Bachelor of Technology

in

Materials Engineering

Course Structure, Scheme of Evaluation and Syllabi

(*Effective from July 2024-25*)

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 be at the forefront of creation and dissemination of knowledge and technology in the multidisciplinary fields of Engineering Mechanics and Materials towards solving the challenges and needs of the discipline and the society.

MISSION

- ➢ To create and disseminate knowledge resource and sustainable technology through research and innovation in emerging Technological domains.
- ➢ To nurture value-based leaders in the Engineering Mechanics, Materials and allied areas capable of solving the challenges and needs of the discipline and the society.

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

Curriculum Structure of B. Tech. Materials Engineering

S. No.	Code	Category	Course	L-T-P	Credit	Contact Hours
Semester-I						
1.	PHN11502 /CYN11502	CEF	Engineering Physics-II/Engineering Chemistry-II	2-1-2	4	5
2.	MAN11101	CEF	Mathematics-I	3-1-0	4	4
3.	HSN11600/ CSN11601	PCE	Professional Communication/Introduction to Artificial Intelligence andMachine Learning	2-0-2	3	4
4.	AMN11103	CEE	Introduction to Materials Engineering	3-0-0	3	3
5.	AMN11102	CEE	Engineering Mechanics	3-0-2	4	5
6.	MEN11602/ MEN11601	PCE	Workshop and Manufacturing Processes/Engineering Graphics	1-0-2	2	3
7.	IDN11600	PCE	Introduction to Environmental and Climate Change	2-0-0	2	2
8.	********	EAA	Extra Academic Activity-A/ Extra Academic Activity-B	0-0-4	2	4
				Total	**24**	**30**

Semester-II						
1.	CYN12502/ PHN12502	CEF	Engineering Chemistry-II/Engineering Physics-II	2-1-2	4	5
2.	MAN12106	CEF	Mathematics-II	3-1-0	4	4
3.	CSN12601/ HSN12600	PCE	Introduction to Artificial Intelligence and Machine Learning/Professional Communication	2-0-2	3	4
4.	AMN12103	CEE	Metallurgical Thermodynamics and Kinetics	3-1-0	4	4
5.	AMN12102	CES	Fluids Mechanics	3-0-0	3	3
6.	MEN12602/ MEN12601	PCE	Engineering Graphics/Workshop and Manufacturing Processes	1-0-2	2	3
7.	********	EAA	Extra Academic Activity-A/ Extra Academic Activity-B	0-0-4	2	4
				Total	**22**	**27**

Semester-III						
1.	AMN13111	CEE	Phase Diagrams and Phase Transformation	3-0-2	4	5
2.	AMN13101	CEE	Mechanics of Materials	3-0-2	4	5
3.	AMN13112	CEE	Extractive Metallurgy	3-0-0	3	3
4.	AMN13113	CEE	Polymer Science and Engineering	3-0-2	4	5
5.	EEN*****	CES	Basic Electrical and Electronics	2-0-2	3	4
6.	HSN13601	CEF	Management Concepts and Application/ Business Economics	3-0-0	3	3
7.	********	EAA	Extra Academic Activity-B	0-0-4	2	4
				Total	**23**	**29**

Semester-IV						
1.	AMN14102	CES	Applied Mathematics and Computation	3-0-2	4	5
2.	AMN14109	CEE	Ceramic Engineering	3-0-0	3	3
3.	AMN14110	CEE	Electrical, Electronic and Magnetic Materials	3-0-0	3	3
4.	AMN14111	CEE	Mechanical Behaviour of Materials	3-1-0	4	4
5.	AMN14112	CEE	Characterization of Materials	3-0-2	4	5
6.	********	EAA	Extra Academic Activity-B	0-0-4	2	4
				Total	**20**	**24**

Semester-V						
1.	AMN15106	CEE	Materials Selection and Design	3-0-2	4	5
2.	AMN15107	CEE	Nano-materials	3-0-2	4	5
3.	AMN15108	CEE	Advances in Materials Application	3-0-0	3	3
4.	AMN15109	CEE	Composite Materials	3-0-0	3	3
5.	AMN*****	CEE	Core Elective Course - 1	3-0-0	3	3
6.	AMN*****	CEE	Core Elective Course - 2	3-0-0	3	3
7.	AMN15351	CEE	Group Project/Research Project-I (Contd.)	1-0-2	2	2
				Total	**22**	**24**

Semester-VI						
1.	AMN16104	CEE	Introduction to Computational Materials Science	3-0-2	4	5
2.	AMN16105	CEE	Materials in Services	3-0-2	4	5
3.	AMN*****	CEE	Core Elective Course – 3	3-0-2	4	5
4.	AMN*****	CEE	Core Elective Course – 4	3-0-0	3	3
5.	AMN*****	CEE	Core Elective Course – 5	3-0-0	3	3
6.	HSN16603	PCE	Soft Skills and Personality Development	2-0-1	3	3
7.	AMN16351	CEE	Group Project/Research Project -II (Contd.)	0-0-4	2	4
				Total	**23**	**28**

Semester-VII						
1.	AMN17102	CEE	Modelling and Simulation in Materials Processes	1-0-4	3	5
2.	AMN17103	CEE	Machine Learning in Materials Science	3-0-2	4	5
3.	AMN*****	CEE	Core Elective Course – 6	3-0-2	4	5
4.	AMN*****	CEE	Core Elective Course – 7	3-0-0	3	3
5.	AMN*****	CEE	Core Elective Course – 8	3-0-0	3	3
6.	AMN17351	CEE	Group Project/Research Project -III	0-0-8	4	8
				Total	**21**	**29**

Semester-VIII						
1.	AMN18351	IT/GP	Industrial Training/ Group Project	0-0-28	14	28
				Total	**14**	**28**

List of Electives for Core electives for 5th Semester

S No	Courses	L-T-P-Credit
Core Elective Course – 1 and 2		
1	AMN15255 High Temperature Materials	3-0-0-3
2	AMN15256 Ferroelectric Materials	3-0-0-3
3	AMN15257 Energy Materials	3-0-0-3
4	AMN15258 Smart Materials and Systems	3-0-0-3
5	AMN15259 Materials for Nuclear Applications	3-0-0-3
6	AMN15260 Electronic Ceramics	3-0-0-3
7	AMN15261 Automotive and Aerospace Materials	3-0-0-3
8	AMN15262 Biomaterials	3-0-0-3

List of Electives for Core electives for 6th Semester

S No	Courses	L-T-P-Credit
Core Elective Course – 3		
1	AMN16250 Finite Element Method	3-0-2-4
2	AMN16251 Optimization Methods in Engineering	3-0-2-4
3	AMN16252 Non-Destructive Testing	3-0-2-4
4	MAN***** Statistics for Engineers	3-1-0-4
Core Elective Course – 4		
5	AMN16253 Electroacoustic Transducers	3-0-0-3
6	AMN16254 MEMS and Bio-MEMS	3-0-0-3
7	AMN16255 Plasma Technology	3-0-0-3
8	CSN***** Data Structure	2-0-2-3
Core Elective Course – 5		
9	AMN16256 Fatigue and Fracture of Materials	3-0-0-3
10	AMN16257 Continuum Damage Mechanics	3-0-0-3
11	AMN16258 Physical Chemistry of Steels	3-0-0-3

List of Electives for Core electives for 7th Semester

S No	Courses	L-T-P-Credit
Core Elective Course – 6		
1	AMN17255 Advanced Manufacturing	3-0-2-4
2	AMN17256 Thin-films and Applications	3-0-2-4
3	AMN17257 Powder Metallurgy	3-0-2-4
Core Elective Course – 7		
4	AMN17258 Corrosion Science and Engineering	3-0-0-3
5	AMN17259 Tribology	3-0-0-3
6	AMN17260 Life Cycle Assessment	3-0-0-3
7	AMN17261 Critical Minerals and Supply Chain of Materials	3-0-0-3
Core Elective Course – 8		
8	AMN17262 Nano-Fluids	3-0-0-3
9	AMN17263 Carbon Nanotubes and Nanostructures	3-0-0-3
10	AMN17264 Alternate Routes to Steel Manufacturing	3-0-0-3

Semester-I

PHN11502/PHN12502 Engineering Physics-II

Designation	:	Compulsory	
Pre-requisites	:	None	
Credit and Contact hrs	:	2(L) - 1(T) – 2(P) – 4(Cr)	
Assessment Methods	:	Theory Part: End Semester Exam: 40% Mid Semester Exam: 20% Teacher Assessment: 10%	Practical Part: End Semester Exam: 15% Teacher Assessment: 15%
Course Outcomes	:	**The successful student will learn:** 1. Basics of optics are introduced to understand many related technologies e.g., interference, polarization and diffraction, etc. 2. Laser is a powerful tool and is used in several applications relevant to mechanical and production engineers. Fundamentals of lasers are introduced to explain the working and use of lasers. 3. Make students familiar with the unexpected outcomes in the regime of extremely high-speed objects. The topic is introduced to help them understand many technical objects and phenomena such as GPS technology, the physics of astronomical objects, etc.	
Modes of Delivery	:	Talk and chalk, 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		√	√		√		√	√		

Physical Optics Interference: Condition of observing interference. Fresnel's Biprism. Stoke's treatment. Interference in thin films. Newton's rings.

Diffraction: Fraunhofer's diffraction - Single slit, Double slit and N-slit or plane transmission grating. Rayleigh's criterion of resolution. Resolving power of grating and telescope.

Polarisation: Polarisation by reflection. Double refraction. Half wave and quarter wave plates. Production and analysis of plane. elliptical and circularly polarised light. Optical activity. Specific rotation. Laurent half-shade polarimeter.

Laser: Characteristics of Laser light, Stimulated and spontaneous emission. Population inversion. Einstein's coefficients. Laser emission, Nd-YAG and He-Ne lasers. Applications of laser in engineering.

Special Theory of Relativity Frame of reference. Inertial and non-inertial frames. Postulates of special theory of relativity, Lorentz transformation of space and time, Length contraction, Time dilation, Addition of velocities. Energy Mass equivalence.

List of experiments in practical:

1. To measure height of a building using Sextant.
2. Interference of light: Newton's ring.
3. Interference of light: Fresnel's Biprism.
4. Diffraction by a plane transmission grating.
5. Specific rotation of sugar using Polarimeter.
6. Resolving power of a telescope.
7. Surface tension measurement.
8. Variation of magnetic field along the axis of a current carrying coil.
9. Magnetic field distribution due to Helmholtz coil setup.

References books

1. R. Resnick, Introduction to Special Relativity (John Wiley & Sons, New York, 1968)
2. A. Ghatak, Optics (McGraw Hill Education, New Delhi, 2017)
3. E. Hecht, Optics (Addison-Wesley, New York, 2002)
4. A. Beiser, Concepts of Modern Physics (McGraw-Hill, New York, 2003)
5. B. B. Laud, Lasers and Non-Linear Optics (Wiley, New York, 1991)

CYN11502/CYN12502 Engineering Chemistry-II

Designation	:	Compulsory	
Pre-requisites	:	Nil	
Credit and Contact hrs	:	2(L) - 1(T) – 2(P) – 4(Cr)	
Assessment Methods	:	Theory Part: End Semester Exam: 40% Mid Semester Exam: 20% Teacher Assessment: 10%	Practical Part: End Semester Exam: 15% Teacher Assessment: 15%
Course Outcomes	:	**The successful student will learn:** 1. To achieve the understanding of different fundamental chemical concepts of chemical bonding, fuel, corrosion, lubricant, polymer, water chemistry, and biochemical synthesis and process. 2. The ability to interpret the experimental data related to fuel, lubricant, polymer, and water chemistry. Also, understand and draw inferences related to the biochemical processes and the role of metal ions in biological systems. 3. Develop the capability to apply the knowledge for the industrial 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	2	2	1	1	1	-	-	-	1	1
CO2	2	2	1	1	2	-	-	-	1	2
CO3	2	2	1	1	1	-	-	-	1	1

Syllabus

Chemical Bonding: Drawbacks of Valence bond theory, Molecular orbital theory of small molecules, bonding in metals, semiconductors, and insulators, impurity semiconductors, symmetry, symmetry elements, point groups and group theory.

Fuels: Classifications, calorific values, analysis of solid fuels, liquid fuels and their properties, refining, cracking and reforming of petroleum, knocking and octane rating, biofuels.

Corrosion and Lubricants: Causes and effects of corrosion, theories of corrosion, types, factors of corrosion, its prevention and control, case study on corrosion control in industry. Corrosion and lubricant relation, functions of lubricants, tribology and lubrication, classification, mechanism and testing of lubricants.

Polymers: Classification (origin: natural, synthetic, semi-synthetic, biopolymers (natural & synthetic) and biodegradable polymers), types: plastics, rubber, fibre, adhesives, composites, thermoplastic and thermosetting polymers, characterization and properties, industrial uses.

Water Chemistry: Importance of water, sources of impurities and their treatment processes, hard water, alkalinity of water, softening of water, boiler feed water, boiler corrosion, prevention of scale formation, break point of chlorination, modern water purification systems

Biochemical Synthesis and Process: Introduction, manufacture of ethyl alcohol and acetic acid by fermentation, role of metal ions (Fe and Co) in biological systems.

Practical: List of Experiments

Part A:

1. To determine the percentage of available chlorine in the supplied sample of bleaching powder.
2. To determine the total hardness, Ca2+ hardness, and Mg2+ hardness in the supplied water sample by titrating with standard EDTA solution.
3. To determine the alkalinity of the supplied water sample.
4. To determine the strength of supplied K2Cr2O7 solution using Ferrous Ammonium Sulphate solution as intermediate and Potassium Ferricyanide solution as an external indicator.
5. Preparation of Methyl Orange using a diazonium coupling reaction.

Part B:

6. Determination of flash point of oils by Abel’s apparatus.
7. Determination of flash point of lubricating oil by Pensky-Martens closed cup tester.
8. To study the kinematic viscosity of the given lubricating oil at various temperatures using a Redwood viscometer.
9. To find out the aniline point of the given fuel samples.
10. Determination of viscosity average molecular weight of a polymer sample by Ostwald Viscometer.

Part C:

11. Preparation and characterization of biodiesel from waste cooking oils

Text Books:

1. Engineering Chemistry, Jain & Jain, 2013, Dhanpat Rai Publishing Co., New Delhi.
2. Engineering Chemistry, Shashi Chawla, 2017, Dhanpat Rai Publishing Co., New Delhi.

Reference Books:

1. Inorganic Chemistry: Principles of Structure and Reactivity, James E. Huheey, Ellen A. Keiter, Richard L. Keiter, and Okhil K. Medhi, 2006, Pearson Education, India.
2. Chemical Applications of Group Theory, F. Albert Cotton, 2003, John Wiley & Sons, New Jersey, USA.
3. Elements of Physical Chemistry, Peter Atkins and Julio D. Paula, 2006, Oxford, UK.
4. Engineering Chemistry - A Textbook, Harish Kumar Chopra and Anupama Parmar, 2007, Narosa Publishing House Pvt. Ltd., New Delhi.
5. Polymer Science, V R Gowariker, N V Viswanathan, and Jayadev Sreedhar, 2021, New Age International Private Limited, New Delhi.
6. Biochemical Methods, A. Pingoud, C. Urbanke, J. Hoggett, and A. Jeltsch, 2002, Wiley-VCH Verlag GmbH, UK.
7. Online resources.

MAN11101 Mathematics-I		
Designation	:	Compulsory
Pre-requisites	:	Nil
Credit and Contact hrs	:	3(L) - 1(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 50 marks Mid Semester Exam: 25 marks Teacher Assessment: 25 marks
Course Outcomes	:	**The successful student will learn:** 1. The course provides a basic understanding of the limit, continuity, and differentiability of the function of single and several variables, which are fundamental for solving many engineering problems. 2. Development of basic understating of partial derivatives, change of variables, Jacobins, maxima-minima of function of several variables to address some engineering-based problems. 3. This unit provides sufficient knowledge to apply double and triple integrals in calculating arc length, surface area, volume, the moment of inertia, and the centre of gravity of surfaces to solve complex engineering problems. 4. Make students familiar with the basic knowledge of beta, gamma, and error functions, which frequently appear in engineering problems. 5. Students will learn basic concepts like gradient, directional derivative, divergence, curl, etc. They will also learn to calculate line, surface, and volume integrals and apply conversion techniques between them. 6. Solution methods of the ordinary differential equation are fundamental concepts for engineering problems. This unit will help the students to have a clear understanding of differential equations. Also, students will be able to learn solution techniques for several kinds of first and higher-order ordinary differential equations
Modes of Delivery	:	Talk and chalk, etc.

Mapping of course outcomes with program outcomes

Course outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	1	1	-	-	-	-	-	1
CO2	3	3	2	2	-	-	-	-	-	1
CO3	3	3	3	3	-	-	-	-	-	2
CO4	3	3	1	2	-	-	-	-	-	1
CO5	3	3	3	3	-	-	-	-	-	2
CO6	3	3	3	3	-	-	-	-	-	2

Syllabus

Continuity and Differentiability: Limit and Continuity (ε–δ definition of one variable), Rolle's Theorem, Lagrange and Cauchy Mean Value Theorem, Limit and Continuity (ε–δ definition for several variables) and Differentiability for several variables.

Partial Derivatives and Taylors Theorem: Partial derivatives, Euler's homogeneous theorem, Implicit function, Change of variables, Jacobian, Taylor's theorem for functions of several variables. Extrema of functions of several variables, 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, Convergence of improper integral, Beta Function, Gamma functions, Improper Integrals involving a parameter.

Vector Calculus: Gradient, Directional derivatives, Divergence and Curl, line integral, Green's theorem, Surface and volume integrals, Gauss theorem, 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, Method of undetermined coefficients.

Text Books:

1. R. K. Jain and S. R. K. Iyenger, Advanced Engineering Mathematics, Edition: 5th, 2016 Narosa Pub. House
2. B.S. Grewal, Higher Engineering Mathematics, 44nd edition, 2018, Khanna Publishers.

Reference Books and Online Source:

1. Thomas and Finney, Calculus, 10th Edition, 2001, Addison Wesley
2. Erwin Kreyszig, Advanced Engineering Mathematics,10th Edition, 2015, John Wiley & Sons.
3. Online Source: NPTEL.

HSN11600/HSN12600 Professional Communication		
Designation	:	Compulsory
Pre-requisites	:	Nil
Credit and Contact hrs	:	2(L) - 0(T) – 2(P) – 3(Cr)
Assessment Methods	:	Theory Part: End Semester Exam: 40% Mid Semester Exam: 20% Teacher Assessment: 10% Practical Part: End Semester Exam: 15% Teacher Assessment: 15%
Course Outcomes	:	**The successful student will learn:** 1. Understand basic grammar principles. 2. Write clear and coherent passages 3. Write effective letters for job application and complaints 4. Prepare technical reports and interpret graphs 5. Enhance reading comprehension 6. Comprehend English speech sound system, stress and intonation.
Modes of Delivery	:	Talk and chalk, Power point presentations, and practical etc.

Syllabus

Remedial Grammar: It is the basic core for the development of the English language and it can be more enhanced through our mini language lab currently, though in future with computerized language lab containing tense busters and other softwares to develop interests in students to learn language through games. Content: Articles, Prepositions, Tenses, Active and Passive forms.

Effective comprehension: In this global era effective comprehension is an attempt to develop in technical students to comprehend different topics relative to varied scientific and social myriad happenings in the world thus bridging the gap from the scientific- technical culture from the liberal arts culture. Content: Passages from News Papers, magazines and short comprehensions from GRE packages

Effective Composition: Liberal space has been devoted to written composition and an overall initiative will be taken to show the students that most effective writing scientific or literary-adapts certain principles of rhetoric which can be learnt and put into practice through artistic writing. Content: Discussions on varied topics in tutorials, excerpts from magazines and newspapers.

Pronunciation Skill: One of the important aspects in communication and personality impression of the students. This will be enhanced through the aid of language lab and the instructors own drilling exercises. So that availing such a skill can create great space for themselves and for job in this age of globalisation, where overall developed personality is more easily absorbed. Content: With the help of language lab and instructors drilling exercises

References books

1. A Textbook of English for Engineers and Technologists (combined edition, Vol. 1 & 2); Orient Black Swan 2010.

CSN11601 Introduction to Artificial Intelligence and Machine Learning			
Designation	:	Compulsory	
Pre-requisites	:	Nil	
Credit and Contact hrs	:	2(L) - 0(T) – 2(P) – 3(Cr)	
Assessment Methods	:	Theory Part: End Semester Exam: 40% Mid Semester Exam: 20% Teacher Assessment: 10%	Practical Part: End Semester Exam: 15% Teacher Assessment: 15%
Course Outcomes	:	**The successful student will learn:** 1. Understand the basics of programming languages for problem-solving. Understanding 2. Understand data storage, processing, and its use in model evaluation Understanding 3. Explain the basics of AI and its applications. Analyzing 4. Apply the machine learning algorithms for the classification and regression problems. Applying 5. Develops the ability to analyze problems and their solutions using clustering-based approaches Understanding	
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	3	3	2	3	1	-	-	-	-	-
CO2	2	3	3	2	2	-	-	-	-	-
CO3	2	2	2	3	-	1	-	-	-	-
CO4	3	3	3	3	2	1	-	-	-	-
CO5	3	3	3	3	2	1	-	-	-	-

Syllabus

Unit-1: Fundamentals of Programming: Basics of Programming Languages, Algorithms, Data types, Expressions and Operators, Control Statements, Iterations, and Functions.

Unit-2: Programming Constructs:Data Import and Export, Operations on Data: Traversing, Searching, and Arranging the data, String Operations, Mathematical operations on arrays.

Unit 3: Introduction to Artificial Intelligence:Evolution of AI, Various Approaches to AI, Intelligence and Machines, Intelligent Agents, Solving Problems by Searching, Considering the uses of AI for Society.

Unit-4: Introduction to Machine Learning: What and Why? Types of Machine Learning:Supervised, Unsupervised and Reinforcement learning, Under-fitting vs Over- fitting Problem, Training, Testing and Validation Process,Applications of Machine Learning, Linear Regression, Naïve Bayes Classifier, KMeans.

Text Books:

1. Russell, Stuart, and Peter Norvig. "Artificial intelligence: a modern approach."(2002).
2. Mueller, John Paul, and Luca Massaron. Artificial intelligence for dummies. John Wiley & Sons, 2021.

Reference Books:

1. Alpaydin, Ethem. Introduction to machine learning. MIT Press, 2020. Michalski, Ryszard Stanislaw, Jaime Guillermo Carbonell, and Tom M. Mitchell, eds. Machine learning: An artificial intelligence approach. Springer Science & Business Media, 2013

AMN11103 Introduction to Materials Engineering

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: 50 marks Mid Semester Exam: 25 marks Teacher Assessment: 25 marks
Course Outcomes	:	**The successful student will learn:** 1. Primary objective is to present the basic fundamentals of materials science and engineering. Expose to different classes of materials, their properties, structures and imperfections present in them. 2. Help understand the subject with ease by presenting the content in a simplified and logical sequence at a level appropriate for students/teachers/researchers. 3. Aid the teaching learning process through relevant illustrations, animations, web content and practical examples. 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.

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

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

Polymers and 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”.

AMN11102 Engineering Mechanics		
Designation	:	Compulsory
Pre-requisites	:	Nil
Credit and Contact hrs	:	3(L) - 0(T) – 2(P) – 4(Cr)
Assessment Methods	:	Theory Part: End Semester Exam: 40% Mid Semester Exam: 20% Teacher Assessment: 10% Practical Part: End Semester Exam: 15% Teacher Assessment: 15%
Course Outcomes	:	**The successful student will learn:** 1. Identify and quantify all the external forces associated with the rigid body with the help of free body diagrams, their resultant and its location and use of equations of equilibrium. 2. To locate the centroid of an area and calculate the moment of inertia of a section and assessment of the internal forces in beams. 3. Apply Newtons laws of motion to particles and rigid bodies. 4. Solve the problems involving kinematics, energy and momentum and write simple programs for problems of real life.
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	3	2	-	-	-	-	-	1	-	2
CO2	3	2	-	-	-	-	-	1	-	2
CO3	3	3	1	1	-	-	-	-	-	2
CO4	3	3	2	1	-	-	-	-	-	-
CO5	3	3	2	2	1	-	-	-	-	-

Syllabus

Review of Force, moment and Couple, Equilibrium of rigid bodies, Centroid and Moment of inertia, Beams - Shear force, and Bending moment diagrams.

Kinematics and Kinetics of particles: Plane and Space motion, Force, Mass and Acceleration, Work & Energy, Impulse & Momentum, Impact, and Central Force Motion. Kinetics of system of particles: Conservation of Energy and Momentum, Steady mass flow, Variable mass.

Plane Kinematics and Kinetics of a rigid body: Relative velocity and Acceleration, Instantaneous center of zero velocity, Rotating axis, Force, Mass and Acceleration, Work & Energy, Impulse & Momentum.

Introduction to three-dimensional kinematics and kinetics of rigid bodies.

List of experiments:

1. Friction between inclined plane and sliding box
2. Friction between inclined plane and roller
3. Mass moment of inertia of flywheel
4. Equilibrium of parallel forces
5. Belt and pulley friction
6. Screw jack
7. Polygon law of forces

References books

1. Meriam J.L., Kraige L.G and Bolton J.N., Engineering Mechanics Statics and Dynamics, 9ed (An Indian Adaptation), Wiley India.
2. Beer F.P. and Johnston E.R., Mechanics for Engineers – Vol.1- Statics, Vol.2- Dynamics, McGraw Hill, New York.
3. Shames I.H., Engineering Mechanics, Prentice Hall, New Delhi.
4. Hibbeler R.C., Engineering Mechanics - Vol.1 –Statics, Vol.2- Dynamics, Pearson Press

MEN11602/MEN12602 Workshop and Manufacturing Processes			
Designation	:	Compulsory	
Pre-requisites	:	None	
Credit and Contact hrs	:	1(L) - 0(T) – 3(P) – 3(Cr)	
Assessment Methods	:	Theory Part: End Semester Exam: 40% Mid Semester Exam: 20% Teacher Assessment: 10%	Practical Part: End Semester Exam: 15% Teacher Assessment: 15%
Course Outcomes	:	**The successful student will learn:** 1. Students will be able to understand the importance of manufacturing which comprises materials, processes and systems. 2. Students will be able to understand the metal casting, metal working process and able to perform casting of metals, forging and sheet metal operations through practical classes. 3. Students will be able to understand the machining operations, permanent joining processes. They will be able to perform machining operations on Lathe machine and joining through arc and gas welding processes. 4. Students will be able to learn and perform operations related to carpentry, fitting, plastic molding, and Computer Numerical Control (CNC) machines.	
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	2	1	1	-	2	1	1	-	1	1
CO2	2	1	1	-	-	1	1	-	1	1
CO3	2	1	1	-	-	1	1	-	1	1
CO4	2	1	1	-	3	1	1	-	1	1

Syllabus

Concept of Manufacturing- Manufacturing definition; Role of materials, processes and systems in manufacturing; Classification and brief introduction of engineering materials such as metals & alloys, Classification and brief introduction of manufacturing processes.

Sand Casting Process of Metals- Elements of Green Sand Mould; Pattern design and making, 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, Forging, Extrusion, Drawing

Machining Processes: Classification of machining processes & machine tools; Construction, Specification, and operations on Lathe Machine and Drilling machine

Fabrication Processes- Classification of Welding Operations, Types of Joints & Welding Positions; Brief description of Arc, Resistance and Gas welding techniques. Brazing and Soldering.

List of Practical

1. Safety in Workshop (Demonstration) Safety precautions and utilization of hand tools and machines of different shops with safe working habits. Introduction to measuring equipments and gauges of different shops.
2. Carpentry Study of wood works, types of hand tools and machine. Making of one job involving wood work joint
3. Fitting Study of different fits and hand tools. Making of one job involving fitting to size, malefemale fitting with drilling and tapping
4. Welding Study of electric arc welding and gas welding, tools, types of weld joints and safety precaution during welding. Making of one joint using electric and gas welding. Students will be introduced to brazing and soldering (demonstration)
5. Sheet Metal Work Study of different hand tools, machine and sheet metal joints. Making of one utility job in sheet metal
6. Foundry Principles of molding, methods, core & core boxes, preparation of sand mould of given pattern and casting (demonstration)
7. Black Smithy Introduction to hot working and Study of forging hand tools, furnace and machine. Making a job on hot upset forging.
8. Machining Study of lathe machine, cutting tools and turning related operations. Making of one job on lathe machine including facing, step and taper turning, threading operations.
9. Plastic Processing Introduction to plastics and different plastic molding techniques. Study of injection molding process with demonstration.
10. Computer Numerical Control (CNC) Introduction to automation & CNC, Assembly of models of CNC, CNC wood router, engraving and exposure to part programming. Preparation of part program for simple profiles. Making a job on

CNC (Demonstration). 11. Mini Project Team activity – Fabrication of prototype model based on above practical
Text Books: 1 Principles of Modern Manufacturing: Materials, Processes and Systems Mikell P. Groover John Wiley **References books** 1. Elements of Workshop Technology (Volume 1: Manufacturing Processes, Volume 2: Machine Tools) S. K. Hajra Choudhury, A. K. Hajra Choudhury and N. Roy Media Promoters & Publishers Pvt Ltd., 2010 2. Manufacturing Engineering and Technology Serope Kalpakjian and Steven R. Schmid Pearson, 2013 3. Machinery's Handbook Erik Oberg, Franklin D. Jones, Holbrook L. Horton, Henry H. Ryffel, and Christopher J. McCauley Laura Brengelman Industrial Press, Inc., 2020 4. Mechatronics HMT McGraw Hill Education, 2017 5. Manufacturing Processes I, https://nptel.ac.in/courses/112107144 NPTEL course 6. Fundamentals of manufacturing processes https://onlinecourses.nptel.ac.in/noc22_me71/preview Swayam Course

MEN11601/MEN12601 Engineering Graphics			
Designation	:	Compulsory	
Pre-requisites	:	Nil	
Credit and Contact hrs	:	1(L) - 0(T) – 2(P) – 2(Cr)	
Assessment Methods	:	Theory Part: End Semester Exam: 40% Mid Semester Exam: 20% Teacher Assessment: 10%	Practical Part: End Semester Exam: 15% Teacher Assessment: 15%
Course Outcomes	:	**The successful student will learn:** 1. Understand the importance and principles of engineering drawing by hand practice and using computer aided drafting software. 2. Understand the isometric and orthographic projections of different objects. 3. Create assembly drawing of simple machine 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			√		√	√		√		

1. Introduction to engineering drawing and its importance in real life design and manufacturing. Standards in drawing practice viz. types of lines, lettering, dimensioning, scales etc.
2. Introduction to isometric and orthographic projection. Orthographic projection of points, projection of lines, projection of planes, orthographic views of solids sketching of the same for conceptualization.
3. Introduction to computer aided drafting software and hands on practice of orthographic views of solid objects.
4. Sectional views of solid objects and hands on practice of sectional views of solid objects using computer aided drafting software.
5. Introduction to temporary fasteners (e.g. screwed fasteners, keys, cotters etc.) Details of screwed fasteners (e.g. bolt, nut, stud, screw etc), terminology of threads, types (e.g. V, square, acme, single/multi start, left/right-handed etc). Assembly drawing of nut-bolt using computer aided drafting software.

<u>Text Books:</u>

1 Engineering Drawing Jolhe D. A. Tata McGraw Hill Education

<u>References books</u>

1. Engineering Drawing Basant Agrawal, C. M. Agrawal Tata McGraw Hill Education.
2. Machine Drawing K L Narayana, P. Kannaiah, K. Venketa Reddy New Age International publishers
3. Machine Drawing includes AutoCAD Ajeet Singh Tata McGraw Hill Publishing Company Ltd.
4. Elementary Engineering Drawing Bhatt ND Charotar Publishing.

IDN11600 Introduction to 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: 50 marks Mid Semester Exam: 25 marks Teacher Assessment: 25 marks
Course Outcomes	:	**The successful student will learn:** 1. This course enables the students to become conversant with the structural and functional attributes of ecosystem and environment. Moreover, the students will understand the impact of climate change and pollution on its resources including biodiversity.
Modes of Delivery	:	Talk and chalk, Power point presentations, and practical etc.
Mapping of course outcomes with program outcomes		

Syllabus

Unit-1 Introduction to environmental science. Ecology, biodiversity and conservation. Biomagnification and Biotransformation. Bioremediation and phytoremediation. Biosorption and bioaccumulation. Biological wastewater treatment. Bioenergy. Need for public awareness.

Unit-2 Environmental pollution: sources, causes and effects. Environmental monitoring (EMP) and EIA. Control/ mitigation measure for water, soil and air pollution. Solid waste management. Sustainable development goals (SDG). Environmental laws/ Acts.

Unit-3 Current environmental issues of major concerns - acid rain, ozone layer depletion, global warming and climate change. Carbon ecology footprint and reduction. Case studies highlighting the impacts on society. Technological intervention.

References books

1. A Basic Course in Environmental Studies. Deswal. Pub. Dhanpat Rai Sons. 2013
2. Environmental Studies. E. Bharucha. Pub. University Press. 2018
3. Environmental Engineering. Peavy et.al. Pub. McGraw Hill. 2013
4. A Text Book of Environmental Engg. Venugpal Rao. Pub. PHI learning. 2012

Semester-II

MAN12106 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: 50 marks Mid Semester Exam: 25 marks Teacher Assessment: 25 marks
Course Outcomes	:	**The successful student will learn:** 1. This unit is designed to make students familiar with the basic concepts of linear algebra, such as vector spaces, basis, dimension, linear transformation, solvability of a system of linear equations. 2. Students will learn basic concepts like eigenvalues, eigenvector, quadratic form, and diagonalization, which are fundamental concepts in many engineering problems. 3. The course provides a basic understanding of Laplace transformation to address the engineering problems governed by ordinary and partial differential equations. 4. This unit provides fundamental knowledge about the Fourier series and Fourier transforms, which are fundamental concepts for solving boundary value problems and signal processing. 5. Development of the basic understanding and solution methods for the linear/nonlinear partial differential equations which arises in the modelling of engineering/physical problems. 6. The student will be able to classify and solve the PDE's of second order which arises in the modeling of many engineering/physical problems. Also, the students will be able to apply the technique to solve wave and Laplace equations
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	2	2	1	1	1	-	-	-	-	1
CO2	2	2	1	1	1	-	-	-	-	1
CO3	3	3	1	2	1	-	-	-	-	1
CO4	3	3	1	2	1	-	-	-	-	1
CO5	3	2	2	1	1	-	-	-	-	1
CO6	3	3	2	2	1	-	-	-	-	1

Syllabus

Linear Algebra:

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

Eigenvalues and Eigenvectors:

Eigenvalues and Eigenvectors, Cayley-Hamilton theorem, Application of Eigenvalues and Eigen-vectors, Quadratic form, Diagonalization, Canonical forms.

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 Transform, 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.

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, Non-homogeneous 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 and Wave equation, Laplace Equation

Text Books:

1. R.K. Jain & S. R. K. Iyenger, Advanced Engineering Mathematics, 5th edition**,** 2016, Narosa Pub.
2. B.S. Grewal, Higher Engineering Mathematics, 44nd edition**, 2018,** Khanna Publishers.

Reference Books and Online Source:

1. Erwin Kreyszig, Advanced Engineering Mathematics, 10th Edition, 2015, John Wiley & Sons.
2. Qazi Zameeruddin & Surjeet Singh, Modern Algebra, 9th edition 2021, S Chand Publication
3. Online Source: NPTEL.

AMN12103 Metallurgical Thermodynamics and Kinetics

Designation	:	Compulsory
Pre-requisites	:	Phase diagrams
Credit and Contact hrs	:	3(L) - 1(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 50 marks Mid Semester Exam: 25 marks Teacher Assessment: 25 marks
Course Outcomes	:	**The successful student will learn:** 1. To identify thermally activated processes in materials and metallurgy. 2. To understand thermal properties of materials. 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), Applications to heat treatments.

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

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

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.

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'

AMN12102 Fluid Mechanics		
Designation	:	Compulsory
Pre-requisites	:	Engineering Mechanics, Mathematics-I
Credit and Contact hrs	:	3(L) - 0(T) – 0(P) – 3(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 50 marks Mid Semester Exam: 25 marks Teacher Assessment: 25 marks
Course Outcomes	:	**The successful student will learn:** 1. To give fundamental knowledge of fluid, its properties, hydrostatic laws and application of mass, momentum and energy equation in fluid flow. 2. To develop understanding about Dimensional Analysis, different types of flows and losses in a flow system. 3. To learn the importance of flow measurements and its applications in Industries. 4. To develop basic knowledge of hydraulic machines and its 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	3	2	1	1	1	-	-	-	-	-
CO2	3	2	1	1	2	-	-	-	-	-
CO3	-	-	2	-	2	-	-	-	-	-

Syllabus

Introduction to Fluid Mechanics: Statics and Kinematics Fluid and continuum, Physical properties of fluids, Types of fluid flows, Rheology of fluids. Manometers, pressure transducers, pressure on plane and curved surfaces, centre of pressure, Kinematics of Fluid flow: steadiness, uniformity, rotational and irrotational flows, streamline, streakline, pathline, continuity equation, stream function and velocity potential, applications of potential flow.

Dynamics Of Fluid Flow and Dimensional Analysis: Euler's Equation of motion along a streamline and its integration, Bernoulli's equation and its applications, momentum equation and its application to pipe bends. Dimensional Analysis, Buckingham's Pi theorem, important dimensionless numbers and their physical significance, geometric, kinematic and dynamic similarity, model studies, Hydraulic similitude.

Laminar and Turbulent Flows: Equation of motion for laminar flow through pipes, Stokes law, transition from laminar to turbulent flow, types of turbulent flow, isotropic and homogenous turbulence, scale and intensity of turbulence, eddy viscosity, Prandtl's mixing length theory, velocity distribution in turbulent flow over smooth and rough surfaces, resistance to flow, minor losses, pipe in series and parallel, power transmission through a pipe, three reservoir problems and pipe network.

Hydrodynamic Boundary Layer: Introduction with a historical background, boundary layer, displacement and momentum thickness, boundary layer over a flat plate, Prandtl boundary layer equation, laminar boundary layer, application of momentum equation, turbulent boundary layer, laminar sub-layer, separation and its control, drag and lift, drag on a sphere, 2D cylinder and aerofoil, Magnus effect.

Measurement Techniques & Introduction to Hydraulic Machines: Flow measurement by Pitot tube, orifice, Venturi, nozzle, and bend meter, rotameter, Introduction to Hydroelectric power station and its components, Classification of turbines and pumps, similarity laws and specific speed, efficiency, cavitation.

References books

1. Munson, Young and Okiishi's Fundamentals of Fluid Mechanics, 9e by Philip M. Gerhart, Andrew L. Gerhart, John I. Hochstein, Wiley.
2. Fox, R.W., McDonald, A.T., Introduction to Fluid Mechanics, 7th edition, Wiley India.
3. Som, S.K. and Biswas G, Introduction of Fluid Mechanics & Fluid Machines, TMH, New Delhi. •
4. Mohanty, A.K., Fluid Mechanics, PHI Learning, New Delhi.
5. Shames, I.H., Mechanics of Fluids, McGraw Hill, International Students Edition.
6. Agarwal, S.K., Fluid Mechanics and Machinery, TMH, New Delhi.
7. Rathakrishnan E., Instrumentation, Measurements and Experiments in Fluids, CRC Press, New York
8. Jagdish Lal, Fluid Mechanics, Metropolitan Book Company Ltd., Delhi

Semester-III

AMN13111 Phase Diagrams and Phase Transformation			
Designation	:	Compulsory	
Pre-requisites	:	Chemistry	
Credit and Contact hrs	:	3(L) - 0(T) – 2(P) – 4(Cr)	
Assessment Methods	:	Theory Part: End Semester Exam: 40% Mid Semester Exam: 20% Teacher Assessment: 10%	Practical Part: End Semester Exam: 15% Teacher Assessment: 15%
Course Outcomes	:	**The successful student will learn:** 1. To understand the thermodynamics parameter affecting the phase formations 2. To analyse and tailor the phase in materials 3. To understand the importance of phase on the properties of the materials	
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			√	√		√	√	√		

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;

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

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.

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.

Heat Treatment Processes: Transformation rate effects and TTT diagrams. Microstructure and property changes in iron-carbon system, Iron-Carbon (Fe-C or Fe-Fe3C) Diagram

List of experiments:

1. Concepts in Phase Transformations & Heat Treatment.
2. Annealing & Normalizing.
3. Spherodising & Hardening.
4. Nucleation of Ice from Water: A Modelling Approach.
5. Study of nucleation and growth in Eutectoid steel
6. Jominy End Quench Test.
7. Carburization of Steel.
8. Precipitation Hardening.
9. Differential Scanning Calorimetry

References books

1. Phase Transformations in Metals and Alloys, Porter, Easterling; 3ed 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

AMN13101 Mechanics of Materials

Designation	:	Compulsory
Pre-requisites	:	Engineering Mechanics
Credit and Contact hrs	:	3(L) - 0(T) – 2(P) – 4(Cr)
Assessment Methods	:	Theory Part: End Semester Exam: 40% Mid Semester Exam: 20% Teacher Assessment: 10% Practical Part: End Semester Exam: 15% Teacher Assessment: 15%
Course Outcomes	:	**The successful student will learn:** 1. Understand the concept of internal forces and moments, stress, strain, deformations in members subjected to axial, bending and torsional loads 2. Understand the concepts of stress and strain at a point, and principal stress and strain to solve the problems of engineering elasticity 3. Apply the concepts to calculate stress, strain, and displacements in mechanical structures and components containing the fundamental elements such as beams, shaft, shells and springs 4. Analyze the mechanical engineering structures and components for safer mechanical design by considering appropriate failure criteria and the design requirements.
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					√				√	

<u>Syllabus</u>

Analysis of Stress and Strain: Uniaxial Stress and Strain, Hooke's Law, Stress-Strain Curves, Elastic Constants, Strain Energy, Statically Indeterminate Problems, Thermal Effects, Impact Loading.

Biaxial Stress and Strain: Stress at a Point, Stress Transformation, Analysis of Strain, Strain-Displacement Relations, Strain Transformation, Strain Measurements, Principal Stresses and Strain

Bending and Shear Stresses: Shear Force and Bending Moment Diagrams, Pure Bending, Normal Stress and Shear Stresses in beams, Composite Beams

Torsion of Shaft, Springs, and Pressure Vessels: Torsion of Circular Shaft, Power Transmitted by a Shaft, Compound Shaft, Combined Loadings, ThinWalled Shells, and Springs (Open and Closed Coils)

Deflections of Beams: Equation of Elastic Curve, Methods for Determining Deflections: Double Integration, Macaulay's Method, Moment-Area Method, Castigliano's Theorem

Columns and Theories of Failure: Euler's Theory for Long Columns, Rankine-Gordon Formula, Eccentrically Loaded Columns, Theories of failure

List of experiments:

1. Specimen preparation by cutting, grinding, polishing and etching of given materials for comparative micro-structural examination.
2. To perform the Tensile Test on Universal Testing Machine (UTM) for Mild Steel Specimen and draw the stress strain curve. Using stress strain curve find out the following: (a) Yield Stress (b) Ultimate Stress (c) Breaking Stress (d) Percentage Elongation (e) Percent Reduction in Area (f) Modulus of Elasticity.
3. To predict creep characteristics of given materials by plotting strain vs. time curves for different loadings.
4. To study the effect of surface treatment (Etching) on the strength of glass.
5. To perform Torsion Test on Torsion Testing Machine for Mild Steel Specimen and draw Torque-Twist curve. Using Torque-Twist curve find the following (a) Modulus of Rigidity of the material (b) Yield point value and ultimate point value of the Torque
6. Fabrication and mechanical testing of composite materials made by hand-layup technique in the laboratory.
7. To study the fatigue behavior of different materials.
8. To perform the Impact Test on Impact Testing Machines using (a) Charpy Test (b) Izod Test and find the Impact Strength of the material.
9. To perform the Beam Bending Test on Beam Bending Apparatus and find the value of Modulus of Elasticity by measurement of slope & deflection of the beam and draw Load Vs Deflection Curve.
10. To perform the Shear Test on Shear Testing Machine for Wooden Specimen and find the Maximum Shear Stress (parallel to grain) of the Wood.

<u>References books</u>

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

AMN13112 Extractive Metallurgy		
Designation	:	Compulsory
Pre-requisites	:	Chemistry and Introduction to Materials Engineering
Credit and Contact hrs	:	3(L) - 0(T) – 0(P) – 3(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 50 marks Mid Semester Exam: 25 marks Teacher Assessment: 25 marks

Syllabus

Principles of metals extraction: Thermodynamic principles, homogeneous and heterogeneous reactions, Ellingham diagram, kinetic principles, principles of electro-chemistry
General methods of extraction: Pyrometallurgy – calcination, roasting and smelting, Hydrometallurgy – leaching, solvent extraction, ion exchange, precipitation, and electrometallurgy – electrolysis and electro refining)
General methods of refining: Basic approaches, preparation of pure compounds, purification of crude metal produced in bulk
Brief history of iron and steel making, Raw Materials for Iron Making, Burden Preparation from raw materials, Blast Furnace design and operations, Physical-Thermal-Chemical Processes in a Blast Furnace, Alternative Routes of Iron Production, Steelmaking - basic oxygen and electric arc furnace processes - principles, operation and design aspects. Deoxidation, ladle refining processes – VD, VOD and AOD processes - inclusions in steel.
Nonferrous metals in Indian history, uses of nonferrous metals, Sources of nonferrous metals
Extraction of metals from oxide sources: Basic approaches and special features of specific extraction processes, extraction of metals such as magnesium, aluminum, tin and ferro-alloying elements, production of ferro alloys. Extraction of metals from Sulphide Ores: Pyro-metallurgy and hydrometallurgy of sulphides, production of metals such as copper, lead, zinc, nickel etc. Extraction of metals from Halides: Extraction of metals from halides: Production of halides and refining methods, Methods of extraction of metals such as titanium, rare earths, uranium, thorium, plutonium, beryllium, zirconium etc.

References books

1. Ray, H.S., Sridhar, R. and Abraham, K.P. Extraction of nonferrous metals, Affiliated East West Press Pvt Ltd., New Delhi (2007)
2. Dennis, W.H., Extractive Metallurgy, Philosophical Library, New York (1965)
3. Tupkary, R. H., and V. R. Tupkary. "An Introduction to Modern Iron Making.", Khanna publishers (2004).
4. A. Ghosh and A. Chatterjee, Ironmaking and Steel making: Theory and Practice, Prentice Hall of India, New Delhi, 2008

AMN13113 Polymer Science and Engineering		
Designation	:	Compulsory
Pre-requisites	:	Chemistry
Credit and Contact hrs	:	4(L) - 0(T) – 0(P) – 4(Cr)
Course Objectives		This course provides a sound knowledge in field of polymer science namely, polymer synthesis, characterization, rheology, processing, testing and degradation process.
Assessment Methods	:	Theory Part: End Semester Exam: 40% Mid Semester Exam: 20% Teacher Assessment: 10% Practical Part: End Semester Exam: 15% Teacher Assessment: 15%
Course Outcomes	:	**After completion of the course, students will be able to:** 1. Understand the mechanism of polymerization and its various techniques. 2. Determine the molecular weight and various thermal transitions of polymers using a suitable characterization technique. 3. Choose an appropriate material for specific application based on knowledge of structure-property relation. 4. Understand flow behavior of polymer melt and various processing techniques. 5. Demonstrate the plastic testing method to evaluate its mechanical, electrical and thermal properties. 6. Understand the basic mechanics of polymer composites and its fabrication process.
Modes of Delivery	:	Power point presentations, Videos, Talk and chalk, 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	√			√	√		√			
CO5						√				
CO6	√				√		√			

Syllabus

Chemistry of Polymers: Monomers, functionality, degree of polymerizations, classification of polymers, polymerization methods and their kinetics, copolymerization, techniques for copolymerization, molecular weight, transition temperature and associated properties for polymers.

Polymer Characterization: Determination of number average, weight average, viscosity average and Z-average molecular weights, analysis of polymers using IR, XRD, thermal (DSC, DMTA, TGA), microscopic techniques.

Synthesis and Properties: Commodity and general-purpose thermoplastics, Engineering Plastics, Thermosetting polymers, Natural and synthetic rubbers, Thermoplastic elastomers and blends.

Polymer Rheology: Flow of Newtonian and non-Newtonian fluids, dependence of shear modulus on temperature, measurements of rheological parameters by capillary rotating, parallel plate, cone-plate rheometer; viscoelasticity-creep and stress relaxations, mechanical models, 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, 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, surface and volume resistivity, swelling, ageing resistance, environmental stress cracking resistance.

Polymer Composites: Classification of composites, Types of reinforcement, Macromechanics-Engineering constant, determination of strength and stiffness, Micromechanics of lamina, Classical lamination theory, Processing and testing of polymer composites.

References (books/Journals)

1. Polymer Science, Vasant R. Gowariker, N. V. Viswanathan & Jayadev Sreedhar.
2. Essentials of Polymer Science and Engineering, Paul C. Painter and Michael M. Coleman.
3. Plastics Engineering, R. J. Crawford, Pergamon Press.
4. Text Book of Polymer Science, Billmeyer, John Wiley & Sons.
5. Polymer Physics, Ulf W. Gedde, Chapman & Hall.
6. Principles of Composite Material Mechanics: R. F. Gibson
7. Mechanics of Composite Materials: R. M. Jones

EEN*** Basic Electrical and Electronic Engineering**

Designation	:	Compulsory
Pre-requisites	:	None
Credit and Contact hrs	:	2(L) - 0(T) – 2(P) – 3(Cr)
Assessment Methods	:	Theory Part: End Semester Exam: 40% Mid Semester Exam: 20% Teacher Assessment: 10%
		Practical Part: End Semester Exam: 15% Teacher Assessment: 15%
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

DC Circuit Ohm's Law, Kirchhoff's Laws, Source Conversion, Star Delta transformation, Network Theorems - Superposition theorem, Thevenin's theorem, Norton's Theorem, Maximum Power Transfer Theorem

A.C. Circuit Sinusoidal AC voltage, Average value, R.M.S. value, form factor and peak factor of AC quantity, Concept of phasor, Power factor, impedance and admittance, Active, reactive and apparent power, analysis of R-L, R-C, R-L-C circuit, 3-phase AC Circuits: balanced and unbalanced supply and loads. Relationship between line and phase values for balanced star and delta connections. 3-phase Power measurements.

Electrical Machines Basics- construction, working and applications of transformer, DC machine, 3- phase induction motor and synchronous machine. Losses in electrical machines.

Introduction to Power System and Electrical Safety Basics of Power System (Generation, Transmission & Distribution-general layout). Electrical safety, domestic wiring & electrical measurements, Electrical lightning devices, Energy saving and star ratings, Basic principle of earthing.

Fundamental of Electronics: Basic Electronics - Construction, working and V-I characteristics of diodes. SCR and their applications. Transistors-(BJT, FET, MOSFET), Construction, working, type of configuration, and characteristics Digital– number system, logic gates, Karnaugh map

References books

1. Vincent Del Toro, "Electrical Engineering Fundamentals"
2. Smarajt Ghosh, "Fundamentals of Electrical & Electronics Engineering", Second edition, PHI Learning, 2007.
3. Metha V.K, Rohit Metha, "Basic Electrical Engineering", Fifth edition, Chand. S & Co. 2012.
4. Kothari. D.P and Nagrath. I.J, "Basic Electrical Engineering", Second edition, Tata McGraw - Hill, 2009.
5. Horowitz and Hill, "Art of Electronics", Cambridge University Press.
6. Robert L. Boylestad and Louis Nashelsky "Electronic Devices and Circuit Theory" Tenth Edition,Pearson Education, 2013

HSN13601 Management Concepts and Application

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: 50 marks Mid Semester Exam: 25 marks Teacher Assessment: 25 marks
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

Unit I: Introduction and Development of Management Approaches

Concept and definition of management, Various ways to understand the management, function of Managers, managerial skill, Role of managers, Functional areas of management, Principles of management, Management Vs. Administration. Approaches to management, Classical theories, Management process approach, Bureaucracy Approach, Neo-classical approach, 20 | P a g e

Behavioral Sciences Approach, System Approach, Contingency Approach, Functions of Management.

Unit II: Planning

Nature and Definition of planning, Benefits of planning, Principles of planning, Kind of planning, steps in planning, Standing and single use planning, corporate planning and strategy formulation, Management by Objective, Management by Exception, Planning premises.

Unit III: Organizing

Concept and definition of Organization, Organization structure, Principles of organization, Form of organization, Departmentation, Formal and informal organization, Organizational culture and conflict management.

Unit IV: Direction

Concept and definition of direction, principles of direction, supervision and its significance, Leadership, Motivation, Communication and Coordination.

Unit V: Control and other Managerial Practices

Concept and definition of control, characteristics and principles of control, Control techniques, Budgetary Control, Change Management, Stress management, Emerging challenges in Management, Case Studies and Social Entrepreneurship.

References books

1. VSP RAO-Managing Organization (EXCEL 1 EDITION)
2. Chaturvedi& Saxena -Managing Organization (Himalaya Publication)
3. Stoner, Freeman & Gilbert Jr - Management (Prentice Hall of India)
4. 4 Robbins-Organization Behavior -15 e Prentice Hall
5. Koontz Harold &Weihrich Heinz – Essentials of management
6. T.N. Chhabra- Principles and Practices of Management, (Dhanpat Rai & Co.)
7. Luthans Fred - Organizational Behaviour (Tata Mc Graw Hill)
8. Mc Shane L. Steven, Glinow Mary Ann Von & Sharma Radha R. - Organizational Behaviour (Tata Mc Graw Hill)

Semester-IV

AMN14102 Applied Mathematics and Computation			
Designation	:	Compulsory	
Pre-requisites	:	Mathematics	
Credit and Contact hrs	:	3(L) - 0(T) – 2(P) – 4(Cr)	
Assessment Methods	:	Theory Part: End Semester Exam: 40% Mid Semester Exam: 20% Teacher Assessment: 10%	Practical Part: End Semester Exam: 15% Teacher Assessment: 15%
Course Outcomes		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 Modelling. 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	

Syllabus

Review of Elementary Engineering Mathematics: Error and its propagation, Solution of homogeneous and non-homogeneous equations; Power series.
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.
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.
Statistical Computations: Frequency Chart, Regression Analysis, Least Square fit, Polynomial fit, Linear and Nonlinear Regression, Multiple Regression, Statistical Quality Control Methods.

Lab Exercises on Numerical Methods:

1. Numerical Linear Systems Gaussian Elimination method with pivoting Gauss-Seidal iterative methods, Power methods
2. Interpolation, Approximations and Quadratures Newton divided-difference and finite difference Interpolation, Composite Simpson and Composite Gaussian quadratures Cubic Spline Approximation.
3. Numerical methods for ordinary Differential Equations Euler's method. Fourth order Runge-Kutta Method, Adams-Bashforth Multi-Step method
4. Finite Difference Methods for BVP s Two-Point BVP, Elliptic Equations, Parabolic Equations, Hyperbolic Equation
5. Linear Programming Models Simplex Method, Big M method – Bounded Variables method.
6. Integer Programming Models Cutting plane method, Branch and Bound method

References books

1. S. C. Chapra and R. P. Canale, Numerical Methods for Engineers.
2. R. W. Hamming, Numerical Methods for Scientists and Engineers (Dover Books on Mathematics).
3. Amos Gilat, Numerical Methods for Engineers and Scientists.
4. K.E. Atkinson, An Introduction to Numerical Analysis.
5. G. E. Golub and C.F. Van Loan, Matrix Computations.

AMN14109 Ceramic Engineering		
Designation	:	Compulsory
Pre-requisites	:	Introduction to Materials Engineering
Credit and Contact hrs	:	3(L) - 0(T) – 0(P) – 3(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 50 marks Mid Semester Exam: 25 marks Teacher Assessment: 25 marks

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, 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 & cold pressing, fibre forming, blowing, powder crushing, slip casting, hydro plastic forming, extrusion, centering, 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, polymerization, 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, 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.

References books

1. Introduction to ceramics, W. D. Kingery, Harvey Kent Bowen, Donald Robert Uhlmann.
2. Ceramic Materials: Science and Engineering, C. Barry Carter, M. Grant Norton, Springer.
3. Handbook of Advanced Ceramics Vol II, Processing and their Applications, Shigeyuki Somiya, Elsevier Acadmic Press.
4. Mechanical Properties of Ceramics, Watchman J. B., John Wiley, New York.
5. Series in Materials Science and Engineering – Fundamentals of Ceramics, Michel W. Barsoum, Institute of Physics Publishing, Bristol and Philadelphia.
6. Phase Equilibria and Crystallography of Ceramic Oxides, Journal of Research of the National Institute of Standards and Technology, Volume 106, Number 6, November–December 2001.
7. Electronic Ceramics, IEEE transactions.
8. Ceramic Processing and Sintering, M. N. Rahman, Marcel Dekker, Inc./CRC Press.

AMN14110 Electrical, Electronic and Magnetic Materials		
Designation	:	Compulsory
Pre-requisites	:	Introduction to Materials Engineering
Credit and Contact hrs	:	3(L) - 0(T) – 0(P) – 3(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 50 marks Mid Semester Exam: 25 marks Teacher Assessment: 25 marks
Course Outcomes	:	1. Understand various electrical phenomenon such as band gap theory, ferro electricity, piezo electricity and pyro electricity along with dielectric behaviour of materials 2. To study various kinds of magnetism principles, various types of materials exhibiting magnetism and their day-to-day applications in industry with recent advancements 3. To study the theory of superconductivity phenomenon and superconducting materials and their applications along with recent advancements 4. Understand the fundamentals of semiconducting materials and operational principles of solid-state devices made of these semiconducting materials. To learn various methods of producing semiconductors and their processing methods used in the semiconducting materials industry. **5.** To learn about photoconduction phenomenon, optical materials and various optical devices and their performances

Syllabus

Free electron theory - Band theory - discussion on specific materials used as conductors - Dielectric phenomena - concept of polarization- frequency and temperature dependence - dielectric loss - dielectric breakdown - ferro electricity - piezo electricity and pyro electricity – $BaTiO_3$ – structure and properties.

Origin of Magnetism - Introduction to dia, para, ferri and ferro magnetism – Curie temperature – Magnetic anisotropy - hard and soft magnetic materials- iron based alloys - ferrites and garnets – rare earth alloys - fine particle magnets.

Concept of superconductivity – BCS theory of super conductivity – Types of super conductors –YBCOstructure and properties – specific super conducting materials – Fabrication and engineering applications.

Semiconducting materials and types; simple, compound and oxide semiconductors – semiconducting materials in devices – Production of silicon starting materials – methods for crystal growth for bulk single crystals- zone melting – Czochralski method – Epitaxial films by VPE, MBE and MOCVD techniques – Lithography

Principles of photoconductivity, luminescence- - photo detectors – Optical disc and optoelectronic materials –LCD, LED and diode laser materials - electro optic modulators - Kerr and Pockel's effect – $LiNbO_3$

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.
5. Introduction to Magnetic Materials, B. D. Cullity, Addison-Wesley Publishing Company, California, London, 1972.
6. Magnetism and Magnetic Materials, J. P. Jakubovics, Institute of Materials, London, 1994.
7. Physics of Dielectric Materials, Tareev B., MIR, 1975.
8. Electronic Properties of Materials, Rolf E. Hummel, Springer, 2004.
9. Principles of Electronic Materials and Devices, Safa O. Kasap, McGraw-Hili, 2005.
10. Electronic Materials Science, Irene, Wiley-Interscience, 2006.

AMN14111 Mechanical Behaviour of Materials

Designation	:	Compulsory	
Pre-requisites	:	Mechanics of Materials	
Credit and Contact hrs	:	3(L) - 1(T) – 0(P) – 4(Cr)	
Assessment Methods	:	Theory Part: End Semester Exam: 40% Mid Semester Exam: 20% Teacher Assessment: 10%	Practical Part: End Semester Exam: 15% Teacher Assessment: 15%
Course Outcomes	:	**After the completion of this course, students will be able to** 1. To identify the properties of materials. 2. Understand the behaviour of materials under different type of loading conditions. 3. Able to develop materials against actual engineering problems.	

<u>Syllabus</u>

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 Burger's 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, 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.

Mechanical Characterization of Materials: Mechanical testing for material Characterization, Measurement techniques in experimental solid mechanics, Nondestructive testing

<u>References books</u>

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.

AMN14112 Characterization of Materials		
Designation	:	Compulsory
Pre-requisites	:	Introduction to Materials Engineering
Credit and Contact hrs	:	3(L) - 0(T) – 2(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 50 marks Mid Semester Exam: 25 marks Teacher Assessment: 25 marks
Course Outcomes	:	**After the completion of this course, students will be able to** 1. To provide an introduction to materials characterization and its importance. 2. To discuss different types of characterization techniques and their uses. 3. To review the topic of crystal structure and how structures can be determined using diffraction methods. 4. To describe the properties and behavior of x-rays and their use in materials characterization. 5. To describe the operation and use of a TEM, SPM and a SEM.

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, phase diagram determination.

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, polarized light microscopy, hot-stage microscopy, sample preparation.

Electron Microscopy: Electron sources, electron diffraction, principles and operation of scanning electron microscope. Construction 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 tunneling microscope, atomic force microscope, magnetic force microscopy, topography studies, nano-indentation and its probing.

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

List of experiments:

1. X-ray diffraction
2. Optical Microscopy
3. Electron Microscopy
4. Scanning probe microscopy
5. Thermal analysis

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.

Semester-V

AMN15106 Materials Selection and Design			
Designation	:	Compulsory	
Pre-requisites	:	None	
Credit and Contact hrs	:	3(L) - 0(T) – 2(P) – 4(Cr)	
Assessment Methods	:	Theory Part: End Semester Exam: 40% Mid Semester Exam: 20% Teacher Assessment: 10%	Practical Part: End Semester Exam: 15% Teacher Assessment: 15%
Course Outcomes	:	**After the completion of this course, students will be able to** 1. Recognize and develop lists of independent and dependent parameters for an engineering design from which to develop quantitative measures of performance. 2. Develop optimization equations for selection of materials for defined design projects. 3. Use material property plots to identify the best performing materials for a given 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			√		√	√		√	√	

Syllabus

Materials Selection in Design: General criteria for selection, performance characteristics of materials, materials selection process, design process and materials selection, economics of materials, recycling and materials selection.

Materials Properties and Design: Role of Crystal Structure. Stress – Strain diagram, Design forstrength, Rigidity. Effect of static strength, stiffness, fracture toughness, Design for yielding and fracture toughness fatigue, creep and wear resistance, brittle fracture, fatigue failure, corrosion resistance. Designing with plastics, brittle materials. Design examples with shaft design, spring design and C-frames

Manufacturing Considerations in Design: Surface finish, Texture, Dimensional tolerances in fitting, interchange ability selective assembly, and geometric tolerance.

Types of design, Design tools and materials data Design under static loading, variable loading,and eccentric loading – stress concentration. Design examples with shaft design, spring design andC-frames, Materials and shape – microscopic and microstructural shape factors – limit to shape efficiency Comparison of structural sections and materials indices – case studies.

Materials Selection using Ashby Method, Case Studies, Multiple Constraints in materials selection,Multiple Objectives, Role of Materials in Shaping the Product Character.

Lab Work

6. To study cooling curve of a binary alloy.
7. Determination of the elastic modulus and ultimate strength of a given fiber strand.
8. To determine the dielectric constant of a PCB laminate.
9. Detection of flaws using ultrasonic flaw detector.
10. To determine fiber and void fraction of a glass fiber reinforced composite specimen.
11. To investigate creep of a given wire at room temperature.
12. To estimate the Hall coefficient, carrier concentration and mobility in a semiconductor crystal.
13. To estimate the band-gap energy of a semiconductor using four probe technique.
14. To measure grain size and study the effect of grain size on hardness of the given metallic specimens.

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.

AMN15107 Nano-materials			
Designation	:	Compulsory	
Pre-requisites	:	None	
Credit and Contact hrs	:	3(L) - 0(T) – 2(P) – 4(Cr)	
Assessment Methods	:	Theory Part: End Semester Exam: 40% Mid Semester Exam: 20% Teacher Assessment: 10%	Practical Part: End Semester Exam: 15% Teacher Assessment: 15%
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: Introduction to nano composites, their synthesis and applications
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 bilk nano-structuring on magnetic properties, Dynamics of nano-magnets, Nanopore containment, Nanocarbon ferromagnets, Giant and colossal magnetoresistance, and Ferrofluids.

List of Experiments

1. Synthesis of aluminosilicate by sol-gel route.
2. Characterization of aluminosilicate by XRD.
3. Hydrothermal synthesis of ceramic powders.
4. Precipitation reaction of mixed metal oxides.
5. Particle size distribution and zeta potential analysis of mixed metal oxides.
6. Bottom up synthesis of CdS/CdSe nanoparticles; Optical absorption spectra; Band gap estimation from the band edge.
7. Characterization of semiconductor nanomaterial by FESEM and DLS.
8. Chemical synthesis of Ag nanoparticles-Turkevich method; UV-Visible absorption of the colloidal sol; Mie formalism; Estimation of size by curve fitting.
9. Synthesis of TiO2 by sol gel method and study its photocatalytic activity in the degradation of organic contaminants.
10. Preparation of polymer nanocomposite and study of its mechanical properties.
11. Thermal analysis of polymer materials using TGA/DSC.
12. Synthesis of polysilanes and characterization by IR spectroscopy

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.

AMN15108 Advances in Materials Application

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: 50 marks Mid Semester Exam: 25 marks Teacher Assessment: 25 marks
		Internal Assessment: (Scheme) 25 marks (Marks on the basis of assignment submission, Surprise Tests, Term paper etc)
Course Outcomes	:	**The successful student will learn:** 1. . 2. . 3. .
Modes of Delivery	:	Talk and chalk, Demonstration in laboratory, 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

Materials for Energy Applications: Materials for nuclear power generation, Materials in fuel cells and solar cells, Materials in thermal power generation, Materials in hydro power generation, Energy storage material applications.

Intelligent and Smart Material Applications: Piezoelectric, electrostrictive, magnetostrictive, pyroelectric, electrooptic, Piezomagnetic, etc. materials, Smart composites, Biomorphs/Moonies, Memory devices, Sensors and actuators, Liquid Crystal display, etc.

Ceramics for Advanced Applications: Advanced ceramics, Ceramics for conduction, Ceramics for magnetic applications, Ceramics for multilayer devices and their applications, Ceramics for batteries and solar cells application, Ceramics for sensors and actuators, Ceramics for aerospace applications, Ceramics for bio-medical applications, etc.

Materials for Aerospace Applications: Essential requirements of materials for automotive and aerospace applications, Light metals and alloys, High temperature materials, Rare earth elements, Superalloys, High performing composites, and Metallic an non-metallic foams.

Materials for Nanotechnology and Nanoscience: Micro and nano sensors, Micro and nano actuators, Micro and nano system, Carbon nanostructures,

Materials for Semiconductor Devices and Electronics: Semiconductor nanoparticles–applications, Optical luminescence and fluorescence from direct band gap semiconductor nanoparticles, Semiconductor quantum dots, Semiconductor quantum dot arrays, etc.

References books

1. Nuclear Reactor Materials and Applications, B.M. Ma, Van Nostrand Reinhold Company.
2. Handbook of Fuel Cells, Wolf Vielstich, Arnold Lamm, Hubert A. Gasteiger, and Harumi Yokokawa, John Wiley and Sons, Inc.
3. Advanced Power Plant Materials, Design and Technology, Edited by D Roddy, Woodhead Publishing Series in Energy No. 5 and CRC Press.
4. Ferroelectric Devices- Kenji Uchino, Marcell Decker Inc., 2000.
5. Smart Material Systems: Model Developments, Ralph C. Smith, Cambridge University Press, Series: Frontiers in Applied Mathematics (No. 32), 2005.
6. Ceramic Materials for Electronic Application, edited by R. C. Buchanon, CRC Press.
7. Introduction to Ceramics, W. D. Kingery, Harvey Kent Bowen, Donald Robert Uhlmann.
8. Modern Magnetic materials: Principles and Applications, R. C. O'Handly, John Willy & Sons, Inc.
9. Light Alloys: From Traditional Alloys to Nanocrystals, I. J. Polmear, Elsevier/Butterworth-Heinemann.
10. The Superalloys Chester T. Sims, Wiley-Interscience.
11. Victor I. Klimov, Semiconductor and Metal nanocrystals, Marcell-Dekker

AMN15109 Composite Materials

Designation	:	Elective
Pre-requisites	:	Polymer Science and Composites, Basic Engineering Mathematics, Linear Algebra, Differential Equations
Credit and Contact hrs	:	3(L) - 0(T) – 0(P) – 3(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 50 marks Mid Semester Exam: 25 marks Teacher Assessment: 25 marks
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: 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.

References books

1. Mechanics of fibrous composites: Carl T. Herakovic
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

<table>
<tr><td colspan="4" align="center">AMN15351 Group Project/Research Project-I</td></tr>
<tr><td>Designation</td><td>:</td><td colspan="2">Compulsory</td></tr>
<tr><td>Pre-requisites</td><td>:</td><td colspan="2">None</td></tr>
<tr><td>Credit and Contact hrs</td><td>:</td><td colspan="2">1(L) - 0(T) – 2(P) – 2(Cr)</td></tr>
<tr><td>Assessment Methods</td><td>:</td><td>Theory Part:
End Semester Exam: 40%
Mid Semester Exam: 20%
Teacher Assessment: 10%</td><td>Practical Part:
End Semester Exam: 15%
Teacher Assessment: 15%</td></tr>
</table>

Syllabus

Purpose and Objectives of independent project, Classification of projects based on different types of industries. The Art of “Searching, Reading and Selecting” the relevant project. Formulation of project. Role of mentor.

Project Design: Qualitative and Quantitative project design. Representation of Data, Types of Measurement Scales, Concept of Normality, Skewness and Dispersion of Data.

Project Writing and Presentation: Analysis with Results, Types of Graphs, Structure and Components of Reports, Tyes of Report, Steps in the Preparation of Report, Layouts, Excel, power point presentations, Illustrations and Tables, Bibliography, Referencing, Footnotes, Planning and Preparation of Presentation, Visual Aids in Presentation and use of other online medias etc. Conclusion and Future works related to the projects.

References books

1. CR Kothari and Gaurav Garg: Research methodology: Methods and Techniques, New Age International Publication.
2. Barbara Gastel and Robert A. Day: How to Write and Publish a Scientific Paper, Greenwood Publication.
3. Arnold D. Well, et al.: Research Design and Statistical Analysis, Routledge Publications.

Semester-VI

AMN16104 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 Part: End Semester Exam: 40% Mid Semester Exam: 20% Teacher Assessment: 10%	Practical Part: End Semester Exam: 15% Teacher Assessment: 15%
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.

Molecular dynamics: Introduction to Molecular Dynamics and Monte-Carlo simulations.

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.

Experiments related to Calculation of optical properties, magnetic moment in a system, surface energy, stacking fault energy, stiffness tensor, phonon dispersion relation, thermodynamic properties from the phonon dispersion relation, Raman spectra and IR spectra. Performing an ab initio Molecular dynamics simulation.

List of Experiments

1. Plotting of state variables (Phase space & state space) of a given dynamical system.
2. Numerical solution of different integral and differential equations using Scilab/Python/MATLAB.
3. Molecular dynamics.
4. Monte-Carlo simulation.
5. Plasticity modeling using dislocation models.
6. Simulation of fracture processes.
7. Atomistic modeling of nano-scale fracture and failure.
8. Designing ultra-strong alloys by nanostructuring.
9. Deformation mechanisms in metallic multilayers with modulated grain sizes.
10. Mechanics of 2D materials.
11. Damage and failure in composite materials.

Hands-on training is be provided on state-of-the-art atomistic modeling techniques, specifically molecular dynamics (MD) and density functional theory (DFT). For MD, LAMMPS, whereas for DFT Quantum-Espresso.

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.

AMN16105 Materials in Services

Designation	:	Compulsory
Pre-requisites	:	Chemistry
Credit and Contact hrs	:	3(L) - 0(T) – 2(P) – 4(Cr)
Assessment Methods	:	Theory Part: End Semester Exam: 40% Mid Semester Exam: 20% Teacher Assessment: 10% || Practical Part: End Semester Exam: 15% Teacher Assessment: 15%
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
CO1										
CO2										
CO3										
CO4										

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.

Tribology: definition, significance, economic aspects, trends. Factors influencing tribological phenomena. Engineering surfaces - Surface characterization, Genesis of friction, friction in contacting rough surfaces, sliding and rolling friction, various laws and theory of friction. Wear and wear types. Mechanisms of wear - Adhesive, abrasive, corrosive, erosion, fatigue fretting, etc., Introduction to lubrication. Introduction to micro and nano tribology.

Life Cycle Assessment: Introduction to Life Cycle Assessment (LCA), Importance of LCA for the Engineering professionals, Guidance for life cycle assessment, Overview of International Standards ISO 14044 (2006), Four major stages or steps of LCA and ther relevant guidelines, Environmental impact categories in LCA.

Introduction to Life cycle assessment software. Expectation from the basic results, Inventory and impact categories and assessment, Contribution analysis, Sensitivity and Monte Carlo analysis, Interpreting the results and their meaning, Implications and strength of LCA studies, Limitations of an LCA. Sustainability in resources industries, energy, mining and mineral processing, Sustainability in the context of metal production.

Environmental Management System (EMS), benefits, procedures and guidelines to develop EMS documents according to ISO. PDCA in the context of EMS.

Experiments related to Corrosion testing, Surface topography measurements, Friction testing, Scratch testing and wear testing.

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, Metals Handbook, Vol.13 A & B, 9th ed., ASM.
4. The Fundamental of Corrosion, J. C. Scully, 2nd ed., Pergamon Press.
5. Fundamentals of Electrochemical Corrosion, E. E. Stansbury and R. A. Buchanan, ASM International.
6. Heinrichs, H., Martens, P., Michelsen, G., Wiek, A., Sustainability Science An Introduction, Springer.
7. Hauschild, M.Z., Rosenbaum, R.K., Olsen, S.I., Life Cycle Assessment Theory and Practice, Springer.
8. Klöpffer, W., Grahl, B., Life Cycle Assessment (LCA): A Guide to Best Practice, Wiley.
9. Hoekstra, A.Y., Chapagain, A.K., Aldaya, M.M., Mekonnen, M.M., The water footprint assessment manual: Setting the global standard. Routledge.

HSN16603 Soft Skills and Personality Development

Designation	:	Compulsory
Pre-requisites	:	None
Credit and Contact hrs	:	2(L) - 0(T) – 1(P) – 3(Cr)
Assessment Methods	:	Theory Part: End Semester Exam: 40% Mid Semester Exam: 20% Teacher Assessment: 10%
		Practical Part: End Semester Exam: 15% Teacher Assessment: 15%
Course Outcomes	:	**The successful student will learn:** 1. Understand the significance of soft skills and personality development. 2. Communicate effectively through soft skills and improve the listening skills. 3. Enable them to actively participate in group discussion, meetings, interviews and prepare and deliver presentations. 4. Learn the techniques to improve soft skills and personality. 5. Enable them to understand themselves and evaluate the individual's personality.
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										

Unit I: Introduction to Soft Skills and its Significance
Introduction of soft skill, significance of soft skill, Behavioural Approaches to Enhance Communication Skills, types of soft skills, Positive Thinking and Negotiation Skills.
Unit II: Personality Improvement and its techniques Time Management and its Relevance, Interpersonal Skills and Group Behaviour, Change and Conflict Management, Identification of Self and Self Esteem, Mindfulness and Quality of Work Life.
Unit III: Personality Evaluation and Enhancement Managing Emotions and its Relevance in Personality Development, Life Management with Success and Failure, Personality and Social Skills Development, 7 C s of Communication and Personality Development
Unit IV: Information and Communication Technology Skills understanding the technology for effective communication, contemporary use of technology, technology and personality development, limitations in technology for communication.
Unit V: Activities for Soft Skills and Personality Development Professional Etiquettes and Work-Life Management, Stress Management and Coping Strategies, Personal Efficiency and its Effectiveness, Professional Ethics and its Role in Personality Development, Developing Leadership Skills through Soft Skill and Personality Development.

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.

AMN16351 Group Project/Research Project-II		
Designation	:	Compulsory
Pre-requisites	:	None
Credit and Contact hrs	:	0(L) - 0(T) – 4(P) – 2(Cr)
Assessment Methods	:	As per UG Ordinance
Review on the progress on the project		

Semester-VII

AMN17102 Modelling and Simulation in Materials Processing		
Designation	:	Compulsory
Pre-requisites	:	Mechanics of materials, Heat treatment, Mechanical Processing of Materials.
Credit and Contact hrs	:	1(L) - 0(T) – 4(P) – 3(Cr)
Assessment Methods	:	Theory Part: End Semester Exam: 40% Mid Semester Exam: 20% Teacher Assessment: 10% Practical Part: End Semester Exam: 15% Teacher Assessment: 15%
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 software.

Experiments related to simulation of different process based on commercial and open source software.

References books

1. Modeling in Welding, Hot Powder Forming and Casting (Eds. L. Koarlsson), ASM, Materials Park, 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).

AMN17103 Machine Learning in Materials Science

Designation	:	Compulsory	
Pre-requisites	:	Engineering Mathematics	
Credit and Contact hrs	:	3(L) - 0(T) – 2(P) – 4(Cr)	
Assessment Methods	:	Theory Part: End Semester Exam: 40% Mid Semester Exam: 20% Teacher Assessment: 10%	Practical Part: End Semester Exam: 15% Teacher Assessment: 15%
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.

Experiments related to Machine Learning in the field of Materials 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.

AMN17351 Group Project/Research Project -III		
Designation	:	Compulsory
Pre-requisites	:	None
Credit and Contact hrs	:	0(L) - 0(T) – 6(P) – 3(Cr)
Assessment Methods	:	As per UG ordinance
Progress and final report submission.		

Semester-VIII

AMN18351 Industrial Training/ Group Project		
Designation	:	Compulsory
Pre-requisites	:	None
Credit and Contact hrs	:	(L) - 0(T) – 16(P) – 16(Cr)
Assessment Methods	:	As per UG ordinance

Syllabus

Purpose and Objectives of Industrial Training/ Group Project, Classification of projects based on different types of industries. The Art of "Searching, Reading and Selecting" the relevant project. Formulation of project. Role of mentor.

Project Design: Qualitative and Quantitative project design. Representation of Data, Types of Measurement Scales, Concept of Normality, Skewness and Dispersion of Data.

Project Writing and Presentation: Analysis with Results, Types of Graphs, Structure and Components of Reports, Tyes of Report, Steps in the Preparation of Report, Layouts, Excel, power point presentations, Illustrations and Tables, Bibliography, Referencing, Footnotes, Planning and Preparation of Presentation, Visual Aids in Presentation and use of other online medias etc. Conclusion and Future works related to the projects

List of Core Electives

AMN15255 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: 50 marks Mid Semester Exam: 25 marks Teacher Assessment: 25 marks **Internal Assessment: (Scheme)** 25 marks (Marks on the basis of 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		√	√	√	√			√	√	√
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

AMN15256 Ferroelectric Materials

Designation	:	Elective
Pre-requisites	:	Introduction to Materials Engineering
Credit and Contact hrs	:	3(L) - 0(T) – 0(P) – 3(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 50 marks Mid Semester Exam: 25 marks Teacher Assessment: 25 marks
Course Outcomes	:	**The successful student will learn:** 1. Understand the fundamentals of ferroelectric materials 2. Uses of ferroelectric materials in devices 3. Can apply the knowledge of ferroelectric for innovative 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

Fundamentals of dielectrics, Clausius-Mossotti relation, Dielectric dispersion and loss, Dielectric polarization and relaxation, Linear and non-linear dielectric, piezo-, pyro- and ferroelectric crystals Classification and properties of selected ferroelectrics, Structural, dielectric, electrical, spectroscopic and optical properties of ferroelectrics order-disorder and displacive type of phase transition

Phenomenological theory of Ferroelectrics: Dipole theory of phase transition, and thermodynamical theory of ferroelectrics: 1st order and 2nd order (Landau theory) phase transitions, critical phenomena, Lattice dynamics of Displacive phase transition, Quantum Ferroelectrics.

Ferroelectric devices: pyroelectric detectors, transducers, computer memory and display devices, non-volatile memory devices.

Piezoelectric devices: Piezoelectric Materials and Properties, Pressure Sensors/Accelerometers/Gyroscopes, Piezoelectric Actuators, Piezoelectric Vibrators / Ultrasonic Transducers, Surface Acoustic Wave Devices, Piezoelectric Transformers, Ultrasonic Motors

Electrooptic devices: Electrooptic Effect, Transparent Electrooptic Ceramics, Bulk Electrooptic Devices, Waveguide Modulators

PTC materials; composite ferroelectric materials; multiferroics; future of ferroelectric devices

References books

1. K. Uchino, *Ferroelectric Devices*, Marcel, Dekker, Inc. New York, 2000.
2. M. E. Lines and A. M. Glass, *Principle and Applications of Ferroelectrics and Related Materials*, Clarndon Press, Oxford, 1977.
3. Ferroelectric Devices, Kenji Uchino, Marcel Dekker, 2000.
4. Dielectric Phenomena in Solids, Kwan Chi Kao, Elsevier, 2004.
5. Electroceramics, Herbert & Moulson, Chapman & Hall, 1993.
6. Physics of Ferroelectrics - A Modern Perspective, Ed. Karin M. Rabe Charles H. Ahn
7. Jean-Marc Triscone, Springer-Verlag Berlin Heidelberg, 2007.
8. Ferroelectric Memories, J.F. Scott, Springer Verlag, 2000.

AMN15257 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: 50 marks Mid Semester Exam: 25 marks Teacher Assessment: 25 marks
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

Unit 1: *Energy sources and energy materials*: Introduction to energy sources, non-renewable and renewable sources, materials used for energy generation and storages.: Nuclear**,** Photovoltaics**,** Piezoelectric, Pyroelectric and Thermo-electrics materials, Electrostatic (capacitive), Energy Harvesting and materials. Bio energy Materials, batteries and fuel cells, application, principal and characterization of energy materials.

Unit 2: *Materials for Photovoltaics:* Principles of photovoltaic energy conversion (PV), Types of photovoltaics Cells, Physics of photovoltaic cells, First and second-generation solar cell materials; such as single and polycrystalline Silicon, amorphous silicon: growth and wafer processing, CdSe, CdTe, Copper Indium Gallium Selenide (CIGS), Gallium Arsenide, thin film solar cells, Application of Thin film processing, and properties for solar cells.

Unit 3: *Materials for Batteries:* Primary and secondary batteries, Galvanic Cells and Electrolytic Cells, Nomenclature, Potential Representation, Cathodic and Anodic Currents and Potentials, Electrolytic Cells, Electrodes, Electrolyte, Open Circuit Potential, Reference Electrodes, Cell Setup Electrochemistry and electro-chemical Battery materials, battery parameters and specifications, polarization, thermodynamics of battery materials, different battery technologies such as Lead–acid battery, Nickel–cadmium battery (NiCd), Nickel–metal hydride battery (NiMH), Lithium-ion battery, Lithium-ion polymer battery.

Unit 4: *Materials for Super Capacitor, and fuels cells*: Electrochemical supercapacitors, Basic components of supercapacitors like types of electrodes like high surface area, activated carbons, metal oxide and conducting polymers, aqueous and organic electrolytes. Fuel Cells, components of fuel cells, Types of fuel cells, Acid/alkaline fuel cells, polymer electrolyte fuel cell, phosphoric acid fuel cell, molten carbonate fuel cell, Solidoxide fuel cells (SOFC), Proton exchange membrane fuel cells (PEMFC); Direct methanol fuel cells (DMFC).

Unit 5: *Materials for Bio energy*: Bio-ethanol, Bio-ethanol feed stocks, Fuel Properties of ethanol, Ethanol from Biomass, Bio-ethanol production by fermentation of Carbohydrates, Bio-diesel Production methods of Bio-diesel.

References books

1. Lamarsh, J.R. (1966) Introduction to Nuclear Reactor Theory, Wesley
2. Walter, A.E. and Reynolds, A.B. (1981) Fast Breeder Reactors, Pergamon Press
3. Solar Energy: Principles of Thermal Collection and Storage by SP Sukhatme, Tata McGraw-Hill. 2. Solar Engineering of Thermal Processes by JA Duffie and WA Beckman, John Wiley.
4. Linden D. and Reddy Thomas B., "Handbook of Batteries", 2001, McGraw Hill Publications 5. Larminie and A. Dicks, Fuel Cell Systems Explained, 2nd Edition, Wiley (2003).
5. Dieter, G. E., "Mechanical Metallurgy", 3rd Ed., 1988, McGrawHill
6. Bio-fuels: biotechnology, chemistry, and sustainable development by DM Mousdale, CRC Pres

AMN15258 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: 50 marks Mid Semester Exam: 25 marks Teacher Assessment: 25 marks
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 Senorics, 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.

AMN15259 Materials for Nuclear Applications

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: 50 marks Mid Semester Exam: 25 marks Teacher Assessment: 25 marks
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

1. R. Stephenson, Introduction to Nuclear Engineering, McGraw-Hill.
2. H.S. Ray, R. Sridhar and K.P. Abraham: Extraction of Nonferrous Metals, Affliated East-West Press Private Limited.
3.S. Glasstone and A.Sesonke: Nuclear Reactor Engineering, Van Nostrand

AMN15260 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: 50 marks Mid Semester Exam: 25 marks Teacher Assessment: 25 marks
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

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, Fabrications 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'Handly, John Willy & Sons, Inc.

AMN15261 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: 50 marks Mid Semester Exam: 25 marks Teacher Assessment: 25 marks
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			√			√		√		
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

AMN15262 Biomaterials			
Designation	:	Elective	
Pre-requisites	:	Structure of Materials	
Credit and Contact hours	:	3(L) - 0(T) – 0(P) – 3(Cr)	
Assessment Methods	:	Theory Part: End Semester Exam: 40% Mid Semester Exam: 20% Teacher Assessment: 10%	Practical Part: End Semester Exam: 15% Teacher Assessment: 15%
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	√	√					√		√	√
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.

AMN16250 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 Part: End Semester Exam: 40% Mid Semester Exam: 20% Teacher Assessment: 10%
		Practical Part: End Semester Exam: 15% Teacher Assessment: 15%
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.

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.

List of experiments:

1. Basic problems in Structural Mechanics and Heat Transfer Analysis using Finite element codes.
2. 1D, 2D and 3D field problems.
3. Conduction and Convection based problems.
4. Transient analysis.
5. Vibration analysis.

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.

AMN16251 Optimization Method in Engineering

Designation	:	Elective	
Pre-requisites	:	Mathematics	
Credit and Contact hrs	:	3(L) - 0(T) – 2(P) – 4(Cr)	
Assessment Methods	:	Theory Part: End Semester Exam: 40% Mid Semester Exam: 20% Teacher Assessment: 10%	Practical Part: End Semester Exam: 15% Teacher Assessment: 15%
Course Outcomes	:	**The successful student will learn:** 1. Development of the skill of finding optimum value of desired variable in a reallife engineering problem. 2. Development of knowledge of expressing a real-life problem in terms of mathematics i.e to develop the skill of Mathematical Modeling 3. To develop the skill to apply Linear & Non-linear Programming, Gradient Methods & Artificial Neural Networks etc in real life engineering 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

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 and Nonlinear Programming: Simplex method, Geometric Programming: Application to simple problems. 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 and Constrained Optimization, and penalty function technique search procedures.

Introduction to Genetic Algorithm: Artificial Neural Network, Dynamic programming, Application to Process Equipment, Structural Mechanics, Development of computer programmes.

Laboratory exposure to deal with Optimization problems of Engineering

List of Experiments:

1. Matrix operations in Matlab
2. Differentiation and integration of a vector and matrix in Matlab
3. Simplex algorithm in Matlab
4. Implementation of Newton's method in Matlab
5. Implementation of Secant method in Matlab
6. Implementation of Lagrange multiplier method in Matlab
7. Implementation of KKT theorem in Matlab
8. Implementation of BFGS method in Matlab

References books

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 • Nonlinear and Dynamic Programming, Vol.II: G. Hadley

AMN16252 Non-Destructive Testing

Designation	:	Elective
Pre-requisites	:	Physics
Credit and Contact hrs	:	3(L) - 0(T) – 2(P) – 4(Cr)
Assessment Methods	:	Theory Part: End Semester Exam: 40% Mid Semester Exam: 20% Teacher Assessment: 10% Practical Part: End Semester Exam: 15% Teacher Assessment: 15%
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-Radiography, Computed Radiography, Computed Tomography.

List of Experiments:

1. Liquid penetrant test.
2. Magnetic particle testing.
3. Analysis of defects by ultrasonic flaw detector.
4. Eddy current testing.
5. Radiographic technique.
6. Panoramic technique
7. Thermographic technique
8. Immersion C- Scan

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'.

MAN***** Statistics for Engineers		
Designation	:	Compulsory
Pre-requisites	:	None
Credit and Contact hrs	:	3(L) - 1(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 50 marks Mid Semester Exam: 25 marks Teacher Assessment: 25 marks
Course Outcomes	:	**The successful student will learn:** 1. To formulate complete, concise, and correct mathematical proofs. 2. To frame problems using multiple mathematical and statistical representations of relevant structures and relationships 3. To apply and solve the pboblems using standard 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

Unit 1. Presentation of Data: Data type, classification and summarization of data, diagrams and graphs, measures of dispersion, skewness and kurtosis.

Unit 2. Probability and Distribution: Introduction to probability, laws of probability, bayes theorem, binomial distribution, poisson distribution, normal distribution and gaussian distribution, mean and variance, expectation and moments, moment generating functions of these distributions.

Unit 3. Correlation and Regression: Positive and negative correlation, pearson and Mathew correlation coefficient, non-parametric tests, receiver operating characteristics (ROC) curve, linear non-linear regression, multiple regression.

Unit 4. Sampling: Concept of population and sample, random sample, methods of taking a random sample.

Unit 5. Tests of Significance: Sampling distribution of mean and standard error, large sample tests (tests for an assumed means and equality of two population means with known S.D.), small sample test (t-test for an assumed mean and equality of means of two populations when sample observations are independent, paired and unpaired), t-test for correlation and regression coefficients, t-test for comparison of variances of two populations, chi-square test for independence of attributes, goodness of fit and homogeneity if samples.

Unit 6. Experimental Designs: Principles of experimental designs, completely randomized, randomized block and latin square designs, simple factorial experiments of 22,23, 24 and 32 types. Confounding in factorial experiments (mathematical derivations not required, analysis of variance (ANOVA) and its use in the analysis of RBD.

References books

1. Statistical methods in Biology by T.J. Bailey., Cambridge University Press.
2. Statistical methods by George W. and William G., IBH Publication.
3. Introduction of Biostatistics by Ipsen J., Harper and Row Publication.
4. Statistical methods in Biology by N.T.J. Bailey. English University Press.
5. A Text Book of Agricultural Statistics by R. Rangaswami, New Age Intl. Pub

AMN16253 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: 50 marks Mid Semester Exam: 25 marks Teacher Assessment: 25 marks **Internal Assessment: (Scheme)** 25 marks (Marks on the basis of 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				√			√	√		

<u>Syllabus</u>

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

<u>References books</u>

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.

AMN16254 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: 50 marks Mid Semester Exam: 25 marks Teacher Assessment: 25 marks
		Internal Assessment: (Scheme) 25 marks (Marks on the basis of 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 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.

AMN16255 Plasma Technology		
Designation	:	Elective
Pre-requisites	:	Physics
Credit and Contact hrs	:	3(L) - 0(T) – 0(P) – 3(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 50 marks Mid Semester Exam: 25 marks Teacher Assessment: 25 marks
		Internal Assessment: (Scheme) 25 marks (Marks on the basis of 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).

CSN***** Data Structures

Designation	:	Elective
Pre-requisites	:	C programming and Basic of Mathematics
Credit and Contact hrs	:	2(L) - 0(T) – 2(P) – 3(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 50 marks Mid Semester Exam: 25 marks Teacher Assessment: 25 marks
		Internal Assessment: (Scheme) 25 marks (Marks on the basis of assignment submission, Surprise Tests, Term paper etc)
Course Outcomes	:	CO-1 Students Understood elementary Data organization, Complexity, Revision of Programming concepts CO-2 Students Understood Basic &Advanced Knowledge of Array, Stack, Queue& Linked List CO-3 Students Understood Basic Advanced Knowledge of Tree CO-4 Students Understood Basic& Advanced Knowledge of Searching and Sorting CO-5 Students Understood Basic& Advanced Knowledge of Tree Graph
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	3	2	3	2	2	0	0	1	2	0
CO2	2	2	3	3	1	0	1	1	2	1
CO3	1	2	3	2	2	0	2	2	1	1
CO4	2	3	3	3	2	1	1	1	1	1
CO5	2	2	3	3	2	1	1	1	1	1

Syllabus

UNIT-1: Introduction: Basic Terminology, Elementary Data Organization, Algorithm, Efficiency of an Algorithm, Time and Space Complexity, Asymptotic notations: Theta, Big-O, and Omega, Time-Space tradeoff. Abstract Data Types (ADT)

UNIT-II:Arrays: Definition, Single and Multidimensional Arrays, Representation of Arrays: Row Major Order, and Column Major Order, Application of arrays, Sparse Matrices and their representations. Linked Lists: Array Implementation and Dynamic Implementation of Singly Linked Lists, Doubly Linked List, Circularly Linked List, Operations on a Linked List. Insertion, Deletion, Traversal, Polynomial Representation and Addition, Generalized Linked List Stacks: Abstract Data Type, Primitive Stack operations: Push & Pop, Array and Linked Implementation of Stack in C, Application of stack: Prefix and Postfix Expressions, Evaluation of postfix expression, Recursion, Tower of Hanoi Problem, Simulating Recursion, Principles of recursion, Tail recursion, Removal of recursion Queues: Abstract Data Type, Operations on Queue: Create, Add, Delete, Full and Empty, Circular queues, Array and linked implementation of queues in C, Deque and Priority Queue.

Unit III:Trees: Basic terminology, k-ary trees, Binary Trees, Binary Tree Representation: Array Representation and Dynamic Representation, Complete Binary Tree, Algebraic Expressions, Extended Binary Trees, Array and Linked Representation of Binary trees, Tree Traversal algorithms: In order, Preorder and Post order, Binary Search Trees, Threaded Binary trees, Traversing Threaded Binary trees, Forest, Huffman algorithm, Heap, B/B+ Tree, AVL tree

Unit IV: Searching& Sorting: Sequential search, Binary Search, Comparison and Analysis Internal Sorting: Bubble Sort, Selection Sort, Insertion Sort, Two Way Merge Sort, Heap Sort, Quick Sort Hashing

UNIT V: Graphs: Terminology, Sequential and linked Representations of Graphs: Adjacency Matrices, Adjacency List, Adjacency Multi list, Graph Traversal: Depth First Search and Breadth First Search, Connected Component, Spanning Trees, Minimum Cost Spanning Trees: Prims and Kruskal algorithm. Shortest Path algorithm: Dijikstra Algorithm

Text Books:

1. Aaron M. Tenenbaum, YedidyahLangsam and Moshe J. Augenstein —Data Structures Using C and C++‖, PHI

Reference Books:

1. Horowitz and Sahani, —Fundamentals of Data Structures‖, Galgotia Publication
2. Donald Knuth, —The Art of Computer Programming‖, vol. 1 and vol. 3.
3. Jean Paul Trembley and Paul G. Sorenson, —An Introduction to Data Structures with applications‖, McGraw Hill
4. R. Kruse etal, —Data Structures and Program Design in C‖, Pearson Education Lipschutz, —Data Structures‖ Schaum‗s Outline Series, TMH

AMN16256 Fatigue and Fracture of Materials

Designation	:	Compulsory
Pre-requisites	:	Mechanics of Materials, linear Algebra
Credit and Contact hrs	:	3(L) - 0(T) – 0(P) – 3(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 50 marks Mid Semester Exam: 25 marks Teacher Assessment: 25 marks
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 Burger's 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, 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.

Mechanical Characterization of Materials: Mechanical testing for material Characterization, Measurement techniques in experimental solid mechanics, Non-destructive testing

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.

AMN16257 Continuum Damage Mechanics

Designation	:	Elective
Pre-requisites	:	Physics
Credit and Contact hrs	:	3(L) - 0(T) – 0(P) – 3(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 50 marks Mid Semester Exam: 25 marks Teacher Assessment: 25 marks
Course Outcomes	:	1. Make use of the concepts of tensor formalism for practical applications 2. Identify stresses acting on components subjected to complex loads 3. Apply deformation and damage concepts for practical situations 4. Develop constitutive relations and solve problems.
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

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.

References books

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.

AMN16258 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: 50 marks Mid Semester Exam: 25 marks Teacher Assessment: 25 marks
		Internal Assessment: (Scheme) 25 marks (Marks on the basis of 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			√							√

<u>Syllabus</u>

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 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.

<u>References books</u>

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..

AMN17255 Advanced Manufacturing

Designation	:	Elective	
Pre-requisites	:	Nil	
Credit and Contact hrs	:	3(L) - 0(T) – 2(P) – 4(Cr)	
Assessment Methods	:	Theory Part: End Semester Exam: 40% Mid Semester Exam: 20% Teacher Assessment: 10%	Practical Part: End Semester Exam: 15% Teacher Assessment: 15%
Course Outcomes	:	**After the completion of this course, students will be able to** 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			√		√	√		√	√	
CO4			√	√	√	√			√	
CO5				√		√	√		√	

Syllabus

Powder Metallurgy Processes: Powder Production Methods -Chemical, Electrolytic, Atomization, Mechanical; Powder Characterization Methods -Chemical Composition and Structure, Particle Size and Surface Topography; Powder Compaction and Consolidation; Densification and Sizing; Impregnation and Infiltration; Sintering-Solid-State Sintering; Non-Isothermal Sintering; Liquid-State Sintering; Super Solidus Sintering; Activated Sintering; Pressure-Assisted Sintering.

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

List of experiments

1. AM Pre-processing and Post-processing
2. 3D Modelling of a single component. Assembly of CAD modelled Components
3. Exercise on CAD Data Exchange. Generation of .stl files.
4. Identification of a product for Additive Manufacturing and its process plan.
5. Printing of identified product on an available AM machine.
6. Post processing of additively manufactured product.
7. Inspection and defect analysis of the additively manufactured product.

References books

1. Ghosh and Mallik, Manufacturing Science, East-West Press Pvt Ltd.
2. Brent Stucker, David Rosen, and Ian Gibso, Additive Manufacturing Technologies, Springer, 2010
3. Chua C.K., Leong K.F., and Lim C.S., Rapid prototyping: Principles and applications, Third Edition, World Scientific Publishers, 2010
4. Gebhardt A., Rapid prototyping, Hanser Gardener Publications, 2003.
5. Kamrani A.K. and Nasr E.A., Rapid Prototyping: Theory and practice, Springer, 2006.

AMN17256 Thin Films and Applications

Designation	:	Elective	
Pre-requisites	:	Physics	
Credit and Contact hrs	:	3(L) - 0(T) – 2(P) – 4(Cr)	
Assessment Methods	:	Theory Part: End Semester Exam: 40% Mid Semester Exam: 20% Teacher Assessment: 10%	Practical Part: End Semester Exam: 15% Teacher Assessment: 15%
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.

List of experiments:

1. Dip coating of a poly thin film on glass substrates
2. Deposition of the metal (Al) thin film on glass substrates by spin coating method
3. To deposit polymer thin film by spin coating technique
4. To measure D.C. resistivity of thin film by four Probe method
5. Annealing study of thin films at different temperature
6. Study of composition variation in synthesis of thin films
7. Preparation of the Metal Oxide thin films by using spin coating technique.
8. Preparation of the metal oxide thin films by using Dip coating technique.

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.

AMN17257 Powder Metallurgy

Designation	:	Elective
Pre-requisites	:	Nil
Credit and Contact hrs	:	3(L) - 0(T) – 2(P) – 4(Cr)
Assessment Methods	:	Theory Part: End Semester Exam: 40% Mid Semester Exam: 20% Teacher Assessment: 10%
		Practical Part: End Semester Exam: 15% Teacher Assessment: 15%
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.

Experiments related to fabrication, characterization and testing of components using powder metallurgy

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

AMN17258 Corrosion Science and Engineering

Designation	:	Elective
Pre-requisites	:	Chemistry and Introduction to Material Science.
Credit and Contact hours	:	3(L) - 0(T) – 0(P) – 3(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 50 marks Mid Semester Exam: 25 marks Teacher Assessment: 25 marks
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.

AMN17259 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: 50 marks Mid Semester Exam: 25 marks Teacher Assessment: 25 marks
		Internal Assessment: (Scheme) 25 marks (Marks on the basis of 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.

AMN17260 Life Cycle Assessment

Designation	:	Elective
Pre-requisites	:	Materials in Service
Credit and Contact hrs	:	3(L) - 0(T) – 0(P) – 3(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 50 marks Mid Semester Exam: 25 marks Teacher Assessment: 25 marks
Course Outcomes	:	**The successful student will learn:** 1. The basic concepts of life cycle assessment (LCA) and life cycle impact assessment (LCIA) including the social and economic dimensions. 2. The fundamental concepts related to interaction of industrial and environmental/ ecological systems, sustainability challenges facing the current generation 3. The application of life cycle assessment methodology using appropriate case studies
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

1. Introduction to Life Cycle Assessment (LCA), Importance of LCA for the Engineering professionals, Guidance for life cycle assessment, Overview of International Standards ISO 14044 (2006), Four major stages or steps of LCA and ther relevant guidelines, Environmental impact categories in LCA.
2. Introduction to Life cycle assessment software- SimaPro, GaBi, and Open LCA, LCA databases- EcoInvent, US LCI, ELCD, AusLCI, Indian LCI databases, Data quality considerations, The steps involved in carrying out an LCA.
3. Introducing example system, data collection templates for input in LCA software, inputting data into LCA software, the structure of an LCA model, performing a calculation, basic procedures behind the calculation.

a. Expectation from the basic results, Inventory and impact categories and assessment, Contribution analysis, Sensitivity and Monte Carlo analysis, Interpreting the results and their meaning, Implications and strength of LCA studies, Limitations of an LCA.

4. Sustainability in resources industries, energy, mining and mineral processing, Sustainability in the context of metal production, Recycling of materials, E-waste processing issues. Uses of LCA in case studies- open-cut, underground, in-situ leaching mining method, iron ore, copper ore, and bauxite processing. LCA for steel making and steel industry, Ferroalloys, LCA for gold production, Aluminium and comparison of production using various energy sources.
5. LCA of various energy systems (coal-based electricity, gas powered power plants, nuclear, solar, wind, hydro), Introduction to water management and ISO-14046 for life cycle-based water footprint determination and concept of embodied water of products. Introduction to ISO-14001 Environmental Management System (EMS), benefits, procedures and guidelines to develop EMS documents according to ISO. PDCA in the context of EMS

References books

1. Heinrichs, H., Martens, P., Michelsen, G., Wiek, A., Sustainability Science An Introduction, Springer.
2. Hauschild, M.Z., Rosenbaum, R.K., Olsen, S.I., Life Cycle Assessment Theory and Practice, Springer.
3. Klöpffer, W., Grahl, B., Life Cycle Assessment (LCA): A Guide to Best Practice, Wiley.
4. Hoekstra, A.Y., Chapagain, A.K., Aldaya, M.M., Mekonnen, M.M., The water footprint assessment manual: Setting the global standard. Routledge.

AMN17261 Critical Minerals and Supply Chain of Materials

Designation	:	Elective
Pre-requisites	:	Introduction to Materials Engineering
Credit and Contact hrs	:	3(L) - 0(T) – 0(P) – 3(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 50 marks Mid Semester Exam: 25 marks Teacher Assessment: 25 marks
Course Outcomes	:	**The successful student will learn:** 1. To identify significance of Critical Minerals. 2. To develop an understanding of the importance of logistics in the formulation of supply chain operations. 3. Develop an in-depth understanding of logistics operating areas and their interrelationship.
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

An overview of the principles of classification and assessment of critical metals and minerals and their application globally

The supply of critical metals and minerals.

The mineralogy of critical metals, the metallogenetic context of present and near-future deposit types for critical metals and minerals.

Deposit classification and distribution. Problems surrounding substitution and recycling potential.

Supply chain strategy: strategic fit, network design, global dual sourcing

Managing supply chain risks: risk-sharing contracts, risk pooling, risk hedging

Coordinating supply chain: sales & operations planning, bullwhip effect

Individual student projects focused on certain types of critical metal and mineral deposits, their character and origin, and include evaluating their present and future potential.

References books

1. Keith Liverman, Metals and Minerals: Science and Technology, NY Research Press 2017
2. Gus Gunn, Critical Metals Handbook (Wiley Works), American Geophysical Union, 2014
3. Supply Chain Management: Strategy, Planning, and Operations (5th Edition) by Sunil Chopra and Peter Meindl. Prentice Hall, 2012
4. Operations Strategy: Principles and Practice by Jan A. Van Mieghem. Dynamic Ideas, 2008.

AMN17262 Nano-Fluids		
Designation	:	Elective
Pre-requisites	:	Fluid Mechanics
Credit and Contact hrs	:	3(L) - 0(T) – 0(P) – 3(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 50 marks Mid Semester Exam: 25 marks Teacher Assessment: 25 marks
Course Outcomes	:	**The successful student will learn:** 1. Understand the fundamental properties and synthesis methods of nanofluids. 2. Analyze the thermophysical properties of nanofluids and their impact on heat transfer. 3. Evaluate the suitability of nanofluids for various engineering applications. 4. Conduct experimental procedures to measure key properties of nanofluids. 5. Explore emerging trends and research directions in the field of nanofluids.
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 Nanofluids: Definition and history of nanofluids, Types of nanoparticles used in nanofluids, Base fluids and their properties, Synthesis of Nanofluids, Preparation methods (single-step and two-step), Stability and dispersion techniques, Surface modification of nanoparticles.

Properties of Nanofluids: Thermophysical Properties (Thermal conductivity, Viscosity, Density, Specific heat capacity), Optical and Electrical Properties (Optical properties and applications in solar energy, Electrical conductivity and dielectric properties).

Theoretical Models and Experimental Techniques: Theoretical Models (Maxwell's model, Hamilton-Crosser model, Buongiorno's two-phase model), Experimental Techniques (Measurement of thermal conductivity, Viscosity measurement methods, Particle size and zeta potential analysis).

Heat Transfer & Energy Applications of Nanofluids: Nanofluids in Heat Exchangers (Heat transfer enhancement mechanisms, Applications in shell and tube heat exchangers), Cooling of Electronic Devices (Microchannel cooling, Data centers and electronic cooling systems), Renewable Energy Systems (Nanofluids in solar collectors, Applications in geothermal energy systems), Nanofluids in Nuclear Reactors (Role in coolant systems, Safety and efficiency improvements),

Biomedical & Industrial Applications of Nanofluids: Drug Delivery Systems (Targeted drug delivery, Hyperthermia treatment), Imaging and Diagnostics (Nanofluids in MRI and CT imaging, Contrast enhancement), Lubrication and Friction Reduction (Nanofluids as lubricants, Tribological properties), Environmental and Chemical Applications (Nanofluids in wastewater treatment, Chemical reaction enhancement).

Challenges and Future Trends: Challenges in Nanofluid Applications (Stability and agglomeration issues, Economic and environmental impacts), Future Trends and Research Directions (Emerging applications, Recent advancements and ongoing research).

Textbooks:

1. "Nanofluids: Science and Technology" by Sarit K. Das, Stephen U. Choi, Wenhua Yu, T. Pradeep, Wiley, 412 pages. ISBN: 978-0-470-07473-2
2. "Nanofluids: Fundamentals and Applications" by S. K. Das, S. U. S. Choi, H. E. Patel, and R. S. Vajjha.

AMN17263 Carbon Nanotubes 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: 50 marks Mid Semester Exam: 25 marks Teacher Assessment: 25 marks
		Internal Assessment: (Scheme) 25 marks (Marks on the basis of 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

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 - archiral 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 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, 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.

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.

AMN17264 Alternate Routes 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: 50 marks Mid Semester Exam: 25 marks Teacher Assessment: 25 marks
		Internal Assessment: (Scheme) 25 marks (Marks on the basis of 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