibration – Direct (Explicit & Implicit) Integration Methods. Nonlinear & Stability problems, Error & Error estimation, Conforming & Non-conforming Elements, Patch test.
6.	**Application through Computer Programming:**

			➢ Input for Geometric & Material Configuration, Loading and Boundary Conditions. ➢ Automatic Mesh Generation, Nodal Coordinate and Nodal Connectivity. ➢ Calculation of Element Matrices (Stiffness & Mass Matrices, Load Vector). ➢ Assembly of Element Matrices to Global Matrices, Imposing Boundary Conditions. ➢ Solution (Gauss Elimination & other methods), Post Processing.
Text books, References	:	1. Energy and Finite Element Methods in Structural Mechanics: I. H. Shames and C. L. Dym. 2. Concepts and Applications of Finite Element Analysis: R. D. Cook, D. S. Malkus and M. E. Plesha. 3. The Finite Element Method Vol. I-II: O.C. Zienkiwicz and R.L. Taylor. 4. Finite Element Procedures: K. J. Bathe. 5. An Introduction to Finite Element Methods: J.N. Reddy. 6. Finite Element Methods in Engineering: S.S. Rao.	

AM21312 Optimization Techniques				
Designation	:	Elective		
Pre-requisites	:	*Differential Calculus & Computer Programming*		
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)		
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks		
		Internal Assessment (Scheme):20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).		
Course Outcomes	:	**Sl. No.**	**On successful completion of the course, student is expected to be able to:**	**Mapping into POs**
		1.	Development of the skill of finding optimum value of desired variable in a real life engineering problem.	1,2
		2.	Development of knowledge of expressing a real life problem in terms of mathematics i.e to develop the skill of Mathematical Modeling.	3,4
		3.	To Identify and develop the skill to solve real life engineering problems e.g. Linear & Non-linear Programming, Gradient Methods & Artificial Neural Networks	4, 4, 6
		4.	To develop skill of writing Flow Charts of real life engineering problems and transform those into computer programming	6, 7, 8
Modes of Delivery	:	Talk and chalk (main), Power point presentations (sometimes), Self-study (as assigned), Hands on training through Computer Programming.		
Topics to be Covered	:	**Units**	**Details**	
		1.	**Introduction to Optimization:** Design variables, Design constraints, Objective function Design space, feasible region, Problem statement, Local and Global optima, Classification of optimization problems, Solution by calculus and numerical methods.	
		2.	**Linear Programming:** Simplex method, Geometric Programming: Application to simple problems.	
		3.	**Non-Linear Programming:** Method of approximation programming, Kelly's Cutting Plane method.	
		4.	**Gradient Methods:** Steepest descent and Side step method. Conjugate Gradient method, Rosin's Gradient Projection Method, Zotendik's method of feasible directions, Unconstrained minimization, and penalty function technique search procedures.	
		5.	**Genetic Algorithm:** Artificial Neural Network, Dynamic programming	
		6.	**Application to problems of Process Equipment, Development of computer programmes.**	
Text books, References		1. Engineering Optimization, Theory and Practice: S. S. Rao 2. Optimization of Structural and Mechanical Systems: J. S. Arora 3. Elements of Structural Optimization: R. T. Haftka and Z. Gürdal 4. Cost Optimization of Structures: Fuzzy Logic, Genetic Algorithm and Parallel Computing: H. Adeli and K. C. Sarma 5. An Introduction to Optimization: Edwin K. P. Chong and Stanislaw H. Żak 6. Nonlinear Optimization- Theory and Algorithms: L.C.W. Dixon 7. Linear Programming Vol.I: G. Hadley 8. Nonlinear and Dynamic Programming, Vol.II: G. Hadley		

AM21313 Computational Solid Mechanics				
Designation	:	Elective		
Pre-requisites	:	*Engineering and Numerical Mathematics, Computer Programming, Advanced Solid Mechanics / Continuum Solid Mechanics, Finite Element Method (basic).*		
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)		
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks		
		Internal Assessment (Scheme):20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).		
Course Outcomes	:	**Sl. No.**	**On successful completion of the course, student is expected to be able to:**	**Mapping into POs**
		1.	Recognize the type, variables involved etc. for a complex solid mechanics problem and develop complete formulation in terms of discretized system of equations, through the use of energy principles and Variational methods, for obtaining solution using different numerical methods, primarily the FEM.	1, 2, 4, 7
		2.	Develop algorithm and implement the developed mathematical formulation through computer programming for obtaining solution of the solid mechanics problem, as well as compare these solution with those obtained from commercial packages.	1, 2
		3.	Analyze, interpret and communicate the results obtained for the complex solid mechanics problem and re-plan on how to improve the accuracy of the results obtained for the same.	3, 5
		4.	Be prepared for extending the complete knowledge of solving a complex solid mechanics problem, to a more general type of initial-boundary value problem of practical relevance, related to other areas of engineering / science.	6, 7
		5.	Pursue higher / self-study and research, in the domain of computational solid mechanics.	8
Modes of Delivery	:	Power point presentations / Talk and chalk (as per requirement), Self-study (as assigned), Hands on training through Computer Programming.		
Topics to be Covered	:	**Units**	**Details**	
		1.	**Introduction and Review of Mathematical Preliminaries:** Vector and Tensor Analysis, Elements of Linear Algebra, Multivariable Calculus, Linearization of Nonlinear PDE's, Different numerical methods for Computational Solid Mechanics, Programming Languages and Softwares for Computational Solid Mechanics.	
		2.	**Review of Continuum Solid Mechanics and FEM:** Kinematics and Deformation Gradient, Material and Spatial Description, Stress and Strain Tensor, Compatibility Equations, Constitutive relations, Elasticity Tensor and Generalized Hooke's law, Different Material Models, Balance Laws and Equilibrium equations, Transformation of Coordinates, Energy Principles based Variational Formulation of Finite Element Equations for General Solid Mechanics Problem.	
		3.	**Elements of Computer Programming (Through programming in FORTRAN/C++):** Brief history and evolution of Computers and Programming Languages, Constants and variables, Character variables, Numerical variables - integers and floating point, Variable type declaration, Intrinsic functions, Input-Output formats and statements, Assignment statements, Arithmetic expressions, logical calculations and repetitive calculations through looping, Arrays - of Rank *1*, *2* and *n* - dimension, Dynamic allocation and de-allocation, Procedures and structured programming – Subroutines and Module procedures etc, Pointers and dynamic data structures, Control structures and program design.	
		4.	**Programming for Solution of Linear Problems in One Dimension:** Energy Principles and FE formulation for boundary value problems in structural	

			mechanics – Bars, Beams, Shafts etc., Final discretized system of equations and solution techniques for linear problems, Basic structure of a standard FE analysis program, Implementation to the structural mechanics and heat conduction problems, Comparison with results obtained from Softwares like ANSYS, MATLAB etc (depending upon availability).
		5.	**Programming for Solution of Nonlinear Problems in One Dimension:** Mathematical problem formulation, linearization and basic numerical solution procedure, geometric nonlinear elastic problem, elasto-plastic and inelastic problems, Structure of computer program for the solution of nonlinear problems, Comparison with results obtained from Softwares.
		6.	**Programming for Solution of Linear Problems in Two and Three Dimension:** Mathematical problem formulation for – Plates and/or Shells, 3D problems, Final discretized system of equations, Implementation through computer programming, Comparison with results obtained from Softwares.
		7.	**Project / Term Paper:** On a real-life computational solid mechanics problem, as would be assigned to students.
Text books, References			1. Fortran 95/2003 for Scientists and Engineers: Stephen J. Chapman. 2. Modern Fortran Explained: Michael Metcalf, John Reid and Malcolm Cohen. 3. Computer Programming in Fortran 90 and 95: V. Rajaraman. 4. Finite Elements in Plasticity: D. R. J. Owen and E. Hinton. 5. Computational Inelasticity: J.C. Simo and T. J. R. Hughes. 6. Computational Continuum Mechanics: Ahmed A. Shabana. 7. An Introduction to Computational Micromechanics: Tarek I. Zohdi and Peter Wriggers. 8. Classical and Computational Solid Mechanics: Y.C. Fung and Pin Ton. 9. Computational Solid Mechanics: Variational Formulation and High Order Approximation: Marco L. Bittencourt. 10. Handbook of Computational Solid Mechanics: Survey and Comparison of Contemporary Methods: Michal Kleiber.

AM21314 Dynamics of Structures		
Designation	:	Elective
Pre-requisites	:	Engineering Mechanics, Mechanics of Materials, Engineering Mathematics including Differential Equations, Linear Algebra
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment (Scheme):** 20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).
Course Outcomes	:	see table below
Modes of Delivery	:	Talk and chalk (main), Power point presentations (sometimes), Self-study (as assigned), Hands on training through Computer Programming.
Topics to be Covered	:	see table below

Course Outcomes:

Sl. No.	On successful completion of the course, student is expected to be able to:	Mapping into POs
1.	Apply the basic principles of analytical dynamics to the system of practical interest.	1,2,4,8
2.	Determine the frequency, mode shapes and displacement response	3,4,6
3.	Analyze the dynamic behavior of continuous systems	5,7
4.	Understand the Random nature of loading and its effect on dynamic response	2,4,7

Topics to be Covered:

Units	Details
1.	**Introduction:** Objectives, Types of Loadings, Essential Characteristics of Dynamic Problems, Discrete & Continuous systems, Rigid body dynamics vs. Vibration.
2.	**Fundamental Concepts:** Formulation of the Equation of Motion, Newton's laws & D'Alembert's Principle, Lagrange's Equation, Functionals and Energy Principles, Variational Formulations, Hamilton's Principle, Formulation of Vibration Problems: Taught String, Axial Vibration of Bar, Torsional Vibration of Shaft, Flexural Vibration of Beam, Membranes and Plates, 3D Solid etc.
3.	**Discrete Single-Degree-of-Freedom Systems:** Analysis of Free and Forced Vibrations, Response to Harmonic, Periodic & Impulsive Loadings, Duhamel's Convolution Integral, Vibration Isolation, Complex-Stiffness Damping, Response to General Dynamic Loading, Using Fourier Analysis.
4.	**Discrete Multi-Degree-of-Freedom Systems:** Formulation of Equations of Motion for Idealized MDOF Systems - Evaluation of Structural Property Matrices, Reduction of dynamic matrices; Undamped Free Vibration of MDOF Structures – Mode Shapes and Modal Frequencies, Properties of Mode Shape Vectors – Orthogonality, Linear Independence and Normalization; Forced Vibration of MDOF Structures – Modal Expansion Theorem, Uncoupled Modal Equations; Damped MDOF Structure Subjected to Ground Motion; Analysis of Dynamic Response- Superposition method, Iteration method.
5.	**Continuous Systems:** Free vibration of an n-DOF system to vibration of a Continuous system, Axial vibration of Bars and Flexural vibration of Beams as Continuous Medium – of different boundary conditions, Mode Shape Functions - Orthogonality and Normalization, Rayleigh quotient; Forced axial vibration of bars – Modal Expansion Theorem, Frequency Response.
6.	**Numerical methods of Vibration Analysis:** Finite Element Formulation for Dynamic Analysis of Structural Elements (Bars, Beams, Plates etc.), Rayleigh's Method, Rayleigh-Ritz Method; Numerical Solution Methods: Solution for Free Vibration - Eigen Value Problems, Solution for Forced Vibration - Direct time integration of linear systems – Explicit & Implicit methods - Newmark's Method etc.

		7.	**Further Study:** Introduction to Nonlinear Vibration and Random Vibration (depending upon time).
Text books, References		1. Structural Dynamics: Theory and Computation: Mario Paz. 2. Elements of Vibration Analysis: Leonhard Meirovitch. 3. Mechanical Vibrations: Geradin and Rixen. 4. Dynamics of Structures: Clough and Penzien. 5. Theory of Vibration with Applications: William T. Thomson. 6. Dynamics of Structures: J L Humar 7. Dynamics of Structures: W C Hurty and M F Rubinstein 8. Structural Dynamics: M. Mukhopadhyay 9. Dynamic loading and design of structures: A. J. Kappos	

AM21315 Structural Reliability

Designation	:	Elective
Pre-requisites	:	Probability Theory, Mechanics of Solids and Structures, Finite Element Methods (basic).
Credit and Contact hours	:	4(L) - 0(T) - 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment (Scheme):** 20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).

Course Outcomes:

Sl. No.	On successful completion of the course, student is expected to be able to:	Mapping into POs
1.	Develop fundamental understanding on mathematical tools for quantifying uncertainties using theories of probability, random variables and random processes.	1, 2
2.	Acquire fundamental knowledge on the methods of structural reliability analysis based on concept of reliability indices, including first and second order reliability methods.	1, 2, 4
3.	Apply methods of reliability analysis using Monte Carlo simulations, including variance reduction techniques and response surface methods.	1, 3
4.	Carry out reliability based design and quantify risks and uncertainties associated to a structural design as well as explain the basic principles of structural design code calibration.	4, 5, 7
5.	Get prepared with required overall knowledge and confidence required for undertaking research in the area of stochastic computational analysis and design.	5, 6, 7, 8

Modes of Delivery: Talk and chalk (main), Power point presentations (sometimes), Self-study (as assigned), Hands on training on simulation methods.

Topics to be Covered:

Units	Details
1.	**Introduction:** Course Overview, Basic Statistics, Theory of Probability, Probability Distributions (Continuous & Discrete), Random Variables
2.	**Analytical Methods Reliability Analysis:** Failure Surface & Definition of Reliability in Normal Space (Cornell's Reliability Index), First Order Reliability Method (FORM), Hasofer-Lind's Definition of Reliability, Rackwitz-Fiessler Algorithm, Asymptotic Integral, Second Order Reliability Method (SORM)
3.	**Simulation Methods:** Monte-Carlo Methods Latin Hypercube Sampling, Variance Reduction Technique, Importance Sampling and Adaptive Sampling, Subset Simulation
4.	**Stochastic Analysis:** Implicit Performance Function, Polynomial Response Surface Method (RSM), Stochastic Response Surface Method (SRSM), Stochastic Models of Loads, Code Calibration, Partial Safety Factors, LRFD Format, System Reliability, Time Varying Reliability Analysis
5.	**Applications:** Reliability Based Optimization, Introduction to Stochastic FEM, Case Studies, Term Project.

Text books, References:

1. Probability, Statistics and Reliability for Engineers and Scientists: Ayyub B. M, McCuen R. H.
2. Probability, Random Variables and Stochastic Processes: Papoulis A.
3. Structural Reliability Analysis and Design: Ranganathan R.
4. Structural Reliability: Analysis and Prediction: Melchers R E.
5. Methods of Structural Safety: Madsen H O, Krenk S. and Lind N. C.
6. Reliability Based Structural Design: Choi S. K, Grandhi R. V. and Canfield R A.
7. Reliability and Optimization of Structural Systems: Rackwitz R., Augusti G.

		and Borri A. 8. Structural Reliability Using Finite Element Methods: Wuarts P. H., 9. Reliability Assessment Using Stochastic Finite Element Analysis: Haldar A. and Mahadevan S. 10. Computational Analysis of Randomness in Structural Mechanics: Bucher C.

AM21316 Design of Thin Walled Structures		
Designation	:	Elective
Pre-requisites	:	Mechanics of Materials, Differential Equations, Linear Algebra
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment (Scheme):** 20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).
Course Outcomes	:	see table below
Modes of Delivery	:	Talk and chalk (main), Power point presentations (sometimes), Self-study (as assigned), Hands on training through Computer Programming.
Topics to be Covered	:	see table below
Text books, References		1. Introduction to the Theory of Thin Walled Structures: N W Murray 2. Stability Analysis and Design of Structures: M L Gambhir 3. Fundamental of heat exchanger and pressure vessel technology: J P Gupta 4. Pressure Vessel Design: Concepts and principles: J Spence and A S Tooth 5. Pressure vessels design and practice: S Chattopadhyay 6. Handbook of piping Design: G K Sahu

Course Outcomes:

Sl. No.	On successful completion of the course, student is expected to be able to:	Mapping into POs
1.	Apply to different theories to derive the equations of Thin walled Beams	1, 2, 8
2.	Solve the equations to analyze different aspects of Beams	3, 4, 7
3.	Understand the behavior of pressure vessels and pipes used in industries.	1, 2
4.	Apply the basic principles in designing thin walled structures for industrial applications.	4,5, 6, 8

Topics to be Covered:

Units	Details
1.	**Introduction:** Line and surface structures; Internal/induced forces-Axial/Membrane, Bending/Flexure, Shear and Torsion; Thin and thick structures, Sandwich constructions.
2.	**Thin walled Beams:** Introduction to Beam Theories, Bending, Torsion, Lateral Buckling, Flexural Torsional Buckling of Columns.
3.	**Design of Pressure Vessels and Piping:** Design of pressure vessels-Introduction, Design of different kind of vessels, Openings and nozzles; Design of pipings- Introduction, Design of different piping systems, Branch connections, Pipe flanges.

AMXXXXX Non-Destructive Testing		
Designation	:	Elective
Pre-requisites	:	*Basic Material Science and Engineering*
Credit and Contact hours	:	4(L) - 0(T) – 0(P) - 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment (Scheme):**20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials, Term paper).
Course Outcomes	:	See table below
Modes of Delivery	:	Talk and chalk (main), Power point presentations (sometimes), Self-study (as assigned)
Topics to be Covered	:	See table below
Text books, References		See list below

Course Outcomes

Sl. No.	On successful completion of the course, student is expected to be able to:	Mapping into POs
1.	To use various Non Destructive Evaluation and Testing methods, theory and their industrial applications	1, 2, 3
2.	To use testing methods for defects and characterization of industrial component	4, 6, 7, 8

Topics to be Covered

Units	Details
1.	**Overview of NDT:** NDT Versus Mechanical testing, Overview of the Non Destructive Testing Methods for the detection of manufacturing defects as well as material characterization. Relative merits and limitations, Various physical characteristics of materials and their applications in NDT, Visual inspection Unaided and aided.
2.	**Surface NDE methods:** Liquid Penetrant Testing - Principles, types and properties of liquid penetrants, developers, advantages and limitations of various methods, Testing Procedure, Interpretation of results. Magnetic Particle Testing-Theory of magnetism, inspection materials Magnetisation methods, Interpretation and evaluation of test indications, Principles and methods of demagnetization, Residual magnetism.
3.	**Thermography and eddy current testing (ET):** Thermography- Principles, Contact and non-contact inspection methods, Techniques for applying liquid crystals, Advantages and limitation – infrared radiation and infrared detectors, Instrumentations and methods, applications.Eddy Current Testing-Generation of eddy currents, Properties of eddy currents, Eddy current sensing elements, Probes, Instrumentation, Types of arrangement, Applications, advantages, Limitations, Interpretation/Evaluation.
4.	**Ultrasonic testing (UT) and acoustic emission (AE):** Ultrasonic Testing-Principle, Transducers, transmission and pulse-echo method, straight beam and angle beam, instrumentation, data representation, A/Scan, B-scan, C-scan. Phased Array Ultrasound, Time of Flight Diffraction. Acoustic Emission Technique, AE parameters, Applications.
5.	**Radiography (RT):** Principle, interaction of X-Ray with matter, imaging, film and film less techniques, types and use of filters and screens, geometric factors, Inverse square, law, characteristics of films – graininess, density, speed, contrast, characteristic curves, Penetrameters, Exposure charts, Radiographic equivalence. Fluoroscopy- Xero-Radiography, Computed Radiography, Computed Tomography.
6.	**Term Paper:** On recent advances based on literature survey and/or lab/industry visit

Text books, References

1. Practical Non-Destructive Testing: Baldev Raj, T.Jayakumar, M.Thavasimuthu
2. Non-Destructive Testing Techniques: Ravi Prakash
3. ASM Metals Handbook, Non-Destructive Evaluation and Quality Control, American Society of Metals, Metals Park, Ohio, USA, 200, Volume-17.
4. Introduction to Non-destructive testing: a training guide: Paul E Mix

		5. Handbook of Nondestructive evaluation: Charles J. Hellier 6. ASNT, American Society for Non Destructive Testing, Columbus, Ohio, NDT Handbook, Vol. 1, Leak Testing, Vol. 2, Liquid Penetrant Testing, Vol. 3, Infrared and Thermal Testing Vol. 4, Radiographic Testing, Vol. 5, Electromagnetic Testing, Vol. 6, Acoustic Emission Testing, Vol. 7, Ultrasonic Testing

AMXXXXX Biomechanics				
Designation	:	Elective		
Pre-requisites	:	Basics of engineering mechanics, and Anatomy of human body		
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)		
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks		
		Internal Assessment (Scheme): 20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).		
Course Outcomes	:	**Sl. No.**	**On successful completion of the course, student is expected to be able to:**	**Mapping into POs**
		1.	Determine internal forces in different parts of body	1, 2
		2.	Design experiments involving single molecule statics	4, 7
		3.	Compute forces within anatomical joint and describe motion with precise, well-defined mechanical and anatomical terminology	1, 3, 5, 8
		4.	Understand the mechanics of connective tissue and injury and able to understand the kinetic and kinematic assessment of posture(s)	4, 6, 7, 8
Modes of Delivery	:	Talk and chalk (main), Power point presentations (sometimes), Self-study (as assigned), Hands on training through Computer Programming.		
Topics to be Covered	:	**Units**	**Details**	
		1.	**Application of Statics to Biomechanics:** Basics concepts of Force Moments and Torque Equilibrium, analysis of systems in equilibrium. Skeletal joints, Skeletal muscle. Mechanics of the elbow, shoulder, Spinal column, Hip, Knee and ankle. Basic assumptions and limitations.	
		2.	**Deformable body Mechanics:** Applied forces and Deformations, internal forces and moments, Stress and Strain, Basic loading configurations, Uniaxial tension test, Load- elongation diagrams, Hooke's Law, Work and Strain Energy, Properties based on Stress-strain Diagrams, Idealized model for material behavior and Mechanical properties of materials.	
		3.	**Multi axial Deformation and stress analysis:** Poisson's ratio, Biaxial and tri axial stresses, Failure theories, allowable stress and factor of safety, Fatigue and endurance, Torsion, Bending and combined loading.	
		4.	**Mechanical Properties of Bone and Soft Tissues:** Mechanics of bone, Composition of bone, Mechanical properties of bone, Bone fractures and Bone Remodeling, Biomechanics of Tendon and Ligaments, Biomechanics of Skeletal Muscles. Biomechanics of Articular cartilage.	
		5.	**Term Paper:** On recent advances based on literature survey and/or lab/industry visit	
Text books, References		1. Biomechanics: Fung Y.C. 2. Biomechanics and Motor Control of Human Movement: Winter D.A. 3. Basic Biomechanics of the Skeletal System: Frankel V.H. and Nordin Margareta 4. Fundamentals of Biomechanics: Nihat Ozkaya and Margareta Nordin		

AMXXXXX Advanced Fluid Mechanics

Designation	:	Elective
Pre-requisites	:	*Engineering Fluid Mechanics, Thermodynamics*
Credit and Contact hours	:	4(L) - 0(T) - 0(P) - 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment (Scheme):**20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).
Course Outcomes	:	see below
Modes of Delivery	:	Talk and chalk (main), Power point presentations (sometimes), Self-study (as assigned), Hands on training through Computer Programming.
Topics to be Covered	:	see below
Text books, References	:	see below

Course Outcomes

Sl. No.	On successful completion of the course, student is expected to be able to:	Mapping into POs
1.	An ability to apply control volume approach to problems in fluids engineering.	1,2
2.	An ability to use potential flow theory to solve fluid mechanics problems.	1,2, 3
3.	An ability to identify Boundary layer separation, its causes and control.	2
4.	An ability to apply the concepts developed for fluid flow analysis to issues in aerospace design.	6, 7

Topics to be Covered

Units	Details
1.	**Basic Conservation & Governing Laws:** Statistical & continuum methods, Eulerian & Lagrangian coordinates, material derivatives, control volumes, Reynolds' transport theorem (RTT), conservation of mass, momentum and energy, constitutive equations, Navier-Stokes equations-differential & integral approach, energy equations, governing equations for Newtonian fluids, boundary conditions.
2.	**Potential Flows:** Stokes stream functions, solution of potential equation, flow in a sector, flow around a sharp edge, flow near a blunt nose, force and moment on a circular cylinder and sphere, conformal transformations, Joukowski transformations.
3.	**Viscous Incompressible Flows:** Exact solutions for Couette flow, Poiseuille flow, flow between rotating cylinders, Stokes' first problem, Stokes' second problem, pulsating flow between parallel surfaces, stagnation-point flow, flow in convergent and divergent channels, flow over porous wall. Stokes approximation, rotating sphere in a fluid, uniform flow past a sphere and cylinder, Ossen's approximation, Hele-Shaw flow.
4.	**Introduction to Boundary Layer:** Derivation of boundary layer equation, Flow potential flow complements B.L. equation, Integral solution of B.L., Laminar and turbulent boundary layers, transition; B.L. separation and control.
5.	**Introduction to Compressible Flow:** Velocity of sound and its importance, physical difference between incompressible, subsonic and supersonic flows, Mach number and its significance. Isentropic flow through nozzles, shocks and expansion waves, Rayleigh and Fanno Flow.

Text books, References

1. Fundamental Mechanics of Fluids: I.G. Currie
2. Foundations of Fluid Mechanics: S.W. Yuan
3. Advanced Fluid Mechanics: K. Muralidhar and G. Biswas
4. Boundary Layer Theory: H. Schlichting
5. Modern Compressible Flow with Historical Perspective: John D. Anderson
6. Fundamentals of Aerodynamics: J.D. Anderson
7. Fundamentals of Fluid Mechanics: B.R. Munson, D.F. Young and T.H. Okiishi
8. Introduction to Fluid Mechanics: R.W. Fox and A.T. McDonald
9. Viscous Fluid Flow: F.M. White

MEXXXXX Computer Aided Design		
Designation	:	Elective
Pre-requisites	:	Engineering Mathematics
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment: (Scheme)** 20 marks (5 marks for attendance + 15 marks for assignments based on software and programming, Surprise Tests, Quizzes, and Tutorials etc)
Course Outcomes	:	see below
Modes of Delivery	:	Talk and chalk (main), Power point presentations (sometimes), Self-study (as assigned), Hands on training through Computer Programming.
Topics to be Covered	:	see below
Text books, References		1. CAD/CAM-Principles and Applications: Posinasetti Nageswara Rao 2. CAD/CAM-Computer-Aided Design and Manufacturing: M P Groover

Course Outcomes:

Sl. No.	On successful completion of the course, student is expected to be able to:	Mapping into POs
1.	Understand and manipulate coordinate systems, views, and transformations, the main curve and surface representations and their differential properties	1, 2, 3
2.	Construct sketches and place geometric and topologic constraints on them. Construct parametric and feature models solid models	2, 3, 4
3.	Perform construction, analysis, and interrogation of CAD models	4, 5, 6, 7
4.	Build assembly models and fits. Construct mechanical drawings and annotations. Perform basic finite element analysis	5, 8

Topics to be Covered:

Units	Details
1.	**Introduction:** Historical Development, Explicit and Implicit Equations, Intrinsic Equations, Parametric Equations, Coordinate Systems
2.	**Curves:** Fundamental of Curve Design, Parametric Space of a Curve, Reparametrization, Space Curves: Spline Curves, Bezier Curves, B-Spline Curve, Rational Polynomials, Rational curves, NURBS
3.	**Surfaces:** Fundamental of Surface Design, Parametric Space of a Surface, Reparametrization of a Surface patch, Sixteen point form, Four Curve Form, Plane, Cylindrical and Ruled Surfaces, Surfaces of Revolutions, Bezier Surface, B-Spline Surface
4.	**Solids:** Fundamental of Solid Design, Parametric Space of a Solids; Continuity and composite Solids, Surface and Curves in a Solid
5.	**Solid Modeling:** Topology and Geometry, Set theory, Euler Operators, Regularized Boolean Operators, Construction Criteria, Graph Based Models, Instances and Parameterized Shapes, Cell-decomposition and Spatial Occupancy Enumeration, Sweep representation, CGS, BRep, Wireframe Analytical properties, Relational properties and Intersection. Applications in Biomedical Engineering Design

AM22101 Analysis and Design of Plates and Shells

Designation	:	Compulsory
Pre-requisites	:	Mechanics of Materials
Credit and Contact hours	:	4(L) - 0(T) - 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment (Scheme)**:20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).
Course Outcomes	:	See table below
Modes of Delivery	:	Talk and chalk (main), Power point presentations (sometimes), Self-study (as assigned), Hands on training through Computer Programming.
Topics to be Covered	:	See table below

Course Outcomes

Sl. No.	On successful completion of the course, student is expected to be able to:	Mapping into POs
1.	Apply to different theories to derive the equations of plates and shells.	1, 2, 8
2.	Solve the equations to analyze the plates and shells.	3, 5, 6
3.	Understand the bending behavior of plates and shells in small deformation.	1, 2
4.	Apply the basic knowledge in design of Plate and Shell Structures	4,7, 8

Topics to be Covered

Units	Details
1.	**Introduction:** Line and surface structures, Membrane, Thin and thick plates.
2.	**Pure Bending of Plates:** Slope and curvature of slightly bent plates. Relations between moments and curvatures.
3.	**Small Deflection theory of Laterally Loaded Plates:** Governing differential equation and boundary conditions. Bending of Rectangular Plates. Simply supported rectangular plates. Naviers' solution, Rectangular plates with various loading and edge conditions, levy's solution.
4.	**Bending of Circular plates:** Governing equation, Axisymmetric loading, Various types of circular plates, Design of Circular Plates, Plate on elastic
5.	**Shells:** Classification of shells, Engineering use of shell structures.
6.	**Membrane Theory:** Cylindrical shells and shell of revolution, Axisymmetric and unsymmetrical loading. Solution for stress resultants and displacements. Cylindrical, spherical and conical shells supported at isolated points. Analysis for wind and periodic loads.
7.	**Bending Theory of Cylindrical Shell:** Governing equations for stresses and displacements for symmetric and general conditions. Flugge and Donnel theories. Cylindrical shells with uniform and Non-uniform thickness.
8.	**Design of Plates & Shells:** Design Considerations, Design load and other criterions, Design of Rectangular Plates, Design of Shells of Revolution, Design of Cylindrical Shells, Indian Codes of Practice, Other Design Codes, Design of Thin-Walled Industrial Structures.

Text books, References

1. Theory of Plates and Shells: S.Timoshenko and W.Krieger
2. Analysis of Plates: Szilard
3. Plates and Shells: Turner
4. Analysis of Plates: T.K.Vardan and K.Bhaskar.
5. Design of Plate and Shell Structures: Maan H. Jawad

AM22201 Experiments and Computations in Solid Mechanics		
Designation	:	Compulsory
Pre-requisites	:	*Engineering Mathematics, Theoretical Solid Mechanics*
Credit and Contact hours	:	0(L) - 0(T) – 6(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 50 marks **Internal Assessment: (Scheme)** 50 marks (10 marks for attendance + 40 marks for sessional assessment based on regular performance on Practical and Virtual Experimentation, Demonstration of knowledge and skill development through Surprise / Quiz Tests, Viva etc. and Assignments & Report Writing.

Course Outcomes:

Sl. No.	On successful completion of the course, student is expected to be able to:	Mapping into POs
1.	Recognize the importance of experimentation in solid mechanics, identify when experimentation is required for addressing a solid mechanics problem and be acquainted with experimental terminology and measurement devices used in this area.	1, 2, 3
2.	Identify the variables to be involved with experimentation and accordingly design and fabricate the required experimental system, for addressing the solid mechanics problem at hand.	1, 3, 4
3.	Properly acquire the experimental results / data, analyze and interpret them, including developing and using required computer program for this purpose.	3, 4, 5
4.	Appreciate the importance of virtual experimentation, Perform the same through Computer Simulation / modeling, using modern commercial software available for this purpose.	2, 3, 5, 6
5.	Judge the validity of results / data obtained from practical / virtual experimentation, devise corrective measures required, if any, as well as write report / communicate the results on the experiments performed in a manner commensurate to the scientific / engineering community.	3, 4, 7, 8

Modes of Delivery	:	Power point presentations (as required), Self-study (as assigned), Hands on training through Practical Experimentation and Computer Programming.

Topics to be Covered:

Units	Details
1.	**<u>Part-A: Formal Concepts on Experimentation</u>** **Introduction to Experimentation:** Basic Concepts, Definition of Terms, Calibration, Standards, Dimensions and Units, Measurement Systems - Sensors, Load cells and Electrical Resistance Strain Gages, System Response, Distortion, Experiment Planning, Analysis of Experimental Data. **Experimental Methods in Solid Mechanics:** Displacement and Dimensional Measurements, Pressure Measurement, Force, Torque and Strain Measurements, Motion and Vibration Measurement, Data Acquisition and Processing, Report Writing and Presentations, Introduction to Design of Experiments.
2.	**<u>Mid Term Project Submission:</u>** Design of an Experiment / Fabrication of an Experimental Specimen or Setup (as assigned).
3.	**<u>Part-B: Practical Performance of Experimentation</u>** **Mechanical Experiments:** Review of Undergraduate Experiments in Mechanics of Solids, Shear Centre of Thin Walled Sections, Combined Bending and Torsion, Behavior of Corrugated / Folded Plate. **Fabrication (hand lay-up) and Testing with Composite Laminates** - Tensile / Buckling Tests on Composite Plates / Laminates, Short Beam Test, Torsion of Composite Tube, Dynamic / Viscoelastic Beam

			Experiment. Strain Measurements using Electrical Strain Gage / Strain Rosette, in: Beams, Truss, Composite Laminate, and Pressure Vessel.
		4.	<u>**Part-C: Computer Programming for Numerical Computation and Analysis of Experimental Data; Simulation of Solid Mechanics Problems Using Commercial Software:**</u> **Analysis of Obtained Experimental Data Using Computer Programming:** Introduction to Computer Programming. Regression Analysis of Experimental Data, Graphical Analysis and Curve Fitting. **Simulation Using Commercial Software:** Computational Modeling / Simulation and Validation of Problems Performed through Experiments, subjected to different loading and boundary conditions.
		5.	<u>**End Semester Project Submission:**</u> Practical Experimentation, Computational Modeling and Validation, as well as Statistical / Regression Analysis of Designed / Fabricated Experiment or of Other Problem (as assigned).
Text books, References		1. Experimental Methods for Engineers: Jack P. Holman. 2. Experimental Stress Analysis: James W. Dally and William F. Riley 3. Design & Analysis of Experiments: D. C. Montgomery 4. Design of experiments for Engineers & Scientists: J. Antony 5. Measurement Systems- Applications and Design: E.O. Doebelin 6. Mechanical Measurement: T.G. Beckwith 7. Mechanical Measurements: D.S. Kumar 8. Fortran 95/2003 for Scientists & Engineers: Stephen J. Chapman	

AM22310 Wave Propagation in Solids

Designation	:	Elective
Pre-requisites	:	Engineering Mathematics including Differential and Integral Calculus, Advanced Solid Mechanics / Continuum Mechanics.
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment (Scheme):** 20 marks (5 marks for attendance + 15 marks for Take-home assignments and Class Tutorials).
Course Outcomes	:	see below
Modes of Delivery	:	Talk and chalk as well as Power point presentations (as required), Self-study (as assigned), Practical demonstration (depending upon availability of facility).
Topics to be Covered	:	see below

Course Outcomes

Sl. No.	On successful completion of the course, student is expected to be able to:	Mapping into POs
1.	Identify an elastodynamic problem in solid mechanics also as an wave propagation problem and recognize this mathematically as an Initial-Boundary Value Problem.	1
2.	Understand the basic notions of mechanical disturbance / stress wave propagation in a solid continuum and Formulate relevant wave equations using Continuum Mechanics / Elastodynamic principles, for given mechanical disturbance, material and geometric configuration of the structure / solid continuum.	1, 4
3.	Obtain analytical solution for simple cases of wave propagation problems in solid continuum and formulate process for obtaining approximate numerical solutions for more general cases.	1, 2, 4
4.	Acquire preliminary knowledge on different methods of *Nondestructive Evaluation* (NDE) and *Structural Health Monitoring* (SHM) based upon principles of Wave Propagation in Solids / Structures.	2, 3, 7
5.	Continue with higher / self study for attaining knowledge / skill required for pursuing research / industrial career in areas of *Nondestructive Evaluation* (NDE) and *Structural Health Monitoring* (SHM).	5, 6, 8

Topics to be Covered

Units	Details
1.	**Introduction, Elements of Continuum Mechanics and Linear Elastodynamics:** Purpose and overview of the course, Examples of wave propagation in forced and free vibration of Solids / structures, **Review of Continuum Mechanics**, Problem statement in Linear Elastodynamics, The dynamic reciprocal identity, Reduction to wave equation using Helmholtz decomposition of Displacement field into Scalar and vector potentials.
2.	**Waves Propagation in One Dimension:** Wave Propagation in general one dimensional elastic continuum, Wave equation for transverse displacement of freely vibrating **Taut String**, Solution by separation of variables, Travelling and Standing wave interpretation and mode shapes; **Axial wave in Bars**, D'Alembert solution for the wave equation, Strain waves and stress waves, Particle velocity vs. wave velocity, Acoustic Impedance, Reflection and transmission at Interface of two materials, Power and energy transport in axial wave, **Flexural waves in Beams**, Solution, Dispersion of Flexural waves, Phase velocity and Group velocity, Power and energy in flexural wave.
3.	**Waves Propagation in Two and Three Dimension:** General time-harmonic elastic waves in plane, Polar and axial symmetry, Propagation of wavefront, Reflection and transmission at plane boundary, Free waves in infinite space, **Wave motion in Membrane**- Transverse vibration of a membrane. **Axial and flexural wave equations in Plate**, Solution methods. **Waves in three dimension**- Eigenvalues and Eigen vectors of free Wave, Pressure (P) wave and Shear (SH, SV) wave, Dilatational and Distortional wave, Scattering by a circular cavity, Diffraction by a long crack.

		4.	**Waveguides and Guided Waves:** Overview on waveguides, **Rayleigh waves** – Governing equations and solution, Wave speed & Particle motion, **SH Plate waves** - Symmetric and Antisymmetric modes, Dispersion, Cut-off frequencies, **Lamb Waves** –Group velocity dispersion curves, Guided waves in Isotropic and **Composite Plates**, Dispersion curves for guided waves in composite plates, Guided waves in cylindrical shells, Conclusion.
		5.	**Application of Wave Propagation for NDE and SHM** (Partial self study, as assigned): Overview, Nondestructive Evaluation (NDE) techniques for Structural Health Monitoring (SHM), Electroactive and Magnetoactive Materials for SHM, Ultrasonic systems for industrial NDE, Guided waves for Inspection of Plates, Application of Waveguides, Laser-Ultrasonic techniques, Electromagnetic Acoustic Transducers, Acoustic Microscopy, Piezoelectric Wafer Active Sensors (PWAS), Coupled-field analysis of PWAS Resonators, PWAS Ultrasonic Transducers, Wave propagation and In-situ SHM using PWAS, Signal Processing and pattern recognition for PWAS based SHM, Practical issues with PWAS, Scopes and conclusion.
Text books, References	:		1. Wave Propagation in Elastic Solids: J. D. Achenbach. 2. Structural Health Monitoring with Piezoelectric Wafer Active Sensors: Victor Giurgiutiu. 3. Ultrasonic Nondestructive Evaluation - Engineering and Biological Material Characterization: Tribikram Kundu. 4. Wave Propagation: Chiang Mei, Rodolfo R. Rosales and Triantaphyllos Akylas. 5. Wave Motion in Elastic Solids: Karl F. Graff. 6. Fundamentals of Shock Wave Propagation in Solids: Lee Davison. 7. Structural Health Monitoring: F. K. Chang.

AM22312 Theory of Stability

Designation	:	Elective
Pre-requisites	:	Differential Equations, Engineering Mechanics, Mechanics of Solids, Theory of Elasticity.
Credit and Contact hours	:	4(L) - 0(T) - 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks; Mid Semester Exam: 20 marks **Internal Assessment (Scheme):** 20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).
Course Outcomes	:	see below
Modes of Delivery	:	Talk and chalk (main), Power point presentations (seldom), Self-study (as assigned).
Topics to be Covered	:	see below
Text books,	:	1. Theory of elastic Stability: S. P. Timoshenko and J. M. Gere

Course Outcomes

Sl. No.	On successful completion of the course, student is expected to be able to:	Mapping into POs
1.	Understand the basic notion of elastic stability, method of neutral equilibrium, design curves based on effective length concept etc. and identify when an elastic stability problem may arise for a real life structure.	1, 4
2.	Formulate problems of elastic stability for columns, beam-columns, frames, plates etc. and obtain analytical solution for buckling modes and critical loads for simple idealized cases.	1, 2
3.	Frame process for obtaining approximate solutions using numerical methods like the *Finite Difference Method*, as well as develop knowledge on experimental procedures and commercial software for determining critical loads for more general cases of aforementioned type of structures.	2, 3, 4
4.	Apply overall idea from elastic stability to design of structures.	6, 7

Topics to be Covered

Units	Details
1.	**Introduction and Buckling of Columns:** Concepts of Stability, Equilibrium path, Stability criteria, Method of Neutral Equilibrium; Recapitulation of Critical Load for Euler Column, Columns with Different Boundary Conditions, Effective-length concept and design curve, Effects of imperfections / Initial curvature, Eccentricity of loading etc.; Inelastic buckling of columns, Double and Tangent Modulus theory, Shanley's theory.
2.	**Beam-columns and Frames:** : Governing equation for Beam-columns, Displacement solution and stability for single concentrated transverse load, Beam-Columns with other transverse loading and boundary conditions, Semi-analytic / Series solution based on Energy Principles, Post-buckling behavior; Introduction to buckling of Frames, Modes of Buckling, Critical Load of a Frame by Slope-Deflection Equations and Matrix Analysis, Effect of Initial Bending, Framed Columns.
3.	**Torsional and Lateral Stability:** Stability of Thin-walled open sections, buckling by torsion and torsion-flexure; Lateral stability of beams with various loadings and end conditions.
4.	**Stability of Plates and Shells:** Differential Equations of plate Buckling linear theory, stability of Rectangular plates under axial compression and shear, Effect of imperfections, Post-buckling behavior of plates; Stability of cylindrical Shells under uniform axial pressure and torsion, Effect of imperfections.
5.	**Approximate Methods of Analysis:** Energy Principles and Variational Calculus, Rayleigh-Ritz and Galerkin method, Finite Difference and Finite Element Method.

References		2. Principle of Structural Stability Theory: A.Chazes 3. Stability of Theory of Structures: Ashwani Kumar 4. Background to Buckling: H.G. Allen and P.S. Bulson 5. Structural Stability of Columns and Plates: N.G.R. Iyengar

AM22313 Mechanics of Composite Materials				
Designation	:	Elective		
Pre-requisites	:	*Continuum Mechanics / Solid Mechanics, Basic Engineering Mathematics, Linear Algebra, Differential Equations*		
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)		
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment (Scheme):** 20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).		
Course Outcomes	:	**Sl. No.**	**On successful completion of the course, student is expected to be able to:**	**Mapping into POs**
		1.	Predict effective properties of composite lamina from the constituent properties by applying the micromechanical theories	1
		2.	Predict the effective properties and response of the laminate from the fiber orientation details of the lamina and the stacking sequence by applying the macro mechanical theories.	1, 4, 7
		3.	Understand the behavior of laminate in different environmental conditions	4, 7
		4.	To predict the failure conditions by applying the basic aspects of damage mechanics	2,4,7, 8
Modes of Delivery	:	Talk and chalk (main), Power point presentations (sometimes), Self-study (as assigned), Hands on training through Computer Programming.		
Topics to be Covered	:	**Units**	**Details**	
		1.	**Introduction:** Classification and characteristics of composites, Conventional vs. Composite materials, Advantages and limitations, Salient applications in various fields, Fabrication technologies, Properties of matrix and reinforcement materials.	
		2.	**Micromechanics:** Fiber volume fraction, micro-mechanical relations, determination of strength and stiffness, Environmental effects-Hygro-thermal behavior.	
		3.	**Macromechanics:** Basic stress-strain relationships for anisotropic materials, engineering constants for orthotropic materials, stress-strain relations for a lamina of arbitrary orientation, effective moduli, invariant properties of anorthotropic lamina, special cases of laminate stiffness, laminate strength analysis, concept of inter-laminar stresses and delamination.	
		4.	**Failure theories and Damage mechanics:** Failure mechanisms, maximum stress theory, maximum strain theory, Tsai-Hill theory, Tensor polynomial failure criterion, first ply failure theory, Introduction to damage theory based on continuum damage mechanics.	
Text books, References	:	1. Mechanics of fibrous composites: Carl T. Herakovich 2. Principles of Composite Material Mechanics: R. F. Gibson 3. Mechanics of Composite Materials: R. M. Jones 4. Introduction to Composite Material: Stephen W.Tsai and H. Thomas Hahn 5. Composite Materials and their use in Structures: J. R. Vinson and T.W. Chou		

AM22314 Multi-Functional Materials and Structures

Designation	:	Elective
Pre-requisites	:	Engineering Mathematics, Basic Materials Science, Advanced Solid Mechanics.
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment (Scheme):** 20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).

Course Outcomes:

Sl. No.	On successful completion of the course, student is expected to be able to:	Mapping into POs
1.	Understand the meaning of multi-functionality with regard to engineering materials and structures and recognize the importance of such multi-functionality in modern engineering.	1, 7, 8
2.	Develop overall understanding on different available advanced multifunctional materials and structures made thereof, recent trends regarding their engineering application and further research ongoing.	1, 2
3.	Develop fundamental knowledge on the mechanical and other characteristic of different multifunctional materials and their pros and cons.	1, 2, 4
4.	Choose judiciously the most suitable one, amongst a range of existing multifunctional materials, for an engineering application.	5, 6, 7, 8

Modes of Delivery: Power point presentations (main), Talk and chalk (seldom), Self-study (as assigned).

Topics to be Covered:

Units	Details
1.	**Introduction and Mathematical Preliminaries:** History of advanced material developments, Basic ideas, Demand and applications of multifunctional materials in industry, Tensor analysis, PDEs.
2.	**Elementary Anisotropic Elasticity:** Deformation, Stress and Strain Tensor, Strain-Displacement and Compatibility Equations, Constitutive relations, Elasticity Tensor and Generalized Hooke's law, Balance Laws and Equilibrium equations, Constitutive relations for Orthotropic, transversely isotropic and isotropic materials.
3.	**FRP Reinforced Laminated Composites:** Effective lamina properties from fiber-matrix micro mechanics, material and reference axis system, Transformed stiffness of lamina, Stiffness of a laminate, Multidirectional FRP Reinforced Laminated Composites, Hygro-thermal effects.
4.	**CNT Reinforced Composites:** Basics and categories of CNTs, Effective mechanical properties of CNTs – MD simulation and other methods, Effective properties of CNT reinforced composites.
5.	**Functionally Graded Materials (FGMs):** Basic idea based on Lessons from Nature, Graded microstructure - Characteristic dimensions and spatial variations, Volume Fraction, rules of mixture and effective field parameters; Characterization of properties of FGM, Macro-structural-thermo-mechanical properties, Effective material properties for ceramic-metal FGMs, Basic mathematical modeling.
6.	**Smart Materials and Composites:** Piezoelectric materials, Shape Memory Alloys and Super-elastic Materials, Numerical Modeling of Smart Materials, Aerospace and Biomedical Applications of Smart Materials.
7.	**Analysis of Structures (beams and plates) of Functional Materials:** Basic beam and plate theory, Analysis of FRP / CNT reinforced laminated composite structures, Analysis of Functionally graded structures, Smart structures with electromechanical loading, Failure criterion and design philosophies.

Text books, References	:	1. Structural Analysis of Polymeric Composite Materials: Tuttle, Mark E. 2. Shape Memory Alloys: Modeling and Engineering Applications: Lagoudas, Dimitris C. (Ed.) 3. Smart Materials and Structures: M.V. Gandhi and B.S. Thompson 4. Functionally Graded Materials - Nonlinear Analysis of Plates and Shells: Hui-Shen Shen

AM22315 Multiscale Modeling of Advanced Materials

Designation	:	Elective
Pre-requisites	:	Engineering Mathematics, Basic Materials Science, Advanced Solid Mechanics.
Credit and Contact hours	:	4(L) - 0(T) - 0(P) - 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment (Scheme):** 20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).
Course Outcomes	:	see below
Modes of Delivery	:	Talk and chalk / Power point presentations (as required), Self-study (as assigned).
Topics to be Covered	:	see below
Text books, References	:	see below

Course Outcomes

Sl. No.	On successful completion of the course, student is expected to be able to:	Mapping into POs
1.	Demonstrate understanding on the fundamental principles of molecular dynamics, including equations of motion for atoms, atomic interactions etc.	1
2.	Develop awareness on available commercial software for molecular dynamic simulation and skill for designing molecular dynamics simulations using such software.	2, 4, 7
3.	Acquire knowledge on the connection between information available on small (i.e., atomistic) and large (i.e., macroscopic / continuum) scales.	1, 2, 4
4.	Use molecular dynamic simulation data in a finite element simulation, and be able to analyze, interpret / explain and communicate the results, commensurate to the scientific community.	4, 5, 7, 8

Topics to be Covered

Units	Details
1.	**Introduction:** Examples and motivation for exploring multiscale behaviour of materials, Relevant material properties at different scales.
2.	**Review of Preliminaries:** Prerequisite mathematics, Fundamentals of Thermodynamics and statistical mechanics.
3.	**Molecular Dynamics and Related Issues:** Particle-based methods, EAM/MEAM potentials: bridging from QM, Atomistic Plasticity, Damage & Fatigue, Molecular Dynamic Simulation Methods.
4.	**Meso-scale methods:** Overview and need, Quasi-continuum methods, Density Functional method.
5.	**Homogenization and Bridging:** Multi-scale homogenization and stochastic homogenization, Inter-scale exchange and Scale bridging.
6.	**Computational Application:** Variational multiscale methods, Numerical resolution and asymptotic behaviour of stochastic PDEs, Enriched continuum models and design.

Text books, References

1. Nano Mechanics and Materials: Theory, Multiscale Methods and Applications: Liu, Wing Kam, Karpov, Eduard G., and Park, Harold S.
2. An Introduction to Thermal Physics: Schroeder, Daniel V.
3. A First Course in Finite Elements: Fish, Jacob and Belytschko, Ted
4. Nonlinear Finite Elements for Continua and Structures: Belytschko, Ted, Liu, Wing Kam, and Moran, Brian

AM22316 Applied Plasticity				
Designation	:	Elective		
Pre-requisites	:	*Continuum Mechanics/Applied Elasticity*		
Credit and Contact hours	:	4(L) - 0(T) - 0(P) - 4(Cr)		
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks		
		Internal Assessment (Scheme):20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).		
Course Outcomes	:	**Sl. No.**	**On successful completion of the course, student is expected to be able to:**	**Mapping into POs**
		1.	Understand the elastic and plastic behavior from stress-strain curves for materialsat normal temperatures as related to questions of strength of structures	1, 2, 3
		2.	Understand the physical interpretation of material constants in mathematical formulation of constitutive relationship	1, 2, 3
		3.	Use plasticity theory to design beams, plates and shells and the system consisting of these structural element	4, 5, 6, 7
		4.	Develop constitutive models based on experimental results on material behavior	3, 8
Modes of Delivery	:	Talk and chalk (main), Power point presentations (sometimes), Self-study (as assigned), Hands on training through Computer Programming.		
Topics to be Covered	:	**Units**	**Details**	
		1.	**Crystal plasticity:** Resolved shear stress & strain, Lattice slip systems, Hardening, Yield surface, Flow rule, Micro to Macro plasticity.	
		2.	**Stresses and Strains:** The Stress–Strain Behaviour, Analysis of Stress, Mohr's Representation of Stress, Velocity gradient and rate of deformation, Kinematics of large deformation, The Criterion of Yielding, Yielding of materials under complex stress state, Choice of yield function.	
		3.	**Non-Hardening & Elastic-Perfect Plasticity:** Classical theories and its application to uniform & non uniform stress states, Hencky vs. Prandtl-Reuss, Elastic–Plastic Torsion and Bending of Beams, Thick walled cylinders.	
		4.	**Theory of the Slipline Field:** Formulation of the Plane Strain Problem, Properties of Slipline Fields and Hodographs, Stress Discontinuities in Plane Strain, Construction of Slipline Fields and Hodographs, Analytical and Matrix Methods of Solution, Explicit Solutions for Direct Problems, Some Mixed Boundary-Value Problems, Superposition of Slipline Fields.	
		5.	**Limit Analysis:** Collapse of Beams & Structures, Transverse loading of circular plates.	
		6.	**The Flow Curve:** Uniaxial tests, Torsion tests, Compression tests, Bulge test, Equations to flow curve, Strain & work hardening hypothesis.	
		7.	**Plasticity with Hardening:** Isotropic hardening, Non associated flow rules, Prandtl-Reuss flow theory, Kinematic hardening.	
		8.	**Plastic Instability:** Inelastic buckling of struts, Buckling of plates, Tensile instability, Circular bulge instability, Plate stretching.	
Text books, References		1. Theory of Plasticity: J. Chakrabarty 2. Plasticity Theory: Jacob Lubliner. 3. Basic Engineering Plasticity: DWA Rees		

		4. The Mathematical theory of plasticity: R.Hill 5. Finite Elements in Plasticity- Theory & Practice: D. R. J. Owen and E. Hinton 6. Continuum Theory of Plasticity: S. Huang 7. Fundamentals of the Theory of Plasticity: L.M. Kachanov 8. Plasticity for Engineers: Theory and Applications: C. R. Calladine

AM22317 Fracture Mechanics		
Designation	:	Elective
Pre-requisites	:	*Continuum Mechanics/Applied Elasticity*
Credit and Contact hours	:	4(L) - 0(T) - 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment (Scheme)**:20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).
Course Outcomes	:	see below

Sl. No.	On successful completion of the course, student is expected to be able to:	Mapping into POs
1.	Understand the principles, application and limitations of fracture mechanics	1, 2
2.	Calculate the fracture toughness of a material of standard specimen geometry	3, 4, 7
3.	Understand the micro-mechanisms of fracture failure in metals	1, 2
4.	Formulate problems in terms of fracture mechanics	5, 7, 8

Modes of Delivery	:	Talk and chalk (main), Power point presentations (sometimes), Self-study (as assigned), Hands on training through Computer Programming.

Topics to be Covered:

Units	Details
1.	**Introduction:** Modes of loading, Crack growth and fracture mechanisms, Need for fracture mechanics, Linear elastic fracture mechanics and elastic plastic fracture mechanics.
2.	**Energy Release Rate:** Surface Energy, Resistance, Griffith Theory of fracture, Extension of Griffith Theory by Irwin and Orowan, R-Curve, Pop-in phenomena, Crack branching. Necessary and sufficient conditions for fracture.
3.	**Crack-Tip Stress and Displacement Fields:** Airy's stress function, Westergaard's approach, Generalized Westergaard's approach, William's Eigen function approach, Multi-parameter stress field equations, Influence of the T-stress and higher order terms, Role of photoelasticity on the development of stress field equations in fracture mechanics.
4.	**Stress Intensity Factor:** Equivalence between SIF and *G*, Various methods for evaluating Stress Intensity Factors.
5.	**Crack Tip Plastic Zone:** Modeling plastic zone at the crack-tip, Irwin and Dugdale models.
6.	**Fracture Toughness Testing:** Qualitative toughness testing, K_{Ic} testing, K-R curve testing, J_{Ic} measurements, J-R curve testing, CTOD testing.
7.	**Micromechanics of Fracture:** Cohesive strength of solids, Cleavage fracture, Intergranular fracture, Ductile fracture, Crack detection methods.

Text books, References:

1. Elementary Engineering Fracture Mechanics: D. Broek
2. Elements of Fracture Mechanics: Prashant Kumar
3. Fracture Mechanics - Fundamentals and Applications: T. L. Anderson
4. Introduction to Fracture Mechanics: Kare Hellan
5. Fracture Mechanics- With an Introduction to Micromechanics: Dietmar Gross and Thomas Seelig
6. Fracture Mechanics- An Introduction: E.E. Gdoutos

AM22318 Continuum Damage Mechanics

Designation	:	Elective
Pre-requisites	:	*Continuum Mechanics, Linear Algebra, Differential Equations*
Credit and Contact hours	:	4(L) - 0(T) - 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment (Scheme):** 20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).

Course Outcomes:

Sl. No.	On successful completion of the course, student is expected to be able to:	Mapping into POs
1.	To select appropriate damage measures and to model damage using suitable variables	1, 2
2.	To understand and derive thermodynamically consistent dissipation potentials, constitutive equations and evolution equations	1, 4
3.	To classify and describe different kinetic laws of damage evolution	1, 4, 7
4.	To implement the damage theories for analysis of damage in structures	4, 6, 7, 8

Modes of Delivery: Talk and chalk (main), Power point presentations (sometimes), Self-study (as assigned), Hands on training through Computer Programming.

Topics to be Covered:

Units	Details
1.	**Essentials of Continuum mechanics:** Tensorial notation, stress, strain, invariants, equilibrium equations, Domain and validity of continuum damage mechanics, concept of representative volume element.
2.	**Phenomenological aspects of damage:** Damage, measurement of damage, modeling of damage through effective area reduction, void volume fraction and stiffness reduction, representation of damage through different orders of tensors, concept of effective stress, hypothesis of strain equivalence, strain energy equivalence, and complementary strain energy equivalence.
3.	**Thermodynamics of damage:** State variables, damage as state variables, first and second law of thermodynamics, thermodynamics potentials, dissipation potentials, constitutive equations, evolution equations.
4.	**Kinetic Laws of Damage Evolution:** Unified formulation of damage laws, damage laws for brittle, quasi-brittle, ductile, creep, low cycle and high cycle fatigue.
5.	**Damage Analysis of Structures:** Implementation of isotropic damage theory, case studies from literature.

Text books, References:

1. A Course on damage mechanics: Jean Lemaitre
2. Continuum damage mechanics: S. Murakami
3. Mechanics of solid materials: Jean Lemaitre and J. L. Chaboche
4. An Introduction to damage mechanics: L. M. Kachanov
5. Damage mechanics with finite elements: P. I. Kattan and G. Z. Voyiadjis
6. Damage mechanics: Dusan Krajcinovic
7. Damage mechanics: George Z. Voyiadjis and Peter I. Kattan

AM22319 Analysis and Design of Composite Structures		
Designation	:	Elective
Pre-requisites	:	*Continuum Mechanics / Solid Mechanics, Basic Engineering Mathematics, Linear Algebra, Differential Equations*
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks; Mid Semester Exam: 20 marks **Internal Assessment (Scheme):** 20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).
Course Outcomes	:	see below

Sl. No.	On successful completion of the course, student is expected to be able to:	Mapping into POs
1.	Apply the basic theories of bending, buckling and vibration to laminated beams, plates and shells	1,2,3
2.	Understand the stress distribution in laminated beams, plates and shells	4,7,8
3.	To understand different mechanical test methods and design new tests for characterization	3,4,6,7
4.	To design the damage tolerant composite structures by applying the failure theories.	4,7,8

Modes of Delivery	:	Talk and chalk (main), Power point presentations (sometimes), Self-study (as assigned), Hands on training through Computer Programming.
Topics to be Covered	:	see below

Units	Details
1.	**Introduction:** Anisotropic elasticity, Virtual Work Principles, Variational Methods, Transformation of Stresses & Strains.
2.	**Analysis of Composite Structures:** Classical lamination theory, shear deformation theories, Bending, Buckling and Vibration of Beams, Plates and Shells, Damage Mechanisms and Failure Theories.
3.	**Characterization and Testing:** Characterization of fiber & matrix, Mechanical Testing: Tension, Compression, Shear, Flexure, Fracture Toughness, Impact and Compression After Impact (CAI).
4.	**Introduction to Composite Design:** Framework for Composite Design, Ply Orientation and arrangement, Use of Failure Criterion, Sizing of the Laminates.

Text books, References

1. Mechanics of fibrous composites: Carl T. Herakovich
2. Introduction to Composite Material: Stephen W. Tsai and H. Thomas Hahn
3. Composite Materials and their use in Structures: J. R. Vinson and T.W. Chou
4. Composite Structures-Testing, Analysis and Design: J. N. Reddy and A.V. Krishna Moorty
5. Composite Materials - Design and Applications: D. Gay, S. V. Hoa, S. W. Tsai
6. Introduction to Composite Materials Design: E J. Barbero

AM22320 Micromechanics		
Designation	:	Elective
Pre-requisites	:	*Continuum Mechanics, Theory of Elasticity*
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment (Scheme):** 20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).

Course Outcomes:

Sl. No.	On successful completion of the course, student is expected to be able to:	Mapping into POs
1.	Recognize the mathematical frameworks and learn fundamental mathematical solutions for various inclusions and inhomogeneity problems.	1, 2
2.	Develop an understanding of micromechanics-based theories for the computation of effective material properties of heterogeneous materials.	1, 2, 4
3.	Understand the different homogenization techniques and develop skills to perform homogenization of heterogeneous materials by commercial software.	2, 4, 7
4.	Understand the complex constitutive material behaviour (viscoelasticity / viscoplasticity) of heterogeneous materials applying micromechanics-based theories.	3, 4, 5, 6, 7, 8
5.	Learn and develop skills to implement the constitutive material behavior in commercial software for solving boundary value problems on heterogeneous materials.	4, 5, 6, 7, 8

Modes of Delivery:

Talk and chalk (main), Power point presentations (sometimes), Self-study (as assigned),

Note: Assignments involving coding and discussion of ongoing research in the related fields (discussion of research papers) need to be given to the students on the following (or similar) topics:

1. Homogenization by computational methods using FEM-based commercial software ABAQUS®.
2. Implementation of material behavior (effective material properties) through user subroutines (UMAT/VUMAT) in ABAQUS®.
3. Computation of effective properties by various micromechanics-based theories

Topics to be Covered:

Units	Details
1.	**Introduction:** Scalars, Vectors, Tensors, Mathematical framework and notations, Mechanics, Micromechanics, Review of linear elasticity
2.	**Inclusions and inhomogeneities:** General theory of eigenstrains, Eigenstrains and eigenstresses, Fundamental solutions to eigenstrain problems, Fourier series and integrals, Three dimensional Green's function, Eshelby's solution for the inclusion problem, Ellipsoidal inhomogeneities, Eshelby's equivalence principle, Interaction between inhomogeneities

		3.	**Effective properties of heterogeneous media:** Average strains and stresses, Hill's lemma, Voigt and Reuss approximations, Upper and lower bounds, Hashin-Shtrikman bounds, Dilute inclusion method, Self-consistent method, Generalized self-consistent method, Differential self-consistent method, Mori-Tanaka method, Composite spheres and composite cylinders models, Effective thermal and electrical properties
		4.	**Homogenization techniques for heterogeneous media:** Representative volume elements, Boundary conditions for representative volume elements, Random and Periodic microstructures, Perturbation methods, Non-linear homogenization methods, Direct numerical homogenization schemes, Computational methods, Numerical examples involving programming in MATLAB / FORTRAN /PYTHON, Numerical practice in applying periodic boundary conditions for computational homogenization using finite element software ABAQUS®
		5.	**Micromechanical modeling:** Micromechanical modeling of viscoelastic and viscoplastic constitutive behavior of composites, numerical implementation of constitutive behavior in finite element software ABAQUS® by user material subroutines through FORTRAN programming
Text books, References			1. "Micromechanics of solids" D.R. Axelrad, Elsevier Scientific Pub., 1978. 2. "Micromechanics of defects in solids" T. Mura, Springer, New York, 1987. 3. "Micromechanics: Overall Properties of Heterogeneous Materials" S. Nemat-Nasser and M. Hori, North Holland, 1998. 4. "Mechanics of Composite Materials" R. M. Christensen, Dover Publications, New York, 2005. 5. "Fundamentals of micromechanics of solids" Jianmin Qu, Mohammed Cherkaoui, John Wiley & Sons, Inc, 2006. 6. "Fracture mechanics: with an introduction to micromechanics", Dietmar Gross and Thomas Seelig, Springer, 2006."Introduction to Micromechanics and Nanomechanics" S. Li and G. Wang, World Scientific, Singapore, 2008. 7. "Modeling materials: continuum, atomistic and multiscale techniques" E.B. Tadmor and R.E. Miller, Cambridge University Press, 2013.

AMXXXXX Electro-acoustic Transducers				
Designation	:	Elective		
Pre-requisites	:	*Basic Electrical/Electronics Engineering, Wave Propagation*		
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)		
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment (Scheme):** 20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).		
Course Outcomes	:	**Sl. No.**	**On successful completion of the course, student is expected to be able to:**	**Mapping into POs**
		1.	Identify the significance of acoustics in human life.	1,5,8
		2.	Apply electro-mechano-acoustical analogy (equivalent circuit method) for electroacoustic transducer.	2,3,6
		3	Design and simulate microphone and loudspeaker.	4,7,8
Modes of Delivery	:	Talk and chalk (main), Power point presentations (sometimes), Self-study (as assigned), Hands on training through Computer Programming.		
Topics to be Covered	:	**Units**	**Details**	
		1.	**Introduction to Acoustics:** Acoustic variables & basic relations, plane & spherical waves, reflection & transmission, radiation & reception of acoustic waves, absorption and attenuation of sound.	
		2.	**Electro-Mechano-Acoustical Analogy:** Introduction, basic equations and impedances, transformer and gyrator, simple harmonic oscillator, Helmholtz resonator, loop analysis, circuit elements, Lagrange equation.	
		3.	**Acoustical Elements:** Basic acoustic elements, specific acoustic impedance, mechanical impedance, electrical impedance, acoustic radiation impedance, duct impedance, equivalent circuit model, various acoustical examples, frequency and wavelength, dB scale, sound pressure level.	
		4.	**Basic Theory and Modeling of Microphone:** Introduction, types, response, sensitivity, specifications, directivity pattern, microphone array, microphone equation, electret condenser microphone (ECM), ECM model for various types of microphone.	
		5.	**Basic Theory and Modeling of Moving Coil Transducer:** Introduction, types, reciprocal and anti-reciprocal system, TS parameters, speaker non-linearities, equivalent circuit representation, loudspeaker enclosure, types of loudspeaker enclosure and corresponding circuits, total harmonic distortion, intermodulation distortion, miniature loudspeaker.	
		6.	**Theory and Analysis of Piezoelectric Transducer:** Brief introduction to piezoelectricity, piezoelectric materials, piezoelectric devices, polarization, equivalent circuit, piezoelectric accelerometer, piezoelectric speaker, piezoelectric microphone.	
		7.	**Term Paper:** On recent advances based on literature survey and/or lab/industry visit.	
Text books, References		1. Acoustics: L. L. Beranek 2. Introduction to Electro acoustics and Amplifier Design: W. M. Leach 3. Acoustics-An Introduction: H. Kuttruff 4. Fundamentals of Acoustics: Kinsler, Frey, Coppens, and Sanders 5. Audio Engineer's Reference Book: Michael Talbot-Smith(Editor)		

Master of Technology

in
FLUIDS ENGINEERING

Course Structure,
Scheme of Evaluation
&
Syllabi

(*Proposed to be Effective from July 2021*)

Department of Applied Mechanics
Motilal Nehru National Institute of Technology Allahabad
Prayagraj, U.P. -211004, INDIA

VISION AND MISSION OF THE INSTITUTE

VISION

To establish a unique identity for the institute amongst national and international academic and research organizations through knowledge creation, acquisition and dissemination for the benefit of society and humanity.

MISSION

- To generate high quality human and knowledge resources in our core areas of competence and emerging areas to make valuable contribution in technology for social and economic development of the nation. Focused efforts to be undertaken for identification, monitoring and control of objective attributes of quality and for continuous enhancement of academic processes, infrastructure and ambience.
- To efficaciously enhance and expand, even beyond national boundaries, its contribution to the betterment of technical education and offer international programmes of teaching, consultancy and research.

VISION AND MISSION OF THE DEPARTMENT

VISION

To establish itself as a department recognized for its quality post graduate education and research in the broad field of Applied Mechanics and Materials.

MISSION

VISION

To establish itself as a department recognized for its quality post graduate education and research in the broad field of Applied Mechanics and Materials.

MISSION

- To produce high quality human resource in the area of Applied Mechanics and Materials Engineering by way of continuous up gradation of curriculum, improvement in academic processes & ambience, and faculty & infrastructure development.
- To create knowledge resource through research in emerging areas of Applied Mechanics and Materials in collaboration with national & international academic, research and industrial organizations and disseminate the same by contributing and conducting STTP, Workshops, Symposiums and Conferences.

Program Educational Objectives (PEOs):

The *Program Educational Objectives* (PEOs) embody the expected accomplishments of students, who successfully passed from the program, during their first few years (about 3-5) following their post-graduation. The PEOs for the presently proposed program in M.Tech. (Fluids Engineering) are as follows.

PEO-1: To apply fundamentals of Fluid Mechanics and related areas of Engineering to define, model and solve wide range of engineering problems pertaining to Fluids, Thermal Engineering and Turbomachines.

PEO-2: To develop Fundamental mathematical and scientific principles as well as computational and experimental techniques to meet the demands of engineering and scientific practice in industry and R&Ds.

PEO-3: To provide continuous thrusts on new areas of research and development in Fluids Engineering, particularly those that cross the boundaries of traditional disciplines.

PEO-4: To strive for collaboration with academia, R&D organizations and industries at national and international platforms.

PEO-5: To inculcate the skills of corporate ethics, environmental, social responsibility, communication, employability, professionalism and leadership in the post-graduate students by involving experts from commerce, industry and small enterprises.

PEO-6: To make students aware about the importance of life-long and self-learning and make them confident and enthusiastic enough for the same for their professional growth. This would also enable them to successfully pursue higher / advanced studies, if they so desire.

PEO-7: To continually review and modify M.Tech. curriculum commensurate with dynamically changing employment/engagement demands by active involvement of stakeholders.

Mapping of *Program Educational Objectives* (PEOs) to *Mission Statements* (MS)

Mission Statements	PEO-1	PEO-2	PEO-3	PEO-4	PEO-5	PEO-6	PEO-7
MS-1	√	√	√	√	√	√	√
MS-2	√		√		√	√	√

Graduate Attributes (GAs):

The following *Graduate Attributes* (GAs), attained through the *Program Outcomes* mentioned later, would help the successful students passing through the program to achieve the aforementioned PEOs.

1. **Scholarship of Knowledge**: Acquire in-depth knowledge of specific discipline or professional area, including wider and global perspective, with an ability to discriminate, evaluate, analyze and synthesize existing and new knowledge, and integration of the same for enhancement of knowledge.
2. **Critical Thinking**: Analyze complex engineering problems critically, apply independent judgment for synthesizing information to make intellectual and/or creative advances for conducting research in a wider theoretical, practical and policy context.
3. **Problem Solving**: Think laterally and originally, conceptualize and solve engineering problems, evaluate a wide range of potential solutions for those problems and arrive at feasible, optimal solutions after considering public health and safety, cultural, societal and environmental factors in the core areas of expertise.
4. **Research Skill**: Extract information pertinent to unfamiliar problems through literature survey and experiments, apply appropriate research methodologies, techniques and tools, design, conduct experiments, analyze and interpret data, demonstrate higher order skill and view things in a broader perspective, contribute individually/in group(s) to the development of scientific/technological knowledge in one or more domains of engineering.
5. **Usage of modern tools**: Create, select, learn and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modeling, to complex engineering activities with an understanding of the limitations.
6. **Collaborative and Multidisciplinary work**: Possess knowledge and understanding of group dynamics, recognize opportunities and contribute positively to collaborative-multidisciplinary scientific research, demonstrate a capacity for self-management and teamwork, decision-making based on open-mindedness, objectivity and rational analysis in order to achieve common goals and further the learning of themselves as well as others.
7. **Project Management and Finance**: Demonstrate knowledge and understanding of engineering and management principles and apply the same to one's own work, as a member and leader in a team, manage projects efficiently in respective disciplines and multidisciplinary environments after consideration of economical and financial factors.
8. **Communication Skill**: Communicate with the engineering community, and with society at large, regarding complex engineering activities confidently and effectively, such as, being able to comprehend and write effective reports and design documentation by adhering to appropriate standards, make effective presentations, and give and receive clear instructions.
9. **Life-long Learning**: Recognize the need for, and have the preparation and ability to engage in life-long learning independently, with a high level of enthusiasm and commitment to improve knowledge and competence continuously.
10. **Ethical Practices, Environment and Social Responsibility**: Acquire professional and intellectual integrity, professional code of conduct, ethics of research and scholarship, consideration of the impact of research outcomes on professional practices and an understanding of responsibility to contribute to the community for sustainable development of society.
11. **Independent and Reflective Learning**: Observe and examine critically the outcomes of one's actions and make corrective measures subsequently, and learn from mistakes without depending on external feedback.

These aforementioned GAs represent the required linkage between the *Program Outcomes* and the *Program Educational Objectives*.

Mapping of *Graduate Attributes* (GAs) to *Program Educational Objectives* (PEOs)

PEOs	GA-1	GA-2	GA-3	GA-4	GA-5	GA-6	GA-7	GA-8	GA-9	GA-10	GA-11
PEO-1	√		√		√					√	
PEO-2	√	√	√		√	√	√		√	√	
PEO-3		√				√	√	√		√	√
PEO-4	√		√	√	√			√	√		√
PEO-5		√	√	√		√	√			√	
PEO-6			√			√			√	√	√
PEO-7		√		√	√				√		√

Program Outcomes (POs):

The *Program Outcomes* (POs), which represent the immediate knowledge, skills and capabilities to be acquired by the students on successful completion of the proposed program and facilitates the attainment of PEOs at a longer time span, are as follows. Numbers inside parentheses indicate relevant PEO(s), to which the POs map.

1. **Fundamental Mathematical, Scientific & Engineering Knowledge and Skill** (1,2)
   - Acquire fundamental knowledge of Mathematics, Natural Sciences and Engineering and ability to apply the same in Fluids Engineering and related areas.
2. **Knowledge Development, Analytical and Problem Solving Skills on Core Fluids Engineering Subjects** (1,2)
   - Knowledge on fundamentals of Fluids, Thermal Engineering and Turbomachines.
   - Ability to identify, formulate and solve engineering problems related to these areas.
3. **Ability for Practical Experimentation and Information Retrieval Skill** (2)
   - Ability to design and conduct experiments, perform computation and numerical analysis, as well as to analyze and interpret data obtained from experimentation related to Fluids Engineering.
4. **Acquaintance with Modern Tools, Softwares etc in Fluids Engineering** (2,3)
   - Awareness on and skills to use modern tools, software and equipment for analysis / experimentation on problems from Fluids Engineering or related areas.
5. **Communication Skills and Personality Development, for Team Work and Leadership Qualities** (5)
   - Ability to communicate effectively, both orally and in writing.
   - Ability to function as a productive member of a team, including leading a team if required, for handling multi-disciplinary engineering projects.
6. **Innovation, Creativity and Real-life Engineering Design Skill** (3,4,5)
   - Inculcation of innovation and creativity for design competence, considering current standards and regulations, for conceptual design, which requires integration of ideas from different Fluids Engineering topics.
   - Ability to design a system, component or process to meet desired needs within technological, socio-economic, environmental, political and ethical constraints.
7. **Awareness on Latest Trends in and Role of Fluids Engineering** (6,7)
   - Knowledge of contemporary and emerging issues in Fluids Engineering and related areas as well as the role and importance of Fluids Engineering in the society.
8. **Immediate Employment and Preparedness for a Successful Career** (5, 6, 7)
   - Development of ability and skills to face and succeed in competitive examinations, jobs, and higher studies, research.
9. **Motivation and Awareness on Importance of Continuing and Higher Education** (6)
   - Awareness on the need for, and an ability to engage in life-long learning and self-learning.
   - Motivation for advanced and higher study on fluids and relevant areas of engineering, for further developing professional skill and research potential.
10. **Professional Integrity, Environmental and Social Awareness** (5)

- Ability to understand the impact of an engineering solution on global, economic, environmental and societal context.
- Understanding of professional, ethical and social responsibility.

Mapping of *Program Outcomes* (POs) to *Program Educational Objectives* (PEOs)

POs	PEO-1	PEO-2	PEO-3	PEO-4	PEO-5	PEO-6	PEO-7
PO-1	√	√		√			
PO-2		√		√			
PO-3	√		√				
PO-4	√	√		√	√	√	
PO-5			√		√		
PO-6	√			√			
PO-7	√	√		√	√		
PO-8	√			√	√		
PO-9			√	√		√	√
PO-10					√		√

Proposed Programme Structure
M.Tech. (Fluids Engineering)

I Semester (Total Credits = 20):

Course Code	Subject Name	L	T	P	Credits	Distribution of Marks out of 100		
						TA	Mid Sem. Exam	End Sem. Exam
AM21101	Applied Mathematics and Computation	4	0	0	4	20	20	60
AM21105	Advanced Fluid Mechanics	4	0	0	4	20	20	60
AM21XXX	Elective-I	4	0	0	4	20	20	60
AM21XXX	Elective-II	4	0	0	4	20	20	60
AM21XXX	Elective-III	4	0	0	4	20	20	60

List of Electives (Semester I):

List of Electives (for Electives-I, II and III)	
AM21106	Computational Fluid Dynamics
AM21343	Aerodynamics.
AM21344	Wind Engineering.
AM21345	Research Methodology.
AM21310	Applied Elasticity
AM21341	Bio-Fluid Dynamics.
AM21346	Multiphase Flow.
AM21347	Design of Experiments.
AM****	Applied Thermal Engineering
AM****	Wave Hydrodynamics
AM21342	Convective Heat Transfer.
AM****	Micro and Nano-Scale Flows
ME21348	Gas Turbine and Jet Propulsion.

II Semester (Total Credits = 20):

Course Code	Subject Name	L	T	P	Credits	Distribution of Marks out of 100		
						TA	Mid Sem. Exam	End Sem. Exam
AM22104	Turbulence	4	0	0	4	20	20	60
AM22204	Fluids Engineering Laboratory	0	0	6	4	20	20	60
AM22XXX	Elective-IV	4	0	0	4	20	20	60
AM22XXX	Elective-V	4	0	0	4	20	20	60
AM22XXX	Elective-VI	4	0	0	4	20	20	60

List of Electives (Semester II):

List of Electives (for Electives-IV, V and VI)	
AM22349	Advanced Computational Fluid Dynamics
AM22340	Fluid-Structure Interaction.
AM22341	Boundary Layer Theory.
AM22342	Design of Pipe Networks.

ME22343	Thermo-Fluid Dynamics.
AM22343	Design of Heat Exchangers.
AM22344	Design of Hydraulic Turbines.
AM22345	River Engineering.
ME22335	Advanced Gas Dynamics.
AM22346	Industrial Aerodynamics.
AM22347	Design of Impeller Pumps.
AM22348	Condition Monitoring, Diagnosis and Predictive Maintenance of Pumps.
AM22349	Numerical Methods for Compressible Flows
AM22350	Water Footprint and Life Cycle Analysis
AM223**	Particle Technology
AM223**	Bulk Solids Handling
AM223**	Multiphase Flow Laboratory
AM223**	Computational Heat Transfer

III Semester (Total Credits = 20):

S. No.	Subject Name	Credits
AM23654	Special Study/Term Project/State of the Art/Colloquium Industrial/Research Training	4
AM23604	Thesis/Project	16

IV Semester (Total Credits = 20):

S. No.	Subject Name	Credits
AM24604	Thesis/Project	20

Note: The distribution of thesis evaluation marks will be as follows:

1. Supervisor(s) evaluation component: 60%
2. Oral Board evaluation component: 40%

Semester-I

AM21101 Applied Mathematics and Computation				
Designation	:	Required / Elective		
Pre-requisites	:	*Engineering Mathematics &Computer Programming*		
Credit and Contact hours	:	L+T+P=4		
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks		
		Internal Assessment (Scheme):20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).		
Course Outcomes	:	**Sl. No.**	**On successful completion of the course, student is expected to be able to:**	**Mapping into POs**
		1.	To Identify the differences between "Exact methods & Computational Methods" and applications of these methods.	1, 2
		2.	To Develop knowledge of expressing a real life problem in terms of mathematics i.eto develop the skill of Mathematical Modelling.	3.4
		3.	To Identify and develop the skill to solve real life engineering problems e.g. Nonlinear Problems, Initial Value & Boundary Value Problems, Numerical Differentiation & Integration problems.	4, 5, 6
		4.	To develop skill of writing Flow Charts of real life engineering problems and transform those into computer programming	6, 7, 8
Modes of Delivery	:	Talk and chalk (main), Power point presentations (sometimes), Self-study (as assigned), Hands on training through Computer Programming.		
Topics to be Covered	:	**Units**	**Details**	
		1.	**Review of Elementary Engineering Mathematics:** Solution of homogeneous and non-homogeneous equations; Power series; Laplace transform and its applications; Fourier series and Fourier transform	
		2.	**Linear Algebra:** Matrices and Linear Transformations, Operational Fundamentals of Linear Algebra, Systems of Linear Equations, Gauss Elimination Family of Methods, Special Systems and Special Methods, Numerical Aspects in Linear Systems, Eigenvalues and Eigenvectors, Diagonalization and Similarity Transformations, Jacobi and Givens Rotation Methods, Tri-diagonal Matrices, QR Decomposition Method, Eigenvalue Problem of General Matrices, Singular Value Decomposition, Direct and Iterative solvers.	
		3.	**Ordinary Differential Equations:** Introduction to ordinary differential equations, homogeneous linear equations of second order, non-homogeneous linear equations of second order, free and forced oscillation problems, problems with variable coefficients, system of equations.	
		4.	**Partial Differential Equations (PDEs):** Existence and uniqueness of differential equations, nature of solution, Hyperbolic, Parabolic and Elliptic PDEs, nonlinear PDEs.	
		5.	**Nonlinear Equations:** Motivation, Open and brakcting method, Bisection, Fixed point, Newton's method, Secant and False position method, Rate of convergence, Merits and demerits of methods.	
		6.	**Numerical Integration:** Motivation, Newton-Kotes method, Trapezoidal rule, Simpson's rule, Rhomberg integration, Gauss Quadrature.	
		7.	**Initial Value Problem:** Motivation, Euler's method, Modified Euler method, Runge-Kutta methods, Adaptive integrations and multistep methods.	
		8.	**Boundary-value and Eigen-value Problem:** Methods and Applications in Mechanics.	

Text books, References		1. Numerical Methods in Engineering: M. Salvadori 2. Applied Numerical Methods: B. Carnahan 3. Applied Numerical Analysis: C.F. Gerald and P.O. Wheatley 4. Numerical Mathematics & Computing: W. Cheney and D. Kincaid 5. Applied Partial Differential Equations; Paul DuChateau and David Zachmann. 6. Partial Differential Equations for Scientists and Engineers: Stanley J. Farlow. 7. Numerical Methods for Partial Differential Equations: William F. Ames. 8. Numerical Methods for Elliptic and Parabolic Partial Differential Equations: John R Levison, Peter Knabner, Lutz Angermann

AM21105 Advanced Fluid Mechanics		
Designation	:	Required / Elective
Pre-requisites	:	*Engineering Fluid Mechanics, Thermodynamics.*
Credit and Contact hours	:	L+T+P=4
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment (Scheme)**:20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).
Course Outcomes	:	see below
Modes of Delivery	:	Talk and chalk (main), Power point presentations (sometimes), Self-study (as assigned), Hands on training through Computer Programming.
Topics to be Covered	:	see below
Text books, References		1. "Fundamental Mechanics of Fluids", I. G. Currie. 2. "Foundations of Fluid Mechanics", S.W. Yuan, Prentice-Hall India Pvt. Ltd, New Delhi. 3. "Advanced Fluid Mechanics", K. Muralidhar & G. Biswas, Narosa Publishing, 2005. 4. "Boundary Layer Theory", H. Schlichting, 6th Edition, McGraw-Hill Inc.,

Course Outcomes

Sl. No.	**On successful completion of the course, student is expected to be able to:**	**Mapping into POs**
1.	An ability to apply control volume approach to problems in fluids engineering.	1,2
2.	An ability to use potential flow theory to solve fluid mechanics problems.	1,2, 3
3.	An ability to identify Boundary layer separation, its causes and control.	2
4.	An ability to apply the concepts developed for fluid flow analysis to issues in aerospace design.	6, 7

Topics to be Covered

Units	**Details**
1.	**Basic Conservation & Governing Laws:** Statistical & continuum methods, Eulerian & Lagrangian coordinates, material derivatives, control volumes, Reynolds' transport theorem (RTT), conservation of mass, momentum and energy, constitutive equations, Navier-Stokes equations-differential & intergral approach, energy equations, governing equations for Newtonian fluids, boundary conditions.
2.	**Potential Flows:** Stokes stream functions, solution of potential equation, flow in a sector, flow around a sharp edge, flow near a blunt nose force and moment on a circular cylinder and sphere, conformal transformations, Joukowski transformations.
3.	**Viscous Incompressible Flows:** Exact solutions for Couette flow, Poiseuille flow, flow between rotating cylinders, Stokes' first problem, Stokes' second problem, pulsating flow between parallel surfaces, stagnation-point flow, flow in convergent and divergent channels, flow over porous wall. Stokes approximation, rotating sphere in a fluid, uniform flow past a sphere and cylinder, Ossen's approximation, Hele-Shaw flow.
4.	**Introduction to Boundary Layer:** Derivation of boundary layer equation, How potential flow complements B.L. equation, Integral solution of B.L., Laminar and turbulent boundary layers; transition; B.L. separation and control.
5.	**Introduction to Compressible Flow:** Velocity of sound and its importance, physical difference between incompressible, subsonic and supersonic flows, Mach number and its significance, Isentropic flow through nozzles, shocks and expansion waves, Rayleigh and Fanno Flow.

		1986. 5. "Modern Compressible Flow with Historical Perspective", John D. Anderson, McGraw Hill. 7. "Fundamentals of Aerodynamics" (2nd ed), J. D. Anderson, McGraw Hill. 8. "Fundamentals of Fluid Mechanics", B.R. Munson, D.F. Young & T.H. Okiishi, 2nd Ed., John Wiley. 9. "Introduction to Fluid Mechanics", R.W. Fox & A.T. McDonald, 5^{th} Edition, John Wiley, 2001. 10. "Viscous Fluid Flow", F. M. White, 2^{nd} Edition, McGraw-Hill, 1991.

AM21106 Computational Fluid Dynamics		
Designation	:	Required / Elective
Pre-requisites	:	*Engineering Fluid Mechanics, Heat Transfer, Engineering Mathematics, CAD, Computer programming.*
Credit and Contact hours	:	L+T+P=4
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment (Scheme):** 20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).

Course Outcomes:

Sl. No.	On successful completion of the course, student is expected to be able to:	Mapping into POs
1.	To mathematically model the engineering problems.	1, 2
2.	To discretize the governing equations of engineering problems using various discretization techniques.	2, 3
3.	To solve various types of engineering problems using CFD.	3, 4, 5
4.	Latest development in CFD techniques and newer applications.	6, 7, 8, 9

Modes of Delivery: Talk and chalk (main), Power point presentations (sometimes), Self-study (as assigned).
Note: Term paper, Assignments and Demonstration need to be given to the students on the following (or similar) topics using available CFD software:
- CFD analysis of an external flow problem (example, airfoil).
- CFD analysis of an internal flow problem (example, flow inside curved ducts, channels).
- CFD analysis of an unsteady flow problem.

Topics to be Covered:

Units	Details
1.	**Basic Ideas of CFD:** Introduction to CFD, role of CFD and its applications, future of CFD. **Governing equations (GE's) of Fluid dynamics:** Modeling of flow, control volume concept, substantial derivative, physical meaning of the divergence of velocity. Continuity equation, momentum equation, energy equation and its conservation form. Equations for viscous flow (Navier-Stokes equations), equations for inviscid flow (Euler equation). Different forms of GE's, initial and boundary conditions.
2.	**FVM for Diffusion Problems:** FVM for 1D steady state diffusion, 2D steady state diffusion, 3d steady state diffusion. Solution of discretised equations- TDMA scheme for 2D and 3D flows.
3.	**FVM for Convection-Diffusion Problems:** FVM for 1D steady state convection-diffusion, Central differencing scheme, Conservativeness, Boundedness, Transportiveness, Upward differencing scheme, Hybrid differencing scheme for 2D and 3D convection-diffusion, Power-law scheme, QUICK scheme.
4.	**Solution Algorithm for Pressure-velocity Coupling in Steady Flows:** Concept of staggered grid, SIMPLE, SIMPLER, SIMPLEC, PISO algorithm.
5.	**FVM for Unsteady Flows:** 1D unsteady heat conduction (Explicit, Crank-Nicolson, fully implicit schemes), Implicit methods for 2D and 3D problems, Discretization of transient convection-diffusion problems, solution procedure for transient unsteady flow calculations (transient SIMPLE, transient PISO algorithms).
6.	**Latest development in CFD techniques and newer applications.**

Text books, References:

1. "An Introduction to Computational Fluid Dynamics: the Finite Volume Method", H.K. Versteeg and W. Malalasekara, 2nd edition, Pearson Education, England, 2007.
2. "Computational Fluid Dynamics for Engineers" B. Andersson & others, 1st edition, Cambridge University Press, U.K., 2012.
3. "Computational Fluid Flow and Heat Transfer" (2nd edition), K. Muralidhar and T. Sundararajan, Narosa Publishing, 2004.
4. "Numerical Heat Transfer and Fluid Flow", S.V. Patankar, McGraw-Hill, New York, 1980.
5. "Principles of Computational Fluid Dynamics", P. Wesseling, Springer-Verlag.
6. "Computational Techniques for Fluid Dynamics Volume I & II" (2nd edition), C.A.J. Fletcher,

		Springer-Verlag, 1991.
	7.	"Computational Fluid Mechanics and Heat Transfer" (2[nd] edition), J.C. Tannehill, D.A. Anderson and R.H. Pletcher, Taylor and Francis, 1997.
	8.	"Numerical Computation of Internal and External Flows" (Vols. I & II), C. Hirsch, Wiley International, 1988.
	9.	"Computational Fluid Dynamics for Engineers" (Vols. I & II), K. Hoffmann and S. T. Chiang, Engineering Education System, 1993.

AM21343 Aerodynamics				
Designation	:	Required / Elective		
Pre-requisites	:	*Engineering Fluid Mechanics, Thermodynamics.*		
Credit and Contact hours	:	L+T+P=4		
Assessment Methods	:	Theory Examination: (Scheme) End Semester Exam: 60 marks Mid Semester Exam: 20 marks		
		Internal Assessment (Scheme):20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).		
Course Outcomes	:	**Sl. No.**	**On successful completion of the course, student is expected to be able to:**	**Mapping into POs**
		1.	To understand fundamentals of Aerodynamics and Flight Principles.	1,2
		2.	To design and draw airfoils based on various conditions.	2,4
		3.	To analyze various wing configurations of low-speed and high-speed aircrafts	2,4, 6
		4.	To realize the fundamentals of wind tunnels and measuring principles of various flow parameters.	2,4, 6
		5.	To understand the latest development and trends in Aerodynamics, newer applications.	6,7
Modes of Delivery	:	Talk and chalk (main), Power point presentations (sometimes), Self-study (as assigned).		
Topics to be Covered	:	**Units**	**Details**	
		1.	**Introduction to Aerodynamics:** Hot air balloon and aircrafts, Various types of airplanes, Wings and airfoils, lift and Drag, Centre of pressure and aerodynamic centre, Coefficient of pressure, moment coefficient, Application of potential flow in aerodynamic problems.	
		2.	**Incompressible Flow Theory:** Design of airfoils using conformal transformation, Kutta condition, Karman – Trefftz profiles, Thin aerofoil Theory and its applications, Vortex line, Horse shoe vortex, Biot - Savart law, Prandtl lifting line theory, Panel methods.	
		3.	**Compressible Flow Theory:** Potential equation for compressible flow, small perturbation theory, Prandtl- Glauert Rule, Linearised supersonic flow, Method of characteristics.	
		4.	**Airfoils, Wings and Airplane configuration in High Speed Flows:** Critical Mach number, Drag divergence Mach number, Shock stall, super critical airfoils, Transonic area rule, Swept wings (ASW and FSW), supersonic airfoils, wave drag, delta wings, Design considerations for supersonic airplanes.	
		5.	**Viscous Flow Measurements:** Types of wind tunnels – Flow visualization processes – Measurement of force and moments in wind tunnels. Measurement of pressure, velocity and wall shear stress, Flow visualizations.	
		6.	**Latest developments and trends in Aerodynamics:** UAV, MAV.	
Text books, References		1. L.J. Clancey, Aerodynamics, Indian Edition 2006, Sterling Book House, Mumbai. 2. J.D. Anderson, "Fundamentals of Aerodynamics", McGraw-Hill Book Co., New York, 1985. 3. Rathakrishnan.E., Gas Dynamics, Prentice Hall of India, 1995. 4. Shapiro, A.H., Dynamics & Thermodynamics of Compressible Fluid Flow, Ronald Press, 1982. 5. E.L. Houghton and N.B. Caruthers, Aerodynamics for Engineering Students, Edward Arnold Publishers Ltd., London (First Indian Edition), 1988 6. Zucrow, M.J., and Anderson, J.D., Elements of gas dynamics McGraw-Hill Book Co., New York, 1989. 7. W.H. Rae and A. Pope, "Low speed Wind Tunnel Testing", John Wiley Publications, 1984.			

AM21344 Wind Engineering				
Designation	:	Required / Elective		
Pre-requisites	:			
Credit and Contact hours	:	L+T+P=4		
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment (Scheme)**:20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).		
Course Outcomes	:	**Sl. No.**	**On successful completion of the course, student is expected to be able to:**	**Mapping into POs**
		1.	To understand various aspects of Wind Engineering and importance of associated factors.	1, 2
		2.	To study and analyze Bluff body Aerodynamics and its applications.	2, 3
		3.	To study and understand Structural dynamics and Aero-elastic phenomena in Wind engineering.	2, 4
		4.	To study various aspects of Wind loading, wind tunnel simulation, effects of tornado on structures, wind turbines etc.	2, 3, 4
		5.	Latest trends and advancement in Wind Engineering and newer applications.	5, 6, 7, 9
Modes of Delivery	:	Talk and chalk (main), Power point presentations (sometimes), Self-study (as assigned).		
Topics to be Covered	:	**Units**	**Details**	
		1.	**Introduction to Wind engineering**: Wind climates and wind-induced phenomena, extreme wind climatology. Atmospheric boundary layer: Governing equations, mean velocity profiles, power law, logarithmic law wind speeds, atmospheric turbulence profiles, general characteristics of atmospheric turbulence, spatio-temporal expressions of wind fluctuations, spatio-temporal scales of fluctuations, spectral density function, length scale of turbulence, roughness parameters.	
		2.	**Bluff body aerodynamics**: flow around bluff bodies and pressure distributions, governing equations, boundary layers and flow separations, wake and vortex formation, Strouhal number, Reynolds number, flow separation and reattachments, oscillatory flow patterns, vortex shedding, flow switching– Time varying forces to wind velocity in turbulent flow and its three-dimensional structures. Static wind forces and dynamic wind forces, quasi-steady assumption and fluctuating wind pressures, motion-induced forces and aerodynamic damping, wind force correlation and wind force combination.	
		3.	**Structural dynamics**: human comfort and habitability of buildings to vibrations, damping in buildings and sophisticated evaluation techniques, suppression of wind-induced vibrations.	
		4.	**Aeroelastic phenomena**: Vortex shedding and lock in phenomena in turbulent flows, across wind galloping, wake galloping – Torsional divergence, along wind galloping of circular cables, cross wind galloping of circular cables, wind loads and their effects on tall structures.	
		5.	***Wind loading***: Introduction, analysis and synthesis loading coefficients, local & global coefficients, pressure shear stress coefficients, force and moment coefficients. Assessment methods, quasi steady method, peak factor method, extreme value method.	
		6.	Wind tunnel and its full-scale testing, simulation techniques in wind tunnels. Tornado wind and its effects on structures, microburst and its effects on structures, ASCE7 standard provisions. Aerodynamics of wind turbines, wind-induced cable vibration.	
		7.	**Latest trends and advancement in Wind Engineering and newer applications.**	

Text books, References		1. Wind Effects on Structures: Fundamentals and Applications to Design" by Simiu and Scanlan, , 3rd Ed. John Wiley and Sons, Inc., 1996. 2. "Building Aerodynamics" by Tom Lawson, Imperial College Press, London, 2001. 3. "Aerodynamics and drag mechanisms of bluff bodies and road vehicles", M.Sovran (Ed), Plenum press, New York, 1978. 4. "Winds forces in engineering" by P. Sachs, Pergamon Press, 1978. 5. "Flow induced vibrations" by R.D. Blevins, Van Nostrand, 1990. 6. "Wind Power Principles" by N.G. Calvent, Charles Griffin & Co., London, 1979. 7. "Car Aerodynamics" by Hucho. 8. "Design Guides to wind loading of buildings structures (Part I & II)" by N J Cook, Butterworths, London, 1985. 9. ASCE/SEI 7-10 Minimum Design Loads for Buildings and Other Structures. 10. IS: 875 (1987) Part III Wind loads, Indian Standards for Building codes.

AM21345 Research Methodology		
Designation	:	Required / Elective
Pre-requisites	:	*Engineering Mathematics & Computer Programming*
Credit and Contact hours	:	L+T+P=4
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment (Scheme):**20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).
Course Outcomes	:	See table below
Modes of Delivery	:	Talk and chalk (main), Power point presentations (sometimes), Self-study (as assigned), Sample experimentation.
Topics to be Covered	:	See table below
Text books, References		Research Methodology: Methods And Techniques, C R Kothari.

Course Outcomes:

Sl. No.	On successful completion of the course, student is expected to be able to:	Mapping into POs
1.	To understand the Research methodology and how to formulate a research problem, consideration of various factors.	1, 2
2.	To conduct small scale experimentation to learn how to generate real-life data and its engineering analysis.	3,4, 5
3.	To conduct engineering analysis of the gathered/obtained data using various statistical techniques.	3, 4, 6
4.	To develop a research plan and to write and present a research proposal (Mid-sem exam.).	5, 6, 9
5.	To write and present a research report.	5, 6, 8

Topics to be Covered:

Units	Details
1.	**Introduction:** A quick glance on research, Conceptualizing a research design Reviewing the literature.
2.	**Formulating a Research Problem:** Identifying variables, Constructing hypotheses, Establishing the validity and reliability, Constructing an instrument for data collection, Measurement and Scaling Techniques, Sampling Fundamentals, Methods of Data Collection, Defining the Research Problem.
3.	Developing a research plan and writing and presenting a research proposal (Mid-sem Exam).
4.	**Experimentation:**
5.	**Processing data:** Analysing Data, Analysis of Variance and Covariance,Testing of Hypotheses, Multivariate Analysis Techniques, Chisquare Test, Displaying data.
6.	Research methodology and practice evaluation.
7.	Writing and presentation of a research report (End Sem Exam).

AM21310 Applied Elasticity		
Designation	:	Required / Elective
Pre-requisites	:	Mechanics of Materials
Credit and Contact hours	:	L+T+P=4
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks Internal Assessment (Scheme):20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).

Course Outcomes:

Sl. No.	On successful completion of the course, student is expected to be able to:	Mapping into POs
1.	Analyze the stress/strain behavior of materials and the stress-strain relations.	1,2,3
2.	Analyze solid mechanics problems using classical and energy methods.	4,6,7
3.	Apply different failure criteria for general state of stress states at points.	5
4.	Understand the time dependent behavior of materials.	1,2

Modes of Delivery: Talk and chalk (main), Power point presentations (sometimes), Self-study (as assigned), Hands on training through Computer Programming.

Topics to be Covered:

Units	Details
1.	**Analysis of Stress:** Concept of Stress, Stress Components, Equilibrium Equations, Stress on a General Plane (Direction Cosines, Axis Transformation, Stress on Oblique Plane through a point, Stress Transformation), Principal Stresses, Stress Invariants, Deviatoric Stresses, Octahedral Stresses, Plane Stress, Stress Boundary Condition Problem.
2.	**Analysis of Strain:** Deformations (Lagrangian Description, Eulerian Description), Concept of Strain, Strain Components (Geometrical Interpretation), Compatibility Equations, Strain transformation, Principal Strains, Strain Invariants, Deviatoric Strains, Octahedral Strains, Plane Strain, Strain Rates.
3.	**Stress-Strain Relations:** Introduction, One-Dimensional Stress-Strain Relations (Idealized Time independent and Time-dependent stress-strain laws), Linear Elasticity (Generalized Hooke's Law), Stress-Strain Relationships for Isotropic and Anisotropic Materials (Plane stress and Plane Strain)
4.	**Basic Equations of Elasticity for Solids:** Introduction, Stresses in Terms of displacements, Equilibrium Equations in terms of displacements, Compatibility equations in Terms of Stresses, Special cases of Elasticity equations (Plane Stress, Plane strain, Polar Co-ordinates), Principle of Superposition, Uniqueness of Solution, Principle of virtual work, Potential and Complementary energy, Variational Principles, St. Venant's Principle, Methods of analysis for Elastic Solutions, Elastic solutions by Displacement and stress Functions, Airy's Stress Function (Plane stress, Plane strain, Polar Co-ordinates).
5.	**Torsion:** Introduction, Circular shaft, Torsion of non-circular cross-section, St. Venant's theory, Warping function, Prandtl's stress function, Shafts of other cross-sections, Torsion of bars with thin walled sections.
6.	**Viscoelasticity:** Introduction, Viscoelastic models (Maxwell, Kelvin-Voigt, Generalized Maxwell and Kelvin models), Viscoelastic stress-strain relationships.

Text books, References:

1. Mathematical Theory of Elasticity: I. S. Sokolnikoff
2. Advanced Mechanics of Materials: Boresi
3. Theoretical Elasticity: A. E. Green and W. Zerna
4. Theory of Elasticity: Timoshenko and Gere
5. Advanced Strength and Applied Elasticity: A. C. Ugural and S. K. Fenster

	6. Applied Elasticity: R.T.Fenner 7. Advanced Strength of Materials: L. S. Srinath

AM21341 Bio-Fluid Dynamics

Designation	:	Required / Elective
Pre-requisites	:	*Engineering Fluid Mechanics, Elementary Biology.*
Credit and Contact hours	:	L-4 T-1 P-4
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment (Scheme)**:20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).

Course Outcomes:

Sl. No.	On successful completion of the course, student is expected to be able to:	Mapping into POs
1.	To study introductory concepts of Fluid Mechanics and the importance of Bio-Fluid dynamics.	1, 2, 6
2.	To study and analyze cardio-vascular system and applications of bio-fluid dynamics in hearts, arteries etc.	2, 3, 6
3.	To study and analyze respiratory and applications of bio-fluid dynamics in human airways.	2, 3, 6
4.	To apply bio-fluid dynamics in engineering applications leading towards product development, like inhaler, artificial hearts, stents etc.	5, 6, 7, 8

Modes of Delivery: Talk and chalk (main), Power point presentations (sometimes), Self-study (as assigned).

Topics to be Covered:

Units	Details
1.	**Introduction to Fluid Mechanics:** Fluid properties, basic laws governing conservation of mass momentum and energy; Laminar flow, Couette flow and Hagen-Poiseuille equation, turbulent flow.
2.	**Bio-fluid Dynamics:** Blood system network and physiology, blood rheology, Vessel structure and mechanical properties Lymphatic system; Body fluids and their motions; Flow of Newtonian and non-Newtonian fluids in rigid tubes, flexible tubes and collapsible tubes.
3.	**Cardio-vascular system:** Heart and pumping process, Blood flow in body, Flow dynamical study of circulatory system, heart and blood vessels, anatomy and physiological considerations; Components and functions of arterial and venous systems; Blood flow through arteries and veins; Kinetic energy, flow, pressure-flow relations in vascular beds; Cardiac cycle; Cardiac valve dysfunctions; Blood pressure, regulation and controlling factors; Coronary circulation, heart failure.
4.	**Human Respiratory system:** Physiology, Weibel's lung model, realistic lung model, studies of flow behavior in upper and lower human respiratory system during different breathing conditions, studies of wall shear stress and its implications, Dispersion and deposition of aerosols/inhaled particles in respiratory system, critical airways, tumorous airways.
5.	**Engineering Applications:** Dialysis, Heart-lung machines. Lung and airways system network and physiology.

Text books, References:

1. "Bio-fluid Mechanics", J.N. Mazumdar, World Scientific, 1992.
2. "Biomechanics: Motion", Flow, Stress, and Growth", Y.C. Fung, Springer-Verlag, 1990.
3. "Cardiovascular Physiology", R.M. Berne, M.N. Levy, 8th Edition, Mosby, 2001.
4. "Bio-fluid Dynamics", C. Klienstreuer, Taylor & Francis.

AM21346 Multiphase Flow		
Designation	:	Required / Elective
Pre-requisites	:	*Engineering Fluid Mechanics, Fluid Machinery.*
Credit and Contact hours	:	L+T+P=4
Assessment Methods	:	Theory Examination: (Scheme) End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment (Scheme):20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).

Course Outcomes:

Sl. No.	On successful completion of the course, student is expected to be able to:	Mapping into POs
1.	To study and understand basics of Multiphase flows, classification and basic equations involved.	1, 2
2.	To study and analyze Cavitation phenomena, its physics, bubble dynamics, understand cavitation characteristics.	2, 4
3.	To study and understand various Numerical methods for complex Multiphase flows.	2, 3
4.	To study the basics and design fundamentals of Slurry pumps, its uses.	2, 3
5.	To study and understand multi-phase flow with phase change phenomena, study of solar based desalination still, wave propagation, Flow instability, Flow pattern transition.	2, 6
6.	Recent advancement in multiphase flow and newer applications.	5, 6, 8, 9

Modes of Delivery: Talk and chalk (main), Power point presentations (sometimes), Self-study (as assigned).

Topics to be Covered:

Units	Details
1.	**Introduction to Multiphase Flow:** Introduction, Estimation of flow patterns, Classification and characteristics of complex Mixture.
2.	**Fundamental Concept of the Flow of Multiphase Mixtures:** mechanics of transportation, Description of general two phase systems, Continuity equation, Momentum equation, Mechanical energy equation, Slip and Hold up effect.
3.	**Flow of Gas-Liquid and Liquid–Liquid Mixture in Pipes:** Flow patterns, Holdup, Empirical overall correlations, Pressure gradient, Bubble flow pattern, Slug flow, Stratified flow, Wave flow and Annular-mist flow.
4.	**Flow of Gas-Solid and Liquid–Solid Mixture in Pipes:** Flow patterns, Holdup, General correlations.
5.	**Freight Pipelines:** Slurry transportation System, Pneumatic transportation System, Capsule transportation System, Measurement techniques.
6.	**Modeling Multiphase Flows:** Introduction, General Multiphase Model, Volume of Fluid (VOF) Model Theory, Mixture Model Theory, Eulerian Model Theory, Modeling Mass Transfer in Multiphase Flows, Modeling Species Transport in Multiphase Flows, and Solution Strategies for Multiphase Modeling.
7.	**Recent advancement in multiphase flow and newer applications.**

Text books, References

1. "The Flow of Complex Mixtures in Pipes", G.W. Govier & K. Aziz, Van Nostrand Reinhold Co., NY, 1972.
2. "Multiphase Fluid Flow Theory & Practice", F.G. Hammitt, McGraw Hill Inc., NY, 1980.
3. "Computational Methods for Multiphase Flow" A. Prosperetti, G. Tryggvason, Cambridge University Press, 2009.

AM21347 Design of Experiments

Designation	:	Required / Elective
Pre-requisites	:	*Engineering Mathematics & Computer Programming*
Credit and Contact hours	:	L-4-T-I-P-4
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment (Scheme):**20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).

Course Outcomes :

Sl. No.	On successful completion of the course, student is expected to be able to:	Mapping into POs
1.	To introduce Design of Experiments and its importance in engineering.	1, 2
2.	To study and understand basic statistical methods, analysis of various, blocking factors.	1, 3
3.	To study and apply various Factorial experiment techniques in designing engineering problems.	2, 3, 4
4.	To study and apply Regression analysis, Response surface methods and Random effect models in engineering problems.	2, 3, 4

Modes of Delivery	:	Talk and chalk (main), Power point presentations (sometimes), Self-study (as assigned).

Topics to be Covered :

Units	Details
1.	**Introduction to Design of Experiments:** Strategy of Experimentation, applications of Experimental Design, Basic Principles, Guidelines for DoE.
2.	**Basic Statistical Methods:** Sampling and Sampling Distributions, Randomized Designs, Paired Comparison Designs, Inferences About the mean and Variances of Normal Distributions.
3.	**Analysis of Variance:** The Analysis of Variance, Analysis of the Fixed Effects Model, Model Adequacy Checking, Practical Interpretation of Results, Determining Sample Size, The Random Effects Model, The Regression Approach to the Analysis of Variance, Nonparametric Methods in the Analysis of Variance.
4.	**Experiments with Blocking Factors:** The Randomized Complete Block Design, The Latin Square Design, The Graeco-Latin Square Design, Balanced Incomplete Block Designs.
5.	**Factorial Experiments:** Basic Definitions and Principles, The Advantage of Factorials, The Two-Factor Factorial Design, The General Factorial Design, Fitting Response Curves and Surfaces, Blocking in a Factorial Design.
6.	**Two-Level Factorial Designs:** The 2^2 Design, The 2^3 Design, The General 2^k Design, A Single Replicate of the 2^k Design, Unreplicated 2^k Design, Addition of Center Points to the 2^k Design.
7.	**Blocking and Confounding Systems for Two-Level Factorials:** Blocking a Replicated 2^k Factorial Design, Confounding in the 2^k Factorial Design, Confounding the 2^k, Factorial Design in Two Blocks.
8.	**Two-Level Fractional Factorial Designs:** The One-Half Fraction of the 2^k Design, The One-Quarter Fraction of the 2^k Design, The General 2^{k-p} Fractional Factorial Design.
9.	**Regression Modeling:** Linear Regression Models, Estimation of the Parameters in Linear Regression Models, Hypothesis Testing in Multiple Regression, Confidence Intervals in Multiple Regression, Prediction of New Response Observations, Regression Model Diagnostics, Testing for Lack of Fit.
10.	**Response Surface Methodology:** Introduction to Response Surface Methodology, The Method of Steepest Ascent, Analysis of a Second-Order

			Response Surface, Experimental Designs for Fitting Response Surfaces, Experiments with Computer Models.
		11.	**Random Effects Models:** Random Effects Models, The Two-Factor Factorial with Random Factors, The Two-Factor Mixed Model, Sample Size Determination with Random Effects, Rules for Expected Mean Squares, Approximate *F* Tests.
		12.	**Other Topics:** Non-normal Responses and Transformations, Unbalanced Data in a Factorial Design, The Analysis of Covariance, Repeated Measures.
Text books, References			1. Design and Analysis of Experiments, Douglas C. Montgomery, 8th Edition, Wiley. 2. Design and Analysis of Experiments (Springer Texts in Statistics), Angela M. Dean, Daniel Voss. 3. Experiments: Planning, Analysis, and Optimization (Wiley Series in Probability and Statistics) C. F. Jeff Wu, Michael S. Hamada. 4. Statistical Design and Analysis of Experiments, with Applications to Engineering and Science, Robert L. Mason, Richard F. Gunst, James L. Hess. 5. Statistical Design and Analysis of Experiments (Classics in Applied Mathematics No 22.) Peter W. M. John. 6. Statistics for Experimenters: Design, Innovation, and Discovery , George Box. 7. Designing Experiments and Analyzing Data: A Model Comparison Perspective, Second Edition by Maxwell and Delaney. 8. The Design of Experiments Sir Ronald Aylmer Fisher. 9. Design of Experiments for Engineers and Scientists, Jiju Antony.

AM21342 Convective Heat Transfer		
Designation	:	Required / Elective
Pre-requisites	:	*Engineering Heat Transfer, Fluid Mechanics, Thermodynamics.*
Credit and Contact hours	:	L+T+P=4
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment (Scheme)**:20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).
Course Outcomes	:	see table below

Sl. No.	On successful completion of the course, student is expected to be able to:	Mapping into POs
1.	To understand governing equations of convective heat transfer.	1, 2
2.	To study heat transfer for both external and internal laminar flow problems and its applications.	2, 3
3.	To study natural convection heat transfer problems and its applications.	2, 3
4.	To study turbulent heat transfer problems and its applications.	2, 3
5.	To understand the latest development and state-of-art in convective heat transfer, applications in newer areas.	6, 7, 8

Modes of Delivery	:	Talk and chalk (main), Power point presentations (sometimes), Self-study (as assigned).
Topics to be Covered	:	see table below

Units	Details
1.	**Introduction:** Physical origins and rate equations, Governing equations, units and dimensions, concepts of thermal boundary layer, displacement thickness, momentum thickness and energy thickness.
2.	**Laminar External flow and heat transfer:** Blasius Solution, Temperature distribution over a flat plate boundary layer, Falkner-Skan and Eckert solutions, flow with transpiration, solutions for flow over an isothermal flat plate, flat plate with constant heat flux and with varying surface temperature, flows with pressure gradient.
3.	**Laminar internal flow and heat transfer:** Exact solutions to Navier–Stokes Equations, Fully developed forced convection in pipes, Forced convection in the thermal entrance region of ducts and channels, heat transfer in the combined entrance region, Integral method for internal flows with different wall boundary conditions.
4.	**Natural Convection heat transfer:** Governing equations for natural convection, Boussinesq approximation, Dimensional Analysis, Similarity solutions for Laminar flow past a vertical, Integral method for natural convection flow past vertical plate, effects of inclination, Natural convection in enclosures, mixed convection heat transfer past vertical plate and in enclosures.
5.	**Turbulent convection:** Governing equations, Turbulence Models, Turbulent flow and heat transfer across flat plate and circular tube, Turbulent natural convection heat transfer, Empirical correlations for different configurations.
6.	**Latest development and state-of-art in convective heat transfer and its applications.**

Text books, References

1. Incropera F P and Dewitt D, "Fundamentals of Heat and Mass Transfer", John Wiley.
2. Kays W M and Crawford M E, "Convective Heat and Mass Transfer",McGraw Hill.
3. Bejan A, "Convection Heat Transfer", John Wiley
4. Schlichting H., " Boundary Layer Theory ", Sixth edition, McGraw Hill.

Micro and Nano-Scale Flows				
Designation	:	Elective		
Pre-requisites	:	*Fluid Mechanics, Heat Transfer, Partial Differential Equation, Engineering Mathematics*		
Credit and Contact hours	:	4(L) - 0(T) – 0(P) – 4(Cr)		
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment (Scheme):**20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).		
Course Outcomes	:	Sl. No.	On successful completion of the course, student is expected to be able to:	Mapping into POs
		1.	Develop a broad and deep understanding of transport phenomena at the micro/nanoscale.	1, 2
		2.	Understand major applications of micro/nanofluidics	2, 3
		3.	Understand major methods to fabricate micro/nanofluidic devices	2, 3, 4
		4.	Be able to design and test new micro/nanofluidic devices for certain applications	3, 4, 5
		5.	Students are encouraged get more actively involved by doing research and submitting reports and holding presentations. There will also be one or two software workshops (optional).	6, 7, 8, 9
Modes of Delivery	:	Talk and chalk (main), Power point presentations (sometimes), Self-study (as assigned). **Note:** Term paper, Assignments and Demonstration need to be given to the students on the following (or similar) topics using modern techniques like experiment or numerical techniques.		
Topics to be Covered	:	**Units**	**Details**	
		7.	**Introduction:** Scaling law and Continuum Model, Pressure driven flow in microchannels and equivalent circuits, Passive Scalar Transport (Diffusion, Dispersion, mixing) stokes flow, Surface tension related microfluidics I Introduction and capillary flow, Surface tension related microfluidics II droplet microfluidics and electrowetting, Electrostatics and Electrical Double Layer, Zeta potential and Surface Charge in Microchannels	
		8.	**Electroosmosis in Microchannel:** Fundamental of Species and Charge Transport Chemical Separation in Microchannels, Particle Electrophoresis, Ion Transport in Nanochannel I (Surface charge governed transport, Surface charge regulation, PNP equation), Onsager Matrix for Nanofluidics	
		9.	**Ion Transport in Nanochannel II:** Current rectification, Ion Concentration Polarization, Electroosmosis in Nanochannel, Basic Fabrication Process	
		10.	**Fabrication of Microfluidic Devices:** Fabrication of Nanofluidic devices, Nanopore Based Resistive Pulse Sensing, Water potential and Phase change Phenomenon at the nanoscale (evaporation, condensation, boiling)	
		11.	**Carbon Nanofluidics:**DNA Transport and Analysis, Separation in Nanochannels, Biochemical reactions in micro/nanoscale confined space	
Text books, References	:	10. Brian Kirby, "Micro-and Nanoscale Fluid Mechanics: Transport in microfluidic devices", Cambridge University Press, 2010 11. Joshua B Edel and Andrew J deMello "Nanofluidics: Nanoscience and Nanotechnology", Royal Society of Chemistry, 2009 12. Patrick Abgrall and Nam-Trung Nguyen "Nanofluidics", Artech House, 2009 13. Jacob Israelachvili, "Intermolecular & Surface Forces", Academic Press.		

ME21348		Gas Turbines and Jet Propulsion
Designation	:	Required / Elective
Pre-requisites	:	*Engineering Fluid Mechanics, Thermodynamics.*
Credit and Contact hours	:	L+T+P=4
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment (Scheme):20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).

Course Outcomes :

Sl. No.	On successful completion of the course, student is expected to be able to:	Mapping into POs
1.	To understand and review Gas dynamics and Thermodynamics fundamentals.	1, 2
2.	To study and design various components of Gas turbine and its applications.	2, 4
3.	To study basics of Jet Propulsion and its design considerations.	2,4, 6
4.	Latest trends and advancement in Gas Turbine and Jet Propulsion.	5, 6, 7, 9

Modes of Delivery	:	Talk and chalk (main), Power point presentations (sometimes); Self-study (as assigned).

Topics to be Covered :

Units	Details
1.	**Review of Gas Dynamics:** Physical difference between incompressible, subsonic and supersonic flows, three reference speeds, dimensionless velocity, concepts of static and stagnation parameters. Pressure waves, finite, shock and detonation waves, compound waves, Analysis of piston excited waves, shock tubes, one-dimensional isentropic flow, normal shocks, Rayleigh flow, Fanno flow.
2.	**Gas Turbine Outline:** Review of Thermodynamic principles, Gas turbine cycles, main components of Gas turbine power plants, performance characteristics, typical Gas Turbine Plants. Methods of improving efficiency and power output of gas turbine plants.
3.	Design considerations of Centrifugal and axial flow compressors.
4.	Types of Gas turbine plants and their theory of operation, design consideration of gas turbine plants. Detailed study of main systems of gas turbine plants.
5.	Selection of materials of Gas turbine components. Trouble shooting, maintenance and actual performance evaluation of gas turbine plants. Recent development of gas turbine plants.
6.	**Jet Propulsion Outline:** Basic theory of Jet & rocket propulsion devices and historical development. Types of various jet propulsion plants like air screw, turboprop, turbojet, Ram jet, pulse jet, rocket propulsion, etc. and their comparative study.
7.	Performance study of various jet propulsion devices from ideal and practical consideration.
8.	Study and design considerations of main components of jet propulsion plants. Thrust augmentation devices and their thermodynamic analysis.
9.	Combustion performance, products of combustion and their properties. Recent advances in jet propulsion and Rocket propulsion devices. Latest trends and advancement in Gas Turbine and Jet Propulsion.

Text books, References

1. "Gas Dynamics", E. Rathakrishnan, Prentice-Hall of India, New Delhi, 2002.
2. "Compressible Fluid Flow", M.A. Saad, Prentice-Hall, New Jersey, 1985.
3. "The Dynamics and Thermodynamics of Compressible Fluid Flow" (2 volumes), A. H. Shapiro, The Ronald Press, New York, 1953.
4. "Gas Turbine Fundamentals", Cohen, Rogers and Saravanamutto, Pearson

		Education. 5. "Jet Propulsion", Jack D. Mattingly, McGraw Hill Inc. 6. "Gas Turbines", V. Ganeshan, Tata-McGraw-Hill, New Delhi. 7. "Gas Turbines", R. Yadav.

Semester-II

AM22104 Turbulence		
Designation	:	Required / Elective
Pre-requisites	:	*Engineering Fluid Mechanics, Thermodynamics, Engineering mathematics, Statistical methods.*
Credit and Contact hours	:	L+T+P=4
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment (Scheme):**20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).
Modes of Delivery	:	Talk and chalk (main), Power point presentations (sometimes), Self-study (as assigned).

Course Outcomes:

Sl. No.	On successful completion of the course, student is expected to be able to:	Mapping into POs
1.	To identify physical processes and dynamics involved in Turbulence,	1, 2
2.	To describe mathematical and statistical expressions of Turbulence.	1,2
3.	To apply turbulence modeling in various physical problems.	2, 3, 4
4.	To assess the importance of turbulence in different flow problems.	6
5.	Latest advancement in turbulence research.	6, 7

Topics to be Covered:

Units	Details
1.	**Introduction:** Flow instability and transition to turbulence, Nature of Turbulence, Indicial notation for tensors, Fourier transforms and Parseval's theorem.
2.	**Governing Equations of Turbulence:**
3.	**Eulerian, Lagrangian and Fourier descriptions of turbulence:**
4.	Statistical description of turbulence: Reynolds Averaged Navier-Stokes equations, Reynolds stress evolution equations.
5.	**Kolmogorov's Hypothesis:** Diffusivity of turbulence and turbulence length scale.
6.	**Filtered Description of Turbulence:** Bridging methods and large eddy simulation (LES).
7.	**Turbulent Free Shear Flows:** Free Shear Flows- jet flows including heat transfer- 2D flows, wall jet and plane jets, its structure; turbulent jets, turbulent mixing layer and buoyancy effects- its structure; turbulent wake flows, wake of self propelled bodies; wall-bounded shear flows- its structure; boundary layer flows; thermal plume.
8.	**Wall Bounded Turbulent Flows:** Turbulent flows in pipes, channels and boundary layers, Law-of-the-wall, Effects of surface roughness on turbulence.
9.	**Development of Turbulent closure models:** Boussinesq approximation, Reynolds stress evolution closures.
10.	**Rapid Distortion Theory (RDT) of Turbulence:**
11.	Dynamics of Turbulence: Linear Instability Theory, Nonlinear Stability Analysis, Dynamical Systems, Introduction to Chaos. Vorticity dynamics-Reynolds stress and vorticity, vortex stretching, mean vorticity equation, kinetics energy and mean flow, kinetic energy of fluctuations, energy cascade, dissipation, material element deformation, mixing Navier-Stoke's equation for turbulent flow, turbulent energy dissipation equation.

		12.	**Turbulence modeling:** General comments on turbulence models; Method of solving turbulent equations- Direct numerical simulation (DNS), Large-eddy simulation (LES), Reynolds averaged Navier-Stokes equation (RANS), k-ε models. Turbulence models: Eddy viscosity models - zero equation models (constant eddy viscosity and mixing length models), one equation models, two equation models; Reynolds stress transport models (RSM). Wall treatments.
		13.	**Latest advancement in turbulence research.**
Text books, References			1. "Turbulent Flows", S.B. Pope, Cambridge University Press, 2000. 2. "Turbulence Modeling for CFD" David C. Wilcox, DCW Industries, 3rd Edition, 2006. 3. "Viscous Fluid Flow", F.M. White, Tata McGraw Hill, 2011. 4. "A First Course in Turbulence", H. Tennekes and J.L. Lumley, The MIT Press, 1972. 5. "Turbulence", O. Hinze, McGraw Hill Inc. 6. "Turbulent Flow: Analysis, measurement and Prediction", Bernard, P.S., A.D. Wallace, J.M., John Wiley & Sons Inc., New Jersey, 2002. 7. "Turbulent Flows", Biswas, G. and Eswaran, V. Narosa Publishing, 2002. 8. "Turbulent Flows" (3rd ed.), Garde, New Age International, New Delhi.

AM22204		Fluids Engineering Laboratory		
Designation	:	Required / Elective		
Pre-requisites	:	*Basic knowledge of Fluid Mechanics and Engineering Mathematics, Computer Programming, CFD.*		
Credit and Contact hours	:	L+T+P=6		
Assessment Methods	:	**Practical Examination:** (Scheme) End-Semester Exam: 50 marks.		
		Internal Assessment: (Scheme) 50 marks (10 marks for attendance + 40 marks for sessional assessment and/or Term paper based on regular performance on Practical and Experimentation, Demonstration of knowledge and skill development through Surprise / Quiz Tests, Viva etc. and Assignments & Report Writing..		
Course Outcomes	:	**Sl. No.**	**On successful completion of the course, student is expected to be able to:**	**Mapping into POs**
		1.	To use latest flow measuring devices and to conduct experiments related to Fluid Mechanics/Aerodynamics.	3,4, 5
		2.	To use CFD techniques to simulate flow problems using CFD codes.	3, 4, 5
		3.	To draw/plot graphs derived from results, write technical report.	6, 7
		4.	To compare and contrast computational results with experimental/ theoretical trends.	6, 7
Modes of Delivery	:	Power point presentations (as required), Self-study (as assigned), Hands on training through Practical Experimentation and Computer Programming.		
Topics to be Covered	:	**Units**	**Details**	
		1.	Experiment 1: Study of the pressure distribution over smooth and rough cylinder.	
		2.	Experiment 2: Study of the Pressure distribution over symmetric airfoil.	
		3.	Experiment 3: Study of the Pressure distribution over cambered airfoil& thin airfoils.	
		4.	Experiment 4: Study of the characteristics of three dimensional airfoils involving measurement of lift, drag, pitching moment.	
		5.	Experiment 5: Performance of an aerofoil with flap, influence of flap angle on lift, drag and stall.	
		6.	Experiment 6: Flow visualization studies in low speed flow over airfoil with different angle of Incidence.	
		7.	Experiment 7: Pressure distribution around a two- dimensional model in supersonic flow conditions, at different angles of attack.	
		8.	Experiment 8: Lift coefficient for aerodynamic models in supersonic flow.	
		9.	Experiment 9: Shock waves and expansion patterns around a two - dimensional model in supersonic flow conditions. (Flow visualization with Schlieren Apparatus.)	
		10.	Experiment 10: Measurement of the Velocity profile in laminar and turbulent boundary layers.	
		11.	Experiment 11: Measurement of the Velocity profile in the boundary layer at on rough and smooth plates. Measurement of the Velocity profile in the boundary layer at various distances from the leading edge of the plate.	
		12.	Experiment 12: Measurement of Performance of a Centrifugal Pump and its Vibration Analysis.	
Text books, References		1.	"Instrumentation, Measurements & Experiments Fluids", E. Rathakrishnan, CRC Press, NY, 2007.	
		2.	"Low-Speed Wind Tunnel Testing", A. Pope and J.J. Harper, John Wiley &	

		Sons Inc., NY, 1966. 3. "Experimental Methods for Engineers", J.P. Holman, McGraw-Hill Inc., NY, 2001. 4. "Design & Analysis of Experiments", D.C. Montgomery, Wiley, 7th ed., 2009.

Notes:

- The above-mentioned list is a suggestive one. The course coordinator/ laboratory instructors may offer similar problems depending upon availability of experimental set-up and computational platform. The total number of problems/assignments given will be decided by the course coordinator/ laboratory instructors.
- Suitable experimental tools (example, Hot-wire anemometry, pressure transducers, flowmeters, Schileren apparatus, smoke generators etc.) available in the laboratory should be used in experimentation.
- A Term paper based on relevant topic will be assigned to each student at the start of the semester, which is to be submitted by the student before the end of the course. A presentation will be given by the students based on this term paper.

		AM22349 Advanced Computational Fluid Dynamics
Designation	:	Required / Elective
Pre-requisites	:	*Computational Fluid Dynamics..*
Credit and Contact hours	:	L+T+P=4
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks; Mid Semester Exam: 20 marks **Internal Assessment (Scheme):**20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).
Course Outcomes	:	see below
Modes of Delivery	:	Talk and chalk (main), Power point presentations (sometimes), Self study (as assigned).
Topics to be Covered	:	see below

Course Outcomes

Sl. No.	On successful completion of the course, student is expected to be able to:	Mapping into POs
1.	To understand multiphase flow modeling.	1, 2
2.	To understand FVM for complex geometries.	2, 3
3.	To understand accelerated CFD methods and use of computer architecture, parallelization in CFD.	
4.	To solve various types of advanced engineering problems using CFD.	4, 5
5.	Latest development in CFD techniques and newer applications.	

Topics to be Covered

Units	Details
1.	**Finite Volume Method for complex geometries:** Types of grids, Cartesian vs. curvilinear grids, Block structured grids, Body fitted grids in complex geometries, orthogonal grids, difficulties of curvilinear grids, structured/unstructured/hybrid. Mapping functions: grid transformation on complex geometries, Transformation of governing equation in plane, Conservative and Non-conservative form of equations, transformation of Laplace equation, N-S Equations in transformed plane, matrices and Jacobians. Unstructured grids and its discretization, discretization of diffusion and convective terms, treatment of source terms, assembly of discretized equations, Boundedness and Transportiveness, TVD Scheme, Pressure-velocity coupling in unstructured meshes, staggered vs. co-located grid arrangements. Rhie and Chow's pressure interpolation. Grid Selection, Grid-independence study and criteria for numerical convergence, grid refinement, Grid quality, Best Practice guidelines.
2.	**Accelerated CFD Methods:** Advanced Numerical Techniques: Multigrid, Conjugate Iteration, and Generalised Minimal Residual (GMRES) Methods. Hardware Techniques: Introduction to PC and HPC Architecture, CPU and GPGPU parallel programming.
3.	**Multiphase Flow Modeling:** Introduction: Multiphase flow classification (separated and dispersed flows), examples, Challenges in modeling, Variables of interest, Fluid-particle coupling (1-way, 2-way, and 4-way coupling) Lagrange-Euler model: Discrete Phase Modelling (DPM) for particles and suspended phases, Discrete Phase Boundary conditions and its effects Discrete Element Method (DEM) Arbitrary Lagrangian and Euler (ALE) method, Immersed boundary method; Immersed interface methods, Hybrid methods Introduction to Euler-Euler model, Volume of Fluid (VoF) Method, Interface

			tracking & capturing methods, Level Set (LS) method, Coupled VoF-LS method, Eulerian multiphase model (EMM), Mixture (Algebraic Slip) mode (ESM), Eulerian Granular Multiphase model (EGMM) Comparison of Models and their selection
		4.	**Application of CFD for modelling and simulation** like flow inside a gate valve, cyclone Separator, rotating fan immersed in fluid, slurry flow, open channel flow, cavitation and combustion etc.
Text books, References		1.	"An Introduction to Computational Fluid Dynamics: the Finite Volume Method", H.K. Versteeg and W. Malalasekara, 2nd edition, Pearson Education, England, 2007.
		2.	"Computational Fluid Dynamics for Engineers", B. Andersson & others, 1st edition, Cambridge University Press, U.K., 2012.
		3.	"Using HPC For Computational Fluid Dynamics: A Guide to High Performance Computing for CFD Engineers", Shamoon Jamshed , Academic Press, 2015.
		4.	"Computational Fluid Flow and Heat Transfer" (2nd edition), K. Muralidhar and T. Sundararajan, Narosa Publishing, 2004.
		5.	"Numerical Heat Transfer and Fluid Flow", S.V. Patankar, McGraw-Hill, New York, 1980.
		6.	"Principles of Computational Fluid Dynamics", P. Wesseling, Springer-Verlag.
		7.	"Computational Techniques for Fluid Dynamics Volume I & II" (2nd edition), C.A.J. Fletcher, Springer-Verlag, 1991.
		8.	"Computational Fluid Mechanics and Heat Transfer" (2nd edition), J.C. Tannehill, D.A. Anderson and R.H. Pletcher, Taylor and Francis, 1997.
		9.	"Numerical Computation of Internal and External Flows" (Vols. I & II), C. Hirsch, Wiley International, 1988.
		10.	"Computational Fluid Dynamics for Engineers" (Vols. I & II), K. Hoffmann and S. T. Chiang, Engineering Education System, 1993.

		AM22340 Fluid-Structure Interaction
Designation	:	Required / Elective
Pre-requisites	:	*Engineering Fluid Mechanics, Strength of materials.*
Credit and Contact hours	:	L+T+P=4
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment (Scheme)**:20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).
Course Outcomes	:	**Sl. No.** | **On successful completion of the course, student is expected to be able to:** | **Mapping into POs** 1. To review mathematical equations and Elementary Continuum mechanics. | 1, 2 2. To study and understand fluid dynamic phenomena and equations. 3. To study and understand structural dynamic phenomena and equations. | 1, 2 4. To study and analyze coupled fluid-structural systems, applications and solution strategies. 5. Latest development in Fluid-structure interaction.
Modes of Delivery	:	Talk and chalk (main), Power point presentations (sometimes), Self-study (as assigned).
Topics to be Covered	:	**Units** | **Details** 1. **Introduction to Fluid-structure interaction:** Concept of fluid-structure interaction, brief history of fluid-structure interaction, dimensional analysis, concept of the hydrodynamic mass (added mass), hydrodynamic mass matrix. 2. **Mathematical formulation of a simple fluid-structure interaction problem:** Fluid domains, solid domains, coupling of the equations for fluid and structure. 3. **Analysis Methods for Fluid-structure interaction problems:** One-way separate analysis method (Hydrodynamics mass and damping method), Two-way coupled analysis method. 4. **Vortex induced Vibration:** Vortex wake of a stationary cylinder, Strouhal number, effects of cylinder motion on wake, analysis of vortex-induced vibration and its reduction. 5. **Galloping and Flutter:** Introduction to galloping, galloping instability, galloping response, vortex shedding, turbulence and galloping, flutter, prevention of galloping and flutter. 6. **Instability of tube and cylinder arrays:** Description of elastic instability, theory of fluid elastic instability, vibration of pairs of cylinders. 7. **Vibration induced by Oscillatory flow:** Inline forces and their maximum, inline motion, fluid force coefficients, transverse force and response, reduction of vibration induced by oscillating flow, ship motion in a seaway.

		8.	**Vibration induced by turbulence and sound:** Elements of the theory of random vibrations, sound and turbulence-induced vibration of panels, turbulence induced vibration of tubes and rods, wind-induced vibration, response of aircraft to gusts, reduction of vibration induced by turbulence.
		9.	**Fluid Coupling:** Concentric cylinders with open ends of fluid filled annular gap, concentric cylinders with closed ends of fluid annular gap.
		10.	**Damping of structures:** Elements of damping, Definitions of damping coefficient and damping ratio, total damping, fluid (hydrodynamic) damping, structural (or support) damping, damping of bridges, towers, buildings, piping and aircraft structures.
		11.	**Sound induced by Vortex shedding:** Sound from single and vibrating cylinders, sound from multiple tubes and heat exchangers, sound from flow over cavities.
		12.	**Examples of Fluid-structure interaction analyses:** One-way separate analysis of fluid-induced vibration of steam generator tubes, two-way coupled analysis of flow-induced vibration of two tubes. Latest development in Fluid-Structure interaction.
Text books, References		1. Robert D. Belvins (2001), Flow-induced Vibration, 2nd ed., 477 pp., Krieger Publishing Company, Malabar, Florida, USA. 2. J. Ballmann (ed.) (2003), Flow Modulation and Fluid-Structure Interaction at Airplane Wings, Springer. 3. N.G. Barton and J. Periaux (eds.) (2003), Coupling of Fluids, Structures and Waves in Aeronautics, Springer.	

AM22341 Boundary Layer Theory				
Designation	:	Required / Elective		
Pre-requisites	:	*Engineering Fluid Mechanics, Heat Transfer.*		
Credit and Contact hours	:	L-T-P-4		
Assessment Methods	:	**Theory Examination (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment (Scheme):** 20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).		
Course Outcomes	:	**Sl. No.**	**On successful completion of the course, student is expected to be able to:**	**Mapping into POs**
		1.	To study incompressible boundary layer theory.	1, 2
		2.	To study transition and turbulent incompressible boundary layers.	1, 2
		3.	To study and analyze boundary layer separation and its control techniques.	2,4
		4.	To study and apply Perturbation theory.	2, 4
		5.	To study and understand Thermal boundary layers.	1, 2
Modes of Delivery	:	Talk and chalk (main), Power point presentations (sometimes), Self-study.		
Topics to be Covered	:	**Units**	**Details**	
		1.	**Incompressible Laminar Boundary Layers:** Exact solutions of the Navier-Stokes equation exhibiting boundary layer at low viscosity. The boundary-layer equations in the spirit of Prandtl. Scaling, non-dimensionalisation and Reynolds number. Limitations of potential flow past a cylinder. Prandtl's boundary-layer equations in two dimensions deduced by order-of-magnitude arguments. Blasius solution: displacement thickness, skin friction, drag.	
		2.	**Transition and Incompressible Turbulent Boundary Layers:** Concept of stability; basis of boundary layer stability analysis; physics of transition to turbulence. Reynolds stresses, mean velocity and shear stress in a turbulent boundary layer; the log law and power law profiles. Turbulent boundary layers in zero and non-zero pressure gradients. Separation in adverse pressure gradients. Concept of and occurrence in steady flows, and at rear stagnation point of impulsively started cylinder.	
		3.	**Boundary Layer Separation & Flow Control:** Causes of boundary layer separation and its consequences, active and passive flow control, various different flow control techniques and their applications.	
		4.	**Introduction to Perturbation Theory:** Regular and singular perturbations. Examples from algebraic equations and ordinary differential equations. The classical boundary-layer equations of Prandtl as the leading term in a matched asymptotic expansion. Exact solutions of the classical boundary-layer equations like Flow past a wedge: Falkner Skan. Far wake of a flat plate. Two-dimensional jet. Lock's mixing layer. Prandtl transformation. Prandtl-Glauert law for subsonic flow; Ackeret's law and applications. Axisymmetric flows: Mangler's transformation. Split disc Ekman layer problems: Stewartson layers. Glauert wall jet.	
		5.	**Thermal Boundary Layer:** Introduction to thermal boundary layer, heat transfer in boundary layer, convective heat transfer, importance of non dimensional numbers, Prandtl number, Nusselt number, Lewis number etc.	
Text books, References		1. "Boundary Layer Theory", Schlichting, H., McGraw Hill Inc. 2. "The Laminar Boundary-Layer Equations", Curle, N., Oxford University Press. 3. "Laminar Boundary Layers", Rosenhead, L. (Edited). Oxford University Press. 4. "An Introduction to Fluid Mechanics", Batchelor, G. K., Oxford University Press. 5. "Separation of Flow", C.T. Chang, McGraw Hill Inc.		

AM22342 Design of Pipe Networks		
Designation	:	Required / Elective
Pre-requisites	:	*Engineering Fluid Mechanics, Computer Programming*
Credit and Contact hours	:	L+T+P=4
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment (Scheme):** 20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).

Course Outcomes:

Sl. No.	On successful completion of the course, student is expected to be able to:	Mapping into POs
1.	To study introduction to pipe networks, basic principles and formulae.	1, 2
2.	To study Pipe network analysis methods, cost consideration, and to apply general principles of pipe network synthesis.	2, 4
3.	To develop Optimal design of branched pipe networks by linear programming problems (LPP).	3, 4, 6
4.	To conduct Reliability analysis of Distribution systems, Fluid transients, Operation and maintenance of pipe networks.	4, 6, 7
5.	To present a term paper on Development of program for Analysis and optimization of pipe network.	5, 6, 7, 8

Modes of Delivery	:	Talk and chalk (main), Power point presentations (sometimes), Self-study (as assigned).

Topics to be Covered:

Units	Details
1.	**Introduction:** uses, requirements, flow and pressure, Layout, PIPE GRAPHICS, Main sizing, Storage and pumping, Pipe valve fittings, Water meter, installation and testing **Basic Principles** of Pipe Flow, Head Loss Equations.
2.	**Pipe Network Analysis Methods**, Loop flow correction method, linear method. **Cost Considerations.**
3.	**General Principles of Pipe Network Synthesis:** Water Transmission Lines, Water Distribution Mains, Single Input Source Branched Systems, Single Input Source Looped Systems, Multi Input Source Branched Systems, Multi Input Source Looped Systems, Decomposition of a Large Water System and Optimal Zone Size, Reorganization of Water Distribution Systems.
4.	**Optimal design of branched pipe networks by linear programming problems (LPP):** Dynamic and nonlinear programming for looped networks.
5.	**Reliability of distribution system**
6.	**Fluid transients:** water hammer: theory, boundary conditions, water column separation unsteady flow analysis by rigid column method graphical water hammer analysis air in pipeline .
7.	**Operation and maintenance of Pipe networks.**
8.	**Term Paper:** Development of program for Analysis and optimization of pipe network.

Text books, References		Introduction to Urban Water Distribution: Unesco-IHE Lecture Note Series: by NemanjaT rifunovic. Design of Water Supply Pipe Networks by Prabhata K. Swamee, Ashok K. Sharma Analysis of flow in water distribution networks by Pramod R. Bhave Pipe Network Analysis, Eds. Lambert M Surhone, Mariam T Tennoe, Susan F Henssonow Liquid Pipeline Hydraulics, E. ShashiMenon Water distribution systems: simulation and sizing, Thomas M. Walski, Johannes

		Gessler, John W. Sjostrom Analysis of flow in pipe networks, Roland W. Jeppson Water distribution modeling, Volume 1, Thomas M. Walski, Donald V. Chase, DraganSavic Analysis of Water Distribution Systems, Thomas M. Walski Modeling, analysis, and design of water distribution systems, Lee Cesario, American Water Works Association Pipeflow Analysis, D.J. Stephenson Advanced water distribution modeling and management, Volume 1, Thomas M. Walski. Simulation and analysis of gas networks, AndrzejOsiadacz ASME guide for gas transmission and distribution piping systems, 1986, American Society of Mechanical Engineers Gas transmission and distribution piping systems, American Society of Mechanical Engineers The Distribution of Gas, Walter Hole A Manual of Gas Distribution, Walton Forstall Hydraulic analysis of unsteady flow in pipe networks, J. A. Fox Solving the Pipe Network Analysis Problem Using Optimization Techniques, School of Engineering and Applied Science, Southern Methodist University Nonlinear programs Optimal design of water distribution networks, P.R. Bhave Reliability analysis of water distribution systems, Larry W. May. Performance in water distribution: a systems approach, SérgioTeixeira Coelho Improving Efficiency and Reliability in Water Distribution Systems, Enrique Cabrera, Antonio F. Vela Computer modeling of water distribution systems, American Water Works Association Computer Applications in Water Supply: Systems optimization and control, Bryan Coulbeck Integrated computer applications in water supply: Applications and implementations for systems operation and management. Vol. 2 Comprehensive Water Distribution Systems Analysis Handbook for Engineers and Planners Paul F. Boulos, Kevin E. Lansey, Bryan W. Karney Water transmission and distribution, American Water Works Association Water distribution systems handbook, Larry W. Mays Introduction to Pipe Stress Analysis, Sam Kannappan Piping Stress Handbook, Victor Helguero Piping Handbook, Mohinder L Nayyar, NayyarMohinder Pipe Stress Engineering, Asme Press, Liang ChuanPeng.

ME22343 Thermo-Fluid Dynamics				
Designation	:	Required / Elective		
Pre-requisites	:	*Engineering Mathematics & Computer Programming*		
Credit and Contact hours	:	L+T+P=4		
Assessment Methods	:	Theory Examination (Scheme) End Semester Exam: 60 marks Mid Semester Exam: 20 marks		
		Internal Assessment (Scheme):20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).		
Course Outcomes	:	Sl. No.	**On successful completion of the course, student is expected to be able to:**	**Mapping info POs**
		1.	To identify thermodynamic systems, surroundings, work and heat interaction using fluids and their characteristics in various thermodynamic processes.	1, 2
		2.	To model equation of state for ideal and real gases and reduced equation of state.	2, 3
		3.	To understand Kelvin-Planck and Clausius statements and concept of Entropy, Irreversibility, Exergy.	2
		4.	To identify and apply modes of heat transfer related to fluids and surface interaction e.g. conduction and convection.	2, 4
		5.		
Modes of Delivery	:	Talk and chalk (main), Power point presentations (sometimes), Self-study (as assigned).		
Topics to be Covered	:	Units	**Details**	
		1.	**Thermodynamic State Equations:** Perfect and real gases, state equation of perfect gas, Amagat's isothermals, Detailed study of Van der Waal, Dieterio, Berthelot, Redlich and Kwong and other state equations for real gases, compressibility factor and compressibility chart, generalized chart.	
		2.	**Review of Thermodynamic Laws and Entropy:** Reversibility and irreversibility, statements of second law and their discussion Equivalence of Kelvin-Planck and Clausius statements, Carnot engine and Carnot refrigeration, Thermodynamic temperature scale and absolute zero temperature, Clausius theorem and Clausius inequality, concept and characteristics of entropy Principle of increase of entropy and entropy of universe.	
		3.	**Availability and Irreversibility:** Available energy lost work and degradation of energy, Maximum work, Availability – in a closed system and in a steady flow system, Gibbs function, Helmholtz function, Irreversibility and its measurement.	
		4.	**General Thermodynamic Relations:** General relations from energy equations, specific heat relations, relations for internal energy, enthalpy and entropy, Joule-Thomson coefficient, Applications of general thermodynamic relations to ideal gas, Van der Waal and other state equations.	
		5.	**Review of Basic Equations and Steady State Conduction:** General three-dimensional heat conduction equation, Steady one-dimensional heat conduction through simple and composite planes, cylindrical and spherical walls without heat generation, Effect of variable thermal conductivity, Critical thickness of insulation. Steady one-dimensional heat conduction through plane wall, hollow cylinder, solid cylinder and solid sphere with uniform heat generation, Heat transfer from finned surfaces, general equation, efficiency and effectiveness of fins, conduction in cooling of turbine balding, optimum dimensions, comparison of fin materials. Two-dimensional steady state heat conduction, Numerical and graphical methods, Analogical solution.	
		6.	**Unsteady State Heat Conduction:** Heating and Cooling with negligible	

			internal resistance, Temperature-time response of thermocouple, Heating and cooling with negligible surface resistance, Transient heat conduction in semi-infinite solids, Laplace's equation, Separation of Variables, Lumped capacitance methods, Heating and Cooling of infinite plate with finite internal and surface resistance, Numerical and graphical analysis.
		7.	**Convection:** Laminar and turbulent flow, hydrodynamic and thermal boundary layer. Dimensional analysis and dimensionless numbers for free and forced convection. Empirical relations and practical solution of free and forced convection in pipes, over plates and across cylinders and spheres, combined free and forced convection, combined free convection and radiation heat transfer.
Text books, References			1. Introduction to Thermodynamics, Classical and Statistical, Third Edition, Sonntag, R.E., and Van Wylen, G, John Wiley and Sons, 1991. 2. Advanced Engineering Thermodynamics, Bejan, A., John Wiley and Sons, 1988. 3. Advanced Thermodynamics for Engineers, Kenneth Wark Jr., McGraw-Hill Inc., 1995. 4. Fundamentals of Heat & Mass Transfer, Incropera F.P. and DeWitt. D.P., John Wiley & Sons, 1996. 5. Analysis of Heat and Mass Transfer, Ozisik. M.N., McGraw Hill Co., 1980. 6. Heat Transfer - Basic Approach, Eckert. E.R.G., and Drake.R.M., McGraw-Hill Co., 1985. 7. Convection Heat Transfer, Bejan. A., John Wiley and Sons, 1984.

AM22343 Design of Heat Exchangers				
Designation	:	Required / Elective		
Pre-requisites	:	*Engineering Fluid Mechanics, Thermodynamics, Heat Transfer.*		
Credit and Contact hours	:	L+T+P=4		
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment (Scheme)**:20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).		
Course Outcomes	:	**Sl. No.**	**On successful completion of the course, student is expected to be able to:**	**Mapping into POs**
		1.	To review thermo-fluid fundamentals, to study classification and selection of Heat exchangers.	1, 2
		2.	To study and design various types of Heat exchangers.	2, 3
		3.	To study and design Heat exchanger network and its optimization; heat transfer augmentation, fouling, corrosion.	2, 3, 4
		4.	To mechanically design shell and tube heat exchangers, effects of vibration in heat exchangers, material selection and fabrication, quality control	2, 3, 4, 5
		5.	Latest advancement in Heat exchangers.	6, 7, 8
Modes of Delivery	:	Talk and chalk (main), Power point presentations (sometimes), Self-study (as assigned).		
Topics to be Covered	:	**Units**	**Details**	
		1.	Introduction, classification and selection; heat exchanger thermo-hydraulic fundamentals.	
		2.	Heat exchanger design; compact heat exchangers; shell and tube heat exchanger design; regenerators; plate heat exchangers and spiral plate heat exchangers. Boilers, Re-boilers, condensers, Air cooled Heat exchangers.	
		3.	Heat exchanger network design, Targeting and super targeting, Pinch design method, Network optimization.	
		4.	Heat-transfer augmentation; fouling; corrosion.	
		5.	Flow-induced vibration of shell and tube heat exchangers; mechanical design of shell and tube heat exchangers; material selection and fabrication; quality control and quality assurance and nondestructive testing.	
		6.	Latest advancement in Heat exchangers.	
Text books, References		1.Process Heat Transfer by DQ Kern. 2.Heat exchangers: Thermal-hydraulic fundamentals and design SadıkKakaç, A. E. Bergles, F. Mayinger. 3.Heat Exchanger Design Handbook Series:Dekker Mechanical Engineering, 2000, CRC Press.		

AM22344 Design of Hydraulic Turbines				
Designation	:	Required / Elective		
Pre-requisites	:	*Engineering Fluid Mechanics, Thermodynamics and Fluid Machineries.*		
Credit and Contact hours	:	L+T+P=4		
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks		
		Internal Assessment (Scheme):20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).		
Course Outcomes	:	**Sl. No.**	**On successful completion of the course, student is expected to be able to:**	**Mapping into POs**
		1.	To identify various types of hydro-electric plants, study their layouts,	1, 2
		2.	To study and design the various components of Hydro-electric plants and physical phenomena involved.	1,2
		3.	To study and design various hydraulic turbines.	2, 4
		4.	To study and analyze the cavitation phenomena, its detection, monitoring and control in hydraulic turbines.	2, 4, 6, 7
		5.	To analyze the performance characteristics of various hydraulic turbines.	2, 4, 7
		6.	To understand the latest trends and development in hydraulic turbines and its applications in micro and pico hydel power stations.	7, 8, 9
Modes of Delivery	:	Talk and chalk (main), Power point presentations (sometimes), Self-study (as assigned).		
Topics to be Covered	:	**Units**	**Details**	
		1.	**Hydropower plants:** Types, main components. Plant load factor, load duration curve, installed capacity, firm power, secondary power, and load prediction.	
		2.	**Penstocks and Water Hammer:** Types of penstocks and their design criteria, Economical diameter of penstock, Valves, Bends, Manifolds, Effect of Water-hammer in penstock, Surge tanks.	
		3.	**Introduction to Hydraulic Turbines:** Definition of head, discharge, power and efficiency of hydraulic turbines and hydro-unit. Classification based on head, specific speed, degree of reaction and direction of flow. Energy losses in turbines. Euler's energy equation, blade surface equation.	
		4.	**Impulse Turbines:** Energy conversion in Pelton turbine, design parameters, design of turbine runner, nozzle, spear.	
		5.	**Reaction(Francis)Turbines:** Classification, flow in runner, design parameters, determination of meridional flow, one-dimensional method of designing runner blades, relationship between the shape of blades and two-dimensional flow within runners. Blade designing in potential and rotational meridional flow. Draft tube- design and application. Deriaz turbine.	
		6.	**Reaction (Axial Flow) Turbines:** Major definitions and relations concerning the flow within a runner, design parameters, flow upstream and downstream of the runner, determination of velocity triangles at inlet and outlet of the runner. Airfoil method of blade designing –cascade analysis and its performance, loss mechanism, blade profiles, forces acting on blades.	
		7.	**Cavitation in Hydraulic Turbine:** Condition, types, consequences, remedy. Turbine cavitation coefficient, NPSH. Similarity laws in cavitating flows. Method of cavitation investigation in hydraulic turbines at laboratories and hydropower plants.	
		8.	**Turbine Performance Characteristics:** Main characteristics and operating characteristics, iso-efficiency characteristics, Determination of major prototype turbine parameters on the basis of model characteristic curves.	

			Derivation of the complete characteristics of prototype turbine. Distorted model, scale effect and efficiency.
		9.	**Latest Trends and Development in Hydraulic Turbines:** State-of-art for last few decades, latest design trends, newer applications in micro and pico-hydel power stations.
Text books, References			1. "Water Power Engineering", H.K. Barrows, McGraw-Hill Book Co., New York. 2. "Hydropower Structures", R.S. Varshney, Nemchand & Brothers, Roorkee (U.P.), 1992. 3. "Hydraulic Turbines" (Volume I and II), V. V. Barlit, MACT- Bhopal, 1969. 4. "Hydraulic Machines", Jagdish Lal, Metropolitan Book Co., Delhi. 5. "Fluid Mechanics and Thermodynamics of Turbomachinery", 4^{th} Edition, S.L.Dixon, Butterworth and Heinemann, 1998. 6. "Hydraulic Turbine", M. Nechleba, McGraw-Hill Inc., New York, 1957.

AM22345 River Engineering		
Designation	:	Required / Elective
Pre-requisites	:	*Engineering Fluid Mechanics, Mathematics.*
Credit and Contact hours	:	L+T+P=4
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment (Scheme):**20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).

Course Outcomes:

Sl. No.	On successful completion of the course, student is expected to be able to:	Mapping into POs
1.	To study the river characteristics and influential factors, various types of flow.	1, 2
2.	To study sediment transport through rivers.	2
3.	To study and design canalization and flood routing, interlinking of rivers, river confluences and river network.	2, 3, 4
4.	To study river bank erosion, river restoration, strategy for drought and flood management.	2, 4, 6
5.		

Modes of Delivery	:	Talk and chalk (main), Power point presentations (sometimes), Self-study (as assigned).

Topics to be Covered:

Units	Details
7.	Characteristics of River.
8.	Classification of flow, uniform flow, Gradually varied flow, Rapidly varied flow, unsteady flow.
9.	Channelization, sediment transport, canalization and flood routing.
10.	Interlinking of Rivers, River confluences and river network.
11.	Bank erosion, River restoration, draught and flood management.
12.	Latest advancement in river engineering and development of new techniques.

Text books, References:

1.River Mechanics. P Y Julien
2.Principles of river engineering: the non-tidal alluvial river. editorial board, P. Ph. Jansen.
3.Fluvial Processes in River Engineering: Howard H. Chang
4.Open-Channel Flow: M. Hanif Chaudhry.

ME22335 Advanced Gas Dynamics

Designation	:	Required / Elective
Pre-requisites	:	Fluid Mechanics, Thermodynamics
Credit and Contact hours	:	L+T+P=4
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment (Scheme)**:20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).

Course Outcomes:

Sl. No.	On successful completion of the course, student is expected to be able to:	Mapping into POs
1.	To understand the flow situations regarding the application of concepts of compressibility.	1, 2
2.	To calculate the changes in the flow properties across shock waves at different conditions.	2, 4
3.	To design supersonic nozzle, wind tunnel and shock tube to create a condition of high pressure and temperature.	2,4, 6

Modes of Delivery	:	Talk and chalk (main), Power point presentations (sometimes), Self-study (as assigned).

Topics to be Covered:

Units	Details
1.	**Introduction:** Glimpses of classical thermodynamics, statistical thermodynamics; Non-dimensionalization of Navier-Stokes and Energy equation with role of Mach number highlighted; stagnation quantities.
2.	**Normal Shocks:** Governing equations, Rankine – Hugoniot, Prandtl and other relations, weak shocks, thickness of shocks, normal shocks in ducts, performance of convergent-divergent nozzle with shocks, moving shock waves, shock problems in one dimensional supersonic diffuser, supersonic pitot tube.
3.	**Flow in Constant Area Duct with Friction:** Governing equations, working formulas and tables, choking due to friction, performance of long ducts, Isothermal flow in long ducts.
4.	**Flow in Constant Area Duct with Heating and Cooling:** Governing equations, working formula and tables, choice of end states, choking effects, shock waves with changes in stagnation temperature.
5.	**Generalized One-Dimensional Flow:** Working equations, general method of solution, example of combined friction and area change, Example of combined friction and heat transfer.
6.	**Oblique shock:** governing physical equations and general relations, shock polar diagram and auxiliary diagrams, strong and weak shocks, detached shock, interaction and reflection of shocks.
7.	**Method of characteristics:** general principle of integration using method of characteristics, application to one dimensional isentropic progressive waves, application to steady two dimensional irrotational isentropic supersonic flows, Prandtl-Meyer expansion.
8.	**Boundary layer flow** with Prandtl number unity and arbitrary Prandtl number, Integral equations of Laminar boundary layer, Differential and integral equations of Boundary layer, flow past a flat plate with turbulent Prandtl number of Unity. Elementary idea of boundary layer in tubes and in the presence of shock waves. Study of various flow visualization techniques. Study of different types of wind tunnels, their design criteria.

Text books, References:

1. "Gas Dynamics", E. Rathakrishnan, Prentice-Hall of India, New Delhi, 2002.
2. "Compressible Fluid Flow", M.A. Saad, Prentice-Hall, New Jersey, 1985.
3. "The Dynamics and Thermodynamics of Compressible Fluid Flow" (2 volumes),

		A. H. Shapiro, The Ronald Press, New York, 1953. 4. "Low-Speed Wind Tunnel Testing", A. Pope and J.J. Harper, John Wiley & Sons Inc., NY, 1966. 5. "Viscous Flow", F.M. White.

AM22346 Industrial Aerodynamics		
Designation	:	Required / Elective
Pre-requisites	:	*Engineering Fluid Mechanics, Aerodynamics.*
Credit and Contact hours	:	L+T+P=4
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment (Scheme):20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).
Modes of Delivery	:	Talk and chalk (main), Power point presentations (sometimes), Self-study (as assigned).

Course Outcomes:

Sl. No.	On successful completion of the course, student is expected to be able to:	Mapping into POs
1.	To study about atmosphere and various factors related to Industrial aerodynamics.	1, 2
2.	To study principles of various Wind energy collectors and its design methodologies.	2, 3
3.	To study and design Vehicle, Building and sportsballs using aerodynamic principles.	4, 5, 6
4.	To study the latest development in Industrial Aerodynamics.	6, 7, 8

Topics to be Covered:

Units	Details
1.	**Atmosphere:** Types of winds, Causes of variation of winds, Atmospheric boundary layer, Effect of terrain on gradient height, Structure of turbulent flows.
2.	**Wind energy collectors:** Horizontal axis and vertical axis machines, power coefficient, Betz coefficient by momentum theory.
3.	**Vehicle Aerodynamics:** Power requirements and drag coefficients of automobiles, effects of cut back angle, aerodynamics of road vehicles, trains and hovercraft.
4.	**Building Aerodynamics:** Pressure distribution on low rise buildings, wind forces on buildings. Environmental winds in city blocks, special problems of tall buildings. Building codes, building ventilation and architectural aerodynamics.
5.	**Flow induced vibrations:** Effects of Reynolds number on wake formation of bluff shapes, vortex induced vibrations. Galloping and stall flutter.
6.	**Sports Aerodynamics:** Aerodynamic design of Football, tennis, golf, rugby and American football, Performance enhancement in sports using aerodynamics.
7.	**Latest development in Industrial Aerodynamics.**

Text books, References

1. "Wind Effects on Structures: Fundamentals and Applications to Design" by Simiu and Scanlan, , 3rd Ed. John Wiley and Sons, Inc., 1996.
2. "Building Aerodynamics" by Tom Lawson, Imperial College Press, London, 2001.
3. "Aerodynamics and drag mechanisms of bluff bodies and road vehicles", M.Sovran (Ed), Plenum press, New York, 1978.
4. "Winds forces in engineering", P. Sachs, Pergamon Press, 1978.
5. "Car Aerodynamics", Hucho,
6. "Design Guides to wind loading of buildings structures (Part I & II)" by N. J. Cook, Butterworths, London, 1985.
7. ASCE/SEI 7-10 Minimum Design Loads for Buildings and Other Structures.
8. IS: 875 (1987) Part III Wind loads, Indian Standards for Building codes.

AM22347 Design of Impeller Pumps

Designation	:	Required / Elective
Pre-requisites	:	*Engineering Fluid Mechanics, Fluid machinery.*
Credit and Contact hours	:	L+T+P=4
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment (Scheme):**20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).

Course Outcomes :

Sl. No.	On successful completion of the course, student is expected to be able to:	Mapping into POs
1.	To study introduction to various pumps and basics of centrifugal pumps and fundamental principles.	1, 2
2.	To study and design flow through pump impeller and casing.	2, 3, 6
3.	To study and design radial and mixed flow pumps.	2, 3
4.	To study and analyze pump characteristics.	3, 4
5.	To study about special purpose pumps.	2, 6
6.	To study latest advancement in this area.	5, 6, 7

Modes of Delivery : Talk and chalk (main), Power point presentations (sometimes), Self-study (as assigned).

Topics to be Covered :

Units	Details
1.	**Introduction:** Classification of pumps, layout of rotodynamic pumps, head, discharge, power and efficiencies. Dimensional analysis, non-dimensional parameters, condition of similarity, specific speed and its significance. Elements of pumps- impeller, casings, diffusers etc.
2.	**Centrifugal Pumps:** Classification, single stage and multi-stage pumps, components, priming, pressure rise in pumps, cavitation, NPSH, Thomas cavitation factor, axial thrust.
3.	**Flow through Impeller:** Euler's fundamental equations, theoretical head for an infinite number of blades, influence of a finite number of blades, pressure and velocity distribution in impeller passages, influence of circulation in impeller passages, influence of pre-whirl on head, choice of blade outlet angle, stalling and surging.
4.	**Axial & Mixed Flow Pumps:** Geometry of the axial flow impeller vanes, experimental design factors- impeller hub ratio, chord spacing ratio, number of vanes, vane curvature and thickness. Airfoil theory of vanes. Helical pumps and diagonal pumps.
5.	**Impeller Design:** Geometrical velocity fields, evolution of impeller shapes, impellers with blades of single and double curvature, design calculation of the impeller- principal dimensions. Blade design- blade surface area, blade shape and blade angles, method of determining blade angle for centrifugal and axial impellers. Relation between overall efficiency and specific speed.
6.	**Pump Casing:** Flow at the outlet of the impeller, volute casing, volute design for optimum efficiency, circular volutes. Crossover, diffusion casing and diffusion rings, axial diffusers.
7.	**Pump Characteristics:** Classification of characteristics, non-dimensional characteristics, pump operation at off-design conditions, affinity of characteristic curves, iso-efficiency curves, flow conditions corresponding to the optimum efficiency, influence of flow conditions on pump operation. Pump in series and parallel. Matching of pumps to system characteristics; multi-stage pumps. Losses in pumps, total head-discharge curves.
8.	**Pump for special duties:** Deepwell pump– submersible pump and vertical turbine pump. Storage pump, turbine pump, boiler-feed pump, circulating pump, condensate pump, non-clog pump, marine pump, self-priming pump.

		9.	Latest advancement in Pump design and newer technologies.
Text books, References		1. "Impeller Pumps", Stephen Lazarkiewicz and A.T. Troskolanski, Pergamon Press, Warsaw, 1965. 2. "Centrifugal and Axial Flow Pumps- Theory, Design and Applications", A. J. Stepanoff, John-Wiley & Sons, 1967. 3. "Pumps, Fans and Compressors", A. de Kovats and G. Desmur, Blackie & Son Ltd., Glasgow, 1958. 4. "Rotodynamic Pump Design" by R.K. Turton, 5. Centrigfugal Pumps & Blowers" by A. Church and Jagdish Lal, Metropolitan Book Co., Delhi. 6. "Pump Handbook", I.J. Karassic, Tata McGraw Hills Ltd. New Delhi. 7. "Critical Aspects in Rotodynamic Pumps and systems", R.K. Srivastava, Techo Economic Research Institution, New Delhi. 8. "Fluid Mechanics and Thermodynamics of Turbomachinery", 4[th] Edition, S.L.Dixon, Butterworth and Heinemann, 1998. 9. "Hydraulic Machines", Jagdish Lal, Metropolitan Book Co., Delhi. 10. "Hydraulic Machines", V.P.Vasandani.	

AM22348		Condition Monitoring, Diagnosis and Predictive Maintenance of Pumps		
Designation	:	Required / Elective		
Pre-requisites	:	*Engineering Fluid Mechanics, Fluid machinery.*		
Credit and Contact hours	:	L+T+P=4		
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks		
		Internal Assessment (Scheme):20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).		
Course Outcomes	:	**Sl. No.**	**On successful completion of the course, student is expected to be able to:**	**Mapping into POs**
		1.	To study introduction to condition monitoring, diagnosis and maintenance philosophy.	2
		2.	To study and analyze performance and testing of pumps for condition monitoring.	2, 3
		3.	To study and analyze Acoustic monitoring and vibration of various pumps, and to study other monitoring techniques.	2, 3, 4
		4.	To study and develop Performance Improvement Program and Predictive Maintenance for pumps.	2, 4
		5.	To design and develop expert system for Condition Monitoring, diagnosis and prediction of service life and maintenance management.	2, 3, 4
		6.	To study latest advancement in this area.	5, 6, 7
Modes of Delivery	:	Talk and chalk (main), Power point presentations (sometimes), Self-study (as assigned).		
Topics to be Covered	:	**Units**	**Details**	
		1.	**Introduction:** Diagnosis of machine condition and faults, Need and benefits of Condition Monitoring, Machine life cycle, Maintenance Management in Industry, Condition Monitoring and diagnostics of Hydraulic and Electro-pneumatic systems.	
		2.	**Performance analysis and testing of pumps for condition monitoring:** Visual Inspection, Measurement of Temperature, Pressure, Flow, Speed and Power. Head Power Characteristics, Shutoff Head method, Balance leak-off flow method for monitoring of pumps.	
		3.	**Acoustic and Vibration Monitoring:** Setting band levels for monitoring, Measurement of vibration, General severity assessment, Analyzing and Using the vibration spectrum, Vibration phase angle, Resonance, Specific vibration severity standards for pumps, advanced methods of vibration analysis of pumps, Control of vibration.	
		4.	**Wear Monitoring:** Rate of wear, Effects of internal wear on pump performance and its efficiency.	
		5.	**Other monitoring:** Corrosion Monitoring, Condition monitoring of shaft seals, Monitoring of seal-less pumps, Non-Destructive Testing, Analysis of wear debris in lubricants.	
		6.	**Monitoring of Positive displacement pumps:** Performance characteristics, Condition monitoring by vibration analysis, Condition monitoring by performance analysis, Condition monitoring by analysis of wear particles in liquid pumped.	
		7.	**Performance Improvement Program and Predictive Maintenance:** Basic types of maintenance, Application and Benefits of Cost Effective Maintenance, Performance analysis and its application to optimize time for overhaul using shut-off head test results, Knowledge Based Systems for Maintenance Management, Reliability centric maintenance, Modern	

			Maintenance Management Systems.
		8.	**Expert System:** Application of Genetic Algorithm, Artificial Neural Networks and Fuzzy logic for Condition Monitoring, diagnosis and prediction of service life and maintenance management.
		9.	**Standards, Patents and current research** relevant to Condition Monitoring, Diagnosis and Maintenance Management.
		10.	**Case studies and Term Paper:** in detected performance shortfall and in condition monitoring of pumps.
Text books, References		1. Predictive maintenance of pumps using condition monitoring: Ray S. Beebe 2. An introduction to Predictive Maintenance: R. Keith Mobley 3. Engineering condition monitoring: practice, methods and applications: Ron Barron 4. Handbook of condition monitoring: BKN Rao 5. Handbook of Condition Monitoring: Techniques and Methodology: A. Davies 6. Pump User's Handbook: Life Extension, Heinz P. Bloch, Allan R. Budris 7. Intelligent condition monitoring and diagnosis systems: a computational intelligence approach: Kesheng Wang 8. CMS 110 R – Condition Monitoring Standards– Pump Vacuum Nash 9. CMS 111 R – Condition Monitoring Standards– Pump – Vertical - Multistage 10. CMS 153 R - Condition Monitoring Standards– Pump - Progressive Cavity 11. Modern Pumps: A Comprehensive Survey of Modern Pumping Equipment and Practice, Edward Mollo 12. Know and Understand Centrifugal Pumps L. Bachus, A Custodio.	

AM22349		Numerical Methods for Compressible Flows		
Designation	:	Elective		
Pre-requisites	:	*Advanced Numerical Methods for Computation, Advanced Fluid Mechanics, Gas Dynamics*		
Credit and Contact hours	:	L+T+P=4		
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks		
		Internal Assessment (Scheme):20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).		
Course Outcomes	:	**Sl. No.**	**On successful completion of the course, student is expected to be able to:**	**Mapping into POs**
		1.	Numerically simulate the real life engineering problems on compressible flows.	1, 2
		2.	Comprehensively understand the governing equations pertinent to the compressible flows and their solution techniques.	2, 3
		3.	Help to understand the underlying complex flow physics of the compressible flows.	2, 3, 4
		4.	Facilitate in developing the in-house Computational Fluid Dynamics codes.	3, 4, 5
		5.	Help to customize the commercial as well as open source software dedicated for solving problems on compressible flows.	6, 7, 8, 9
Modes of Delivery	:	Talk and chalk (main), Power point presentations (sometimes), Self-study (as assigned). Note: Term paper, Assignments and Demonstration need to be given to the students on the following (or similar) topics using computer programming: Euler simulation of 1D compressible flow solver. Navier-Stokes and Euler simulation for two-dimensional compressible flow. Compressible flow solver for complex geometry.		
Topics to be Covered	:	**Units**	**Details**	
		1.	**Governing Equations:** Basic governing equations (Euler equation and Navier-Stokes-Fourier equations)and relations(Calorically perfect gas, Sutherland formula) describing the compressible flows	
		2.	**Riemann problem and its solution:** Method of characteristics and the solution of linear hyperbolic equations, Riemann problem for linear system of equations and its solution, Riemann problem for Euler equations and its solution	
		3.	**Grid generation techniques:** C-,H-,O- grid topologies, Structured grid (algebraic, elliptic, hyperbolic), unstructured grid (Delaunay triangulation, advancing-front method), mixed element/hybrid grids, grid smoothening, grid adaptation	
		4.	**Spatial discretization based on finite volume method:** Cell-centred and cell-vertex schemes, Convective fluxes(advection upwind splitting schemes, Roe's approximate Riemann solver, total variation diminishing (TVD) scheme, piecewise liner reconstruction, Green-Gauss approach, least-square approach), Limiter functions (minmod, Harten, TVD, superbee) , Viscous fluxes (central difference, Green's theorem, elements based gradients, average of gradients).	
		5.	**Temporal Discretization:** Explicit time stepping schemes(Runge-Kutta multistage scheme, hybrid-multistage scheme, treatment of source term, Courant-Fridreichs-Lewy (CFL) condition)), Implicit time stepping schemes (alternating direction implicit (ADI), lower-upper symmetric Gauss-Siedel (LU-SGS)), dual time stepping schemes for unsteady flows	
		6.	**Numerical treatments of boundary conditions:** Farfield, Inlet/outlet, symmetry, periodic, solid wall (inviscid and viscous flows)	
		7.	**Development of numerical codes:** One dimensional Euler solver, structured and unstructured two dimensional Eulerand Navier-Stokes solvers, Compressible flow solver	

		based on the limiter approach, Development of Euler and Navier-Stokes multicomponent compressible flow solver in both Cartesian and Curvilinear approach. Function of the limiter at high shock strength.
Text books, References	:	1. "Physics of Shock Waves and High Temperature Hydrodynamic Phenomena", Y. B. Zel'dovich , Yu P. Raizer. 2. "Numerical Computation of Internal and External Flows, Volume 2", Charles Hirsch. 3. "Riemann Solvers and Numerical Methods for Fluid Dynamics", E. F. Toro. 4. "Introduction to Compressible Fluid Flow", Oosthuizen Patrick H. 5. "Modern Compressible Flow with Historical Perspective", John D. Anderson, McGraw Hill. 6. "Computational Fluid Dynamics: Principles and Applications", J. Blazek. 7. "Elements of Numerical Methods for Compressible Flows", Doyle D. Knight, Cambridge University Press.

AM22350		Water Footprint and Life Cycle Analysis
Designation	:	Elective
Pre-requisites	:	
Credit and Contact hours	:	L-T-P-4
Assessment Methods	:	Theory Examination: (Scheme) End Semester Exam: 60 marks Mid Semester Exam: 20 marks Internal Assessment (Scheme):20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).

Course Outcomes

Sl. No.	On successful completion of the course, student is expected to be able to:	Mapping into POs
1.	Use the fundamentals of LCA and water footprint to real life engineering problems.	1, 2
2.	Comprehensively understand the fundamentals of LCA and water footprint.	2, 3
3.	Help to understand the nexus of energy-water-environment and the spirit of sustainable development.	2, 3, 4
4.	Facilitate in handling commercial and opensource LCA codes and s/w.	3, 4, 5

Modes of Delivery: Talk and chalk (main), Power point presentations (sometimes), Self-study (as assigned).
Note: Term paper, Assignments and Demonstration need to be given to the students on the topics given by the instructors using commercial/opensource LCA codes.

Topics to be Covered

Units	Details
1.	**Concept of Life Cycle and Sustainability:** Triple Bottom Line (Environment, Economic and Social), Life Cycle Sustainability Analysis (LCA, LCC, SLCA). Why Life Cycle Assessment, Introduction of LCA- Definition, Historical Development, Characteristics and Applications, Benefits and Limitation of LCA. Common terms used in LCA- System Boundary, Functional unit, unit processes, Characterization and Weighting, Midpoint and Endpoint environmental impact categories, Impact methods (Eco-indicator, ReCiPE, CML etc). ISO Framework- ISO 14044 standard (2006). LCA databases- Eco-Invent, US LCI, ELCD, AusLCI, Indian LCI databases.
2.	**LCA Methodology:** Goal and Scope Definition, Life Cycle Inventory (LCI) Analysis, Life Cycle Impact Assessment, Life Cycle Interpretation, Uncertainty and sensitivity analysis, Introduction to Life cycle assessment tool- SimaPro, GaBi, and OpenLCA.
3.	**Sustainability in resources industries:** Energy, mining and mineral processing, sustainability in the context of metal production, recycling of materials, E-waste processing issues.
4.	**LCA of various energy systems:** Coal, gas, oil-based systems, nuclear, biomass, solar, wind, hydro energies.
5.	**LCA and Water footprint:** Concept, components and Need of Water Footprint Introduction to water management, ISO 14046 for life cycle-based water footprint determination and concept of embodied water of products. Case studies- Water footprint in various industries, viz. textile, metal and mining processes and thermal power plant.
6.	**Introduction to Environmental Management System (EMS):** Definition, Goal, Need and Benefits, Introduction to ISO 14001Procedures and guidelines to develop EMS documents. What is PDCA in the context of EMS?

Text books, References:

1. Sustainable Engineering: Concepts, Design and Case studies by David T. Allen and David R. Shonnard.
2. "Life Cycle Assessment, Theory and Practice" by Hauschild, Michael, Rosenbaum, Ralph K., Olsen, Stig (Editors), Springer, 2018.
3. ISO 14044_2006 Code on ' Environmental management — Life cycle assessment'.
4. ISO 14046_2014 'Environmental management — Water footprint' Principle, Requirement and guidelines.
5. Handbook on Life Cycle Assessment: Operational guide to the ISO standards, Kluwer

AM*****		Particle Technology		
Designation	:	Elective		
Pre-requisites	:	None		
Credit and Contact hrs	:	L+T+P=4		
Assessment Methods	:	Theory Examination: (Scheme) End Semester Exam: 60 marks Mid Semester Exam: 20 marks Internal Assessment: (Scheme) 20 marks (5 marks for attendance + 15 marks for Assignment submission, Surprise tests, Term paper, Quiz tests, etc.)		
Course Outcomes	:	**Sl. No.**	**On successful completion of the course, student is expected to be able to:**	**Mapping into POs**
		1.	To overview the industrial applications of powder processing.	1, 2
		2.	To study characterization of powders, unit operations for processing particulate matters.	2, 3
		3.	To read various case studies related to applications of powder and particle technology.	4, 5, 6
		4.	To study the latest development in powder and particle technology-nanoparticle technology etc.	6, 7, 8

Syllabus

Overview of industrial applications of powder processing:
Ash in Thermal Power plants, Pharmaceutical powders, Food Powders, Minerals.
Characterization of powders:
Size distribution, shape, Particle density, flowability.
Unit operations for processing particulate materials:
Single particle fluid systems, Multiple particle fluid systems, Colloaids and fine powders, Size enlargement and size reduction, solid-liquid and solid-gas separation, mixing, storage and flow of powders-Hopper design, pneumatic conveying, fluidization, Slurry conveying.
Nanoparticle technology:
Production, properties and behavior.
Powders and their effects on Human:
Powders and Human Respiratory system, Fire and explosion hazards of powders, industrial dust control and health risks.
Case Studies:
High Windbox Pressure in a Fluidized Bed Roaster, Inappropriate Use of an L-valve, Fluidized Bed Dryer,Aeration of a Hopper Leads to Air Shortage at a Coal Plant,Limestone Hopper Extension Overloads Feeder,The Use of Inserts in Hoppers, Dust Emission Problems during Tanker Unloading Operations, Pneumatic Conveying and Injection of Mill Scale

References books

1. Introduction to Particle Technology, by Martin Rhodes, Wiley; 2008.
2. Powder technology: fundamentals of particles, powder beds, and particle generation. By Masuda, Hiroaki, KoHigashitani, and Hideto Yoshida, eds , CRC press, 2006.
3. Pneumatic conveying of solids: a theoretical and practical approach. By Klinzing, George E., FaridRizk, R. Marcus, and L. S. Leung. Vol. 8. Springer Science & Business Media, 2011.
4. Particle technology. Vol. 1 by Rumpf, Hans. . Springer Science & Business Media, 2012.
5. Powder technology: fundamentals of particles, powder beds, and particle generation. CRC press, 2006.
6. Slurry Handling: Design of solid-liquid systems. By Brown, Nigel P., and Nigel I. Heywood, eds Springer Science & Business Media, 1991.

	Academic Publishers 6. Life Cycle Assessment: Principles and Practice - Scientific Applications International Corporation and MA Curran, National Risk Management Research Laboratory, Office of Research and Development, U.S. Environmental Protection Agency, 2006. 7. ISO 14001: 2015 Environmental Management Systems- Requirements with guidance for use.

AM *****		Bulk Solids Handling		
Designation	:	Elective		
Pre-requisites	:	None		
Credit and Contact hrs	:	L+T+P=4		
Assessment Methods	:	Theory Examination: (Scheme) End Semester Exam: 60 marks Mid Semester Exam: 20 marks Internal Assessment: (Scheme) 20 marks (5 marks for attendance + 15 marks for Assignment submission, Surprise tests, Term paper,Quiz tests, etc.)		
Course Outcomes	:	Sl. No.	On successful completion of the course, student is expected to be able to:	Mapping into POs
		1.	To study characterization, flow and storage of bulk solids.	1, 2
		2.	To study mechanical handling of bulk solids.	2, 3
		3.	To design and analyze of pneumatic and hydraulic conveying, capsule transport.	4, 5, 6
		4.	To study the latest development and industrial applications of bulk solids handling system.	6, 7, 8

Syllabus

Characterization, Flow and Storage of Bulk Solids:
The nature of bulk solids , Gravity flow of bulk solids, Dynamics of fluid/solids systems, The design of storage bins and hoppers, Dust control, Explosion hazards

Mechanical Handling of Bulk Solids:
Belt conveyors, Bucket elevators, Chain and flight conveyors, Screw conveying, Vibratory conveyors.

Pneumatic Transport:
Basic pneumatic conveying systems, Components of pneumatic conveying systems, Pneumatic conveyor design,

Hydraulic conveying and Capsule transport:
Basic Slurry and Capsule transportation systems. Components and design of Slurry and capsule transportation systems.

Industrial application of Bulk Solids Handling systems:
Coal mines, Ash conveying, Food powders, Minerals.

References books

1. *Bulk solids handling: an introduction to the practice and technology* by Woodcock, C. R., and J. S. Mason. Springer Science & Business Media, 2012.
2. Introduction to Particle Technology, by Martin Rhodes, Wiley; 2008.
3. *Powder technology: fundamentals of particles, powder beds, and particle generation*.By Masuda, Hiroaki; Ko Higashitani, and Hideto Yoshida, eds, CRC press, 2006.
4. *Pneumatic conveying of solids: a theoretical and practical approach*. By Klinzing, George E., Farid Rizk, R. Marcus, and L. S. Leung. Vol. 8. Springer Science & Business Media, 2011.
5. *Particle technology*. Vol. 1 by Rumpf, Hans. . Springer Science & Business Media, 2012..
6. *Powder technology: fundamentals of particles, powder beds, and particle generation*. CRC press, 2006.
7. *Slurry Handling: Design of solid-liquid systems*. By Brown, Nigel P., and Nigel I. Heywood, eds., Springer Science & Business Media, 1991.

AM***** Multiphase Flow Laboratory				
Designation	:	Compulsory		
Pre-requisites	:	*Basic knowledge of Fluid Mechanics, Multiphase Flows, CFD.*		
Credit and Contact hours	:	L+T+P=6		
Assessment Methods	:	**Practical Examination: (Scheme)** End-Semester Exam: 50 marks.		
		Internal Assessment: (Scheme) 50 marks (10 marks for attendance + 40 marks for sessional assessment and/or Term paper based on regular performance on Practical and Experimentation, Demonstration of knowledge and skill development through Surprise / Quiz Tests, Viva etc. and Assignments & Report Writing..		
Course Outcomes	:	Sl. No.	**On successful completion of the course, student is expected to be able to:**	**Mapping into POs**
		1.	To use latest flow measuring devices and to conduct experiments related to Multiphase flows.	3,4, 5
		2.	To use CFD techniques to simulate multiphase flow problems using CFD codes.	3, 4, 5
		3.	To draw/plot graphs derived from results, write technical report.	6, 7
		4.	To compare and contrast computational results with experimental/theoretical trends.	6, 7

Syllabus

Experiment 1: Rise of Taylor Bubble through vertical Circular conduits.
Experiment 2: Gas-liquid Two-phase flow through a vertical tube.
Experiment 3: Evaporation Loss from a cryogenic Vessel.
Experiment 4:Charateristics of an air lift pump
Experiment 5: Conductivity probes and signals in two-phase flow.
Experiment 6: Bubble generation, growth and departure from a submerged orifice
Experiment 7: Virtual Lab on steam condensation in Micro Channels
Experiment 8: Two phase flow in a natural circulation loop.
Experiment 9: CFD simulation of liquid-solid flows
Experiment 10: CFD simulation of gas-solid flows
Experiment 11:CFD simulation of gas-liquid flows

References books

1. Davies, R. M. and Taylor, G. (1950) The mechanics of large bubbles rising through extended liquids and through liquids in tubes. Proc. Roy. Soc. 200A, 375-390.
2. One dimensional two phase flows by G B Wallis, Macgraw Hills, 1969.
3. Barron, R.F., Cryogenic Systems, 2nd Ed., Oxford Univeristy Press, 1998.
4. D.Gerlach, G. Biswas, F. Durst, V. Kolobaric, Quasi-static bubble formation on submerged orifice, International Journal of Heat and Mass Transfer,vol.48, pp.425-438, 2005.
5. Harirchian, T., Garimella, S. V., 2009a, The Critical Role of Channel Dimension, Heat Flux, and Mass Flux on Flow Boiling Regimes in Microchannel, International Journal of Multiphase Flow, 35, 349-362,DOC: http://dx.doi.org/10.1016/j.ijmultiphaseflow.2009.01.003
6. Groll, M. Khandekar, S. State of the Art on Pulsating Heat Pipes, Microchannels and Minichannels (ICMM-2004), June 17-19, 2004, Rochester, NY, USA.

AM*****		Applied Thermal Engineering
Designation	:	Elective
Pre-requisites	:	
Credit and Contact hours	:	L+T+P 4
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment (Scheme):**20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).

Course Outcomes :

Sl. No.	On successful completion of the course, student is expected to be able to:	Mapping into POs
1.	To understand various gas and vapour power cycles and heat transfer thereof.	1, 2
2.	To study boilers and its applications.	2, 3
3.	To study steam condensers, cooling towers, steam & gas nozzles and its applications.	2, 3
4.	To study steam turbines and its applications in power generation.	2, 3
5	To understand refrigeration and air conditioning	2,3,6

Modes of Delivery	:	Talk and chalk (main), Power point presentations (sometimes), Self-study (as assigned). Note: Term paper, Assignments and Demonstration.

Topics to be Covered :

Units	Details
1.	**Gas Power cycle:** Air Standard cycles: Carnot, Otto, Diesel, Dual and Stirling cycles, P-V and T-S diagrams, description, efficiencies and mean effective pressures, Comparison of Otto, Diesel and dual cycles. I.C. Engine: Testing of two stroke and four stroke SI and CI engines for performance Related numerical problems, heat balance, Motoring Method, Willian's line method, swinging field dynamometer, Morse test.
2.	**Vapour Power cycles:** Rankine cycle, effect of pressure and temperature on Rankine cycle, Reheat cycle, Regenerative cycle, Feed water heaters, Binary vapour cycle, Combined cycles, Cogeneration. **Fuels and Combustion:** Combustion analysis, heating values, air requirement, Air/Fuel ratio, standard heat of reaction and effect of temperature on standard heat of reaction, heat of formation, Adiabatic flame temperature.
3.	**Boilers:** Classifications and working of boilers, boiler mountings and accessories, Draught and its calculations, air pre-heater, feed water heater, super heater. Boiler efficiency, Equivalent evaporation. Boiler trial and heat balance, Indian Boilers Regulation (IBR).
4.	**Steam Condensers and Cooling Towers:** Introduction, Classification and functions of Steam condenser, air leakage, condenser performance parameters, Jet condensers and surface condensers, Working merits and demerits of surface condensers over jet condensers, Function classification and working of Cooling towers.
5.	**Steam and Gas Nozzles:** Flow through Convergent and convergent-divergent nozzles, variation of velocity, area and specific volume, Choked flow, throat area, Nozzle efficiency, Off design operation of nozzle, Shock waves stationary normal shock waves, Effect of friction on nozzle, Super saturated flow.
6.	**Steam Turbines :** Classification of steam turbine, Impulse and Reaction turbines, Staging, Stage and Overall efficiency, Reheat factor, Bleeding, Velocity diagram of simple and compound multistage impulse and reaction turbines and related calculations, work done, efficiencies of reaction, Impulse reaction turbines, state point locus, Losses in steam turbines, Governing of turbines, Comparison with steam engine.
7.	**Refrigeration & Air-conditioning:** Basic concepts and design, Refrigerants, vapour compression cycle, pressure temperature relation, superheat and sub-cooling, Vapour absorption refrigeration, psychrometry, Classifications, design and working of air conditioning System.

Text books,	:	1. Basic and Applied Thermodynamics by P.K. Nag, McGraw Hill India.

References	2. Applied Thermodynamics for Engineering Technologists by Eastop, Pearson Education 3. Applied Thermodynamics by Venkanna And Swati, PHI 4. Theory of Stream Turbine by WJ Kearton 5. Steme & Gas Turbine by R. Yadav, CPH Allahabad 6. Thermodynamics and Energy Systems Analysis, Borel and Favrat, CRC Press 7. Thermal Engg. By PL Ballaney, Khanna Publisher 8. Thermodynamics and Heat power Engg,. Mathur and Mehta, Tata Mcgraw- Hill 9. Thermal Engineering, M M Rathore, Mcgraw- Hill Education 10. Fundamentals of Engineering Thermodynamics, M. J. Moran, and H. N. Shapiro, John Wiley and Sons. 11. Basic Refrigeration and Air Conditioning, P.N. Ananthanarayanan, Tata McGraw-Hill.

AM*****		Wave Hydrodynamics
Designation	:	Elective
Pre-requisites	:	
Credit and Contact hours	:	L+T+P=4
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment (Scheme)**:20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).

Course Outcomes

Sl. No.	On successful completion of the course, student is expected to be able to:	Mapping into POs
1.	To understand fundamentals of waves and ocean currents.	1,2
2.	To analyze wave kinematics and wave transformation.	2,4, 6
3.	To realize the fundamentals of wave forces and loads	2,4, 6
4.	To understand the latest development and trends in wave power harvesting maschiness, newer applications.	6,7

Modes of Delivery	:	Talk and chalk (main), Power point presentations (sometimes), Self-study (as assigned). Note: Term paper, Assiguments and Demonstration.

Topics to be Covered

Units	Details
1.	**Classification of Waves:** Classification of water waves - Two dimensional wave equation and wave characteristics - wave theories - Small amplitude waves - Finite amplitude waves - Stokian, Solitary and Cnoidal wave theories - Mass transport velocity, Introduction to Random and directional waves. Water particle kinematics - wave energy, power - wave deformation - Reflection, Refraction, Diffraction Breaking of waves - Wave Forecasting Methods - Spectral description of Ocean Waves - Design wave.
2.	**Wave Kinematics:** Wave celerity, water particle velocities, accelerations, displacements and pressures. Approximations for deep and shallow water conditions. Integral properties of waves: Mass flux, Energy and energy flux, Group speed, Momentum and momentum flux.
3.	**Wave Transformations:** Shoaling, bottom friction and damping, refraction, reflection and diffraction. Wave Breaking: Type of breaking, Surf similarity parameter. Keulegan-Carpenter number, Ursell Parameter, Scattering parameter, Reynolds Number.
4.	**Ocean Currents:** Classification - Behaviour - Design Criteria, Scour and other effects of currents.
5.	**Wave Forces/Loads:** Wave forces - Morison equation - wave loads on vertical, inclined and horizontal cylinders. Diffraction theory - wave slamming and slapping - wave impact pressures and forces on Coastal Structures - Breakwaters - Seawalls - Model Experiments.
6.	**Introduction to wave harvesting machines:**

Text books, References

1. Sarpkaya, T. and Isaacson, M., Mechanics of Wave Forces on Offshore Structures, Van Nostrand Reinhold Co., NewYork, 1981.
2. Dean, R.G. and Dalrymple, R.A., Water wave mechanics for Engineers and Scientists, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1994.
3. Ippen, A.T., Estuary and Coastline Hydrodynamics, McGraw-Hill Book Company, Inc., NewYork, 1978.
4. Shore Protection Manual Volume I and II, Coastal Engineering Research Centre, Dept. of the Army, US Army Corps of Engineers, Washington DC, 1984.
5. Sorenson, R.M., Basic Coastal Engineering, A Wiley-Interscience Publication, New York, 1978.
6. Goda,Y. 2000.Random seas and Design of Maritime Structures. 2nd ed. Advance Series on Ocean Engineering.Vol.15. World Scientific Publishers Pvt.Ltd. 443pp.
7. Young,I.R.1999. Wind generated Ocean Waves. Ocean Engineering Book Series.Vol.2. Elsevier.The Netherlands. 288pp.
8. Narasimhan,S., S.Kathiroli,S.andB.Nagendra Kumar (Eds). 2002. Harbour and Coastal Engineering (Indian Scenario) Vol.I. NIOT, Chennai. 729pp.
9. Reeves,D, Chadwick,A and Fleming,C. 2004. Coastal Engineering. Processes Theory and Design Practice. SPON Press, London. 461pp.

AM*****		Computational Heat Transfer		
Designation	:	Elective		
Pre-requisites	:			
Credit and Contact hours	:	L+T+P=4		
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks		
		Internal Assessment (Scheme):20 marks (5 marks for attendance + 15 marks for Take-home assignments, Surprise / Quiz Test and Class Tutorials).		
Course Outcomes	:	**Sl. No.**	**On successful completion of the course, student is expected to be able to:**	Mapping into POs
		1.	To mathematically model the heat transfer problems.	1, 2
		2.	To understand the grid generation of various heat transfer problems.	2, 3, 4
		3.	To solve various types of heat transfer problems using CFD.	3, 4, 5
		4.	Latest development and newer applications in computational heat transfer.	6, 7, 8, 9
Modes of Delivery	:	Talk and chalk (main), Power point presentations (sometimes), Self-study (as assigned). Note: Term paper, Assignments and Demonstration.		
Topics to be Covered	:	Units	**Details**	
		1.	Heat transfer analysis, Modes of heat transfer, Forced vs. natural convection. Prandtl number and thermal boundary layer, Wall boundary conditions, Heat transfer coefficient and Nusselt number. Periodic flows, Conjugate heat transfer (multiple modes of heat transfer) simulation of solid side heat transfer along with the fluid flow.	
		2.	Extracting Solid and Fluid Volumes, Creating Shared Topologies for Creating Conformal Meshes. Setting up Volumetric Heat Sources, Visualizing Heat Transfer Coefficient Distribution.	
		3.	Simulation of the heat transfer in an exhaust manifold when hot exhaust products are flowing through it.	
		4.	Heating, Ventilation, and Air Conditioning (HVAC), HVAC Simulation inside a mixing Tee.	
		5.	External/internal forced convection, Heat transfer, including conduction, convection, and radiation, Fluid flow in practice and heat transfer problems in technical applications.	
Text books, References	:	1. Computational Fluid Flow and Heat Transfer, Second Edition by K. Muralidhar, T. Sundararajan (Narosa), 2011. 2. Numerical Computation of Internal and External Flows by Hirch C., Elesvier 2007. 3. B. Anderson et al., Computational Fluid Dynamics for Engineers, 1st edition, Cambridge University Press, U.K., 2012. 4. H. K. Versteeg, W. Malalasekera, An Introduction to Computational Fluid Dynamics: The Finite Volume Method, 2nd edition, Pearson, Prentice Hall, 2007. 5. Computational Heat Transfer by Y. Jaluria and K.E. Torrance, CRC Press, 2nd Ed., 2003.		

Master of Technology

in

MATERIALS SCIENCE AND ENGINEERING

Course Structure,
Scheme of Evaluation
&
Syllabi

(*Proposed to be Effective from July 2021*)

Department of Applied Mechanics

Motilal Nehru National Institute of Technology Allahabad

Prayagraj, U.P. -211004, INDIA

VISION AND MISSION OF THE INSTITUTE

VISION

To establish a unique identity for the institute amongst national and international academic and research organizations through knowledge creation, acquisition and dissemination for the benefit of society and humanity.

MISSION

- To generate high quality human and knowledge resources in our core areas of competence and emerging areas to make valuable contribution in technology for social and economic development of the nation. Focused efforts to be undertaken for identification, monitoring and control of objective attributes of quality and for continuous enhancement of academic processes, infrastructure and ambience.
- To efficaciously enhance and expand, even beyond national boundaries, its contribution to the betterment of technical education and offer international programmes of teaching, consultancy and research.

VISION AND MISSION OF THE DEPARTMENT

VISION

To establish itself as a department recognized for its quality post graduate education and research in the broad field of Applied Mechanics and Materials.

MISSION

- To produce high quality human resource in the area of Applied Mechanics and Materials Engineering by way of continuous up gradation of curriculum, improvement in academic processes & ambience, and faculty & infrastructure development.
- To create knowledge resource through research in emerging areas of Applied Mechanics and Materials in collaboration with national & international academic, research and industrial organizations and disseminate the same by contributing and conducting STTP, Workshops, Symposiums and Conferences.

Graduate Attributes (GAs):

1. **Scholarship of Knowledge**: Acquire in-depth knowledge of specific discipline or professional area, including wider and global perspective, with an ability to discriminate, evaluate, analyze and synthesize existing and new knowledge, and integration of the same for enhancement of knowledge.
2. **Critical Thinking**: Analyze complex engineering problems critically, apply independent judgment for synthesizing information to make intellectual and/or creative advances for conducting research in a wider theoretical, practical and policy context.

3. **Problem Solving**: Think laterally and originally, conceptualize and solve engineering problems, evaluate a wide range of potential solutions for those problems and arrive at feasible, optimal solutions after considering public health and safety, cultural, societal and environmental factors in the core areas of expertise.

4. **Research Skill**: Extract information pertinent to unfamiliar problems through literature survey and experiments, apply appropriate research methodologies, techniques and tools, design, conduct experiments, analyze and interpret data, demonstrate higher order skill and view things in a broader perspective, contribute individually/in group(s) to the development of scientific/technological knowledge in one or more domains of engineering.

5. **Usage of modern tools**: Create, select, learn and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modeling, to complex engineering activities with an understanding of the limitations.

6. **Collaborative and Multidisciplinary work**: Possess knowledge and understanding of group dynamics, recognize opportunities and contribute positively to collaborative-multidisciplinary scientific research, demonstrate a capacity for self-management and teamwork, decision-making based on open-mindedness, objectivity and rational analysis in order to achieve common goals and further the learning of themselves as well as others.

7. **Project Management and Finance**: Demonstrate knowledge and understanding of engineering and management principles and apply the same to one's own work, as a member and leader in a team, manage projects efficiently in respective disciplines and multidisciplinary environments after consideration of economic and financial factors.

8. **Communication**: Communicate with the engineering community, and with society at large, regarding complex engineering activities confidently and effectively, such as, being able to comprehend and write effective reports and design documentation by adhering to appropriate standards, make effective presentations, and give and receive clear instructions.

9. **Life-long Learning**: Recognize the need for, and have the preparation and ability to engage in life-long learning independently, with a high level of enthusiasm and commitment to improve knowledge and competence continuously.

10. **Ethical Practices and Social Responsibility**: Acquire professional and intellectual integrity, professional code of conduct, ethics of research and scholarship, consideration of the impact of research outcomes on professional practices and an understanding of responsibility to contribute to the community for sustainable development of society.

11. **Independent and Reflective Learning**: Observe and examine critically the outcomes of one's actions and make corrective measures subsequently, and learn from mistakes without depending on external feedback.

DEPARTMENT OF APPLIED MECHANICS

Master of Technology in Materials Science and Engineering

PROGRAM EDUCATIONAL OBJECTIVES

PEO-1	To understand the importance of materials in life and the relationship between structure, properties and processing to evaluate the performance of material in engineering application.
PEO-2	To characterize materials and carry out research to develop materials for advanced application.
PEO-3	To design and develop effective and eco-friendly materials for generic and strategic applications.
PEO-4	To build a character in student to pursue life-long learning by enhancing knowledge and skills for professional advancement.

Mapping of Mission statements with program educational objectives Mission Statement

Mission statements	PEO-1	PEO-2	PEO-3	PEO-4
MS1	√	√	√	
MS2			√	√
MS3		√	√	√
MS4	√	√	√	√

Mapping of program educational objectives with graduate attributes

PEO	GA1	GA2	GA3	GA4	GA5	GA6	GA7	GA8	GA9	GA10	GA11
PEO-1	√	√	√	√		√			√		
PEO-2	√	√	√		√		√				√
PEO-3	√	√	√		√					√	
PEO-4			√	√	√	√	√	√	√	√	√

PROGRAM OUTCOMES: At the end of the program the student will be able to:

PO1	Understand the correlation between structure and properties, their constitutive equations; phenomena to improve the performance of materials.
PO2	Synthesize ceramic and nano-particles and modify structure to improve magnetic electrical and electronic properties of materials.
PO3	Design metallurgical processes to produce products as per specifications.
PO4	Design and evaluate materials/products for their mechanical behavior and modify metallurgical processes.
PO5	Design and fabricate different types of composites.
PO6	Characterize and evaluate materials for specific applications.
PO7	Identify mechanisms for change in behavior of materials after processing and their modeling.
PO8	Develop materials for aerospace, biomedical, eco-friendly and high temperature and other advanced applications.
PO9	Manage project in totality to address issues related to industries.
PO10	Practice professional ethics, moral and human values to improve professionalism and life-long learning.

Mapping of program outcomes with program educational objectives

PO	PEO1	PEO2	PEO3	PEO4
1.	3		2	
2.	2	3	2	
3.	1	2	3	1
4.	3	2	2	1
5.	1	2	3	
6.	2	3	2	1
7.	3		2	
8.	2	2	3	1
9.		1	2	3
10.	1	1	1	3

1: Slightly 2: Moderately 3: Substantially

Course Structure

I Semester (Total Credits = 20):

I Semester (Total Credits = 20):

Course Code	Subject Name	L	T	P	Credits	Distribution of Marks out of 100		
						TA	Mid Sem. Exam	End Sem. Exam
AMxxxxx	Applied Mathematics and Computation	4	0	0	4	20	20	60
AMxxxxx	Advanced Materials Science and Engineering	4	0	0	4	20	20	60
AMxxxxx	Characterization of Materials	4	0	0	4	20	20	60
AMxxxxx	Elective-I	4	0	0	4	20	20	60
AMxxxxx	Elective-II	4	0	0	4	20	20	60

List of Electives (Semester I):

AMxxxxx	Thermodynamics and Kinetics of Materials
AMxxxxx	Electrical, Electronic, Magnetic, and Optical Materials
AMxxxxx	Polymer Science and Engineering
AMxxxxx	Corrosion Science and Engineering
AMxxxxx	Ceramic Technology
AMxxxxx	Non-Destructive Testing
AMxxxxx	Nanomaterials
AMxxxxx	Phase Equilibrium and Phase Diagrams
AMxxxxx	Powder Technology
AMxxxxx	Applied Elasticity
AM21311	Finite Element Methods
AMxxxxx	Continuum Mechanics
AM21312	Optimization Techniques

II Semester (Total Credits = 20):

Course Code	Subject Name	L	T	P	Credits	Distribution of Marks out of 100		
						TA	Mid Sem. Exam	End Sem. Exam
AMxxxxx	Mechanical Behaviour of Materials	4	0	0	4	20	20	60
AMxxxxx	Materials Synthesis and Characterization Laboratory	0	0	6	4	50	-	50
AMxxxxx	Elective-III	4	0	0	4	20	20	60
AMxxxxx	Elective-IV	4	0	0	4	20	20	60
AMxxxxx	Elective-V	4	0	0	4	20	20	60

List of Electives (Semester II):

AMxxxxx	Bio-Materials
AMxxxxx	Computational Materials Science
AMxxxxx	Energy Materials
AMxxxxx	Carbon Nanotube and Carbon Nanostructures
AMxxxxx	Glass Science and Engineering
AMxxxxx	Materials in Service
AMxxxxx	Thin Films
AMxxxxx	Smart Materials
AMxxxxx	MEMS and Bio-MEMS
AMxxxxx	Machine Learning in Materials Science
AM22313	Mechanics of Composite Materials
AMxxxxx	Continuum Damage Mechanics

AM22315	Multiscale Modeling of Advanced Materials
AM22317	Fracture Mechanics
AM22316	Applied Plasticity
AMxxxxx	Electroacoustic Transducers

III Semester (Total Credits = 20):

S. No.	Subject Name	Credits
AM23652	Special Study/Term Project/State of the Art/Colloquium/Industrial/Research Training	4
AM23602	Thesis/Project	16

IV Semester (Total Credits = 20):

S. No.	Subject Name	Credits
AM24602	Thesis/Project	20

Note: The distribution of thesis evaluation marks will be as follows:

1. Supervisor(s) evaluation component : 60%.
2. Oral Board evaluation component : 40%.

Semester-I

AMxxxxx Applied Mathematics and Computation		
Designation	:	Compulsory
Pre-requisites	:	Engineering Mathematics and computer programming.
Credit and Contact hours	:	L+T+P=4
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks. Mid Semester Exam: 20 marks. **Internal Assessment: (Scheme)** 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise tests, Term paper, etc.)
Course Outcomes	:	**The successful student will learn:** 1. To identify the differences between "Exact methods & Computational Methods" and applications of these methods. 2. To develop knowledge of expressing a real life problem in terms of mathematics to develop the skill of Mathematical Modeling. 3. To identify and develop the skill to solve real life engineering problems (Nonlinear problems, Initial and boundary value problems, Numerical differentiation, and Integration problems. 4. To develop skill of writing Flow Charts of real life engineering problems and transform those into computer programming.
Modes of Delivery	:	Talk and chalk, Power point presentations, Practical, etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	√			√					√	
CO2			√		√	√		√	√	
CO3			√		√	√		√		
CO4				√					√	

Syllabus

Review of Elementary Engineering Mathematics: Solution of homogeneous and non-homogeneous equations, Power series, Laplace transform and its applications, and Fourier series and Fourier transform.

Linear Algebra: Matrices and Linear Transformations, Operational Fundamentals of Linear Algebra, Systems of Linear Equations, Gauss Elimination Family of Methods, Special Systems and Special Methods, Numerical Aspects in Linear Systems, Eigen values and Eigenvectors, Diagonalization and Similarity Transformations, Jacobi and Givens Rotation Methods, Tri-diagonal Matrices, QR Decomposition Method, Eigen value Problem of General Matrices, Singular Value Decomposition, and Direct and Iterative solvers.

Ordinary Differential Equations: Introduction to ordinary differential equations, Homogeneous linear equations of second order, Non-homogeneous linear equations of second order, Free and forced oscillation problems, Problems with variable coefficients, and System of equations.

Partial Differential Equations (PDEs): Existence and uniqueness of differential equations, Nature of solution, Hyperbolic, Parabolic and Elliptic PDEs, and Nonlinear PDEs.

Nonlinear Equations: Motivation, Open and braketing method, Bisection, Fixed point, Newton's method, Secant and False position method, Rate of convergence, and Merits and demerits of methods.

Numerical Integration: Motivation, Newton-Kotes method, Trapezoidal rule, Simpson's rule, Rhomberg integration, and Gauss Quadrature.

Initial Value Problem: Motivation, Euler's method, Modified Euler method, Runge-Kutta methods, Adaptive integrations and multistep methods.

Boundary-value and Eigen-value Problem: Methods and Applications in Mechanics.

References books

1. Numerical Methods in Engineering, M. Salvadori, Prentice Hall International.
2. Applied Numerical Methods, B. Carnahan, Krieger Pub.
3. Applied Numerical Analysis, C. F. Gerald and P. O. Wheatley, Fifth edition, Addison-Wesley.
4. Numerical Mathematics and Computing, W. Cheney and D. Kincaid, Brooks/Cole.
5. Applied Partial Differential Equations, P. D. Chateau and D. Zachmann.
6. Partial Differential Equations for Scientists and Engineers, S. J. Farlow.
7. Numerical Methods for Partial Differential Equations, W. F. Ames.
8. Numerical Methods for Elliptic and Parabolic Partial Differential Equations, J. R. Levison, P. Knabner, and L. Angermann.

AMxxxxx Advanced Materials Science and Engineering		
Designation	:	Compulsory
Pre-requisites	:	Basic Materials Science and Engineering and Chemistry.
Credit and Contact hours	:	L+T+P=4
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks. Mid Semester Exam: 20 marks. **Internal Assessment: (Scheme)** 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise tests, Term paper, etc.)
Course Outcomes	:	**The successful student will learn:** 1. To understand microstructure and their correlation with properties. 2. To understand phase diagram and its interpretation. 3. The areas of advanced application and the importance of materials.
Modes of Delivery	:	Talk and chalk, Power point presentations, Practical, etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	√	√		√					√	√
CO2			√	√				√	√	√
CO3			√	√	√	√		√	√	

Syllabus

Crystal Structure: Types of bonding, Crystal structures of metals and alloys, imperfections in crystals, structure, and Properties relationships in engineering materials.

Introduction to Equilibrium Diagrams and Phase Changes: Phase rule, Binary equilibrium diagrams, Types of phase changes, Nucleation and growth kinetics, Solidification, T-T-T-diagrams, C-C-T diagrams.

Processing of Metals: Solidification of metals, Casting, Extrusion, Drawing, Forging and rolling, Powder metallurgy techniques, Fabrication through welding, Influence of processing and heat treatment on microstructure, and Quantitative survey of processing.

Engineering Alloys and Applications: Introduction to steel and alloy specifications, Important alloy steels and non-ferrous alloys, Cast irons – types, High temperature alloys, Light alloys: aluminium and its alloys copper and its alloys, bearing alloys, and Shape memory alloy.

Advanced Materials and Materials Engineering: Smart materials exhibiting ferroelectric, Piezoelectric, Optoelectric, Semiconducting behavior, Lasers and optical fibers, Photoconductivity and superconductivity, Nanomaterials: synthesis, properties and applications, Biomaterials, Superalloys, Shape memory alloys, Superhard cutting tool materials and superhard coatings, Ultra-light Materials and Metallic Foams: Definition and processing, characterization of cellular metals, properties, Various materials and coatings for implants, and Coatings and high temperature materials.

Fundamentals of Molecular Self-Assembly: Nanoscale and colloidal systems, Fundamentals of surface and interfacial chemistry, Surface tension and wettability, Insoluble monolayers, Surface chemistry and monolayers, Electrostatic interactions in self assembling systems, Self-assembly of amphiphiles monolayers, Micelles and Microemulsions, and Structure and properties of micelles.

Term Paper: On recent advances based on literature survey and/or laboratory/industry visit.

References books

1. Material Science for Engineers: An Introduction, W. D. Callister, Jr, John Wily and Sons, Inc.
2. The Science and Engineering of Materials, D. R. Askeland, Pradeep P. Fulay, W. J. Wright, Global Engg.
3. Introduction to Physical Metallurgy, S. H. Avner, McGraw-Hill.
4. Physical Metallurgy, V. Raghavan, Prentice Hall of India.
5. Principles of Thermal Analysis and Calorimetry, P. J. Haines, Royal Society of Chemistry.
6. Modern Physical Metallurgy and Materials Engineering, R. E. Smallman, R. J. Bishop, Butterworth-Heinemann.
7. Phase Transformations in Metals and Alloys, D. A. Porter, K. E. Easterling, N. Thomas, Chapman & Hall.
8. Structure of Metals, C. S. Barrett and T. B. Massalski, McGraw-Hill.

AMxxxxx Characterization of Materials		
Designation	:	Compulsory
Pre-requisites	:	Basic Materials Science and Engineering at UG Level
Credit and Contact hours	:	L+T+P=4
Assessment Methods	:	**Theory Examination:** (Scheme) End Semester Exam: 60 marks. Mid Semester Exam: 20 marks. **Internal Assessment:** (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise tests, Term paper, etc.)
Course Outcomes	:	**The successful student will learn:** 1. Descriptions of a range of common characterization methods for the determination of the structure and composition of solids. 2. Theory and practice of x-ray and electron diffraction. 3. Basic elements of electron microscopy. 4. Basic aspects of optical and thermal characterization including microscopy and spectroscopy.
Modes of Delivery	:	Talk and chalk, Power point presentations, Practical, etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	√			√			√	√		
CO2			√				√	√		√
CO3			√			√		√		
CO4	√		√			√		√		

Syllabus

Crystallography: Overviews in bonding, Bravais lattices, Miller indices, Imperfections in crystals, Crystal structures of common metal, Ceramics, Polymers, Symmetries in crystals, Point groups, Space groups, Reciprocal lattice, and Morphology

X-ray Diffraction Techniques: Production of X-rays, its properties and hazards, photon scattering, X-ray diffraction and Bragg's law, Intensities Calculations, Laue techniques, Debye-Scherrer techniques, Modern diffractometers, Diffractometer measurements, Determination of crystal structure of powder sample, Small angle scattering, Line broadening, Particle size, Crystallite size, Residual stress measurement, Plane indexing, Precise parameter measurement, Phase identification, Phase quantification, Phase diagram determination, Stereographic projection, Pole figure, Preferred orientation (texture analysis) and chemical analysis, and Profile fitting and Rietveld analysis.

Optical Microscopy: Principles and operations of microscopy, Resolution, Magnification, Numerical aperture, Depth of field, Viewing area, Contrast, Geometry of optical microscopes, Application of microscopy in metallurgical studies (qualitative and quantitative), Morphology and symmetry, Grain boundaries and dislocations, Phase contrast microscopy, Polarised light microscopy, Hot-stage microscopy, and Sample preparation.

Electron Microscopy: Electron sources, Electron diffraction, Principles and operation of scanning electron microscope, Geometry of electron microscopes, Specimen handling and preparation, Secondary electron image, Backscattered electron image, Image processing, Analysis of electron micro-graphs and fractography studies, and Transmission electron microscopy (TEM).

Scanning Probe Microscopy: Principles and operation of scanning probe microscopes, Scanning tunnelling microscope, Atomic force microscope, Magnetic force microscopy, Topography studies, and Nanoindentation and its probing.

Thermal Analysis: Thermo gravimetric analysis, Differential thermal analysis, Differential scanning calorimetery, Thermo-mechanical analysis and their applications.

Solid State and Surface Spectroscopies: Electron Energy Loss Spectroscopy (EELS), Reflection Absorption Infra-red Spectroscopy (RAIRS), Transmission IR, Raman, Photoelectron Spectroscopy (PES), Auger Electron Spectroscopy (AES), X-ray Fluorescence (XRF), Nuclear Magnetic Resonance (NMR), and Extended X-ray Absorption Fine Structure (EXAFS).

Term Paper: On recent advances based on literature survey and/or laboratory/industry visit.

References books

1. Crystals and Crystal structures, R. J. D. Tilley, John Wiley and Sons.
2. Elements of X-ray Diffraction, B. D. Cullity, Addison-Wesley Publishing Co.
3. Electron Microscopy and Analysis, P. J. Goodhew, and F.J. Humphreys, Taylor and Francis.
4. Solid state chemistry and its Applications, A. R. West, Wiley Student Edition.
5. Fundamentals of Molecular spectroscopy, C. N. Banwell and E. M. McCash, Tata McGraw-Hill Publishing Co. Ltd.
6. Materials Characterization: Introduction to Microscopic and Spectroscopic, Y. Leng, John Wiley and Sons.

AMxxxxx Thermodynamics and Kinetics of Materials		
Designation	:	Elective
Pre-requisites	:	Thermodynamics.
Credit and Contact hours	:	L+T+P=4
Assessment Methods	:	**Theory Examination:** (Scheme) End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment:** (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise tests, Term paper, etc.)
Course Outcomes	:	**The successful student will learn:** 1. To identify thermally activated processes in materials and metallurgy. 2. To demonstrate thermodynamics of crystal growth and phase transformation, defects, etc. 3. To design and develop thermodynamics of Ceramics, Polymers and Composites during synthesis.
Modes of Delivery	:	Talk and chalk, Power point presentations, Practical, etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	√		√	√				√		
CO2			√					√	√	
CO3			√		√	√		√	√	

Syllabus

Introduction: Review of thermodynamic functions, Laws of thermodynamics, Enthalpy, Heat capacity, Internal entropy, Configurational entropy, Free energy functions and their relationships, Gibbs-Helmholtz relations, Maxwell relations, Clausius-Clapeyron equation, Importance of thermodynamics in materials science-illustrations and examples, Applications in areas of materials technology, Industrial and process metallurgy, and related calculation.

Thermodynamic Reactions and Rate of Processes: Thermally activated processes in materials, stability of materials, Activation energy, Potential barrier, Arrhenius equation, Rate of reactions- first order, second order, etc., Introduction to solutions, Mixing functions, Ideal and non-ideal solutions, Related calculations, and Thermodynamics involved with rate of loading (anelastic behaviour/adiabatic loading).

Thermal Properties of Materials: Specific heat - Debye and other models, Heat capacity, Thermal expansion, Thermal conduction, Thermal stress and shock, and Melting point.

Phase Equilibria: Thermodynamics of solutions, Equilibrium stability of phases, Single phase system, Evolution of phase diagrams – construction, interpolation and thermodynamic evaluation, Hume-Rothery rules, Phase rule, Free-energy, Composition diagrams, Solidus–liquidus lines, Retrograde solidus, Binary, Ternary and Quaternary phase diagrams, Pseudo-binary and pseudo-ternary systems with examples, Calculations in phase thermodynamics.

Crystal Growth: Formation of crystals, Theories of crystal growth, Homogeneous and heterogeneous nucleation/crystal growth; Criteria for equilibria in crystal growth, Solid solubility, Kinetics of growth - nucleation, diffusion and surface migration, Dislocation, Motion of dislocation, Dislocation density, Super-cooling, Growth of single crystal of high perfection, and Whiskers and whiskers growth.

Phase Transformations: Classification of phase transformations, Order of transformation, Gibbs rule and applications, Rapid solidification and its methods, Glass transformation, Alloy solidification – cellular, dendritic, Eutectic, Peritectic, Eutectoid, Boundary transformations, Recrystallization, Grain growth, Effect of alloying elements, Strengthening mechanisms, Shape memory effects/alloys, and Thermodynamics and metallography/polymorphism.

Thermodynamics of Multi-Component System: Gibbs-Duhem equation for ternary and multi-components systems, Kinetics of solidification and melting, and Thermodynamics of melts.

Thermodynamics of Defects/Dislocations: Thermodynamics of lattice defects, Enthalpy of formation of vacancy, Interstitial and substitutional impurity, Frenkel's defects, Calculations on all these topics, and Thermal energy required to minimize the dislocations.

Thermodynamics of Ceramics, Polymers and Composites: Phase changes in Ceramics, Glass transition, Glasses, Phase changes in polymers and amorphous materials, Phase changes in composites, and Metallic glasses.

Thermodynamics of Surfaces and Interfaces: Surface energy, Surface tension, Absorption kinetics of diffusion in solids, Rate controlling mechanism of interface reactions, Energy, Shape, Segregation at external and internal interfaces, and Theory of interface stability.

Term Paper: On recent advances based on literature survey and/or laboratory/industry visit.

References books

1. Introduction to Metallurgical Thermodynamics D. R. Gaskell, McGraw-Hill.
2. The Structure and Properties of Materials-Vol II Thermodynamics of structure, J. H. Brophy, R. M. Rose, and J. Wulff, John Wiley & Sons Inc.
3. Problems in Metallurgical Thermodynamics and kinetics, G. S. Upadhyaya and R. K. Dube, Pergamon Press.

4. Introduction to Materials Science and Engineering, K. M. Ralls, T. H. Courtney and J. Wulff, Wiley Eastern Ltd.
5. Fundamentals of Solidification, W. Kurz and D. J. Fisher, Trans. Tech. Publication.
6. Kinetics of Materials, R. W. Balluffi, S. M. Allen and W. C. Carter, Wiley.
7. Theory of Structural Transformation in Solids, G. Khachaturyan, Wiley Interscience Publishers.
8. Phase Diagrams: Material Science and Technology-Vol. 6, M. Alper, Academic Press.

AMxxxxx Electrical, Electronic, Magnetic, and Optical Materials

Designation	:	Elective
Pre-requisites	:	None.
Credit and Contact hours	:	L+T+P=4
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks **Internal Assessment: (Scheme)** 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise tests, Term paper, etc.)
Course Outcomes	:	**The successful student will learn:** 1. Types of physical properties. 2. Fundamentals of different properties. 3. Advanced materials and their applications.
Modes of Delivery	:	Talk and chalk, Power point presentations, Practical, etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	√	√					√		√	√
CO2		√	√	√	√			√	√	√
CO3			√		√	√		√	√	

Syllabus

Introduction: Classification of materials on the basis of energy gap, Conductors, Semiconductors, Dielectrics, Superconductors, Ferroelectrics, Pyroelectrics, Piezoelectrics, Perovskites (titanates, zirconates, hafnates), etc.

Electrical Properties and Conducting Materials: Mechanism of electrical conduction, Electron theories of solids, Free electron theory, Factors affecting electrical conductivity, Wiedemann-franz law, Lorentz number, Thermoelectric properties, Characteristics, Properties and examples of high voltage conducting materials, High and low resistance materials, Contact fuse and fuse materials. Conductors, Cable and wire materials, Solder, Sheathing and sealing materials, Electrical properties of these materials and related calculations.

Electronic Properties and Semiconducting Materials: Energy band theory, Brillouin zone theory, Fermi energy level, Effective mass, Concept of doping, Energy diagrams, Types of semiconductors, Semiconductor compounds and alloys and their properties, Structures of semiconductors, Amorphous semiconductor, Materials for different devices and related calculations.

Superconductivity and Superconducting Materials: Concept of superconductivity, Phenomenon, Properties of superconductors, Meissner effect, Critical magnetic field & critical temperature, Types of superconducting materials, Type I & II superconductors, Silsbee rule, Mechanism of superconduction, BCS theory, Debye temperature, London's and Glag theories, High temperature ceramic superconductors, Applications: NMR, maglev, MHD, etc., Recent advances and related calculations.

Dielectric Properties and Insulating Materials: Dielectric constant, Dielectric strength and dielectric loss, Polarizability, Mechanism of polarization, Factors affecting polarization, Polarization curve and hysteresis loop, Types of dielectric materials-solid, Liquid and gaseous types, Natural and synthetic types, Characteristic, Properties, and applications of different types of mica, Transformation oil, Vacuum, etc., Ferroelectrics, Piezoelectric, Pyroelectrics, Electrostriction effect, Clausius -Mosotti equation and related calculations.

Magnetic Properties and Magnetic Materials: Origin of magnetism, Basic terms and properties, Types of magnetic materials, Introduction to dia-, Para-, Ferro-, Antiferro- and ferri-magnetic materials, Curie temperature, Laws of magnetic materials, Domain theory, Domain growth and domain wall rotation, Magnetic anisotropy, Magnetostriction & its mechanism, Ferrites, Spinels and garnets, Ferromagnetic domains, Magnetic hysteresis, Magnetoplumbite, Hexaferrite, Magnetic hysteresis loop, Hysteresis loss, Hard and soft magnetic materials, Magnetic tape, Magnetic bubble, Magnetic glasses, High energy hard magnetic materials, Commercial magnetic materials such as supermalloy, Alnico, Cunife, Cunico, etc., Conventional and non-conventional applications, Characterisation of magnetic materials, recent developments and related calculations.

Optical and Optoelectronic Materials: Optical properties, Solar cell, Principles of photoconductivity, Effect of impurities, Principles of luminescence, Types; Semiconductor lasers; LED materials, Photoelectronic materials, Effect of composition on band gap, LCD materials, Photo detectors, Application of photoelectronic materials, Introduction to optical fibers, Light propagation, Electro-optic effect and Kerr effect.

Recent Advances, Developments and Researches: Spintronics: materials and devices, Diamond semiconductors, Ferromagnetic semiconductors, Giant magneto- resistance (GMR), Left handed materials, Left and right handed (LH & RH) composite materials, Diluted magnetic semiconductor etc.

Fabrication of Electronic and Opto-electronic Devices: Methods of crystal growth and zone refining.

Term Paper: On recent advances based on literature survey and/or laboratory/industry visit.

References books

1. Electrical Properties of Materials, L. Solymar, D. Walsh, Oxford University Press.
2. Introduction to the Electronic Properties of Materials, D. C. Jiles, CRC Press.
3. Introduction to Magnetism and Magnetic Materials, D.C. Jiles, Springer.
4. Optoelectronic Materials and Device Concepts, M. Razeghi, SPIE-International Society for Optical Engine.
5. Structure and Properties of Materials Volume IV, R. M. Rose, L. A. Shepard, J. Wulff, Wiley.
6. Electrical and Electronics Engineering Materials, K.M. Gupta, Umesh Publication.
7. Introduction to Magnetic Materials, B. D. Cullity, Addison-Wesley Publishing Company.
8. Modern Ferrite Technology, A. Goldman, Springer.
9. Magnetism and Magnetic Materials, J. P. Jakubovics, Maney Publishing.
10. Physics of Dielectric Materials, B. Tareev, Central Books Ltd.
11. Electronic Properties of Materials, Rolf E. Hummel, Springer.
12. Principles of Electronic Materials and Devices, S Kasap, McGraw-Hill.
13. Electronic Materials Science, E. A. Irene, Wiley-Interscience.
14. Smart Electronic Materials: Fundamentals and Applications, J. Singh, Cambridge University Press.
15. Principles and Applications of Ferroelectrics and Related Materials, M. E. Lines and A. M. Glass, Oxford University Press.
16. Solid State Physics, A. J. Dekker, Macmillan.
17. Modern Magnetic Materials: Principles and Applications, R. C. O' Handley, Wiley.

AMxxxxx Polymer Science and Engineering		
Designation	:	Elective
Pre-requisites	:	Chemistry.
Credit and Contact hours	:	L+T+P=4
Assessment Methods	:	**Theory Examination:** (Scheme) End Semester Exam: 60 marks. Mid Semester Exam: 20 marks. **Internal Assessment:** (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise tests, Term paper, etc.)
Course Outcomes	:	**The successful student will learn:** 1. Classification of polymer and their reactions. 2. Polymer processing and characterization. 3. Selection and use of polymer in real applications.
Modes of Delivery	:	Talk and chalk, Power point presentations, Practical, etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	√			√	√		√			
CO2						√		√		
CO3										

Syllabus

Chemistry of Polymers: Monomers, functionality, Degree of polymerizations, Classification of polymers, Criteria for rubberiness, Polymerization methods: Addition and condensation, Their kinetics, Copolymerization, Monomer reactivity ratios and its significance, Different copolymers, Random, Alternating, Azeotropic copolymerization, Block and graft copolymers, Techniques for copolymerization-bulk, Solution, Suspension, Emulsion, Molecular weight and size of polymers, Glass transition temperature and associated properties for polymers, Kinetics of polymerization and crystallinity in polymers.

Polymer Characterization: Solubility and swelling, Concept of average molecular weight, Determination of number average, Weight average, Viscosity average and Z-average molecular weights, Polymer crystallinity, Analysis of polymers using IR, XRD, Thermal (DSC, DMTA, and TGA) and microscopic (optical and electronic) techniques.

Synthesis and Properties: Commodity and general purpose thermoplastics: PE, PP, PS, PVC, Polyesters, Acrylic, PU polymers, Engineering Plastics: Nylon, PC, PBT, PSU, PPO, and ABS, Fluoropolymers Thermosetting polymers: PF, MF, UF, Epoxy, Unsaturated polyester, and Alkyds, Natural and synthetic rubbers: Recovery of NR hydrocarbon from latex, SBR, Nitrile, CR, CSM, EPDM, IIR, BR, Silicone and TPE.

Polymer Blends and Composites: Difference between blends and composites their significance, Choice of polymers for blending, Blend miscibility-miscible and immiscible blends, Thermodynamics, Phase morphology, Polymer alloys, Polymer eutectics, Plastic-plastic, Rubber-plastic and rubber-rubber blends, FRP, Particulate, Long and short fibre reinforced composites, Polymer Technology: Polymer compounding-need and significance, Different compounding ingredients for rubber and plastics, Cross-linking and vulcanization and Vulcanization kinetics.

Polymer Rheology: Flow of Newtonian and non-Newtonian fluids, Different flow equations, Dependence of shear modulus on temperature, Molecular/segmental deformations at different zones and transitions, Measurements of rheological parameters by capillary rotating, Parallel plate, Cone-plate rheometer, Viscoelasticity-creep and stress relaxations, Mechanical models, Control of rheological characteristics through compounding, Rubber curing in parallel plate viscometer, ODR and MDR.

Polymer Processing: Compression molding, Transfer molding, Injection molding, Blow molding, Reaction injection molding, Extrusion, Pultrusion, Calendaring, Rotational molding, Thermoforming, Rubber processing in two-roll mill and internal mixer.

Polymer Testing: Mechanical-static and dynamic tensile, Flexural, Compressive, Abrasion, Endurance, Fatigue, Hardness, Tear, Resilience, Impact, Toughness. Conductivity-thermal and electrical, Dielectric constant, Dissipation factor, Power factor, Electric resistance, Surface resistivity, Volume resistivity, Swelling, Ageing resistance, Environmental stress cracking resistance and ASTM codes for polymer testing.

Degradation of Polymers: Effects of vapours and solvents on polymeric materials, Oxidation, Mechanical, Photodegradation and thermal degradation of polymers, Compatibility, Solubility, Permeability, Radiation damage and chemical resistance of polymers.

Processing of polymers: Flow properties of polymers, Extrusion, Injection and blow moulding, Calendering, Vacuum and pressure forming and warm forging, Casting of fibres and filaments, Assembly by adhesion, Thermal and mechanical bonding, Control of properties like chain length, Molecular weight distribution etc.

Heat Treatment: Standard heat treatment procedures for polymers.

Term Paper: On recent advances based on literature survey and/or laboratory/industry visit.

References books

1. Polymer Science, V. R. Gowariker, N. V. Viswanathan and J. Sreedhar, Wiley--Blackwell.
2. Encyclopedia of Polymer Science and Technology, H. F. Mark, Wiley.
3. Essentials of Polymer Science and Engineering, P. C. Painter and M. M. Coleman, DEStech Publications.Inc.
4. Physical Properties of Polymers, J. Mark, K. Ngai, W. Graessley, L. Mandelkern, E. Samulski, J. Koenig, G. Wignall, Cambridge University Press.
5. Plastics Engineering, R. J. Crawford, Pergamon Press.
6. Text Book of Polymer Science, Billmeyer, John Wiley & Sons.
7. Polymer Physics, U. W. Gedde, Springer.

ANNEXURE-IV

(1)

विद्या परिषद् डॉक्टरल कार्यक्रम समिति
मोतीलाल नेहरू राष्ट्रीय प्रौद्योगिकी संस्थान इलाहाबाद
प्रयागराज– २११००४, उ0प्र0, भारत
Senate Doctoral Programme Committee
Motilal Nehru National Institute of Technology Allahabad
Prayagraj – 211004 [UP] India

Minutes of the meeting of SDPC

A meeting of the Senate Doctoral Programme Committee [SDPC] was held on July, 02, 2021 at 17.00 PM in online mode using MS Team. Following members were present:

1. Prof.D.K .Yadav -- Convener, DDPC, CSED
2. Dr Sadhana Sachan -- Convener, DDPC, Chemical Engineering
3. Prof. R. M. Singh -- Convener, DDPC, CED
4. Dr.Animesh Ojha -- Convener, DDPC, Physics
5. Dr. Sameer Sarswati -- Convener, DDPC, MED
6. Dr.Mitu Mandal -- Convener, DDPC,HSS
7. Dr. Ashotosh Mani -- Convener, DDPC,Bioteachnology
8. Prof. R. P . Tiwari -- Convener, DDPC,AMD
9. Prof. S. Paulson -- Convener, DDPC,EED
10. Dr. Manish Tiwari -- Convener, DDPC, ECED
11. Prof.V. K. Srivastava,ECED -- Nominee of the Senate
12. Prof. R K Nagaria -- Chairman , SMPC
13. Prof.R. S. Yadav, CSED -- Outgoing Chairman SDPC
14. Prof. A. K. Sachan -- Chairman, SDPC

Following member could not attend meeting

1. Prof. Neeraj Tyagi -- Nominee of the Senate
2. Prof. S. S. Narvi -- Convener, DDPC, Chemistry
3. Dr. Ramji Dwivedi -- Convener, DDPC, GIS Cell
4. Dr. Pramod Kumar Yadav -- Convener, DDPC, Maths
5. Dr. Tanuj Nandan -- Convener, DDPC, SMS

Attested
5/7/2021

Following were the resolutions of the meeting

1. The committee discussed the request of Ms Meenakshi Tripathi (Reg no 2020REL03) to add Dr. Anand Sharma in place of Prof. Rajeev Tripathi as supervisor and recommends the same.

2. The committee discussed the request of Mr. Rishi Kumar Verma (Reg No. 2019RCL01) to give extension of three months to deliver the state art seminar as due to some problem he could not deliver it in allotted time of six months and resolved to recommend the same.

3. The committee discussed the request of Ms. Chetana Sachdeva (Reg No. 2019RMS04) to give extension of three months to deliver the state art seminar as due to some problem she could not deliver it in allotted time of six months and resolved to recommend the same.

4. The Committee discussed the requests of Mr. Pavan Kumar Singh (2016 REE05) regarding three months extension for submission of his Ph.D. thesis as he could not submit the thesis within specified period after delivering the open seminar. The committee approves the same.

5. The Committee discussed the requestsof Mr. Ankur Kumar (2015 REE 13) regarding furtherfour months extension to deliver the state art seminar as due to some problem he could not deliver it in allotted time of six months and even after the extension given up-to 28/05/21 . The committee after discussion resolves to recommend the same, as special case due to condition of covid, one last time extension may be given.

6. The Committee discussed the requests of Mr. Ashish Kumar Sankhwar (2015 REE 06) regarding further four months extension to deliver the state art seminar as due to some problem he could not deliver it in allotted time of six months and even after the extension given up-to 01/04/21 . The committee after discussion resolves to recommend the same, as special case due to condition of covid, one last time extension may be given.

7. The Committee discussed the requests of Mr. Indradeo Pratap Bharti (2015 REE 12) regarding further four months extension to deliver the state art seminar as due to some problem he could not deliver it in allotted time of six months and even after the extension given up-to 01/06/21 . The committee after discussion resolves to recommend the same, as special case due to condition of covid, one last time extension may be given.

8. The Committee discussed the request of Mr. Rajit Ram Yadava (2013RCS04), regarding extension of his Ph.D. program by one year starting from July 2021, and resolved to recommend the same.

9. The Committee discussed the request of Mr. Praveen Kumar (2013RCS07), regarding extension of his Ph.D. program by one year starting from July 2021, and resolved to recommend the same.

10. The Committee discussed the request of Ms Garima Singh (2015RCS03), regarding extension of his Ph.D. program by one year starting from July 2021, and resolved to recommend the same.

5/7/2021

(8)

11. The Committee discussed the request of Mr. Brijesh Kumar Umarao (2015RCS13), regarding extension of his Ph.D. program by one year starting from July 2021, and resolved to recommend the same.

12. The Committee discussed the request of Mr. Satya Deo Kumar Ram (2015RCS11), regarding extension of his Ph.D. program by one year starting from July 2021, and resolved to recommend the same.

13. The Committee discussed the requests of Mr Kamlakant Laxman Bawankula (QIP Poly Scheme) (2018 RCS 12) regarding conversion of his Ph. D. program from regular to part time. He has delivered the state of art seminar and completed residential requirement as per clause (7.1). The committee recommends the same.

14. The Committee discussed the request of Ms. Seema Yadav (2020REE04), regarding addition of Prof. Nand Kishor as supervisor and resolved to recommend the same.

15. The Committee discussed the request of Ms. Anju Yadav (2020REE01), regarding addition of Prof. Nand Kishor as supervisor and resolved to recommend the same .

16. The Committee discussed the request of Mr. Avinash K. Pandey (2019REE09), regarding addition of Prof. Paulson Samuel as supervisor and resolved to recommend the same .

17. The Committee discussed the request of Ms. Kiran Rana (2019REE08), regarding addition of Prof. Richa Negi as supervisor and resolved to recommend the same .

18. The Committee discussed the requests of Mr. Biranchi Narayan Kar (QIP Scheme) (2018 REE 10) regarding conversion of his Ph. D. program from regular to part time. He has delivered the state of art seminar and completed residential requirement as per clause (7.1). The committee recommends the same.

19. The Committee discussed the requests of Mr. Mohd. Aslam Ansari (QIP Scheme) (2018 REE 11) regarding conversion of his Ph. D. program from regular to part time. He has delivered the state of art seminar and completed residential requirement as per clause (7.1). The committee recommends the same.

chairman senate approval may kindly be granted for point 1-19
5/7/2021

5/7/2021
[A.K.Sachan]
Chairman, SDPC

Approved
5/7/21.

5

---------- Forwarded message ---------
From: Prof. A.K.Sachan SDPC <sdpc@mnnit.ac.in>
Date: Sat, Jul 3, 2021 at 12:05 PM
Subject: consent on SDPC meeting minutes
[Quoted text hidden]
[Quoted text hidden]

draft SDPC_MINUTES_2july2021.docx
64K

Raj Mohan Singh Lect. CED FACULTY <rajm@mnnit.ac.in> Sat, Jul 3, 2021 at 4:11 PM
To: "Prof. A.K.Sachan SDPC" <sdpc@mnnit.ac.in>

It's ok,sir.

Dr. Raj Mohan Singh,
Professor,
Civil Engineering Department,
Motilal Nehru National Institute of Technology
(MNNIT) Allahabad
Prayagraj - 211004
[Quoted text hidden]

Mitu Mandal <mitumandal@mnnit.ac.in> Sat, Jul 3, 2021 at 4:12 PM
To: "Prof. A.K.Sachan SDPC" <sdpc@mnnit.ac.in>
Cc: "Dr. R S Yadav" <rsy@mnnit.ac.in>, "Dharmendra Kumar Yadav Lect. CSED FACULTY" <dky@mnnit.ac.in>, C S E D Neeraj Tyagi <neeraj@mnnit.ac.in>, Vinay Kumar Srivastava FACULTY <vinay@mnnit.ac.in>, Dr S Paulson FACULTY <paul@mnnit.ac.in>, "Dr.Vishnu Agarwal FACULTY" <vishnua@mnnit.ac.in>, "R.K.Nagaria.Prof. ECED FACULTY" <rkn@mnnit.ac.in>, Dean Academic default <academics@mnnit.ac.in>, "Raj Mohan Singh Lect. CED FACULTY" <rajm@mnnit.ac.in>, Ravi Prakash Tewari Faculty <rptewari@mnnit.ac.in>, Siraz <msalam@mnnit.ac.in>, Manish Tiwari Faculty <mtiwari@mnnit.ac.in>, Sameer Saraswati FACULTY <samir@mnnit.ac.in>, samirsaraswati811@hotmail.com, "Dr.animesh ojha" <anlmesh@mnnit.ac.in>, Ashutosh FACULTY <amani@mnnit.ac.in>, "Dr.S S Narvi" <ssn@mnnit.ac.in>, mitumandal@gmail.com, Ramji Dwivedi <ramjid@mnnit.ac.in>, "Dr. Pramod k Yadav" <pramodky@mnnit.ac.in>

Respected Sir,

I hereby give my consent on the Minutes of the SDPC meeting held on 2 July 2021 at 5 pm on ms-team in online mode.

Thank you.

Regards.

Dr Mitu.
DDPC Convener
DHSS
[Quoted text hidden]

R.K.Nagaria.Prof. ECED FACULTY <rkn@mnnit.ac.in> Sat, Jul 3, 2021 at 4:26 PM
To: "Prof. A.K.Sachan SDPC" <sdpc@mnnit.ac.in>

resolved to recommends--->resolved to recommend (in Resolution No. 8-12 & 14-16)

conversion of his admission from regular to part time--> conversion of his PhD Programme from regular to part time(in Resolution No. 13)

9

With kind regards
[Quoted text hidden]
--
Dr. D. K. Yadav
Professor
Computer Science & Engineering Department
Motilal Nehru National Institute of Technology,
Allahabad-211004

Dr. Paulson Samuel <paul@mnnit.ac.in> Sat, Jul 3, 2021 at 2:33 PM
To: "Prof. A.K.Sachan SDPC" <sdpc@mnnit.ac.in>
Cc: "Dr. R S Yadav" <rsy@mnnit.ac.in>, "Dharmendra Kumar Yadav Lect. CSED FACULTY" <dky@mnnit.ac.in>, C S E D Neeraj Tyagi <neeraj@mnnit.ac.in>, Vinay Kumar Srivastava FACULTY <vinay@mnnit.ac.in>, "Dr.Vishnu Agarwal FACULTY" <vishnua@mnnit.ac.in>, "R.K.Nagaria.Prof. ECED FACULTY" <rkn@mnnit.ac.in>, Dean Academic default <academics@mnnit.ac.in>, "Raj Mohan Singh Lect. CED FACULTY" <rajm@mnnit.ac.in>, Ravi Prakash Tewari Faculty <rptewari@mnnit.ac.in>, Siraz <msalam@mnnit.ac.in>, Manish Tiwari Faculty <mtiwari@mnnit.ac.in>, Sameer Saraswati FACULTY <samir@mnnit.ac.in>, samirsaraswati811@hotmail.com, "Dr.animesh ojha" <animesh@mnnit.ac.in>, Ashutosh FACULTY <amani@mnnit.ac.in>, "Dr.S S Narvi" <ssn@mnnit.ac.in>, Mitu Mandal <mitumandal@mnnit.ac.in>, mitumandal@gmail.com, Ramji Dwivedi <ramjid@mnnit.ac.in>, "Dr. Pramod k Yadav" <pramodky@mnnit.ac.in>

Dear Sir,
It seems the case of Ms. Anju Yadav in the DDPC/EED minutes dated 02/07/2021 got left out. You may kindly include the same and correct the name of Prof. Nand Kishore as Nand Kishor.

On Sat, Jul 3, 2021 at 12:06 PM Prof. A.K.Sachan SDPC <sdpc@mnnit.ac.in> wrote:
[Quoted text hidden]

---

samir saraswati <samirsaraswati811@hotmail.com> Sat, Jul 3, 2021 at 2:37 PM
To: "Prof. A.K.Sachan SDPC" <sdpc@mnnit.ac.in>

Sir
I agree to all the resolutions listed in draft minutes of SDPC meeting.

Best regards

Samir Saraswati
Convener DDPC, MED

Sent from my Galaxy
[Quoted text hidden]

Prof. A.K.Sachan SDPC <sdpc@mnnit.ac.in> Sat, Jul 3, 2021 at 2:40 PM
To: "Dr. Paulson Samuel" <paul@mnnit.ac.in>

(8)

Cc: "Dr. R S Yadav" <rsy@mnnit.ac.in>, "Dharmendra Kumar Yadav Lect. CSED FACULTY" <dky@mnnit.ac.in>, C S E D Neeraj Tyagi <neeraj@mnnit.ac.in>, Vinay Kumar Srivastava FACULTY <vinay@mnnit.ac.in>, Dr S Paulson FACULTY <paul@mnnit.ac.in>, "Dr.Vishnu Agarwal FACULTY" <vishnua@mnnit.ac.in>, Dean Academic default <academics@mnnit.ac.in>, "Raj Mohan Singh Lect. CED FACULTY" <rajm@mnnit.ac.in>, Ravi Prakash Tewari Faculty <rptewari@mnnit.ac.in>, Siraz <msalam@mnnit.ac.in>, Manish Tiwari Faculty <mtiwari@mnnit.ac.in>, Sameer Saraswati FACULTY <samir@mnnit.ac.in>, samirsaraswati811@hotmail.com, "Dr.animesh ojha" <animesh@mnnit.ac.in>, Ashutosh FACULTY <amani@mnnit.ac.in>, "Dr.S S Narvi" <ssn@mnnit.ac.in>, Mitu Mandal <mitumandal@mnnit.ac.in>, mitumandal@gmail.com, Ramji Dwivedi <ramjid@mnnit.ac.in>, "Dr. Pramod k Yadav" <pramodky@mnnit.ac.in>

The minutes of the said SDPC meeting are OK from my side.
[Quoted text hidden]

Vinay Kumar Srivastava FACULTY <vinay@mnnit.ac.in> Sat, Jul 3, 2021 at 4:38 PM
To: "R.K.Nagaria.Prof. ECED FACULTY" <rkn@mnnit.ac.in>
Cc: "Prof. A.K.Sachan SDPC" <sdpc@mnnit.ac.in>, "Dr. R S Yadav" <rsy@mnnit.ac.in>, "Dharmendra Kumar Yadav Lect. CSED FACULTY" <dky@mnnit.ac.in>, C S E D Neeraj Tyagi <neeraj@mnnit.ac.in>, Dr S Paulson FACULTY <paul@mnnit.ac.in>, "Dr.Vishnu Agarwal FACULTY" <vishnua@mnnit.ac.in>, Dean Academic default <academics@mnnit.ac.in>, "Raj Mohan Singh Lect. CED FACULTY" <rajm@mnnit.ac.in>, Ravi Prakash Tewari Faculty <rptewari@mnnit.ac.in>, Siraz <msalam@mnnit.ac.in>, Manish Tiwari Faculty <mtiwari@mnnit.ac.in>, Sameer Saraswati FACULTY <samir@mnnit.ac.in>, samirsaraswati811@hotmail.com, "Dr.animesh ojha" <animesh@mnnit.ac.in>, Ashutosh FACULTY <amani@mnnit.ac.in>, "Dr.S S Narvi" <ssn@mnnit.ac.in>, Mitu Mandal <mitumandal@mnnit.ac.in>, mitumandal@gmail.com, Ramji Dwivedi <ramjid@mnnit.ac.in>, "Dr. Pramod k Yadav" <pramodky@mnnit.ac.in>

The minutes of meeting are alright from my side.
V K Srivastava
[Quoted text hidden]

Neeraj Tyagi <neeraj@mnnit.ac.in> Sun, Jul 4, 2021 at 1:46 AM
To: "Prof. A.K.Sachan SDPC" <sdpc@mnnit.ac.in>

Sir,
ok from my side.
[Quoted text hidden]
—
Dr. Neeraj Tyagi
Professor
Department of Computer Science & Engineering
Motilal Nehru National Institute of Technology, Allahabad

Sadhana Sachan FACULTY <sadhanas@mnnit.ac.in> Sun, Jul 4, 2021 at 2:30 PM
To: "Prof. A.K.Sachan SDPC" <sdpc@mnnit.ac.in>

Sir, The minutes are okay from my side.
[Quoted text hidden]

Meeting Summary
Total Number of Participants 14
Meeting Title General
Meeting Start Time 7/2/2021, 4:48:09 PM
Meeting End Time 7/2/2021, 5:22:17 PM

Full Name	Join Time	Leave Time	Duration	Email	Role
Ashutosh Mani	7/2/2021, 4:48:09 PM	7/2/2021, 5:22:00 PM	33m 51s	amani@mnnit.ac.in	Presenter
Anil Kumar Sachan	7/2/2021, 4:48:42 PM	7/2/2021, 5:22:17 PM	33m 34s	sachan@mnnit.ac.in	Organizer
PaulsonSamuel	7/2/2021, 4:57:32 PM	7/2/2021, 5:22:06 PM	24m 33s	paul@mnnit.ac.in	Presenter
SamirSaraswati	7/2/2021, 4:58:20 PM	7/2/2021, 5:21:58 PM	23m 38s	samir@mnnit.ac.in	Presenter
R.P. Tiwari	7/2/2021, 4:58:27 PM	7/2/2021, 5:21:30 PM	23m 2s	rptewari@mnnit.ac.in	Presenter
V K Srivastava	7/2/2021, 4:58:50 PM	7/2/2021, 5:22:09 PM	23m 18s	vinay@mnnit.ac.in	Presenter
Raj Mohan Singh	7/2/2021, 4:58:58 PM	7/2/2021, 5:21:30 PM	22m 32s	rjm@mnnit.ac.in	Presenter
Sadhana Sachan	7/2/2021, 4:59:14 PM	7/2/2021, 5:22:12 PM	22m 57s	sadhanas@mnnit.ac.in	Presenter
Animesh KumarOjha	7/2/2021, 4:59:34 PM	7/2/2021, 5:21:59 PM	22m 25s	animesh@mnnit.ac.in	Presenter
ManishTiwari	7/2/2021, 4:59:53 PM	7/2/2021, 5:22:09 PM	22m 16s	mtiwari@mnnit.ac.in	Presenter
D K Yadav	7/2/2021, 5:00:40 PM	7/2/2021, 5:22:04 PM	21m 23s	dky@mnnit.ac.in	Presenter
R S Yadav	7/2/2021, 5:03:44 PM	7/2/2021, 5:22:17 PM	18m 32s	rsy@mnnit.ac.in	Presenter
MituMandal	7/2/2021, 5:04:42 PM	7/2/2021, 5:21:38 PM	16m 55s	mitumandal@mnnit.ac.in	Presenter
R K Nagaria	7/2/2021, 5:08:52 PM	7/2/2021, 5:22:17 PM	13m 24s	rkn@mnnit.ac.in	Presenter

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30:03

PaulsonSamuel

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Anil Kumar Sachan
Organizer

AK Animesh KumarOjha

AM Ashutosh Mani

D K Yadav

ManishTiwari

MituMandal

PaulsonSamuel

RN R K Nagaria

R S Yadav

RT R.P. Tiwari

Raj Mohan Singh

SS Sadhana Sachan

S SamirSaraswati

V K Srivastava

Apps

Help

विद्या परिषद् डॉक्टरल कार्यक्रम समिति
मोतीलाल नेहरू राष्ट्रीय प्रौद्योगिकी संस्थान इलाहाबाद
प्रयागराज – २११००४, उ०प्र०, भारत
Senate Doctoral Programme Committee
Motilal Nehru National Institute of Technology Allahabad
Prayagraj – 211004 [UP] India

Minutes of the meeting of SDPC

A meeting of the Senate Doctoral Programme Committee [SDPC] was held on June, 14, 2021 at 16.00 PM in online mode using MS Team. Following members were present:

1. Prof. D. K .Yadav -- Convener, DDPC, CSED
2. Dr Sadhana Sachan -- Convener, DDPC, Chemical Engineering
3. Prof. R. M. Singh -- Convener, DDPC, CED
4. Prof. S. S. Narvi -- Convener, DDPC, Chemistry
5. Dr. Ramji Dwivedi -- Convener, DDPC, GIS Cell
6. Dr. Samir Sarswati -- Convener, DDPC, MED
7. Dr. Mitu Mandal -- Convener, DDPC, HSS
8. Dr. Ashotosh Mani -- Convener, DDPC, Bioteachnology
9. Prof. R. P . Tiwari -- Convener, DDPC, AMD
10. Prof. S. Paulson -- Convener, DDPC, EED
11. Dr. Manish Tiwari -- Convener, DDPC, ECED
12. Dr. Pramod Kumar Yadav -- Convener, DDPC, Maths
13. Dr. Tanuj Nandan -- Convener, DDPC, SMS
14. Dr.Animesh Ojha -- Convener, DDPC, Physics
15. Prof. V. K. Srivastava, ECED -- Nominee of the Senate
16. Prof. Neeraj Tyagi -- Nominee of the Senate
17. Prof. R K Nagaria -- Chairman , SMPC
18. Prof. R. S. Yadav, CSED -- Outgoing Chairman SDPC
19. Prof. A. K. Sachan -- Chairman, SDPC

Following were the resolutions of the meeting

1. The committee discussed the request of Ms Sakshi Agarwal (Reg no 2019RCS51) to extend the date of state of art seminar , all the members were of opinion that considering the situation the candidate may be given additional six month to deliver the state of art seminar and recommends the same.

17/6/2021

2. The committee discussed the request of Mr Nitin Garg, QIP research scholar to complete the remaining 22 days of his pre-registration visit in online mode. Prof R P Tiwari (DDPC of AMD) apprised committee that AICTE has permitted for pre-registration visit in online mode so all the members were of opinion that he may kindly be given permission for pre-registration visit in online mode and recommends the same.

3. The Committee discussed the request of Mr. Dhanjay Singh Yadav (2014 RME10), regarding extension of his Ph.D. program by further six month starting from July 2021, the candidate will be required to deliver the Open Seminar again , and resolved to recommend the same..

4. The Committee discussed the request of Mr. Arun Kumar Rauniyar (2016 RME02), regarding addition of one more supervisor Dr. V. R. Komma , and resolved to recommend the same.

5. The Committee discussed the request of Mr. Shyam Bihari Kaushal (2014 RME02), regarding extension of his Ph.D. program by further six month (up to odd semester of 2021-22), and resolved to recommends the same. The candidate has delivered the open seminar on 11 December 2019 so he will be required to deliver the open seminar again.

6. The Committee discussed the requests of Mr. Sushil Kumar (2016 RHU52) regarding three months extension for submission of his Ph.D. thesis as he could not submit the thesis within specified period after delivering the open seminar. The committee approves the same.

7. The Committee discussed the requests of Mr Iftaqar Ahmad (2015 RHU01) regarding further six months extension for submission of her Ph.D. thesis as he could not submit the thesis within extension given after specified period after delivering the open seminar due to some problems. The committee recommends for further six months extension for the same, he will be required to deliver the open seminar again.

8. The Committee discussed the requests of Mr. Manis (2015RHU03) regarding further six months extension for submission of her Ph.D. thesis as he could not submit the thesis within extension given after specified period after delivering the open seminar due to some problems , Considering the Pandemic situation and considering that his supervisor has already retired from the service as a special case he may be given six month extension and also relaxation from delivering open seminar again and resolved to recommend the same. If he fails to do the same he shall be provided with one more supervisor.

9. The Committee discussed the requests of Ms Divya (2015RHU51) , Mr Jitendra Kumar Kushwaha (2016RHU02) and Ms Swati (2016 RHU 03) regarding three months extension for submission of his Ph.D. thesis as he could not submit the thesis within specified period after delivering the open seminar. The committee approves the same.

17/6/2021

10. The Committee discussed the requests of Mr Himanshu Shekhar (2015 RBT05) regarding six months extension for submission of his Ph.D. thesis as he could not submit the thesis within stipulated time. The committee recommends for further six months extension.

11. The Committee discussed the requests of Ms Bankuru Navyatha (2015 RBT04) regarding three months extension for submission of his Ph.D. thesis as she could not submit the thesis within stipulated time. The committee recommends for further three months extension.

12. The Committee discussed the requests of Mr Vivek Kumar (2015 RBT06) regarding three months extension for submission of his Ph.D. thesis as he could not submit the thesis within stipulated time. The committee recommends for further three months extension.

13. The Committee discussed the request of Mr. Ranjeet Bahadur Chaubey (2019 RBT06), regarding addition of one more supervisor Dr. Kulwant Singh (SGPGI) , and resolved to recommends the same.

14. The Committee discussed the requests of Mr Abhishek Sharan (2015 RBT57) regarding three months extension for submission of his Ph.D. thesis as he could not submit the thesis within stipulated time. The committee recommends for further six months extension.

15. The Committee discussed the requests of Mr B Kranthi Kumar (2018 RAM07) regarding conversion of his admission from regular to part time. He has delivered the state of art seminar and completed residential requirement as per clause (7.1). The committee recommends the same.

16. The Committee discussed the requests of Mr. Abir Roy (2015 RAM05) regarding three months extension for submission of his Ph.D. thesis as he could not submit the thesis within specified period after delivering the open seminar. The committee approves the same.

17. The Committee discussed the request of Mr. Ram Sumukh Shukla (2014 RAM04), regarding extension of his Ph.D. program by one year starting from July 2021, and resolved to recommend the same.

18. The Committee discussed the request of Mr. Ashish Kumar Singh (2015 RAM03), regarding extension of his Ph.D. program by one year starting from July 2021, and resolved to recommend the same. The candidate has delivered the open seminar on 18 December 2020 so he will be required to deliver the open seminar again if he fails to submit his thesis within stipulated time.

19. The Committee discussed the request of Mr. Praveen Kumar Shukla (2015RAM07), regarding extension of his Ph.D. program by one year starting from July 2021, and resolved to recommend the same

20. The Committee discussed the requests of Mr Vaibhav Srivastava (2018 RME07) regarding conversion of his admission from regular to part time. He has delivered the state of art seminar and completed residential requirement as per clause (7.1) he has also delivered his open seminar on 26 Novemebr , 2020. The committee recommends the same.

Atharan

21. The Committee discussed the requests of Mr Vikas Kumar Choudhary (2018 RCL02) regarding conversion of his admission from regular to part time. He has delivered the state of art seminar and completed residential requirement as per clause (7.1) . The committee recommends the same.

22. The Committee discussed the requests of Mr Sachin Kumar Gupta (2016 RCE08) regarding conversion of his admission from regular to part time. He has delivered the state of art seminar and completed residential requirement as per clause (7.1) . The committee recommends the same.

23. The Committee discussed the requests of Ms. Tripti Sonkar (2016 RCE05) regarding conversion of his admission from regular to part time. She has delivered the state of art seminar and completed residential requirement as per clause (7.1) . The committee recommends the same.

24. The Committee discussed the recommendation of DDPC to terminate program of Mr Uma Kant Gautam (2018RCE06) , Mr Amit Kumar Pandey (2017 RCE08) and Mr Abhinav Yadav (2018 RCE 05) and approves the same.

25. The Committee discussed the requests of Mr. Arun Kumar Singh (2012 RME02) regarding three months extension for submission of his Ph.D. thesis as he could not submit the thesis within specified period after delivering the open seminar. The committee approves the same.

26. The Committee discussed the request of Mr. Reetesh Kumar Shukla (2010RME02), regarding semester leave for odd semester session 2020-21 extension of his Ph.D. program up to even semester of 2020-21and also three months extension after 9 month after delivery of open seminar, and resolved to recommend the same .

27. The Committee discussed the request of Mr Deepak Singh (2019 RCE 51) to add Prof . R. M. Singh as another supervisor and approves the same.

28. The committee discussed the request of Mr Ganesh (2020RME17) regarding addition of two more supervisors and resolved that as per ordinance it is not possible and hence not recommended.

29. The committee discussed the request of Mr Umesh (2017RMA01),Mr Shitesh Shukla(2018RMA01), Ms Sushmita Anand(2019RMA08) ,Ms Shangun Panghal (2107RMA03),Ms Akansha Verma (2017RMA02),Ms Rupali Pandey(2018RMA02),MS Pratibha Verma (2018RMA04),Mr Aditya Sharma (2019RMA01) to change the supervisor due to death of Existing supervisor . It is resolved that as suggested by the DDPC the change in supervisor is recommended for approval.

Chairman Senate

Sir a meeting was held on 14/6/21 minutes were circulated on emails of members and given time upto 17/6/2021, 3 pm to give consent or if any discrepancy is there. Responses received are attached with this.

Approval may kindly be granted for 1-29, except 8, 9 and 16

[signature]
17/6/21

[signature]
17/6/2021

[A.K.Sachan]
Chairman, SDPC

+ Considering the continued pandemic situation item no. 08 and 26 are approved as a special case.

+ Other recommendations are approved.

[signature]
17/6/21

Meeting Summary
Total Number of Participants 18
Meeting Title General
Meeting Start Time 6/14/2021, 3:51:10 PM
Meeting End Time 6/14/2021, 5:41:25 PM

Full Name Join Time Leave Time Duration Email Role
Anil Kumar Sachan 6/14/2021, 3:51:10 PM 6/14/2021, 4:57:23 PM 1h 6m sachan@mnnit.ac.in Organizer
MituMandal 6/14/2021, 3:53:36 PM 6/14/2021, 4:57:14 PM 1h 3m mitumandal@mnnit.ac.in Presenter
Pramod KumarYadav 6/14/2021, 3:55:38 PM 6/14/2021, 4:57:14 PM 1h 1m pramodky@mnnit.ac.in Presenter
Ashutosh Mani 6/14/2021, 3:56:14 PM 6/14/2021, 5:18:18 PM 1h 22m amani@mnnit.ac.in Presenter
V K Srivastava 6/14/2021, 3:57:35 PM 6/14/2021, 4:57:04 PM 59m 28s vinay@mnnit.ac.in Presenter
R.P. Tiwari 6/14/2021, 3:57:37 PM 6/14/2021, 4:29:28 PM 31m 51s rptewari@mnnit.ac.in Presenter
R.P. Tiwari 6/14/2021, 4:33:19 PM 6/14/2021, 4:51:59 PM 18m 40s rptewari@mnnit.ac.in Presenter
R K Nagaria 6/14/2021, 3:58:07 PM 6/14/2021, 4:57:06 PM 58m 59s rkn@mnnit.ac.in Presenter
SamirSaraswati 6/14/2021, 3:58:14 PM 6/14/2021, 4:57:11 PM 58m 56s samir@mnnit.ac.in Presenter
S.S. Narvi 6/14/2021, 3:58:32 PM 6/14/2021, 4:00:08 PM 1m 35s ssn@mnnit.ac.in Presenter
S.S. Narvi 6/14/2021, 4:03:29 PM 6/14/2021, 4:56:55 PM 53m 25s ssn@mnnit.ac.in Presenter
R S Yadav 6/14/2021, 4:00:12 PM 6/14/2021, 5:41:25 PM 1h 41m rsy@mnnit.ac.in Presenter
ManishTiwari 6/14/2021, 4:00:19 PM 6/14/2021, 4:57:06 PM 56m 46s mtiwari@mnnit.ac.in Presenter
PaulsonSamuel 6/14/2021, 4:00:37 PM 6/14/2021, 4:57:00 PM 56m 22s paul@mnnit.ac.in Presenter
Neeraj Tyagi 6/14/2021, 4:00:47 PM 6/14/2021, 4:57:15 PM 56m 27s neeraj@mnnit.ac.in Presenter
D K Yadav 6/14/2021, 4:01:02 PM 6/14/2021, 4:57:12 PM 56m 10s dky@mnnit.ac.in Presenter
Raj Mohan Singh 6/14/2021, 4:02:15 PM 6/14/2021, 4:51:27 PM 49m 12s rjm@mnnit.ac.in Presenter
RamjiDwivedi 6/14/2021, 4:18:01 PM 6/14/2021, 4:58:01 PM 39m 59s ramjid@mnnit.ac.in Presenter
Sadhana Sachan 6/14/2021, 4:37:18 PM 6/14/2021, 4:56:52 PM 19m 34s sadhanas@mnnit.ac.in Presenter
Animesh KumarOjha 6/14/2021, 5:05:27 PM 6/14/2021, 5:05:34 PM 6s animesh@mnnit.ac.in Presenter

MNNIT WEBMAIL

Dr. A.K.Sachan FACULTY <sachan@mnnit.ac.in>

Corrected minutes of sdpc meeting on 14 june 2021

7 messages

Dr. A.K.Sachan FACULTY <sachan@mnnit.ac.in> Wed, Jun 16, 2021 at 5:54 PM
To: "Dr. R S Yadav" <rsy@mnnit.ac.in>, "Dharmendra Kumar Yadav Lect. CSED FACULTY" <dky@mnnit.ac.in>, C S E D Neeraj Tyagi <neeraj@mnnit.ac.in>, Vinay Kumar Srivastava FACULTY <vinay@mnnit.ac.in>, Dr S Paulson FACULTY <paul@mnnit.ac.in>, "Dr.Vishnu Agarwal FACULTY" <vishnua@mnnit.ac.in>, "R.K.Nagaria.Prof. ECED FACULTY" <rkn@mnnit.ac.in>, Dean Academic default <academics@mnnit.ac.in>, "Raj Mohan Singh Lect. CED FACULTY" <rajm@mnnit.ac.in>, Ravi Prakash Tewari Faculty <rptewari@mnnit.ac.in>, Siraz <msalam@mnnit.ac.in>, Manish Tiwari Faculty <mtiwari@mnnit.ac.in>, Sameer Saraswati FACULTY <samir@mnnit.ac.in>, samirsaraswati811@hotmail.com, "Dr.animesh ojha" <animesh@mnnit.ac.in>, Ashutosh FACULTY <amani@mnnit.ac.in>, "Dr.S S Narvi" <ssn@mnnit.ac.in>, Mitu Mandal <mitumandal@mnnit.ac.in>, mitumandal@gmail.com, Ramji Dwivedi <ramjid@mnnit.ac.in>, "Dr. Pramod k Yadav" <pramodky@mnnit.ac.in>

Dear Members
some observations were suggested , the corrected minutes are attached
for your consent
It is hubly requested to kindly give your consent positively by 17/6/2021
by 3 PM . If no comment is received it will be assumed that the minutes are acceptable to all. I will proceed for the approval of Director sir
So that after approval the minutes can be shared for further required action by departments
A K Sachan
Chairman , SDPC

SDPC_MINUTES_14junw2021revised.docx
66K

Ravi Prakash Tewari FACULTY <rptewari@mnnit.ac.in> Wed, Jun 16, 2021 at 7:28 PM
To: "Dr. A.K.Sachan FACULTY" <sachan@mnnit.ac.in>

Respected sir
Okay from my side.
Regards
Ravi
[Quoted text hidden]

Mitu Mandal <mitumandal@mnnit.ac.in> Wed, Jun 16, 2021 at 9:32 PM
To: "Dr. A.K.Sachan FACULTY" <sachan@mnnit.ac.in>

Respected Sir,

I hereby give my consent on the Minutes of the SDPC meeting conducted on June 14, 2021 at 4.00 PM.

Regards,

Dr Mitu Mandal
DDPC Convener
DHSS
[Quoted text hidden]

Pramod.FACULTY <pramodky@mnnit.ac.in> Wed, Jun 16, 2021 at 10:32 PM
To: "Dr. A.K.Sachan FACULTY" <sachan@mnnit.ac.in>

Respected Sir,
Please find attached herewith the red marked minutes.

With kind regards,
Pramod

On Wed, Jun 16, 2021 at 5:54 PM Dr. A.K.Sachan FACULTY <sachan@mnnit.ac.in> wrote:
[Quoted text hidden]

--
Dr. Pramod Kumar Yadav
Associate Professor
Department of Mathematics
Motilal Nehru National Institute of Technology Allahabad
Allahabad-211004, (U.P.), INDIA
Email: pramodky@mnnit.ac.in, pramod547@gmail.com
Mob. No.: +91-9559022419

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82K

Sameer Saraswati FACULTY <samir@mnnit.ac.in> Wed, Jun 16, 2021 at 10:39 PM
To: "Dr. A.K.Sachan FACULTY" <sachan@mnnit.ac.in>

Dear Sir
Following are some observations:
1. Resolution number 26.....2021-21 should be corrected to 2020-21
2. The case of Mr Ganesh regarding addition of two co-supervisors Dr Sunil Kumar Gupta and Dr Kavita Agarwal (DMSRDE Lab Kanpur), has not come up into the minutes.
3. Spelling of my name should be corrected from Dr. Sameer Sarswati to Dr. Samir Saraswati

best regards
Samir Saraswati

On Wed, Jun 16, 2021 at 5:54 PM Dr. A.K.Sachan FACULTY <sachan@mnnit.ac.in> wrote:
[Quoted text hidden]

Vinay Kumar Srivastava FACULTY <vinay@mnnit.ac.in> Thu, Jun 17, 2021 at 2:24 PM
To: "Dr. A.K.Sachan FACULTY" <sachan@mnnit.ac.in>
Cc: "Dr. R S Yadav" <rsy@mnnit.ac.in>, "Dharmendra Kumar Yadav Lect. CSED FACULTY" <dky@mnnit.ac.in>, C S E D Neeraj Tyagi <neeraj@mnnit.ac.in>, Dr S Paulson FACULTY <paul@mnnit.ac.in>, "Dr.Vishnu Agarwal FACULTY" <vishnua@mnnit.ac.in>, "R.K.Nagaria,Prof. ECED FACULTY" <rkn@mnnit.ac.in>, Dean Academic default <academics@mnnit.ac.in>, "Raj Mohan Singh Lect. CED FACULTY" <rajm@mnnit.ac.in>, Ravi Prakash Tewari Faculty <rptewari@mnnit.ac.in>, Siraz <msalam@mnnit.ac.in>, Manish Tiwari Faculty <mtiwari@mnnit.ac.in>, Sameer Saraswati FACULTY <samir@mnnit.ac.in>, samirsaraswati811@hotmail.com, "Dr.animesh ojha" <animesh@mnnit.ac.in>, Ashutosh FACULTY <amani@mnnit.ac.in>, "Dr.S S Narvi" <ssn@mnnit.ac.in>, Mitu Mandal <mitumandal@mnnit.ac.in>, mitumandal@gmail.com, Ramji Dwivedi <ramjid@mnnit.ac.in>, "Dr. Pramod k Yadav" <pramodky@mnnit.ac.in>

Please go ahead. I agree with the minutes.
[Quoted text hidden]

Dr. A.K.Sachan FACULTY <sachan@mnnit.ac.in> Thu, Jun 17, 2021 at 2:53 PM
To: Vinay Kumar Srivastava FACULTY <vinay@mnnit.ac.in>

Thanks
[Quoted text hidden]

MNNIT WEBMAIL

Prof. A.K.Sachan SDPC <sdpc@mnnit.ac.in>

Revised minutes as per comments received till 6 am on 17/6/21

9 messages

Prof. A.K.Sachan SDPC <sdpc@mnnit.ac.in> Thu, Jun 17, 2021 at 6:01 AM
To: "Dr. R S Yadav" <rsy@mnnit.ac.in>, "Dharmendra Kumar Yadav Lect. CSED FACULTY" <dky@mnnit.ac.in>, C S E D Neeraj Tyagi <neeraj@mnnit.ac.in>, Vinay Kumar Srivastava FACULTY <vinay@mnnit.ac.in>, Dr S Paulson FACULTY <paul@mnnit.ac.in>, "Dr.Vishnu Agarwal FACULTY" <vishnua@mnnit.ac.in>, "R.K.Nagaria.Prof. ECED FACULTY" <rkn@mnnit.ac.in>, Dean Academic default <academics@mnnit.ac.in>, "Raj Mohan Singh Lect. CED FACULTY" <rajm@mnnit.ac.in>, Ravi Prakash Tewari Faculty <rptewari@mnnit.ac.in>, Siraz <msalam@mnnit.ac.in>, Manish Tiwari Faculty <mtiwari@mnnit.ac.in>, Sameer Saraswati FACULTY <samir@mnnit.ac.in>, samirsaraswati811@hotmail.com, "Dr.animesh ojha" <animesh@mnnit.ac.in>, Ashutosh FACULTY <amani@mnnit.ac.in>, "Dr.S S Narvi" <ssn@mnnit.ac.in>, Mitu Mandal <mitumandal@mnnit.ac.in>, mitumandal@gmail.com, Ramji Dwivedi <ramjid@mnnit.ac.in>, "Dr. Pramod k Yadav" <pramodky@mnnit.ac.in>

Dear Members
Kindly go through with the revised draft and suggest if any modification is required
Kindly reply by 3.00 PM today
Else it will be assumed that you agree with minutes
kinly reply on sdpc mail only
A K Sachan
Chairman SDPC

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67K

Mitu Mandal <mitumandal@mnnit.ac.in> Thu, Jun 17, 2021 at 8:47 AM
To: "Prof. A.K.Sachan SDPC" <sdpc@mnnit.ac.in>

Respected Sir,

I hereby give my consent on the Minutes of the SDPC meeting conducted on June 14, 2021 at 4.00 PM.

Regards.

Dr Mitu Mandal
DDPC Convener
DHSS
[Quoted text hidden]

Dr. S.S. Narvi FACULTY <ssn@mnnit.ac.in> Thu, Jun 17, 2021 at 9:26 AM
To: "Prof. A.K.Sachan SDPC" <sdpc@mnnit.ac.in>

I have seen the minutes and agree with all the decisions taken.
[Quoted text hidden]

R.K.Nagaria.Prof. ECED FACULTY <rkn@mnnit.ac.in> Thu, Jun 17, 2021 at 9:33 AM
To: "Prof. A.K.Sachan SDPC" <sdpc@mnnit.ac.in>
Cc: "Dr. R S Yadav" <rsy@mnnit.ac.in>, "Dharmendra Kumar Yadav Lect. CSED FACULTY" <dky@mnnit.ac.in>, C S E D Neeraj Tyagi <neeraj@mnnit.ac.in>, Vinay Kumar Srivastava FACULTY <vinay@mnnit.ac.in>, Dr S Paulson FACULTY <paul@mnnit.ac.in>, "Dr.Vishnu Agarwal FACULTY" <vishnua@mnnit.ac.in>, Dean Academic default <academics@mnnit.ac.in>, "Raj Mohan Singh Lect. CED FACULTY" <rajm@mnnit.ac.in>, Ravi Prakash Tewari Faculty <rptewari@mnnit.ac.in>, Siraz <msalam@mnnit.ac.in>, Manish Tiwari Faculty <mtiwari@mnnit.ac.in>, Sameer Saraswati FACULTY <samir@mnnit.ac.in>, samirsaraswati811@hotmail.com, "Dr.animesh ojha" <animesh@mnnit.ac.in>, Ashutosh FACULTY <amani@mnnit.ac.in>, "Dr.S S Narvi" <ssn@mnnit.ac.in>, Mitu Mandal <mitumandal@mnnit.ac.in>, mitumandal@gmail.com, Ramji Dwivedi <ramjid@mnnit.ac.in>, "Dr. Pramod k Yadav" <pramodky@mnnit.ac.in>

Approved.
[Quoted text hidden]

Dr. Paulson Samuel <paul@mnnit.ac.in> Thu, Jun 17, 2021 at 10:00 AM
To: "Prof. A.K.Sachan SDPC" <sdpc@mnnit.ac.in>
Cc: "Dr. R S Yadav" <rsy@mnnit.ac.in>, "Dharmendra Kumar Yadav Lect. CSED FACULTY" <dky@mnnit.ac.in>, C S E D Neeraj Tyagi <neeraj@mnnit.ac.in>, Vinay Kumar Srivastava FACULTY <vinay@mnnit.ac.in>, "Dr.Vishnu Agarwal FACULTY" <vishnua@mnnit.ac.in>, "R.K.Nagaria.Prof. ECED FACULTY" <rkn@mnnit.ac.in>, Dean Academic default <academics@mnnit.ac.in>, "Raj Mohan Singh Lect. CED FACULTY" <rajm@mnnit.ac.in>, Ravi Prakash Tewari Faculty <rptewari@mnnit.ac.in>, Siraz <msalam@mnnit.ac.in>, Manish Tiwari Faculty <mtiwari@mnnit.ac.in>, Sameer Saraswati FACULTY <samir@mnnit.ac.in>, samirsaraswati811@hotmail.com, "Dr.animesh ojha" <animesh@mnnit.ac.in>, Ashutosh FACULTY <amani@mnnit.ac.in>, "Dr.S S Narvi" <ssn@mnnit.ac.in>, Mitu Mandal <mitumandal@mnnit.ac.in>, mitumandal@gmail.com, Ramji Dwivedi <ramjid@mnnit.ac.in>, "Dr. Pramod k Yadav" <pramodky@mnnit.ac.in>

Minutes seem to be okay.

Where the candidate has asked for say three months and the committee is recommending six months perhaps a note might be added.

Just wanted to confirm whether the point of granting Mr. Manis of HSS another supervisor has been dropped?

Following general grammatical correction may be incorporated.
"Resolved to recommends" may be corrected as "resolved to recommend".
At one or two places her mah be substituted with him.

Otherwise seems to be okay.
Thanks and regards

On Thu, 17 Jun, 2021, 6:01 AM Prof. A.K.Sachan SDPC, <sdpc@mnnit.ac.in> wrote:
[Quoted text hidden]

Prof. A.K.Sachan SDPC <sdpc@mnnit.ac.in> Thu, Jun 17, 2021 at 10:04 AM
To: "Dr. Paulson Samuel" <paul@mnnit.ac.in>
Cc: "Dr. R S Yadav" <rsy@mnnit.ac.in>, "Dharmendra Kumar Yadav Lect. CSED FACULTY" <dky@mnnit.ac.in>, C S E D Neeraj Tyagi <neeraj@mnnit.ac.in>, Vinay Kumar Srivastava FACULTY <vinay@mnnit.ac.in>, "Dr.Vishnu Agarwal FACULTY" <vishnua@mnnit.ac.in>, "R.K.Nagaria.Prof. ECED FACULTY" <rkn@mnnit.ac.in>, Dean Academic default <academics@mnnit.ac.in>, "Raj Mohan Singh Lect. CED FACULTY" <rajm@mnnit.ac.in>, Ravi Prakash Tewari Faculty <rptewari@mnnit.ac.in>, Siraz <msalam@mnnit.ac.in>, Manish Tiwari Faculty <mtiwari@mnnit.ac.in>, Sameer Saraswati FACULTY <samir@mnnit.ac.in>, samirsaraswati811@hotmail.com, "Dr.animesh ojha" <animesh@mnnit.ac.in>, Ashutosh FACULTY <amani@mnnit.ac.in>, "Dr.S S Narvi" <ssn@mnnit.ac.in>, Mitu Mandal <mitumandal@mnnit.ac.in>, mitumandal@gmail.com, Ramji Dwivedi <ramjid@mnnit.ac.in>, "Dr. Pramod k Yadav" <pramodky@mnnit.ac.in>

Ok, will do that.
thanks
[Quoted text hidden]

Ashutosh FACULTY <amani@mnnit.ac.in> Thu, Jun 17, 2021 at 10:06 AM
To: "Prof. A.K.Sachan SDPC" <sdpc@mnnit.ac.in>

I confirm the same sir.

Thanks & Regards
[Quoted text hidden]

Pramod FACULTY <pramodky@mnnit.ac.in> Thu, Jun 17, 2021 at 10:37 AM
To: "Prof. A.K.Sachan SDPC" <sdpc@mnnit.ac.in>

Respected Sir,
Minutes is OK from my side.

Sir, I corrected the registration number of the Students of Mathematics Department and marked these with red color.

With Kind Regards,
Pramod
[Quoted text hidden]
--
Dr. Pramod Kumar Yadav
Associate Professor
Department of Mathematics
Motilal Nehru National Institute of Technology Allahabad
Allahabad-211004, (U.P.), INDIA
Email: pramodky@mnnit.ac.in, pramod547@gmail.com
Mob. No.: +91-9559022419

SDPC_MINUTES_14junw2021revised (1).doc
91K

Sameer Saraswati FACULTY <samir@mnnit.ac.in> Thu, Jun 17, 2021 at 11:04 AM
To: "Prof. A.K.Sachan SDPC" <sdpc@mnnit.ac.in>

Dear Sir
I agree with all the resolutions of the minutes

best regards
Samir Saraswati
[Quoted text hidden]

MNNIT WEBMAIL

Prof. A.K.Sachan SDPC <sdpc@mnnit.ac.in>

minutes of sdpc meeting held on 14/6/2021

5 messages

Prof. A.K.Sachan SDPC <sdpc@mnnit.ac.in> Wed, Jun 16, 2021 at 11:45 AM
To: "Dr. R S Yadav" <rsy@mnnit.ac.in>, "Dharmendra Kumar Yadav Lect. CSED FACULTY" <dky@mnnit.ac.in>, C S E D Neeraj Tyagi <neeraj@mnnit.ac.in>, Vinay Kumar Srivastava FACULTY <vinay@mnnit.ac.in>, Dr S Paulson FACULTY <paul@mnnit.ac.in>, "Dr.Vishnu Agarwal FACULTY" <vishnua@mnnit.ac.in>, "R.K.Nagaria,Prof. ECED FACULTY" <rkn@mnnit.ac.in>, Dean Academic default <academics@mnnit.ac.in>, "Raj Mohan Singh Lect. CED FACULTY" <rajm@mnnit.ac.in>, Ravi Prakash Tewari Faculty <rptewari@mnnit.ac.in>, Siraz <msalam@mnnit.ac.in>, Manish Tiwari Faculty <mtiwari@mnnit.ac.in>, Sameer Saraswati FACULTY <samir@mnnit.ac.in>, samirsaraswati811@hotmail.com, "Dr.animesh ojha" <animesh@mnnit.ac.in>, Ashutosh FACULTY <amani@mnnit.ac.in>, "Dr.S S Narvi" <ssn@mnnit.ac.in>, Mitu Mandal <mitumandal@mnnit.ac.in>, mitumandal@gmail.com, Ramji Dwivedi <ramjid@mnnit.ac.in>, "Dr. Pramod k Yadav" <pramodky@mnnit.ac.in>

Dear members pls find attached minute of sdpc
kinly go through minutes and give your consent positively by 17/6/2021 12 noon so that i can proceed for approval from Director sir
a k sachan

draft SDPC_MINUTES_14junw2021.docx
66K

Neeraj Tyagi <neeraj@mnnit.ac.in> Wed, Jun 16, 2021 at 5:47 PM
To: "Prof. A.K.Sachan SDPC" <sdpc@mnnit.ac.in>

sir,
i agree.

neeraj tyagi
[Quoted text hidden]
--
Dr. Neeraj Tyagi
Professor
Department of Computer Science & Engineering
Motilal Nehru National Institute of Technology, Allahabad

Raj Mohan Singh Lect. CED FACULTY <rajm@mnnit.ac.in> Wed, Jun 16, 2021 at 1:06 PM
To: "Prof. A.K.Sachan SDPC" <sdpc@mnnit.ac.in>

Sir,

One point from the Minutes of the meeting of CED is left in SDPC minute i.e.

"Addition of supervisor to Mr. Deepak Singh (2019RCE51) was received. The application for the addition of Prof. Raj Mohan Singh by the student along with DP-14 was duly forwarded and recommended by thesis supervisor Dr. N.R. Rawal. DDPC recommended the addition."

Requested to include the above in SDPC minutes, sir.

- R.M. Singh, Convener DDPC, CED

On Wed, Jun 16, 2021 at 11:45 AM Prof. A.K.Sachan SDPC <sdpc@mnnit.ac.in> wrote:
[Quoted text hidden]

सादर / Regards

राज मोहन सिंह, पीएचडी, ए.एम., एएससीई/ Raj Mohan Singh, Ph.D., A.M., ASCE
प्रोफ़ेसर/ Professor
जानपद अभियांत्रिकी विभाग / Department of Civil Engineering,
मोतीलाल नेहरू राष्ट्रीय प्रौद्योगिकी संस्थान इलाहाबाद, प्रयागराज -२११००४, उ.प्र., [भारत[
Motilal Nehru National Institute of Technology Allahabad, Prayagraj- 211004, U.P. [India]
दूरभाष/ Tel No.: +91-532-227-1314 (O)
मोबाइल/Mobile: 9839506133
Email: rajm@mnnit.ac.in; rajm.mnnit@gmail.com

Ashutosh FACULTY <amani@mnnit.ac.in> Wed, Jun 16, 2021 at 4:11 PM
To: "Prof. A.K.Sachan SDPC" <sdpc@mnnit.ac.in>, "Dr. A.K.Sachan FACULTY" <sachan@mnnit.ac.in>

Dear Sir,
Thanks for your email.
There are two minor corrections. I have incorporated them and highlighted them in red color.
1. at point no. 11 in place of Mr Bankru Navyatha , there shall be Ms. Bankuru Navyatha
2. at point no. 14 the extension given to Mr. Abhishek Sharan as per the discussion was six months, so I have made six in place of three months.

I have made the necessary changes at both points. Same is attached for your kind consideration.

Thanks and best regards

Ashutosh Mani, PhD
Assistant Professor
Department of Biotechnology
Motilal Nehru National Institute of Technology Allahabad
India-211004,
Mobile: +91 9455354251

On Wed, Jun 16, 2021 at 11:45 AM Prof. A.K.Sachan SDPC <sdpc@mnnit.ac.in> wrote:
[Quoted text hidden]

draft SDPC_MINUTES_14junw2021.docx
66K

Prof. A.K.Sachan SDPC <sdpc@mnnit.ac.in> Wed, Jun 16, 2021 at 5:25 PM
To: Ashutosh FACULTY <amani@mnnit.ac.in>
Cc: "Dr. A.K.Sachan FACULTY" <sachan@mnnit.ac.in>

Noted.
[Quoted text hidden]

ANNEXURE-V

मोतीलाल नेहरू राष्ट्रीय प्रौद्योगिकी संस्थान इलाहाबाद
प्रयागराज- २११००४ (उ०प्र०) भारत
Motilal Nehru National Institute of Technology Allahabad
Prayagraj – 211004 (UP) India

EIGHTEENTH (18TH) ANNUAL CONVOCATION – 2021

SUMMARY OF DEGREES CONFERRED

Bachelor of Technology (B.Tech.)	–	854
Master of Technology (M.Tech.)	–	365
Master of Computer Applications (MCA)	–	85
Master of Business Administration (MBA)	–	35
Master of Science (M.Sc.)	–	18
Doctor of Philosophy (Ph.D.)	–	31
Total	–	1388

Number of Institute Gold Medals (UG)	–	12
Number of Institute Gold Medals (PG)	–	32
Number of Sponsored Gold Medals	–	10

09/08/2021 9/8/21 9/8/2021

Summary of Degrees and Medals conferred in the Eighteenth (18th) Annual Convocation – 2021 of the Institute

Bachelor of Technology (B.Tech.)

Sl. No.	Branch		No. of Degree Recipients
1.	Biotechnology	–	32
2.	Chemical Engineering	–	44
3.	Civil Engineering	–	91
4.	Computer Science and Engineering	–	176
5.	Electrical Engineering	–	82
6.	Electronics and Communication Engineering	–	153
7.	Information Technology	–	101
8.	Mechanical Engineering	–	136
9.	Production and Industrial Engineering	–	39
	Total Degree Recipients of B.Tech. Programme	–	**854**

Masters' Programmes

Sl. No.	Branch / Specialization		No. of Degree Recipients
1.	M.Tech. – Applied Mechanics (Biomedical Engineering)	–	09
2.	M.Tech. – Applied Mechanics (Engineering Mechanics and Design)	–	15
3.	M.Tech. – Applied Mechanics (Fluids Engineering)	–	20
4.	M.Tech. – Applied Mechanics (Material Science and Engineering)	–	08
5.	M.Tech. – Biotechnology	–	09
6.	M.Tech. – Chemical Engineering	–	05
7.	M.Tech. –Civil Engineering (Environmental Engineering)	–	11
8.	M.Tech. –Civil Engineering (Geotechnical Engineering)	–	15
9.	M.Tech. –Civil Engineering (Structural Engineering)	–	05
10.	M.Tech. –Civil Engineering (Transportation Engineering)	–	12
11.	M.Tech. – Computer Science and Engineering	–	18
12.	M.Tech. – Information Security	–	18
13.	M.Tech. – Software Engineering	–	18
14.	M.Tech. – Software Engineering (Part-time)	–	04
15.	M.Tech. –Electrical Engineering (Control and Instrumentation)	–	18
16.	M.Tech. –Electrical Engineering (Power Electronics and Drives)	–	18
17.	M.Tech. –Electrical Engineering (Power System)	–	18
18.	M.Tech. –Electronics Engineering (Communication Systems)	–	17
19.	M.Tech. –Microelectronics and VLSI Design	–	18
20.	M.Tech. –Electronics Engineering (Signal Processing)	–	18
21.	M.Tech. – Geoinformatics	–	08
22.	M.Tech. –Mechanical Engineering(Computer Aided Design and Manufacturing)	–	18
23.	M.Tech. –Mechanical Engineering(Design Engineering)	–	17
24.	M.Tech. –Mechanical Engineering(Product Design and Development)	–	18
25.	M.Tech. –Mechanical Engineering(Production Engineering)	–	17
26.	M.Tech. –Mechanical Engineering(Thermal Engineering)	–	13
	Total Degree Recipients of M.Tech. Programme		**365**

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Other Masters' Programmes

Sl. No.	Programme / Course		No. of Degree Recipients
1.	Master of Computer Applications	–	85
2.	Master of Business Administration	–	35
3.	Master of Science (Mathematics and Scientific Computing)	–	18

Doctoral Programme

Sl. No.	Programme		No. of Degree Recipients
1.	Doctor of Philosophy (Ph.D.)	–	31

Gold Medals

Sl. No.	Programme		No. of Medal Recipients
1.	Institute Gold Medals(for UG Programmes)	–	12
2.	Institute Gold Medals(for PG Programmes)	–	32
3.	Sponsored Gold Medals	–	10

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ANNEXURE–VI

मोतीलाल नेहरू राष्ट्रीय प्रौद्योगिकी संस्थान इलाहाबाद
प्रयागराज - २११००४ (उ०प्र०) भारत
Motilal Nehru National Institute of Technology Allahabad
Prayagraj – 211004 (UP) India

List of Institute Gold Medal recipients for Seventeenth (18th) Annual Convocation – 2021 of the Institute

GOLD MEDALS FOR POST GRADUATE EXAMINATION – 2021

1. Gold Medal awarded to **Mr. Chandra Prakash Pandey** (Registration No. **2019BM01**) for standing first at M.Tech. Biomedical Engineering, Final Examination 2021. **(CPI 8.50)**
2. Gold Medal awarded to **Mr. Pachipala Dharmateja** (Registration No. **2019EM07**) for standing first at M.Tech. Engineering Mechanics and Design, Final Examination 2021. **(CPI 8.65)**
3. Gold Medal awarded to **Mr. Vaibhav Srivastava** (Registration No. **2019FE01**) for standing first at M.Tech. Fluids Engineering, Final Examination 2021. **(CPI 9.15)**
4. Gold Medal awarded to **Mr. Swatantra Kumar** (Registration No. **2019MT07**) for standing first at M.Tech. Material Science & Engineering, Final Examination 2021. **(CPI 7.90)**
5. Gold Medal awarded to **Ms. Arisha Arora** (Registration No. **2019BT07**) for standing first at M.Tech. Biotechnology, Final Examination 2021. **(CPI 9.55)**
6. Gold Medal awarded to **Mr. Rajdeep Mukherjee** (Registration No. **2019CL04**) for standing first at M.Tech. Chemical Engineering, Final Examination 2021. **(CPI 9.85)**
7. Gold Medal awarded to **Mr. Nishchaya Kumar Mishra** (Registration No. **2019EN02**) for standing first at M.Tech. Civil Engineering (Environmental Engineering), Final Examination 2021. **(CPI 9.40)**
8. Gold Medal awarded to **Ms. Prity Dhanal** (Registration No. **2019GE10**) for standing first at M.Tech. Civil Engineering (Geotechnical Engineering), Final Examination 2021. **(CPI 9.40)**
9. Gold Medal awarded to **Mr. Brajesh Rajpoot** (Registration No. **2019ST18**) for standing first at M.Tech. Civil Engineering (Structural Engineering), Final Examination 2021. **(CPI 8.90)**
10. Gold Medal awarded to **Mr. Abu Nasar** (Registration No. **2019TR14**) for standing first at M.Tech. Civil Engineering (Transportation Engineering), Final Examination 2021. **(CPI 8.90)**
11. Gold Medal awarded to **Mr. Shyam Kumar** (Registration No. **2019TR10**) for standing first at M.Tech. Civil Engineering (Transportation Engineering), Final Examination 2021. **(CPI 8.90)**
12. Gold Medal awarded to **Ms. Garima Saxena** (Registration No. **2019CS25**) for standing first at M.Tech. Computer Science & Engineering, Final Examination 2021. **(CPI 9.30)**
13. Gold Medal awarded to **Mr. Kumar Shubham** (Registration No. **2019IS14**) for standing first at M.Tech. Information Security, Final Examination 2021. **(CPI 8.65)**
14. Gold Medal awarded to **Mr. Nishkarsh Makhija** (Registration No. **2019SW21**) for standing first at M.Tech. Software Engineering, Final Examination 2021. **(CPI 9.50)**
15. Gold Medal awarded to **Mr. Ashish Khare** (Registration No. **2018PTSW03**) for standing first at M.Tech. Software Engineering (Part-time), Final Examination 2021. **(CPI 8.94)**
16. Gold Medal awarded **Ms. Anushreya Gupta** (Registration No. **2019EE05**) for standing first at M.Tech. Electrical Engineering (Control & Instrumentation), Final Examination 2021. **(CPI 9.40)**
17. Gold Medal awarded **Mr. Maurya Manishchandra Rakeshchandra** (Registration No. **2019EE04**) for standing first at M.Tech. Electrical Engineering (Control & Instrumentation), Final Examination 2021. **(CPI 9.40)**

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18. Gold Medal awarded to **Mr. Gunupuru Govinda Rao** (Registration No. **2019PE13**) for standing first at M.Tech. Electrical Engineering (Power Electronics and Drives), Final Examination 2021. **(CPI 9.45)**

19. Gold Medal awarded to **Mr. Harsh Pachauri** (Registration No. **2019PS17**) for standing first at M.Tech. Electrical Engineering (Power System), Final Examination 2021. **(CPI 9.20)**

20. Gold Medal awarded to **Ms. Sonalika Singh** (Registration No. **2019PS03**) for standing first at M.Tech. Electrical Engineering (Power System), Final Examination 2021. **(CPI 9.20)**

21. Gold Medal awarded to **Ms. Artika Srivastava** (Registration No. **2019CM11**) for standing first at M.Tech. Electronics Engineering (Communication Systems), Final Examination 2021. **(CPI 9.75)**

22. Gold Medal awarded to **Ms. Arunita Mukherjee** (Registration No. **2019VL20**) for standing first at M.Tech. Microelectronics and VLSI Design, Final Examination 2021. **(CPI 9.80)**

23. Gold Medal awarded to **Mr. Anubhav Tripathi** (Registration No. **2019SP01**) for standing first at M.Tech. Electronics Engineering (Signal Processing), Final Examination 2021. **(CPI 9.80)**

24. Gold Medal awarded to **Mr. Pawan Singh** (Registration No. **2019GI02**) for standing first at M.Tech. Geoinformatics, Final Examination 2021. **(CPI 8.75)**

25. Gold Medal awarded to **Mr. Shashi Kumar Kushawaha** (Registration No. **2019CC22**) for standing first at M.Tech. Mechanical Engineering (Computer Aided Design and Manufacturing), Final Examination 2021. **(CPI 8.75)**

26. Gold Medal awarded to **Mr. Pawan Kumar** (Registration No. **2019DN21**) for standing first at M.Tech. Mechanical Engineering (Design Engineering), Final Examination 2021. **(CPI 8.65)**

27. Gold Medal awarded to **Ms. Farheen Nisha** (Registration No. **2019PD01**) for standing first at M.Tech. Mechanical Engineering (Product Design and Development), Final Examination 2021. **(CPI 9.20)**

28. Gold Medal awarded to **Mr. Vikas Diwakar** (Registration No. **2019PR02**) for standing first at M.Tech. Mechanical Engineering (Production Engineering), Final Examination 2021. **(CPI 9.05)**

29. Gold Medal awarded to **Mr. Atul Kumar Ahirwal** (Registration No. **2019TH23**) for standing first at M.Tech. Mechanical Engineering (Thermal Engineering), Final Examination 2021. **(CPI 8.95)**

30. Gold Medal awarded to **Ms. Sakshi Arora** (Registration No. **2019MB08**) for standing first at Master of Business Administration, Final Examination 2021. **(CPI 9.92)**

31. Gold Medal awarded to **Mr. Veeru Tekchandani** (Registration No. **2018CA78**) for standing first at Master of Computer Applications, Final Examination 2021. **(CPI 9.58)**

32. Gold Medal awarded to **Ms. Disha Varshney** (Registration No. **2019MSC01**) for standing first at Master of Science (Mathematics & Scientific Computing), Final Examination 2021. **(CPI 9.62)**

02.08.2021

मोतीलाल नेहरू राष्ट्रीय प्रौद्योगिकी संस्थान इलाहाबाद
प्रयागराज - २११००४ (उ०प्र०) भारत
Motilal Nehru National Institute of Technology Allahabad
Prayagraj – 211004 (UP) India

GOLD MEDALS FOR UNDER GRADUATE EXAMINATION – 2021

1. Gold Medal awarded to **Ms. Nimisha Gupta** (Registration No. **20170003**) for standing first at B.Tech. (Biotechnology), Final Examination 2021. **(CPI 9.43)**
2. Gold Medal awarded to **Mr. Abhijeet Maurya** (Registration No. **20179029**) for standing first at B.Tech. (Chemical Engineering), Final Examination 2021. **(CPI 9.40)**
3. Gold Medal awarded to **Mr. Akshat Jain** (Registration No. **20171031**) for standing first at B.Tech. (Civil Engineering), Final Examination 2021. **(CPI 9.69)**
4. Gold Medal awarded to **Mr. Aayush Agarwal** (Registration No. **20175028**) for standing first at B.Tech. (Computer Science and Engineering), Final Examination 2021. **(CPI 9.48)**
5. Gold Medal awarded to **Mr. Pranjal Tripathi** (Registration No. **20178048**) for standing first at B.Tech. (Information Technology), Final Examination 2021. **(CPI 9.59)**
6. Gold Medal awarded to **Mr. Sachin Kumar** (Registration No. **20172023**) for standing first at B.Tech. (Electrical Engineering), Final Examination 2021. **(CPI 9.55)**
7. Gold Medal awarded to **Mr. Ashish Kaushik** (Registration No. **20175039**) for standing first at B.Tech. (Electronics and Communication Engineering), Final Examination 2021. **(CPI 9.54)**
8. Gold Medal awarded to **Mr. Prashasti Bhai Patel** (Registration No. **20173058**) for standing first at B.Tech. (Mechanical Engineering), Final Examination 2021. **(CPI 9.33)**
9. Gold Medal awarded to **Mr. Aman Yadav** (Registration No. **20176015**) for standing first at B.Tech. (Production and Industrial Engineering), Final Examination 2021. **(CPI 8.54)**

INSTITUTE GOLD MEDAL FOR UNDER GRADUATE EXAMINATION – 2021

1. Institute Gold Medal awarded to **Mr. Akshat Jain** (Registration No. **20171031**) of B.Tech. (Civil Engineering) for standing first amongst students of all branches of the Institute Final Examination 2021. **(CPI 9.69)**

GOLD MEDALS – 2021 FOR UNDER GRADUATE

1. Gold Medal awarded to **Mr. Aryan Mittal** (Registration No. **20184069**) of B.Tech. (Computer Science and Engineering) for standing first at B.Tech. **Third Year** Examination 2021. **(CPI 9.70)**
2. Gold Medal awarded to **Mr. Shubham Dixit** (Registration No. **20194003**) of B.Tech. (Computer Science and Engineering) for standing first at B.Tech. **Second Year** Examination 2021. **(CPI 9.68)**

02.08.2021

अधिष्ठाता (छात्र कल्याण) कार्यालय
मोतीलाल नेहरू राष्ट्रीय प्रौद्योगिकी संस्थान इलाहाबाद
प्रयागराज - २११००४ (उ०प्र०) भारत
Office of the Dean (Student Welfare)
Motilal Nehru National Institute of Technology Allahabad
Prayagraj – 211004 (UP) India

No. 1612/DSW/2021 Dated: 07/8/2021

MINUTES

Minutes of the meeting of the committee constituted by the Director for preparation of the list of Institute and Sponsored Gold Medal for Eighteenth (18th) Annual Convocation 2021 of the Institute held on 07 August, 2021 at 2:00 pm in the Chamber of Dean (Student Welfare).

Following members were present:

1. Dean (Student Welfare)	Chairperson
2. Chairman, SMPC	Member
3. Chairman, SUGC	Member
4. Associate Dean (Academic)	Member
5. Faculty-In-charge(Examination)	Member
6. Assistant Registrar (Academic)	Convenor

Following are the resolutions of the Committee

1.) The total number of sponsored gold medals approved for the current session from Dean SW office is twelve (12). The **Dr. Ramji Sahai and Smt. Vijay Prabha Dev Memorial Gold Medal For Standing first in Physics at B.Tech First Year Examination** is be awarded to B.Tech. First year student and the **Late (Shri) Bhagwati Prasad Mehrotra Memorial Gold Medal for standing first in B.Tech Chemical Engineering (Final Year) Examination** is to be awarded for standing first in B.Tech. (Chemical Engg.) Final year Examination. However due to a typographical mistake the **Late (Shri) Bhagwati Prasad Mehrotra Memorial Gold Medal 2021 for Standing first in B.Tech. (Chemical Engg.) Final year Examination** was wrongly typed as "First year Examination" due to which the awardee for this gold medal and Dr. Ramji Sahay and Smt. Vijay Prabha Devi Memorial Gold Medal was not considered as the B.Tech. First year results are not available.

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2.) To correct the omission the topper in the merit list of the B.Tech. Chemical Engineering Final year has been considered and Mr. Abhijeet Maurya Reg. 20179029 with CPI 9.40 for this Medal is recommended for award of **Late (Shri) Bhagwati Prasad Mehrotra Memorial Gold Medal** for standing first in B.Tech Chemical Engineering (Final Year) Examination. The revised list of awardees is shown in Table 1:-

Table –I

(List of Sponsored Gold Medals for Eighteenth Annual Convocation -2021 of the Institute)

S.No.	Name of Gold Medal	Awarded to	CPI/Marks %
1.	**MADHAVA VIDYADHAR GORE GOLD MEDAL** for standing First in Final Year M.Tech (Computer Science and Engineering) Examination 2021	Name: Ms. Garima Saxsena Registration No. 2019CS25	9.30
2.	**LATE (DR.) MALAY RAJ MUKHERJEE GOLD MEDAL** for standing First amongst the students of B.Tech (Electrical Engineering) B.Tech (Electronics and Communication Engineering) and B. Tech (Computer Science and Engineering) in Examination 2021	Name: Mr. Sachin Kumar Registration No. 20172023	9.55
3.	**DR. YASH P. GUPTA GOLD MEDAL** for standing First in M.Tech (Civil Engineering Structural Engineering) Examination 2021	Name: Mr. Brajesh Rajpoot Registration No. 2019ST18	8.90
4.	**SATYA PRAKASH SINGHAL MEMORIAL GOLD MEDAL** for standing First in Steel Structure – II at B.Tech Final Year (Civil Engineering) Examination 2021	Name: Ankit kumar tripathi Registration No. 20179049	91%
5.	**Mrs. PRABHAWATJI SHAHI MEMORIAL GOLD MEDAL** for standing First Position in B.Tech (Civil Engineering) Final Year Examination 2021	Name: Mr. Akshat Jain Registration No. 20171031	9.69
6.	**PROF. VINEETA AGARWAL GOLD MEDAL** for standing First in M.Tech Electrical Engineering (Power Electronics and Drives) Final Year Examination 2021	Name: Mr. Gunupuru Govinda Rao Registration No. 2019PE13	9.45
7.	**PROF. R.N.SHAHI GOLD MEDAL** for Standing First in M. Tech Civil Engineering (Geotechnical Engineering) Final Examination	Name: Ms. Prity Dhanai	9.40

07.08.2021

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8.	**PROF. DHARMA PRAKASH GUPTA MEMORIAL GOLD MEDAL** for standing First amongst all the B.Tech final Year Students (all Branches) examination 2021	Name: Akshat Jain Registration No. 20171031	9.69
9.	**ICI-ULTRATECH GOLD MEDAL** for Standing First in B.Tech Civil Engineering Final Year Examination 2021	Name: Akshat Jain Registration No.20171031	9.69
10.	**PROF. SATYA SHEEL GOLD MEDAL** for standing First position in B,Tech (Electrical Engineering) Final Year Examination 2021.	Name: Mr. Sachin Kumar Registration No. 20172023	9.55
11.	**LATE (SHRI) BHAGWATI PRASAD MEHROTRA MEMORIAL GOLD MEDAL** for Standing first in B.Tech. Chemical Engg. (Final year) Examination	Name : Mr. Abhijeet Maurya Registration No. 20179029	9.40

Checked
7/8/2021

7/8/21

Assistant Registrar(Academic)

7/08/2021

Faculty-In-charge(Examination)

07/08/21

Associate Dean(Academic)

07.08.2021

Chairman, SMPC

7/8/2021

Chairman, SUGC/Dean Student Welfare

ANNEXURE–VII

कार्यालय अधिष्ठाता [शैक्षिक]
मोतीलाल नेहरू राष्ट्रीय प्रौद्योगिकी संस्थान इलाहाबाद
प्रयागराज - २११००४ [उ०प्र०] भारत
Office of the Dean [Academic]
Motilal Nehru National Institute of Technology Allahabad
Prayagraj – 211004 [UP] India

Director Office
In | Out
Date 07.8.21
Time
No. 1416

Dated:-05-08-2021

Minutes of the Meeting of Standing Committee (Grade Discrepancy) held on 05-08-2021 [Thrusday] at 12:00 Noon in the office of Dean (Academic). Following members were present:

Prof. R.K Singh, Dean (Academic)	-	Chairman
Prof. V.K. Srivastava, ECED	-	Senate Nominee
Dean (Student Welfare) (oftg.)	-	Member
Prof. A. K.Sachan Chairman SDPC & Chairman SUGC (oftg)	-	Member
Prof. R.K.Nagaria, Chairman SMPC	-	Member
Prof. P.K.Dutta Chemistry	-	Special Invitee
Dr. Jyotsna Sinha HSS	-	Special Invitee
Dr. Varun Singh CED	-	Special Invitee
Dr. H.K.Pandey	-	Special Invitee
Dr. R. K.Patel, MED	-	Special Invitee
Dr. Sahadeo Padhye Mathematics	-	Special Invitee
Dr. Y.G.Bala	-	Special Invitee
Dr. K.K.Mishra CSED	-	Special Invitee
Dr. Soni Joseph HSS	-	Special Invitee
Dr. Ravi Prakash Physics	-	Special Invitee
Dr. Abhishek Kumar Tiwari AMD		Special Invitee
Dr. Basant Kumar F.I. [Examination]	-	Convener

1. The committee reviewed the case of following students for grade discrepancy during End Semester (1st & 8th semester) Examinations 2020-21. It is observed that some discrepancies have occurred because of limited interaction and information exchange with students, due to completely new paradigm of teaching / learning in COVID scenario. The Committee recommended the following:

Sl. No	Registration No.	Name of Student/ Department/Group	Course Code	Subject Name	Grade Old	Grade New	Comments	Name of Course Coordinator /Instructor
1	20171047	MD SHAHID HUSSAIN (Civil)	CE18408	Transport Asset Management	B	B	No Change in Grade	Dr Varun Singh
2	20178068	ABDULLAH YOUSUF (Electrical)	CE18502	Water Resources Management	B	B	No Change in Grade	Dr. H.K.Pandey
3	20200027	LOVEKUSH KUSHWAH (H2)	CY11101	Chemistry	B	B	No Change in Grade	Prof. P.K.Dutta
4	20201037	BIPUL KARNA (H1)	CY11101	Chemistry	D	D	No Change in Grade	Prof. P.K.Dutta
5	20201051	**HIMANSHU (H2)**	**CY11101**	**Chemistry**	**B**	**B+**	**Change in grade due to totalling mistake**	**Prof. P.K.Dutta**
6	20201054	ISHAAN PACHAURI (G1)	CY11101	Chemistry	C	C	No Change in Grade	Prof. P.K.Dutta

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7	20203031	ARINA SIDDIQUI (I1)	CY11101	Chemistry	B	B	No Change In Grade	Prof. P.K.Dutta
8	20203059	GAUTAM KUMAR (H2)	CY11101	Chemistry	B	B	No Change in Grade	P. P.K.Dutta
9	20203079	KRISHAN MEENA (J1)	CY11101	Chemistry	F	F	No Change in Grade	Prof. P.K.Dutta
10	20200027	LOVEKUSH KUSHWAH (H2)	HS11102	Communication skills and Workshop	B	B+	Change in grade due to adding 6 marks in TA	Dr. Jyotsna Sinha
11	20203031	ARINA SIDDIQUI (I1)	HS11102	Communication skills and Workshop	A	A	No Change in Grade	Dr. Jyotsna Sinha
12	20206058	VIVEK KUMAR (H2)	HS11102	Communication skills and Workshop	B	B	No Change In Grade	Dr. Jyotsna Sinha
13	20200035	PRAKHAR AGARWAL (I2)	CS11101	Computer Programming	A	A	No Change in Grade	Dr. K.K.Mishra
14	20201054	ISHAAN PACHAURI (G1)	CS11201	Computer Programming (Lab)	B+	B+	No Change in Grade	Dr. K.K.Mishra
15	20203027	ANURAG CHAUDHARY (H2)	CS11201	Computer Programming (Lab)	B	B	No Change in Grade	Dr. K.K.Mishra
16	20203031	ARINA SIDDIQUI (I1)	CS11101	Computer Programming	A	A	No Change in Grade	Dr. K.K.Mishra
17	20203031	ARINA SIDDIQUI (I1)	CS11201	Computer Programming (Lab)	A	A	No Change in Grade	Dr. K.K.Mishra
18	20203044	AYUSH SINGH GOUR (G2)	CS11201	Computer Programming (Lab)	A	A	No Change in Grade	Dr. K.K.Mishra
19	20203079	KRISHAN MEENA (J1)	CS11201	Computer Programming (Lab)	E	E	No Change in Grade	Dr. K.K.Mishra
20	20203092	MAYANK KATARIYA (G1)	CS11101	Computer Programming	C	C	No Change in Grade	Dr. K.K.Mishra
21	20203092	MAYANK KATARIYA (G1)	CS11201	Computer Programming (Lab)	C	C	No Change in Grade	Dr. K.K.Mishra
22	20200035	PRAKHAR AGARWAL (I2)	MA11101	Mathematics I	B+	B+	No Change In Grade	Dr. Sahadeo Padhye
23	20201028	ARYMAN JAIN (H1)	MA11101	Mathematics I	B+	B+	No Change in Grade	Dr. Sahadeo Padhye
24	20201051	HIMANSHU (H2)	MA11101	Mathematics I	B	B	No Change in Grade	Dr. Sahadeo Padhye
25	20203031	ARINA SIDDIQUI (I1)	MA11101	Mathematics I	B+	B+	No Change in Grade	Dr. Sahadeo Padhye
26	20203079	KRISHAN MEENA (J1)	MA11101	Mathematics I	F	F	No Change in Grade	Dr. Sahadeo Padhye
27	20206058	VIVEK KUMAR (H2)	MA11101	Mathematics I	C	C	No Change in Grade	Dr. Sahadeo Padhye

28	20208109	Roshni Mandal (A1)	MA11101	Mathematics I	B+	B+	No Change in Grade	Dr. Sahadeo Padhye
29	20201028	ARYMAN JAIN (H1)	ME11101	Engineering Graphics	B	B+	Change in grade due to increase of PA marks	Dr. R.K.Patel
30	20201054	ISHAAN PACHAURI (G1)	ME11101	Engineering Graphics	B+	B+	No Change in Grade	Dr. R.K.Patel
31	20203031	ARINA SIDDIQUI (I1)	ME11101	Engineering Graphics	A	A	No Change in Grade	Dr. R.K.Patel
32	20203059	GAUTAM KUMAR (H2)	ME11101	Engineering Graphics	B	A	Change in grade due to increase of PA marks	Dr. R.K.Patel
33	20203079	KRISHAN MEENA (J1)	ME11101	Engineering Graphics	E	E	No Change in Grade	Dr. R.K.Patel
34	20203130	SANSKAR SHARMA (G2)	ME11101	Engineering Graphics	F	B	Change in grade due to increase of PE & PA marks	Dr. R.K.Patel
35	20203152	SURYABHAN SINGH (H2)	ME11101	Engineering Graphics	F	B	Change in grade due to increase of PE marks	Dr. R.K.Patel
36	20206026	MRITYUNJAY KUMAR (G1)	ME11101	Engineering Graphics	F	B+	Change in grade due to increase of PE marks	Dr. R.K.Patel
37	20206058	VIVEK KUMAR (H2)	ME11101	Engineering Graphics	C	C	No Change in Grade	Dr. R.K.Patel
38	20201054	ISHAAN PACHAURI (G1)	PH11101	Physics-I	B+	B+	No Change in Grade	Dr. Ravi Prakash
39	20203031	ARINA SIDDIQUI (I1)	PH11101	Physics-I	A	A	No Change in Grade	Dr. Ravi Prakash
40	20203059	GAUTAM KUMAR (H2)	PH11101	Physics-I	B+	B+	No Change in Grade	Dr. Ravi Prakash
41	20208109	Roshni Mandal (A1)	PH11101	Physics-I	B+	B+	No Change in Grade	Dr. Ravi Prakash
42	20208109	Roshni Mandal (A1)	PH11201	Physics (Lab)	A	A	No Change in Grade	Dr. Ravi Prakash
43	20203012	ADITYA SINGH (J2)	CY11201	Chemistry (Lab)	B+	B+	No Change in Grade	Prof. G.K.Mehrotra
44	20203031	ARINA SIDDIQUI (I1)	CY11201	Chemistry (Lab)	B+	B+	No Change in Grade	Prof. G.K.Mehrotra
45	20203044	AYUSH SINGH GOUR (G2)	CY11201	Chemistry (Lab)	A	A	No Change in Grade	Prof. G.K.Mehrotra
46	20203079	KRISHAN MEENA (J1)	CY11201	Chemistry (Lab)	F	F	No Change in Grade	Prof. G.K.Mehrotra
47	20208109	Roshni Mandal (A1)	AM11201	ENGINEERING MECHANICS LABORATORY	B+	B+	No Change in Grade	Dr. Abhishek Kumar Tiwari

48	20208109	Roshni Mandal (A1)	HS11101	English Language and Composition	A	A	No Change in Grade	Dr. Soni Joseph
49	20208109	Roshni Mandal (A1)	ME11102	Workshop	B	B	No Change in Grade	L V.R.Komma

b) The committee examined the case of Mr. Nitin Rao (20165120) and found that the student got registered in 6th semester in the session 2020-21, but the student had already registered in the same semester (6th semester) in the session 2019-20. Committee considered the case in the backdrop of the extra- ordinary pandemic scenario and recommended for the post - facto approval of registration in the 6th semester,2020-21 (All subjects) for Mr. Nitin Rao.

Meeting ended with thanks to Chair.

5/08/2021
Dr. Basant Kumar
Faculty In-Charge Examination

5/8/21
Prof. A. K. Sachan Chairman
SDPC & Chairman SUGC (oftg.)

05.08.2021
Prof. R. K. Nagaria
Chairman, SMPC

5-8-21
Prof. V.K. Srivastava
(Senate Nominee)

05/08/2021
Dean (Student Welfare) (oftg.)

Prof. R. K. Singh
Dean (Academic)

Director

The recommendation of the Committee is submitted for your kind approval please.

07/08/2021

Approved

7/8/21