MOTILAL NEHRU NATIONAL INSTITUTE OF TECHNOLOGY ALLAHABAD

B. Tech. in

Production and Industrial Engineering

SCHEME OF INSTRUCTION AND SYLLABI

For B. Tech. Program

(Effective from 2022-23)

DEPARTMENT OF MECHANICAL ENGINEERING

Vision and Mission of the Institute

Motilal Nehru National Institute of Technology Allahabad

VISION

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

MISSION

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

Vision and Mission of the Department

VISION

To be a centre of excellence in Mechanical, Production and Industrial Engineering education and research for the benefits of society and humanity.

MISSION

- To educate and develop competent human resources for contemporary industry, academia and research.
- To promote interdisciplinary research and innovation skills in the graduates.
- To enhance the efforts to develop sustainable products, processes and technologies by developing competent entrepreneurs for the benefit of the society.

Department of Mechanical Engineering:

Brief about the Department:

The Department of Mechanical Engineering is one of the oldest department of the institute and was established in the year 1961. We are the largest community of excellent, energetic, and dynamic faculty, staff and students in the institute. The department is having highly qualified and experienced faculty (36 faculty members) in all streams of Mechanical Engineering. The department is broadly divided into three academic streams in which students receive outstanding education with a wide choice of specializations, electives and research areas. These three academic streams are: Design Engineering, Production and Industrial Engineering and Thermal Engineering.

The department offers eight semester (i.e. 4 year) Bachelor of Technology (B. Tech.) programmes in Mechanical Engineering and Production and Industrial Engineering. Every year 223 students are admitted through JEE (mains) and 15% of this intake is through Direct Admission to Students Abroad (DASA) scheme for the above two B. Tech. programmes. Some students are also through ICCR and MEA (Govt. of India) Schemes.

The department also offers four semester (i.e. 2 year) Master of Technology (M. Tech.) programmes in Computer Aided Design and Manufacturing, Design Engineering, Product Design and Development, Production Engineering and Thermal Engineering. Every year 125 students (25 in each specialization) are admitted through GATE in the above five M. Tech. programmes.

The department also offers Doctor of Philosophy (Ph.D.) programme in various areas of Mechanical Engineering as well as Production and Industrial Engineering. The strength of the department lies in its Ph.D. programme with more than 100 PhDs already been awarded till March, 2022. About 80 research scholars are presently pursuing their PhDs. Every year the department admits Ph.D. students equal to half of the number of faculty holding Ph.D. degree. The department is also a QIP centre for PhD and M. Tech programmes.

Today, the world of Mechanical Engineering changes under the influence of advanced computational tools, improved simulation and analysis, and entirely different manufacturing protocols. This has opened up new vistas of research in the department.

List of Programmes offered by the Department:

Program	Title of the Program
B. Tech.	Mechanical Engineering
	Production & Industrial Engineering
M. Tech.	Computer Aided Design and Manufacturing
	Design Engineering
	Product Design and Development
	Production Engineering
	Thermal Engineering
Ph.D.	Mechanical Engineering

B. Tech. — Production and Industrial Engineering

Program Educational Objective

PEO-1	To transform our students into employable technologists through education and training to contribute in the frontiers of Production and Industrial Engineering.
PEO-2	To groom the graduates for achieving team work capability and leadership qualities.
PEO-3	To impart multidisciplinary competence in the graduates for exploring ventures in Government, Public, Private, R&D and entrepreneurial sectors.
PEO-4	To imbibe ethical and human values in the graduates for the benefit of the society.

Program Articulation Matrix

PEO / Mission Statement	PEO1	PEO2	PEO3	PEO4
To educate and develop competent human resources for contemporary industry, academia and research.	3	3	2	3
To promote interdisciplinary research and innovation skills in the graduates.	2	3	2	2
To enhance the efforts to develop sustainable products, processes and technologies by developing competent entrepreneurs for the benefit of the society.	2	2	3	2

1-Slight; 2-Moderate; 3-Substantial

B. Tech. — Production and Industrial Engineering

Program Outcomes

PO-01	Engineering Knowledge: Apply knowledge of mathematics, science and engineering fundamentals and Production and Industrial Engineering specialization to the solution of complex Production and Industrial Engineering problems.
PO-02	Problem Analysis: Identify, formulate, research literature and analyze complex Production and Industrial Engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences.
PO-03	Design/ Development of Solutions: Design solutions for complex Mechanical Engineering problems and design system components or processes that meet specified needs with appropriate consideration for public health and safety, cultural, societal and environmental considerations.
PO-04	Conduct investigations of complex Production and Industrial Engineering problems using research-based knowledge and research methods including analysis, interpretation of data and synthesis of information to provide valid conclusions.
PO-05	Modern Tool Usage: To apply appropriate techniques, resources and engineering and IT tools for modeling of different Production and Industrial Engineering problems with an understanding of the limitations.
PO-06	The Engineer and Society: Apply contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to professional engineering practice.
PO-07	Environment and Sustainability: Understand the impact of professional Production and Industrial Engineering solutions in societal and environmental contexts and demonstrate knowledge of and need for sustainable development.
PO-08	Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of Production and Industrial Engineering practice.
PO-09	Individual and Team Work: Function effectively as an individual, and as a member or leader in diverse teams as well as in multi disciplinary settings.
PO-10	Communication: Communicate effectively on complex Mechanical Engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations and give and receive clear instructions.
PO-11	Project Management and Finance: Demonstrate knowledge and understanding of Mechanical Engineering and management principles and apply these to one's own work, as a member and leader of a team, to manage projects and in multidisciplinary environments.
PO-12	Life-long Learning: Recognize the need for the preparation and ability to engage in independent and life- long learning in the broadest context of technological change. Participate and succeed in competitive examinations for PG programs& Govt. services.

Program Specific Outcomes (PSOs)

PSO-01	Graduates will be able to apply fundamental knowledge of science and engineering to design, develop and/or improve the product, process or system with the help of acquired computational and experimental skills
PSO-02	Graduates will be able to solve the technical and managerial problems of an industry / organization using the acquired theoretical knowledge and soft skills in the Production and Industrial Engineering and allied multidisciplinary fields.

SCHEME OF INSTRUCTION

B. Tech. Production and Industrial Engineering –Course Curriculum Structure

S. No.	Code	Course	Credit	L-T-P	Contact Hours
Semester-I					
1	CYN11504	Engineering Chemistry	4	2-1-2	5
2	MAN11101	Mathematics-I	4	3-1-0	4
3	HSN11600	Professional Communication	3	2-0-2	4
4	AMN11101	Materials Science and Engineering	3	3-0-0	3
5	PIN11101	Fluid and Thermal Engineering	3	3-0-0	3
6	MEN11601	Engineering Graphics	2	1-0-2	3
7	IDN11600	Environment and Climate Change	2	2-0-0	2
8	EAN11701-07	Extra Academic Activity-A*	2	0-0-4	4
		Total	**23**		**28**
Semester-II					
1	PHN12502	Engineering Physics	4	2-1-2	5
2	MAN12106	Mathematics-II	4	3-1-0	4
3	CSN12601	Introduction to Artificial Intelligence and Machine Learning*	3	2-0-2	4
4	MAN12107	Computer based Numerical and Statistical Techniques	3	2-0-2	4
5	AMN12400	Engineering Mechanics	3	2-0-2	4
6	MEN12602	Workshop and Manufacturing Processes	2	1-0-2	3
7	EAN12700	Professional Ethics and Social Values	2	0-0-4	4
		Total	**21**		**28**
Semester-III					
1	AMN13101	Mechanics of Materials	4	3-0-2	5
2	PIN13101	Industrial Engineering	4	3-0-2	5
3	AMN13106	Kinematics and Dynamics of Machines	3	3-0-0	3
4	EEN13200	Basic Electrical and Electronics	3	2-0-2	4
5	PIN13102	Instrumentation and Process Control	4	3-0-2	5
6	PIN13103	Operations Research	3	3-0-0	3
7	PIN13301	Fluid and Thermal Engineering Lab	1	0-0-2	2
8	EAA-B	Extra Academic Activity-B	2	0-0-4	4
		Total	**24**		**31**

Semester-IV					
1	PIN14101	Computer Aided Geometrical Modelling	4	3-0-2	5
2	PIN14103	Manufacturing Science and Technology - I	4	3-0-2	5
3	PIN14102	Machine Tools Engineering	4	3-0-2	5
4	PIN14105	Production and Operations Management	3	3-0-0	3
5	HSN14601	Management Concepts and Applications	3	3-0-0	3
6	PIN14104	Metrology and Quality Engineering	3	3-0-0	3
7	CEL	Core Elective Course-1	3	3-0-0	3
8	EAA-B	Extra Academic Activity-B	2	0-0-4	4
9	MN	Minor Course$^{@}$	4$^{@}$	3-1-0	4$^{@}$
		Total	**26$^{@}$**		**31$^{@}$**
Semester-V					
1	PIN15102	Design of Machine Elements	4	3-0-2	5
2	PIN15101	Computer Aided Manufacturing	4	3-0-2	5
3	PIN15103	Industry 4.0 and IOT	3	3-0-0	3
4	PIN15104	Manufacturing Science and Technology II	4	3-0-2	5
5	CEL	Core Elective Course-2	3	3-0-0	3
6	CEL	Core Elective Course-3	3	3-0-0	3
7	MN	Minor Course$^{@}$	4$^{@}$	3-1-0	4$^{@}$
8	HN	Honours Course$^{\#}$	4$^{\#}$	4-0-0	4$^{\#}$
9	RS	Research Course$^{\$}$	4$^{\$}$	4-0-0	4$^{\$}$
		Total	**21$^{@\#\$}$**		**24$^{@\#\$}$**
Semester-VI					
1	PIN16102	Advanced Machining Processes	4	3-0-2	5
2	HSN16603	Soft Skills and Personality Development	3	3-0-0	3
3	PIN16101	Additive Manufacturing	3	3-0-0	3
4	PIN16103	Product Design and Development	4	3-0-2	5
5	CEL	Core Elective Course-4	3	3-0-0	3
6	CEL	Core Elective Course-5	3	3-0-0	3
7	CEE	Colloquium	1	0-0-2	2
8	MN	Minor Course$^{@}$	4$^{@}$	3-1-0	4$^{@}$
9	HN	Honours Course$^{\#}$	4$^{\#}$	4-0-0	4$^{\#}$
10	RS	Research Course$^{\$}$	4$^{\$}$	4-0-0	4$^{\$}$
		Total	**21$^{@\#\$}$**		**24$^{@\#\$}$**
Semester VII					
1	PIN17101	Supply Chain Management	3	3-0-0	3
2	CEL	Core Elective – 6	3	3-0-0	3
3	OEL	Open Elective Course	3	3-0-0	3
4	HSS17602	Business Economics	3	3-0-0	3
5	CEE	Vocational Training*/STTP*	3	0-0-6	6
6	MN	Minor Course$^{@}$	4$^{@}$	3-1-0	4$^{@}$
7	HN	Honours Course$^{\#}$	4$^{\#}$	4-0-0	4$^{\#}$
8	RS	Research Project$^{\$}$	4$^{\$}$	4-0-0	4$^{\$}$
		Total	**15$^{@\#\$}$**		**19$^{@\#\$}$**

Semester VIII					
1	CEE	Major Project/Internship	14	0-0-28	28
		Total	**14**		**28**

1*: A student can opt for Vocational training / STTP (short-term training program) of minimum three to four weeks during the summer vacation after IV and/or VI semester and its three credits will be considered in the VII semester after the submission of successful completion certificate from the Industry, report and successful presentation.

@: A student can opt for one or two Minor courses in IV, V, VI and VII semesters as per the Minor courses offered by the other departments. Total credits in these semesters will be based on the credits of the Minor course(s) opted by the student in a particular semester. In this case the degree of the student will be B.Tech. (Mechanical Engineering) with Minor in ( )

#: **1.** A student can opt for one or more Honours courses in V, VI and VII semesters as per the Honours courses offered by the department. Total credits in these semesters will be based on the credits of the Honours course(s) opted by the student in a particular semester. In this case the degree of the student will be B.Tech. (Mechanical Engineering) with Honours

2. A student, opting for Honours registration, is required to complete a total of 16 credits of the Honours courses offered by the department of Mechanical Engineering. Honours courses will be from any of the M.Tech. programme of Department of Mechanical Engineering.

$: 1. A student can opt for one or more research courses in V, VI and VII semesters as per the Research courses offered by the department. Total credits in these semesters will be based on the credits of the Research course(s) opted by the student in a particular semester. In this case the degree of the student will be B.Tech. (Mechanical Engineering) with Research. In VII semester the research course will be a research project which may continue in VIII semester as Major Project.

2. A student, opting for Research registration, is required to complete a total of 16 credits of the Research courses offered by the department. Research courses will be from any one of the M. Tech. programme of Department of Mechanical Engineering.

List of Electives and Minors: B.Tech. (Production and Industrial Engineering)

II Semester: Core Engineering Supportive Course (for other branches)

S. No	Course Code	Subject
1.	MEN14204	Basic Industrial Engineering
2.	MEN14203	Non-conventional Energy Recourses
3.	MEN14201	Introduction to Engineering and Design
4.	MEN14202	Engineering Innovation & Design

IV Semester: Core Elective Course - 1

S. No	Course Code	Subject
4.	PIN14251	Cryogenics
3.	PIN14252	Design and Analysis of Experiments
5.	PIN14253	Manufacturing of Non-Metallic Product
2.	PIN14254	Modelling and Simulation in Engineering
1.	PIN14255	Optimization Methods in Engineering

V and VI Semester: Core Elective Courses – 2, 3, 4 and 5

S. No	Course Code	Subject
1.	PIN15251/PIN16251	Automatic Control
2.	PIN15252/PIN16252	Automobile Engineering
3.	PIN15253/PIN16253	Composite materials
4.	PIN15254/PIN16254	Computational Fluid Dynamics
5.	PIN15255/PIN16255	Concurrent Engineering
6.	PIN15256/PIN16256	Condition Monitoring and Diagnostics
7.	PIN15257/PIN16257	Design for Manufacturing and Assembly
8.	PIN15258/PIN16258	Energy Management
9.	PIN15259/PIN16259	Failure Mode and Effect Analysis
10.	PIN15260/PIN16260	Finite Element Method in Engineering
11.	PIN15261/PIN16261	Fracture Mechanics in Manufacturing
12.	PIN15262/PIN16262	Industrial Safety and Reliability Engineering
13.	PIN15263/PIN16263	Industrial Tribology
14.	PIN15264/PIN16264	Mechanical Micromachining Technology
15.	PIN15265/PIN16265	Micro and Nano Manufacturing
16.	PIN15266/PIN16266	Noise and Vibration
17.	PIN15267/PIN16267	Non-Conventional Energy Sources
18.	PIN15268/PIN16268	Precision Engineering
19.	PIN15269/PIN16269	Product Life Cycle Management
20.	PIN15270/PIN16270	Refrigeration and Air Conditioning
21.	PIN15271/PIN16271	Surface Treatment and Characterization
22.	PIN15272/PIN16272	Total Quality Management

VII Semester: Core Elective Courses – 6

S. No	Code	Course Name
1.	PIN17251	Advanced Automobile Engineering
2.	PIN17252	Alternative Fuel Technology
3.	PIN17253	Automotive Electronics
4.	PIN17254	Automotive Materials
5.	PIN17255	Automotive Safety
6.	PIN17256	Computer Integrated Manufacturing
7.	PIN17257	Design against Fatigue and Fracture
8.	PIN17258	Electric Vehicle Technology
9.	PIN17259	Energy Management
10.	PIN17260	Green Hydrogen and Alternative fuels
11.	PIN17261	Hybrid Electric and Fuel Cell Vehicles
12.	PIN17262	Industrial Automation
13.	PIN17263	Machine Learning
14.	PIN17264	Mechanics of Composite Materials
15.	PIN17265	Microelectromechanical systems (MEMS)
16.	PIN17266	Smart materials
17.	PIN17267	Solar Energy and applications
18.	PIN17268	Sustainable Engineering
19.	PIN17269	Sustainable Materials and Green Buildings
20.	PIN17270	Vehicle Maintenance
21.	PIN17271	Vehicle Management System

VII Semester: Open Elective Course

S. No	Code	Name
4.	MEN17401	Electrical Vehicles Technology
2.	MEN17402	Energy Management
1.	MEN17403	Non-Conventional Energy Sources
3.	MEN17404	Product Design and Development
6.	MEN17405	Quality Engineering
5.	MEN17406	Solar Photovoltaics
7.	MEN17407	Total Quality Management

Semester-I

Course Code: CYN11502	Engineering Chemistry-II	Credits: 2-1-2:4

Prerequisites: NIL

Course Outcome

S.N.	Outcomes
CO1	Achieve the understanding of different fundamental chemical concepts of the chemical kinetics, fuel, lubricant and polymer.
CO2	Ability to interpret experimental data related to rate of reactions, fuel, lubricants and electrochemical cells.
CO3	Develop the capability to apply the knowledge for the industrial applications.

Course Articulation Matrix:

Module	Content	Lectures
1.	Chemical Kinetics: Rate of a chemical reaction, factors affecting the rate of reactions: concentration, temperature, pressure and catalyst; elementary and complex reactions, order and molecularity of reactions, rate law, rate constant and its units.	**05**
2.	Electrochemical Systems: Electrochemical cells and EMF, Applications of EMF, Case study for electrorefining process.	**04**
3.	Fuels: Classification, calorific values, analysis of solid fuels, liquid fuels and its properties, refining, cracking and reforming of petroleum, knocking and octane and cetane rating, anti-knocking agents, biofuels.	**04**
4.	Corrosion: Theories of corrosion, type of corrosion, its prevention and control, Case study on corrosion control in industry.	**05**
5.	Lubricants: Definition, functions, mechanisms and classifications of lubricants, properties and testing of lubricants.	**04**
6.	Polymers, plastics, rubber and Adhesives: Polymers, composites, thermoplastic and thermosetting plastics, rubber, biodegradable polymers,adhesives.	**04**
7.	Band Theory: Semiconductors, insulators, doping in semiconducting materials.	**02**

Practical: List of Experiments

1. Determination of flash point of oils by Able's apparatus.
2. Determination of flash point of lubricating oil by Pensky Martin's 'closed' tester.
3. To study the viscosity of the given sample of lubricating oil with a Redwood viscometer and to study the viscosity at various temperatures.
4. To find out the aniline point of the given sample of fuel.
5. Determination of Steam Emulsification Number (SEN) of a given lubricating oil.
6. To carry out the % of moisture content only of a given sample of coal as a part of proximate analysis.
7. Determination of viscosity average molecular weight of a polymer sample by Viscometer.

8. Kinetic study of hydrolysis of ethyl acetate by volumetric titration method.
9. Preparation of biodiesel &it's flash point determination.

Text Books:

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

Reference Books:

1. Engineering Chemistry- A Textbook, Harish Kumar Chopra, AnupamaParmar, Narora, New Delhi.
2. Elements of Physical Chemistry, Peter Atkins, Julio D. Paula, Oxford, UK.
3. Polymer Science, V R Gowariker, N V Viswanathan, Jayadev Sreedhar, New Age International Private Limited, New Delhi.
4. Inorganic Chemistry: Principles of Structure and Reacivity, By James E. Huheey, Ellen A. Keither, Richard L. Keiter, Okhil K. Medhi Pearson.
5. Manufacturing Science, Amitabha Ghosh, Ashok Kumar Mallik, Affiliated East- West Press Pvt. Ltd, New Delhi.
6. Advanced Polymer Chemistry – A Problem Solving Guide, Manas Chandra, Marcel Dekker Inc, New Work.
7. Online resources.

Course Code: **AMN11101**	Material Science and Engineering	Credits: 3-0-0:3

Prerequisites: NIL

Course Outcomes:

S.N.	Outcomes
CO1	Understand role of structure at different level on properties.
CO2	Apply concepts of Materials Science to analyze engineering problems.
CO3	Select materials for different engineering applications.

Course Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
AM13103.1	2	1	-	1	1	1	-	1	-	2	2	2	3	3
AM13103.2	3	3	2	2	3	1	-	1	2	2	1	2	3	3
AM13103.3	3	3	3	3	3	2	2	2	2	2	1	2	3	3

Unit	Details	No. Hrs
8.	**Introduction:** Historical perspective of Materials Science; Structure and properties relationship of Engineering Materials; Classification of materials; Introduction to Ceramics, Composites Materials: Processing and Applications; Advanced Materials.	**05**
9.	**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.	**07**
10.	**Imperfections in Crystals:** Point defects, Dislocations, Interfacial Defects, Bulk defects.	**04**
11.	**Diffusion:** Diffusion mechanisms, steady and non-steady state diffusion, Factors that influence diffusion, Law's of diffusion, Applications of Diffusion.	**04**
12.	**Phase Diagrams and Phase Transformations:** Unary, Binary, Equilibrium phase diagrams, Eutectic, Eutectoid, Peritectic and peritectoid reactions, Transformation rate effects and TTT diagrams. Microstructure and property changes in iron-carbon system, Iron-Carbon (Fe-C or Fe-Fe3C) Diagram	**05**
13.	**Mechanical Behaviour of Materials:** Elastic and Plastic properties, Fatigue, Fracture, Creep.	**10**
14.	**Thermal, Electrical, Magnetic, Optical Properties:** Thermal behaviour of Materials; Electrical conduction, Semi conductivity, Super conductivity, Dielectric behaviour, Ferroelectricity, Piezoelectricity, Magnetic behaviour of Materials; Optical properties of materials and their applications.	**05**

Text and Reference Books:

3. Materials Science and Engineering: An Introduction" by William D. Callister Jr., David G. Rethwisch.
4. Materials Science and Engineering: A First Course" by Raghavan V.
5. Mechanical Metallurgy" by George E. Dieter
6. Elements of materials science and engineering" by Lawrence H. Van Vlack

##

Course Code: PIN11101	Fluid and Thermal Engineering	Credits: 3-0-0:3

Prerequisites: Physics, Basic Mathematics

Course Outcomes:

CO1	Students will be able to explain three thermodynamic laws and fundamental principles in fluid mechanics and heat transfer
CO2	Students will be able to solve problems related to thermal and fluid systems by applying thermodynamic laws and fluid principles and heat transfer
CO3	Students will be able to identify different power systems and fluid problems in thermal and fluid systems
CO4	Students will be able to report analyses and results of practical problems and experiments in a format that a technically competent person can follow and obtain the similar findings

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	1	1	1	1	1	-	-	2	1	1	3	1
CO2	3	2	2	1	-	-	1	-	-	2	-	-	2	1
CO3	2	3	2	3	1	-	2	-	-	3	-	-	2	2
CO4	3	3	1	3	1	1	3	1	1	2	1	2	3	3

Unit	Details	No. Hrs
1	Introduction: microscopic and macroscopic viewpoints in thermodynamics, basic concepts of system, control volume, state, extensive and intensive property, equilibrium, processes etc. Introduction to Laws of Thermodynamics (Zeroth, First and Second) and applications.	8
2	Introduction to thermodynamic cycles: Vapour Power and Gas Power Cycles.	5
3	Review of fluid properties: density, specific gravity, specific volume, viscosity, surface tension. Classification of fluid,	4
4	Hydrostatics: forces on plane surfaces and curved surfaces submerged in fluid, stability of submerged and floating bodies. Kinematics of fluid motion: methods of describing fluid motion, different types of fluid lines; concept of control volume & system; continuity equations (one dimension, two dimension & three dimension); Dynamics of fluid flow; Simple applications: different flow measuring instruments: venturimeter, orificemeter, Pitot tube etc;	8
5	Introduction: modes of heat transfer, heat exchanger applications; Phase change heat transfer	8

Text Books:

1	Engineering Thermodynamics	P.K. Nag	McGraw Hill
2	Fluid Mechanics	Cengel& Boles,	McGraw Hill
3	Heat and Mass Transfer (In SI units) A practical approach	Yunus A. Cengel,	McGraw Hill.

References:

1	Thermodynamics: An engineering	Cengel& Boles,	McGraw Hill
2	Introduction of Fluid Mechanics & Fluid Machines	Som, S.K., and Biswas G	TMH, New Delhi.
3	Heat Transfer	J.P. Holman	McGraw-Hill International edition

##

Course Code: MEN12602	Workshop and Manufacturing Processes	Credits: 1-0-2:2

Prerequisites: NIL

Course Outcomes:

CO1	Students will be able to understand the importance of manufacturing which comprises materials, processes and systems.
CO2	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.
CO3	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.
CO4	Students will be able to learn and perform operations related to carpentry, fitting, plastic molding, and Computer Numerical Control (CNC) machines.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1	1	-	2	1	1	-	1	1	1	1
CO2	2	1	1	-	-	1	1	-	1	1	1	1
CO3	2	1	1	-	-	1	1	-	1	1	1	1
CO4	2	1	1	-	3	1	1	-	1	1	1	1
ME11102	2	1	1	-	2	1	1	-	1	1	1	1

Correlation between ME11102 Workshop subject and the PSOs

Name of the B. Tech. Program	PSO1	PSO2	PSO3	PSO4
B. Tech. (Civil Engineering)	2	1	1	-
B. Tech (Mechanical Engineering)	3	3		
B. Tech (Production & Industrial Engineering)	3	3		

Unit	Details	No. Hrs
1	**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	4
2	**Sand Casting Process of Metals-** Elements of Green Sand Mould; Pattern design and making, Method of Preparation of Green Sand Mould; Casting Defects	2
3	**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	3

4	**Machining Processes:** Classification of machining processes & machine tools; Construction, Specification, and operations on Lathe Machine and Drilling machine	2
5	**Fabrication Processes-** Classification of Welding Operations, Types of Joints & Welding Positions; Brief description of Arc, Resistance and Gas welding techniques. Brazing and Soldering	3

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, male-female 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 Fundamental of Modern Manufacturing: Materials, Processes and Systems — Mikell P. Groover — John Wiley

References:

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

##

Course Code: MEN11601	Engineering Graphics	Credits: 2-0-2:4

Prerequisites: NIL

Course Outcomes:

CO1	Understand the importance and principles of engineering drawing by hand practice and using computer aided drafting software.
CO2	Understand the isometric and orthographic projections of different objects.
CO3	Create assembly drawing of simple machine components

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	3	1	-	3	-	-	2	1	2	-	2	2	1
CO2	2	2	2	1	3	-	-	2	1	2	-	1	2	2
CO3	3	3	3	2	3	-	-	2	1	2	-	1	2	3

Unit	Details	No. Hrs
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.	2L+2P
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.	4L+8P
3	Introduction to computer aided drafting software and hands on practice of orthographic views of solid objects.	2L+6P
4	Sectional viewsof solid objects and hands on practice of sectional views of solid objects using computer aided drafting software.	2L+4P
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.	1L+2P

Text Books:

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

References:

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.

##

Semester-II

Course Code: PHN11102	Engineering Physics-II	Credits: 2-1-2:4

Prerequisites: Engineering Physics- II

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 Rayleight'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.

Practical: List of Experiments

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.

Reference Books:

1. R. Resnik, Introduction to Special Relativity, John Wiley & Sons, Inc.
2. A. Ghatak, Optics, Tata McGraw-Hill.
3. E. Hecht Optics, Addison Wesley.
4. A. Beiser, Concepts of Modern Physics, Tat Mc Graw Hill.
5. B. Laud Laser and Non –Linear Optics, Wiley.

Course Code: MAN12107	Computer Based Numerical Methods and Statistical Techniques	Credit: 2-0-2:3

Prerequisites: Nil

Course Outcomes:

CO1	Students will be able to understand the concept of errors and will be able to find the roots of some algebraic and transcendental equations.
CO2	Students will be able to formulate the interpolating polynomial with the help of several interpolation formulas by analyzing and using the data points.
CO3	Students will be able to predict the value of the derivative at an intermediate point for a given set of data points. Also, they will be able to solve definite integrals using some numerical techniques and apply the knowledge in research and development activity for the betterment of society.
CO4	Students will be able to solve a system of linear equations arising in several engineering problems and find the eigen value and eigenvector of matrices.
CO5	Students will have basic knowledge of statistical techniques and will be able to derive the probability density function of random variables and calculate the expected value of a random variable. They will also be able to find several linear and nonlinear regression curves/planes for a set of data points.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	2	1	-	-	-	-	1	-	2	3	3
CO2	3	3	2	2	1	-	-	-	-	1	-	2	3	3
CO3	3	3	2	2	2	-	-	-	-	1	-	2	3	3
CO4	3	3	2	2	1	-	-	-	-	1	-	2	3	3
CO5	3	3	2	2	2	-	-	-	-	1	-	2	3	3

Unit	Details	No. Hrs
1	**Unit-I Errors in Numerical Computation, Algebraic and Transcendental Equations** Errors in Numerical Computation and Their Analysis, Bisection Method, Method of False Position, Iteration Method, Newton-Raphson Method, Rate of Convergence, Method for complex root: Muller's Method, Quotient Difference Method.	6
2	**Unit-II Interpolation** Introduction, Errors in Polynomial Interpolation, Interpolation by Evenly Spaced Points::Finite Differences, Missing Terms Technique, Newton's Forward & Backward Interpolation Formula, Gauss, Sterling, Bessel's, Everett's Formula, Interpolation by Unevenly Spaced Points: Lagrange Interpolation Formula, Divided Difference, Newton's General Interpolation Formula.	7
3	**Unit III: Numerical Differentiation and Integration** Numerical Differentiation, Numerical Integration, Trapezoidal Rule, Simpson's 1/3Rule, Simpson's 3/8 Rule, Boole's & Weddle's Rules.	4

4	**Unit IV: Numerical Linear Algebra** Numerical Techniques for Finding Solution of a System of Linear Equations: LU & LL* Decomposition Method, Gauss-Jacobi and Gauss-Seidel Iteration Methods, Power Method For Estimating Eigenvalues.	5
5	**Unit V: Statistical Computations** Random Variables, Discrete and Continuous Random Variables and Their Probability Distribution, Poisson, Bernoulli and Normal Distribution, Frequency Chart, Regression Analysis, Least Square Fit, Linear and Non-linear Regression, Multiple Linear Regression.	4

Text Books:

1. S. S. Sastry, Introductory Methods for Numerical Analysis, Prentice Hall (Fifth Edition-2012)
2. M. K. Jain, S. R. K. Iyenger& R.K. Jain: Numerical Methods for Scientific and Engineering Computations, Wiley Eastern Ltd. (Sixth Edition-2016)
3. S. C. Gupta and V. K. Kapoor: Fundamental of mathematical Statistics, S Chand Publication (Twelfth Edition -2020)

Reference Books:

1. C. F. Gerald and P. O. Wheatley: Applied Numerical Analysis, Pearson Education
2. S. Rajashekharan: Numerical Methods for Science and Engineering, S. Chand Publication
3. S. C. Chapra and R. P. Canale: Numerical Methods for Engineers, McGraW-HillEducatio
4. W. George and G. William: Statistical Techniques, IBH Pulications

Computer Based Numerical Methods & Statistical Techniques (Lab)

Experiment 1: Make a program to find the derivative of a given polynomial f(x) for a given value of x.

Experiment 2: Make a program to find the roots of a given polynomial f(x) using the following methods.

(a) Bisection Method
(b) Method of False Position
(c) Iteration Method
(d) Newton-Raphson Method
(a) Muller's Method
(b) Quotient-Difference Method

Experiment 3: Make a program to create the following difference tables for a given set of data points:

(a) Forward Difference Table
(b) Backward Difference Table
(c) Central Difference Table
(d) Divided Difference Table

Experiment 4: Make a program to find the interpolation polynomial/interpolation value of f(x) at a specified value for evenly spaced data points using the following methods:

(a) Newton's Forward and Backward Difference Formulae.
(b) Gauss's, Stirling's, Bessel's, and Everett's interpolation Formulae.

Experiment 5: Make a program to find the interpolation polynomial/interpolation value of f(x) at a specified value for unevenly spaced data points using the following methods:

(a) Lagrange's Interpolation Formula.
(b) Newton's Divided Difference Formula.

Experiment 6: Make a program to find the nth (n=1,2 and 3) derivative of f(x) at a specified value of x for a given set of data points.

Experiment 7: Make a program to find the numerical integration of f(x) at a specified value of x for a given set of data points using the following rules.

(a) Trapezoidal Rule
(b) Simpson's 1/3 Rule
(c) Simpson's 3/8 Rule
(d) Boole's and Weddle's Rule.

Experiment 8: Make a program to find regression curves for a given set of data points using the following rules:

(a) Linear and Nonlinear Regression
(b) Multiple Linear Regression

Core Engineering Supportive Course (for other branches)

##

Core Engineering Supportive Course (for other branches)

Course Code: **MEN14204**	**Basic Industrial Engineering**	Credits: 2-0-0-2

Prerequisites: NIL

Course Outcomes:

S.N.	Outcomes
CO1	Students will be able to identify and use the elements of cost, methods of depreciation and investment techniques. Productivity, Productivity Measurements and develop entrepreneurial attitude.
CO2	Students will be able to describe the job evaluation and merit rating.
CO3	Students will be able to implement work study techniques for better productivity and learn to do work measurement and calculate the standard time for doing a job.
CO4	Students will be able to describe and use different material handling devices,

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	-	-	-	3	2	2	2	2	3	3	2
CO2	2	2	2	-	-	1	2	2	2	2	3	2	2	2
CO3	3	2	2	1	-	1	2	2	2	1	2	3	3	2
CO4	3	2	2	2	2	-	3	2	2	2	2	2	3	2
CO5	2	2	2	-	2	1	3	2	2	2	3	3	2	2

Module	Details	No. Hrs
1.	Introduction, Engineering Economy and Costing-Plant Location and Layouts, Production Systems, Cost Analysis, Break-even Analysis, Methods of Depreciation,	8
2.	Concepts of Production and Productivity, Productivity Measurements.	
3.	Job evaluation, Benefits of Job evaluation, Methods of Job evaluation, Merit Rating, Methods of Merit Rating, Requirements for success of Merit Rating System,	12
4.	Work Measurement, Time Study, PMTS, Work Sampling, Method Study, Micro Motion Study, Principles of Motion Economy.	8
5.	Material Handling System- principles, types, and devices.	6

Text/Reference Books

1. Turner, W.C., et. al., 1993, "Introduction to Industrial and System Engineering", Prentice Hall.
2. Del Mar, Donald, "Operations and industrial management: designing and managing for productivity", McGraw-Hill,2007
3. Ralph M. Barnes, "Motion and Time Study: Design and Measurement of Work", Wiley Publishers
4. Chandler Allen Phillips, "Human Factors Engineering", John Wiley and Sons, New York,

##

Course Code: **MEN14203**	Non-conventional Energy Resources	Credits: 3-0-0:3

Prerequisites: Basic knowledge of Heat Transfer, Thermodynamic.

Course Outcomes:

CO1	Understand the concept of energy crisis, non-conventional energy resources, availability and their importance.
CO2	Understand various methods to harness non-conventional energy resources.
CO3	Apply the methods for better harness, conversion techniques, and utilization of non-conventional energy resources.
CO4	Analyse various problems, limitations, complexities and performances of power plants based on non-conventional energy resources.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	2	2	3	3	3	2	2	2	3	3	2
CO2	3	3	2	2	2	3	3	3	2	2	2	3	3	2
CO3	3	3	3	3	3	3	3	3	3	3	2	3	3	3
CO4	3	3	3	3	3	3	3	3	3	3	3	3	3	3

Unit	Details	No. Hrs
1	Introduction: The energy crisis – causes and options, various conventional and non-conventional forms of energy and their characteristics, availability of non-conventional energy and land area requirements.	4
2	Solar energy: Introduction, Solar radiation, Sun-Earth angles, Measurement of solar radiation at the earth's surface, Types of collectors such as flat-plate and concentrating collectors, solar thermal power generation, solar ponds and energy storage. Principle of Solar photovoltaic, materials, mono-crystalline, polycrystalline and amorphous silicon cells and their production technology, I-V characteristics, parameters of performance, modules, array and PV plant configurations and power generation.	6
3	Biomass energy: Introduction, Incineration, Thermo-chemical and biochemical conversion to solid, liquid and gaseous fuels; Production technologies for bio-ethanol, biogas and producer gas, Urban waste to energy processes.	5
4	Ocean, Wave and Tidal energy: Introduction, Ocean thermal energy conversion (OTEC) – closed and open cycles and their limitations, Wave energy and its conversion processes, Tidal energy – nature of the tides and tidal barrages for power generation.	5
5	Wind energy: Fundamentals, power in the wind, site selection, maximum power coefficient, wind turbine and its types – horizontal axis and vertical axis machines, performance of wind machines, wind energy farms.	5
6	Geothermal energy: Introduction, Geothermal energy resources, Hot aquifers and hot dry rock systems, geothermal electric power plants.	4
7	Other Technologies: Magnetohydrodynamics (MHD) Energy conversion, Fuel Cells, Nuclear Energy, Hydrogen, Methanol, Energy Storage.	4

Text Books:

1	Renewable Energy Sources and Emerging Technologies	D.P. Kothari, K.C. Singal and R. Ranjan	PHI Learning Pvt. Ltd., New Delhi
2	Solar Energy-Fundamentals, Design, Modeling & Applications'	G.N. Tiwari	Narosa Publishing House, New Delhi, India

References:

1	Advanced Renewable Energy Sources	G.N. Tiwari and R.K. Mishra	RSC Publishing, Cambridge, U.K
2	Biogas Systems: Principles and Applications	K.M Mittal	New Age International Limited Publishers.
3	Wind Energy Come of Age	Gipe P	John Wiley and sons, New York.
4	Solar Energy Fundamentals	S. Kalogirou	Academic Press
5	Solar Photovoltaics: FundamentalsTechnologies and Applications	C.S. Solanki	PHI Learning Pvt. Ltd., New Delhi
6	Energy Technology (Non Conventional, Renewable And Conventional)	S. Rao, BB Parulekar	Khanna Publishers

##

Course Code: MEN14201	Introduction to Engineering and Design	Credits: 2-1-0:3

Prerequisites: NIL

Course Outcomes:

CO1	Students will be able to develop an understanding of the engineering & Technology in general.
CO2	Students will be able to develop an understanding on how design differs in same category of products.
CO3	Students will be able to identify the needs that is to fulfilled by a product
CO4	Students will be able to understand how different approach leads to difference in cost and complexity.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	-	2	3	3	2	3	2	-	3	2	2
CO2	3	2	2	-	2	3	3	2	3	2	-	3	2	2
CO3	3	2	2	-	2	3	3	2	3	2	-	3	2	2
CO4	3	2	2	-	2	3	3	2	3	2	-	3	2	2

Unit	Details	No. Hrs
1	Introduction to General Engineering What is Engineering? Difference between Science, Engineering & Technology. History of Engineering. Engineering functions, Characteristics of engineers. Traits of engineers. Engineering Design; Engineering challenges; Ethics; Communication skills; Team work; Attitude. Creative thinking- Invention- innovation & inventiveness in a society.	7
2	Introduction of Engineering Design – needs assessment, problem formulation, concept selection modelling, abstraction, synthesis, economic analysis, materials selection and manufacturing processes. Case histories for illustrating the success and failure in engineering design.	7
3	Concepts of Manufacturing, Casting Processes, Plastics Processing, Metal working Processes, Machining Processes, Fabrication Processes, a glimpse of modern manufacturing processes through different case studies.	7
4	Simple hands on projects, Intellectual Property Rights.	7

Reference Books:

1. Gerard Voland, *Engineering by Design*, 2nd Edition, Pearson, (2004).
2. George E Dieter Linda C Schmidt, Engineering Design, Indian Edition (2016)
3. Product Design & Development- Karl T. Ulrich, Steven D Eppinger, McGraw Hill Publishers.
4. Human Factors in Engineering Design- Mark S sanders & Ernst J. Mc Cornick McGraw Hill Publishers.
5. Robert J. Pond, Jeffrey L. Rankinen, *Introduction to Engineering Technology*: 7th Edition, Prentice Hall, 2009.

##

Course Code: MEN14202	Engineering Innovation & Design	Credits: 2-0-1: 3

Prerequisites: NIL

Course Outcomes:

CO1	Students will be able to visualize the need for engineering for serving the society better
CO2	Students will be able to feel themselves more knowledgeable- at the end of the course.
CO3	Students will be able to identify needs and be able to suggest different alternative solutions considering cost constraints.
CO4	Students will be able to have a watchful eye on happenings in their surrounding for creative analyses. Possibility of taking up entrepreneurship activity, possibility of coming up with new ideas leading to IPR.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	2	2	2	2	2	-	-	-	2	2	2
CO2	3	3	3	2	2	2	2	2	-	-	-	2	2	2
CO3	3	3	3	2	2	2	2	2	-	-	-	2	2	2
CO4	3	3	3	2	2	2	2	2	-	-	-	2	2	2

Unit	Details	No. Hrs
1	Introduction Design & innovation, Who designs & develops products, Industrial & Practical examples. Projects.	8
2	Creative thinking- Invention- innovation & inventiveness in a society.	6
3	A Generic Development Process & Concept Development.	6
4	Identifying Customer Needs, Concept Generation, Concept Selection	6
5	Product Architecture, Industrial Design, Intellectual Property Rights	6

References:

1. Product Design & Development- Karl T. Ulrich, Steven D Eppinger, McGraw Hill Publishers.
2. Gerard Voland, Engineering by Design, Pearson,
3. Human Factors in Engineering Design- Mark S sanders & Ernst J. Mc Cornick McGraw Hill Publishers.
4. https://ocw.mit.edu/courses/esd-051j-engineering-innovation-and-design-fall-2012/video_galleries/lecture-notes-and-videos/

##

Course Code: MEN12602	Workshop and Manufacturing Processes	Credits: 1-0-2:2

Prerequisites: NIL

Course Outcomes:

CO1	Students will be able to understand the importance of manufacturing which comprises materials, processes and systems.
CO2	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.
CO3	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.
CO4	Students will be able to learn and perform operations related to carpentry, fitting, plastic molding, and Computer Numerical Control (CNC) machines.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	1	1	-	2	1	1	-	1	1	1	1	2	1
CO2	2	1	1	-	-	1	1	-	1	1	1	1	2	1
CO3	2	1	1	-	-	1	1	-	1	1	1	1	2	1
CO4	2	1	1	-	3	1	1	-	1	1	1	1	2	1

Correlation between ME11102 Workshop subject and the PSOs

Name of the B. Tech. Program	PSO1	PSO2	PSO3	PSO4
B. Tech. (Civil Engineering)	2	1	1	-
B. Tech (Mechanical Engineering)	3	3		
B. Tech (Production & Industrial Engineering)	3	3		
B. Tech (Electrical Engineering)	1	1	-	

Unit	Details	No. Hrs
1	**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	4
2	**Sand Casting Process of Metals-** Elements of Green Sand Mould; Pattern design and making, Method of Preparation of Green Sand Mould; Casting Defects	2
3	**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	3

4	**Machining Processes:** Classification of machining processes & machine tools; Construction, Specification, and operations on Lathe Machine and Drilling machine	2
5	**Fabrication Processes-** Classification of Welding Operations, Types of Joints & Welding Positions; Brief description of Arc, Resistance and Gas welding techniques. Brazing and Soldering	3

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, male-female 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:

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

##

Course Code: MEN11601	Engineering Graphics	Credits: 1-0-2: 2

Prerequisites: NIL

Course Outcomes:

CO1	Understand the importance and principles of engineering drawing by hand practice and using computer aided drafting software.
CO2	Understand the isometric and orthographic projections of different objects.
CO3	Create assembly drawing of simple machine components

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	3	1	-	3	-	-	2	1	2	-	2	2	1
CO2	2	2	2	1	3	-	-	2	1	2	-	1	2	2
CO3	3	3	3	2	3	-	-	2	1	2	-	1	2	3

Unit	Details	No. Hrs
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.	2L+2P
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.	4L+8P
3	Introduction to computer aided drafting software and hands on practice of orthographic views of solid objects.	2L+6P
4	Sectional viewsof solid objects and hands on practice of sectional views of solid objects using computer aided drafting software.	2L+4P
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.	1L+2P

Text Books:

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

References:

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.

##

Semester-III

Course Code: AMN13101	Mechanics of Materials	Credits: 3-0-2:4

Prerequisites: NIL

Course Outcomes:

S.N.	Outcomes
CO1	Understand the concept of internal forces and moments, stress, strain, deformations in members subjected to axial, bending and torsional loads
CO2	Understand the concepts of stress and strain at a point, and principal stress and strain to solve the problems of engineering elasticity
CO3	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
CO4	Analyse the mechanical engineering structures and components for safer mechanical design by considering appropriate failure criteria and the design requirements.

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	2	1	-	2	1	2	2	1	1	3	3
CO2	3	3	2	2	1	-	2	1	1	2	1	1	3	3
CO3	3	3	2	2	1	-	1	1	1	1	1	1	3	3
CO4	3	3	3	2	1	1	1	1	1	1	1	2	3	3

Unit	Content	Lectures
1	**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.	06
2	**Biaxial Stress and Strain:** Stress at a Point, Stress Transformation, Analysis of Strain,Strain-Displacement Relations, Strain Transformation, Strain Measurements, Principal Stresses and Strain	08
3	**Bending and Shear Stresses:** Shear Force and Bending Moment Diagrams, Pure Bending, Normal Stress and Shear Stresses in beams, Composite Beams	06
4	**Torsion of Shaft,Springs, and Pressure Vessels:** Torsion of Circular Shaft, Power Transmitted by a Shaft, Compound Shaft,Combined Loadings, Thin-Walled Shells, and Springs (Open and Closed Coils)	06
5	**Deflections of Beams:** Equation of Elastic Curve, Methods for Determining Deflections: Double Integration, Macaulay's Method, Moment-Area Method, Castigliano's Theorem	08
6	**Columns and Theories of Failure**: Euler's Theory for Long Columns, Rankine-Gordon Formula, Eccentrically Loaded Columns, Theories of failure	06

Text Books

1. Mechanics of Materials, Gere and Timoshenko, CBS Publications.
2. Introduction to Mechanics of Solids, Crandall, Dahl and Lardener, Tata Mcgraw Hill Publications.
3. Mechanics of materials, Hibbeler, R.C., 2005, Pearson Education.

Reference Books

1. Elements of Strength of Materials, S.P. Timoshenko and D.H. Young, East-West Press Pvt. Ltd. Publications.
2. Mechanics of Materials, Pytel and Kiusalaas, Cengage Learning Publications.
3. Mechanics of Materials, E. P. Popov, Prentics Hall Publications.
4. Strength of Materials, G. H. Ryder, Macmillan India Limited.
5. Strength of Materials, Pytel and Singer, Harpercollins College division publications.
6. Mechanics of Materials, Riley, Struges and Morris, John Wiley & Sons.

Experiment No.	Details	No. Hrs
1	Specimen preparation by cutting, grinding, polishing and etching of given materials for comparative micro-structural examination.	**2**
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.	**2**
3	To predict creep characteristics of given materials by plotting strain vs. time curves for different loadings.	**2**
4	To study the effect of surface treatment (Etching) on the strength of glass.	**2**
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	**2**
6	Fabrication and mechanical testing of composite materials made by hand-layup technique in the laboratory.	**2**
7	To study the fatigue behavior of different materials.	**2**
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.	**2**
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.	**2**
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.	**2**

Reference Books

1. Pytel A H and Singer F L, “Strength of Materials”, 4th Edition, Harper Collins, New Delhi, 1987.
2. Beer P F and Johnston (Jr) E R, “Mechanics of Materials” SI Version, Tata McGraw Hill, India, 2001.
3. Timoshenko S P and Young D H, “Elements of Strength of Materials”, 5th Edition, East West Press, New Dlehi, 1984.
4. William D. Callister Jr., David G. Rethwisch “Materials Science and Engineering: An Introduction”.
5. Raghavan V “Materials Science and Engineering: A First Course

Course Code: **PIN13101**	**Industrial Engineering**	Credits: **3-0-2-4**

Pre-requisites: NIL

Course Outcomes:

CO1	Students will be able to identify and use the elements of cost, methods of depreciation and investment techniques. Productivity, Productivity Measurements and develop entrepreneurial attitude.
CO2	Students will be able to describe the job evaluation, merit rating and wage-incentive plans.
CO3	Students will be able to iimplement work study techniques for better productivity and learn to do work measurement and calculate the standard time for doing a job.
CO4	Students will be able to describe and use different material handling devices, repair and maintenance methods.
CO5	Students will be able to learn and describe learn about Maintenance Management and Probabilistic Failure causes.

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	-	-	-	3	2	2	2	2	3	3	2
CO2	2	2	2	-	-	1	2	2	2	2	3	2	3	3
CO3	3	2	2	1	-	1	2	2	2	1	2	3	2	2
CO4	3	2	2	2	2	-	3	2	2	2	2	2	3	3
CO5	2	2	2	-	2	1	3	2	2	2	3	3	3	2

Module	**Details**	No. Hrs
1	Introduction, Engineering Economy and Costing-Plant Location and Layouts, Production Systems, Cost Analysis, Break-even Analysis, Methods of Depreciation, Investment/Replacement analysis, Concepts of Production and Productivity, Productivity Measurements.	8
2	Job evaluation, Benefits of Job evaluation, Methods of Job evaluation, Merit Rating, Methods of Merit Rating, Requirements for success of Merit Rating System, Objectives of a Good Wage-Incentive Plan, Basis of a Good Wage-Incentive Plan, Types of Wage-Incentive Plans.	12
3	Work Measurement, Time Study, PMTS, Work Sampling, Method Study, Micro Motion Study, Principles of Motion Economy.	8
4	Material Handling System- principles, types, and devices.	6
5	Maintenance Management- Probabilistic Failure and Repair Times, Preventive Maintenance and Replacement, Total Preventive Maintenance, Concurrent Engineering-steps and CE Environment.	4

Text/Reference Books

1. Turner, W.C., et. al., 1993, “Introduction to Industrial and System Engineering”, Prentice Hall.
2. Del Mar, Donald, “Operations and industrial management: designing and managing for productivity”, McGraw-Hill,2007
3. Ralph M. Barnes, “Motion and Time Study: Design and Measurement of Work”, Wiley Publishers
4. Chandler Allen Phillips, “Human Factors Engineering”, John Wiley and Sons, New York,

Experiment No.	Details	No. Hrs
1	Introduction to industrial engineering, ergonomics and basic laboratory safety	2
2	To determine the light level in different workplaces of an industry	2
3	Measurement of sound level and noise in different workplace	2
4	Analysis of operations for a given job with the help of following charts and diagrams: (a) Outline process chart (b) Flow process chart (for material and workpiece) (c) Activity chart and (d) String diagram	2
5	To make a process sheet for manufacturing of a given job	2
6	To prepare an activity chart (left hand/right hand activity) for a given job (perform any one) (a) Nut and bolt assembly or, (b) Parts of pen or, (c) Roti making	2
7	To determine the standard time (time study) for a given job using stop watch time study	2
8	To analyze the different type of cost associated with a job and suggest the methods to enhance the productivity	2
9	Study of job evaluation using (a) Point rating, and (b) Merit rating using workers comparison	2
10	To study and implement the principle of motion economy	2
11	Pin board study experiment	2
12	Multiple activity chart or, Man machine chart	2

Text Book and References:

1	Industrial Engineering and Ergonomics: Visions, Concepts, Methods and Tools	Christopher M. Schlick	Springer
2	Human Factors in Engineering and Design	Mark S. Sanders and Ernest J. McCormick	McGraw-Hill Education
3	Operations and Industrial Management: Designing and Managing for Productivity	Del Mar, Donald	McGraw-Hill Education
4	Motion and Time Study: Design and Measurement of Work	Ralph M. Barnes	Wiley
5	Production Management: An Integrated Approach to Industrial Engineering	S.K. Hajra Choudhary, Nirjhar Roy, and A. K. Hajra Choudhary	Media Promoters and Publishers

##

Course Code: AMN13106	Kinematics and Dynamics of Machines	Credits: 3-0-0:3

Pre-requisites: NIL

Course Outcomes

CO1	Apply the graphical methods and analytical Computations involved in the mechanisms to analyze the position, velocity and acceleration of a mechanism.
CO2	Draw velocity and acceleration diagrams for cams and followers executing various kind of motions for various configuration of followers.
CO3	Select gear and gear trains for a particular application in automobile and various industries employing gears as power transmission tools.
CO4	Mathematically model and analyze the effects of the static and dynamic forces that mechanisms/machines may experience commonly and work upon the control of fluctuations of energy
CO5	Mathematically model and analyze the effects of the static and dynamic forces that mechanisms/machines may experience commonly and work upon the control of fluctuations of energy

Course Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	1	-	1	2	-	-	1	-	2	1	3	3
CO2	3	3	2	2	2	2	-	-	1	-	2	2	3	3
CO3	3	3	2	2	2	2	3	-	2	2	3	3	3	3
CO4	3	3	3	3	3	1	2	-	2	2	1	2	3	3
CO5	3	3	3	3	1	2	1	-	2	1	1	2	3	3

Unit	Details	Hrs.
1	**Velocity and Acceleration in Mechanism**-Introduction to Kinematic Links and Pairs, Inversion of Mechanism, Velocity of a Link, Relative Velocity Method, Instantaneous Center Method, Kennedy's Theorem for Three Centers, Acceleration Diagram, Coriolis Component of Acceleration.	**12**
2	**Cams**-Classification of Cams and Followers, Nomenclature, Types of Follower Motion, Generation of Cam Profile with Uniform Velocity, SHM, Uniform Acceleration and Retardation, Cycloidal Motion of The Follower.	**6**
3	**Gear and Gear Trains**- Types. Terminology, Fundamental Law of Gearing, Gear Profiles, Undercutting, Gear Trains: Simple, Compound, Reverted and Epicyclic Gear Trains.	**6**
4	**Static and Dynamic Force Analysis**-Static Force Analysis of Planar Mechanisms, Dynamic Force Analysis Including Inertia and Frictional Forces of Planar Mechanisms, Turning Moment Diagram for Engines and Speed Fluctuation, Flywheel.	**10**
5	**Balancing of Rotating and Reciprocating Masses**- Static Balance, Dynamic Balance, Balancing of Rotating Masses, Two Plane Balancing, Balancing of Single and Multi-Cylinder Engine, Firing Order.	**6**

Text Books

1. Kinematics & Dynamics of Machinery by R. L. Norton, McGraw Hill
2. Kinematics, Dynamics and Design of Machinery by K.J. Waldron & G. L. Kinzel, Wiley
3. Theory of Machines and Mechanisms by John J. Uicker, Jr. Gordon R. Pennock& Joseph E. Shigley, Oxford University Press

Reference Books

1. Theory of Machines by S.S. Ratan, Tata McGraw-Hill.
2. Theory of Machines by Thomas Bevan, CBS Publishers & Distributors.
3. Kinematics and Dynamics of Machines by George H. Martin, Overseas Press Pvt. Ltd., India
4. Theory of Mechanisms and Machines by Amitabha Ghosh &Asok Kumar Mallik, Affiliated East-West Press

Course Code: EE*****	Basic Electrical and Electronics	Credits: 2-0-2:3

Pre-requisites: NIL
Course Outcomes:

CO1	Acquire the basic knowledge of electrical circuit simplification along with various concepts to simplify them
CO2	Acquire basic knowledge and general concepts related to 1-phase/ 3-phase AC circuits and power, including its measuring procedure and applications
CO3	Acquire knowledge and be able to conceptualize general concepts related to static and rotating electric machines along with their working and applications
CO4	Be able to understand general concepts of the working of power system along with general domestic wiring including safe and economic use of electrical power
CO5	Be aware with the electronic devices and related basic concepts along with the number system theory

Course Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	3	1	1	2	-	1	-	-	-	-	-	1	1
CO2	1	3	1	2	2	-	1	1	-	-	-	-	1	1
CO3	2	1	1	1	1	-	1	-	-	-	-	1	3	1
CO4	2	1	3	1	1	2	2	1	-	-	-	1	3	2
CO5	2	2	1	2	2	-	2	-	-	-	-	1	1	1

Unit	Contents	Hours
1	**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	
2	**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.	
3	**Electrical Machines** Basics- construction, working and applications of transformer, DC machine, 3-phase induction motor and synchronous machine. Losses in electrical machines.	
4	**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.	
5	**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	

Text / Reference 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, RohitMetha, "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

##

Course Code: **PIN13102**	Instrumentation and Process Control	Credits: **3-0-2:4**

Pre-requisites: Physics, Basic Electrical and Electronic

Course Outcomes:

CO1	Students will be able to understand the basic calibration, possible errors and measures to minimize them based on their characteristics.
CO2	Students will be able to apply knowledge on sensors and their suitability in the application of measuring different physical quantities and their ranges
CO3	Students will be able to apply working principles in the measurement of field quantities.
CO4	Students will be able to analyze the process control systems based on the requirement.

Course Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	1	1	1	1	1	-	1	-	3	3	3
CO2	3	2	2	1	1	1	1	1	-	-	-	3	3	3
CO3	3	3	3	2	3	2	1	1	-	-	-	3	3	3
CO4	3	3	3	2	3	2	1	1	1	1	1	3	3	3

Unit	Details	No. Hrs
1	**Instruments and measurement system:** Functions of instruments and measurement system, Elements of generalized measurement system, error in measurements, calibration and standards, Statistical analysis of experimental data	**7**
2	**Classification and selection of instruments:** Classification of instruments, Analog and digital modes of operation, Instrument selection criteria and installation procedures	**6**
3	**Characteristics of instruments and measurement systems:** Static characteristics of measuring instruments, Dynamic characteristics of measuring instruments	**4**
4	**Indicating instruments:** Essentials of indicating instruments, Principles of indicating instruments and their applications like wattmeter, watt-hour meter, dynamometer type power factor meter	**6**
5	**Transducers:** Introduction to sensors and transducers, Mechanical input transducers, Electrical transducers like Resistive, Capacitive & Inductive transducers, Measurement of various physical quantities like pressure, temperature, force, liquid level, flow, speed and humidity	**7**
6	**Signal Conditioning and Data Acquisition System:** Introduction, Signal Conditioning, Multiplexing, Accuracy of Digital Meter, Aperture Time for Sample and Hold Mechanism, image processing, signal analysis and FFT **Display Devices And Recorders:** Recorders, X-Y Plotter	**5**

7	**Process Control:** Introduction , Proportional Control, Integral Control, Derivative Control, Proportional-cum-integral Control (PI Control), Proportional-cum-integral-cum-derivative (PID) Control, Integral Windup, Electronic Controller, Pneumatic Controller, Selection of Control Technique, Three-element Control (Concept of Feed Forward)	**5**

Text Books

1	Fundamentals Of Industrial Instrumentation and Process Control	William C Dunn	Tata McGraw-Hill, New Delhi

References:

1	Measurement systems – Application and Design	E.O. Doebelin	Tata McGraw-Hill, New Delhi.
2	A course in Electronic and Electrical Measurements	J. B. Gupta	S. K. Kataria and Sons, New Delhi.
3	Process control instrumentation technology	C. D.Johnson	John Wiley & Sons, New York.
4	Mechanical Measurements and Instrumentation	R.K. Rajput	S. K. Kataria & Sons, New Delhi.
5	Principles of Measurement Systems,	John P. Bentley,	Pearson India Ltd.
6	Instrumentation, Measurement and Analysis,	Nakra, Chaudhary,	Tata McGraw-Hill, New Delhi.
7	Transducers and instrumentation.	D. V. S. Moorthy,	Prentice Hall of India Pvt. Ltd.

Unit	Details	No. Hrs
1	Study the displacement and current characteristics in Linear variable differential transformers (LVDT).	**02**
	Find the relationship between displacement and change in signal generated due to Capacitive type transducer (Proximity Tutor).	
2	To draw the calibration graph for the Bimetallic transducer using a thermometer as standard and determine the time constant for the transducer.	**02**
3	Find the relationship between displacement and change in signal generated due to strain gauge.	**02**
	To calibrate the given force measuring elastic transducer for compression and tensile loads.	
4	To plot the calibration graph between the temperature and RTD readings.	**02**
	To study the variation of light intensity with distance form source with a luxmeter.	

5	Calibration of Bourdon pressure gauge for (i) above atmospheric pressure, and (ii) below atmospheric pressure conditions	**02**
6	To make the study and use of micrometer and depth gauge	**02**
	To measure the angle of a given taper specimen with the help of a clinometers first and then calculate the accurate value using sine bar.	
7	To determine the diameter of a specimen and the error in given specimen with the help of passameter and slip gauges.	**02**
8	To measure the screw parameters i.e. external diameter, pitch, flank angle using Tool Makers Microscope.	**02**
	To determine the outside and core diameter of a given specimen with the help of Floating carriage micrometer	
9	Two study the three mode (PID) control of level, flow, pressure and temperature	**03**

Text Books

1	Fundamentals Of Industrial Instrumentation and Process Control	William C Dunn	Tata McGraw-Hill, New Delhi

References:

1	Measurement systems – Application and Design	E.O. Doebelin	Tata McGraw-Hill, New Delhi.
2	A course in Electronic and Electrical Measurements	J. B. Gupta	S. K. Kataria and Sons, New Delhi.
3	Process control instrumentation technology	C. D. Johnson	John Wiley & Sons, New York.
4	Mechanical Measurements and Instrumentation	R.K. Rajput	S. K. Kataria & Sons, New Delhi.
5	Principles of Measurement Systems,	John P. Bentley,	Pearson India Ltd.
6	Instrumentation, Measurement and Analysis,	Nakra, Chaudhary,	Tata McGraw-Hill, New Delhi.
7	Transducers and instrumentation.	D. V. S. Moorthy,	Prentice Hall of India Pvt. Ltd.

Course Code: PIN13103	Operations Research	Credits: 3-0-0:3

Pre-requisites: NIL

Course Outcomes:

CO	Outcomes
CO1	Understand the characteristics of different types of decision-making environments.
CO2	Identification and formulation of the problem in real life
CO3	Understand the appropriate decision making approaches and tools to be used in each type.
CO4	Formulate and solve LPP, Transportation, Assignment, and Scheduling Models with real life problems
CO5	Design new simple models, like: CPM, PERT to improve decision making.

Course Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	3	2	2	3	2	2	2	2	3	3	3	2	2
CO2	3	3	3	3	3	2	2	2	2	2	3	3	2	2
CO3	3	3	3	3	3	2	2	2	2	2	3	3	3	3
CO4	3	2	3	3	3	2	2	2	2	2	3	3	3	3
CO5	3	3	3	3	3	2	2	2	2	2	3	3	3	3

Unit	Content	Lectures
1	**BASICS OF OR** - Development of Operations Research, Definition of Operations Research, Characteristics of Operations Research, Scope of Operations Research, Operations Research and Decision-Making, Scope of Operations Research in Management, Scope of OR in Financial Management ,Application of various OR Techniques, Objective of Operations Research **INVENTORY CONTROL** - Necessity for Maintaining Inventory, Inventory Costs, Inventory Control Problem, Classification of Fixed Order Quality Inventory Models, Inventory Models with Deterministic Demand	6
2	**LINEAR PROGRAMMING** - Introduction, Formulation of Linear Programming problems, Graphical Method of Solution, The General Linear Programming problem, Canonical and Standard Forms of Linear Programming Problem, Theory of Simplex Method, Analytical Method or Trial and Error Method, The Simplex Method (Technique or Algorithm), Artificial Variables Techniques, The Big-M Method, The Two-Phase Method	12
3	**TRANSPORTATION MODELS**-Introduction to the Model, Definition of the Transportation Model, Matrix Terminology, Formulation and solution of Transportation Models, Variants in Transportation Problems, Additional Problems. **ASSIGNMENT MODEL**-Definition of the Assignment Model, Mathematical Representation of the Assignment Model, Comparison with the Assignment Model, The Hungarian Method for Solution of the Assignment Problems, Formulation and solution of the Assignment Models, Variations of the Assignment Problem, The Travelling Salesman Problem. **SEQUENCING MODELS** -Sequencing problems, Assumptions in	12

	Sequencing Problems, Processing n Jobs through one Machine, Processing n Jobs through two Machines, Processing n Jobs through three Machines, Processing two Jobs through m Machines, Processing n Jobs through m Machines, Problems related to Sequencing (Routing Problems in Networks),Minimal Path Problem.	
4	**GAME THEORY** - Game theory, Formulate two-person zero-sum game, Solve a simple game, Solve mixed strategy games using graphical method and LP, Describe reduction using dominated strategy, Introduce saddle point condition, Formulation of Two-person Zero-sum game, Solution of simple games, Mixed strategy games, Solving using Graphical Method, Solving Using LP, Reduction using Dominated Strategies, Saddle point Condition, Examples.	**6**
5	**NETWORK ANALYSIS** - Network models, Identify the situation in which minimum spanning tree algorithm can be used, Identify the situation in which shortest path algorithm can be used, Identify the situation in which maximal flow algorithm can be used, Draw network diagram, Analyze the network, Identify critical path, CPM. Apply PERT using Optimistic, Most likely, pessimistic times of activities, Find the probability of completing the project, Minimal spanning tree problem, Shortest route problem, Maximal flow problem	**6**

Text Books:

1. Operations Research An Introduction by H. Taha
2. Operations Research by Heera and Gupta

References:

1. Introduction to Operations Research by Hillier & Lieberman
2. Operations Research by V K Kapur
3. Operations Research by S D Sharma

##

Course Code: **PIN13301**	Fluid and Thermal Engineering Lab	Credits: 0-0-2:1

Pre-requisites: Concepts of Thermodynamics, Fluid Mechanics and Heat Transfer

Course Outcomes:

CO1	Students will be able to apply the concepts of thermodynamic, fluid mechanics and heat transfer
CO2	Students will be able to solve problems related to thermal and fluid systems.
CO3	Students will be able tocritically analyze the results and identify the problems in the systems and rectify them
CO4	Students will be able to prepare the reports of experiments in a format that a technically competent person can follow and obtain the similar findings.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	1	1	1	1	1	-	-	2	1	-	3	1
CO2	3	2	1	1	-	-	1	-	-	2	-	-	2	1
CO3	2	2	1	3	1	1	2	-	-	3	-	2	2	2
CO4	3	3	1	3	1	1	3	1	1	2	1	2	3	3

Exp. No.	Details	No. Hrs
1.	To estimate the thermal conductivity of metal bar	2
2.	To estimate the thermal conductivity of insulating powder	2
3.	Study of the heat transfer in natural convection apparatus	2
4.	Study of the heat transfer in the forced convection apparatus	2
5.	To study the transition from laminar to turbulent flow and to determine the lower critical Reynolds number.	2
6.	To verify the momentum equation using the experimental set-up on diffusion of submerged air jet.	2
7.	To calibrate an orifice meter, venturimeter, and bend meter and study the variation of the co-efficient of discharge with the Reynolds number.	2
8.	Study and performance of complete steam power plant	2
9.	To find the dryness fraction of wet steam using separation throttling calorimeter	2
10.	Study of 2-Stroke and 4-stroke C.I. & S.I. Engine with valve timing diagram.	2
11.	Disassembly of single cylinder Diesel Engine & Assembly of single cylinder Diesel Engine.	2
12.	Performance study on a vapor Compression refrigerator system.	2

Text Books:

1	Engineering Thermodynamics	P.K. Nag	McGraw Hill
2	Fluid Mechanics	Cengel& Boles,	McGraw Hill
3	Heat and Mass Transfer (In SI units) A practical approach	Yunus A. Cengel,	McGraw Hill.

References:

1	Thermodynamics: An engineering	Cengel& Boles,	McGraw Hill
2	Introduction of Fluid Mechanics & Fluid Machines	Som, S.K., and Biswas G	TMH, New Delhi.
3	Heat Transfer	J.P. Holman	McGraw-Hill International edition

##

Semester-IV

Course Code: **PIN14101**	Computer Aided Geometric Modelling	Credits: **3-0-2:4**

Pre-requisites: Mathematics – I and Mathematics – II

Course Outcomes:

CO1	Students will be able to model the objects geometrically with parametric curves.
CO2	Students will be able to apply geometrical transformations and projection methods to an available geometric model.
CO3	Students will be able todesign surface and solid models of the objects.
CO4	Students will be able to analyse the applications of solid modelling in different fields.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	1	1	3	-	-	1	1	3	-	2	3	3
CO2	3	2	1	1	3	-	-	1	1	3	-	2	3	3
CO3	3	2	1	1	3	-	-	1	1	3	-	2	3	3
CO4	3	2	1	1	3	-	-	1	1	3	-	2	3	3

Unit	Details	No. Hrs
1	Introduction: Historical Development, Vectors, Coordinate Systems, Intrinsic and Extrinsic properties, Explicit and Implicit Equations, Parametric Equations, Parametric Space.	2
2	Design of Curves: Parametric Representation, Hermite curve: Basis functions, Reparametrization, Composite curve, Bezier Curve: Basis functions, de-Casteljau algorithm, Degree elevation, Composite Bezier curve, B-Spline Curve: Basis functions, Knot vectors, Closed B-Spline Curve, Knot insertion, Rational curves, NURBS.	8
3	Geometric Transformations: Translation, Rotation, Shear, Scaling and Reflection, Homogeneous Transformations, Orthographic Projections, Axonometric Projections, Oblique Projections, Perspective Projection.	6
4	Design of Surfaces: Parametric Representation, Plane, Cylindrical and Ruled Surfaces, Surfaces of Revolutions, Bezier Surface, B-Spline and NURBS Surfaces.	7
5	Design of Solids: Topology, Set theory, Boolean operators, Solid Model Construction: Half-Spaces, Constructive Solid Geometry, Boundary Representation, Sweep Representation, Analytical Solid Modelling, Spatial Enumeration, Octree Encoding.	8
6	Data exchange formats, Application of Geometric Models: Finite Element Modelling.	4

Text Books:

1	Geometric Modeling	M E Mortenson	McGraw Hill Education
2	Mathematical Elements of Computer Graphics	D F Rogers and J AAdams	McGraw Hill Education
3	CAD/CAM: Theory and Practice (Special Indian Edition)	Ibrahim Zeid	McGraw Hill Education
4	The Finite Element Method in Engineering	S S Rao	Elseveir

References:

1	Curves and Surfaces for Computer Aided Geometric Design: A Practical Guide	G. Farin	Academic Press
2	Computer-Aided Engineering Design	A Saxena and B Sahay	Springer
3	Bezier and B-spline Techniques	H. Prautzsch, W. Boehm, M. Paluszny	Springer-Verlag
4	Computer Aided Design and Manufacturing	https://nptel.ac.in/courses/112102101	
5	Computer Aided Engineering Design	https://nptel.ac.in/courses/112104031	

Experiment	Details	No. Hrs.
	Using available CAD software, attempt:	
1	To understand the interface, input and output options of the software and create a 2D drawing of a given object.	2
2	To create surface models of a given object.	4
3	To create solid model of a given object.	4
4	To create assembly models of different objects.	4
	Using MATLAB® software, attempt:	
5	To execute the following basic functions: matrix operations, control statements, mathematical operations, 2D and 3D graphical plots, keyboard and mouse inputs, file handling.	2
6	To draw a Bezier curve of n^{th} degree using (a) Matrix and (b) Blending function approach based on the user inputs. Also demonstrate the effect of different control points on the shape of the curve generated.	2
7	To draw B-Spline curve of a given order for the given control points. Also demonstrate the effect of different curve parameters on the shape of the curve generated.	4
8	To demonstrate the applications of different Geometric Transformations (translation, rotation, scaling and reflection) on a rectangle of size $l \times w$ and different Projections (orthographic, axonometric, oblique and perspective) on a rectangular box of size $l \times w \times h$.	2
9	To draw Bezier Surface demonstrating the effect of surface parameters on the shape of the generated surfaces.	2
10	To draw B-spline Surface demonstrating the effect of surface parameters on the shape of the generated surfaces.	2

Course Code: PIN14103	Manufacturing Science and Technology-I	Credits: 3-0-2:4

Pre-requisites: Workshop and Manufacturing Processes

Course Outcomes:

CO1	Students will be able to apply the concept of metal casting processes in any manufacturing or foundry industry.
CO2	Students will be able to apply the concept of plastic moulding and powder metallurgy technique in any manufacturing or powder metallurgy industry.
CO3	Students will be able to apply the concept of bulk and sheet metal forming processes in any manufacturing or metal forming industry.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	1	1	-	1	1	1	2	-	1	3	2
CO2	3	3	2	1	1	-	1	1	1	2	-	1	3	2
CO3	3	3	3	1	1	-	1	1	1	2	-	1	3	2

Course Contents:

Unit	Details	Hrs
1	**Metal Casting:** Sand Mould Casting-Pattern Design and Moulding; Gating Design and Pouring; Solidification and Riser Design; Shell Moulding and Vacuum Moulding; Investment Casting and Evaporative Casting; Plaster Mould and Ceramic Mould; Metal Mould Casting: Die Design and Preparation; Pouring and Solidification; Opening and Ejecting; Gravity and Pressure Die Casting, Vacuum and Slush Casting; Centrifugal and Continuous Casting; Squeeze and Chilled Casting; Defects and Inspection of Casting	12
2	**Plastic Molding and Powder Metallurgy:** Classification of Moulding Processes, Extrusion and Injection Moulding, Compression and Transfer Moulding, Blow and Rotational Moulding; Glass-working Science and Technology: Raw material preparation; shaping of Piece Ware and Flat and Tubular glass. Production and Mixing of Metal Powders; Press Compacting and Sintering, Hot Isostatic Pressing (HIP), and Powder Injection Moulding (PIM); Powder Metallurgy Materials and Products	6
3	**Bulk Metal Forming:** Yielding and Flowing; Hot and Cold Forming; Friction and Lubrication; Flat Rolling: Classification, Process geometry and Analysis using slab method for load and power; Rolling mills and Roll pass design; Rolling defects; Forging: Classification, Process Geometry and Analysis of Strip and Disc forging using slab method for load and power; Forging defects; Wire Drawing: Process Geometry and Analysis using slab method for load and power, Maximum reduction, Drawing defects; Extrusion: Classification, Process Geometry and Analysis of Extrusion using slab method for load and power, Maximum reduction; Extrusion defects	12
4	**Sheet Metal Forming:** Material behaviour; Shearing: Types, Clearance and Calculation of Forces; Miscellaneous sheet metal cutting processes-Cut-off and Parting; Slotting, Perforating and Notching, Trimming, Shaving and Fine Blanking;	6

	Bending-Types, Allowances, Springback and Calculation of Force; Drawing-Types, Clearance, Measure of Drawing, Calculation of Forces; Spinning-Types and Calculation of Forces; Miscellaneous sheet metal forming processes-Ironing, Coining and Embossing; Lancing and Twisting; Stretching and Hydroforming; Impulse Forming (Explosive, Electro-hydraulic and Electro-magnetic) and Laser forming; Dies and Presses for Sheet Metal Processes	

Text/Reference Books:

1. Groover's Principles of Modern Manufacturing: Materials Processes and Systems by M. P. Groover, John Wiley and Sons, New Delhi (SI Edition)
2. Manufacturing Science by Ghosh and Mallik, East West Press Pvt. Ltd., New Delhi
3. *Manufacturing Engineering and Technology by Kalpakjian and Schmid, Pearson Education Pvt. Ltd. New Delhi*

Course Contents:

Unit	Details	Hrs
1	Design and Preparation of a wooden pattern for the given dimensions of a casting of V- block made of Cast Iron/Steel	2
2	Preparation of machine mould as per the dimensions of a given part and study of moulding methods used in Foundry Shop.	2
3	Study of Sieve Shaker and to find Grain Fineness Number for a given sample of foundry sand.	2
4	Study of Permeability Tester and to find Permeability Number for a given sample of foundry sand.	2
5	Study of Strength Tester and to find green compression and shear strength of a given sample of green sand.	2
6	Study of Moisture and Clay Content Tester and to find the moisture content and clay content in a given sample of green sand.	2
7	Study of Shatter Index Tester and to find shatter index of a given sample of green sand.	2
8	Determination of sheet length and bending force required for forming the given 'Z' section.	2
9	Study of Power Press and Power Hammer	
10	Study of Hydro Forming Process and making a cup shaped part using Sheet Hydro Forming Setup.	2

Books:

1. Principles of Foundry Technology by P.L. Jain, Tata McGraw Hill
2. Manufacturing Technology: Foundry ,Forming and Welding by P.N. Rao, Tata McGraw Hill
3. A course in Workshop Technology by B. S. Raghuwanshi, Dhanpat Rai & Co.

Course Code: PIN14102	Machine Tools Engineering	Credits: 3-0-2:4

Pre-requisites: NIL
Course Outcomes:

CO1	Students will be able to design jigs and fixtures for the effective use of machining processes on different components
CO2	Students will be able to understand the machine tool structure, guideways, drives and transmissions in machine tools
CO3	Students will be able to select and/or design the cutting tools to manufacture and inspect the geometric features on parts/components.
CO4	Students will be able to understand the design of tools and dies for cutting, forming and drawing operations.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	1	1	3	-	1	1	2	3	-	3	3	2
CO2	3	2	1	1	3	-	1	1	2	3	-	3	3	2
CO3	3	3	3	2	3	3	3	1	2	3	-	3	3	3
CO4	3	3	2	1	3	3	1	1	2	3	-	3	3	3

Unit	Details	No. Hrs
1	**Gauges**-Classification and Selection of materials for gauges; Construction, working and design of Limit Gauges, Plug gauges, Snap gauges, and Screw gauges;	3
2	**Jigs and Fixtures**-Classification of Jigs and Fixtures, Fundamental Principles of design of Jigs and Fixtures, Location and Clamping in Jigs and fixtures, Simple design for drilling Jigs, Milling fixtures, Indexing Jigs and fixtures, etc.	6
3	**Machine Tools-** Classification and Components of Machine Tools, machine tool structure; Drives and Transmission, Classification of Speed and Feed Boxes, Design of Guideways.	9
4	**Cutting Tools**-Classification of Cutting Tools; Design of single point tools for lathes, shapers and planers; Design of Inserts, Chip breakers; Design of Multi Point Cutting Tools- drills, reamers, milling cutters, broaches, grinding wheels and taps.	9
5	**Forming and Cutting Dies-** Classification of forming and cutting dies and presses; Construction, working and design of bulk metal deformation dies such as wire drawing dies, Extrusion dies, Forging dies and Rolling dies; Construction, working and design of sheet metal working dies such as Blanking dies, Piercing dies, bending and deep drawing dies;	9

Text Books:

1	Machine Tool Design	N.K. Mehta	Tata McGraw Hill
2	Tool Design	Donaldson	Tata-McGraw Hill
3	Jigs and Fixtures	P. H. Joshi	Tata-McGraw Hill

References:

1	Fundamentals of Tool Design	ASTME	Prentice Hall of India Pvt. Ltd
2	Tool Design	H.W. Pollack	Reston Publishing Company, Inc.
3	Principles of Jig and Tool Design	M.H.A. Kempster	English University Press Ltd.
4	Machine Tool Structures	Koenigsberger and Tlusty	Kluwer Academic
5	Geometric Dimensioning and Tolerancing	D. James, and S, Meadow	Marcel Dekker Inc.,

Unit	Details	No. Hrs
1	Study of Box type and Post type Jigs	2
2	Study of Indexing Jigs and Fixtures	2
3	Study of different types of Drill machine tools and drills	2
4	Study of Guide ways of Lathe, Milling, Drill machines	2
5	Study of machine tool structure	2
6	Study of machine tool components	2
7	Study of Speed and Feed mechanisms of machine tools	2
8	Study of Form tools	2
9	Study of Locating and Clamping Devices	2
10	Design of tool for drilling, milling and grinding using CAD software	2

Text / Reference Books:

- Fundamentals of Tool Design by ASTME, Prentice Hall of India Pvt. Ltd.
- Tool Design by Donaldson, Tata-McGraw Hill
- Tool Design by H.W. Pollack, Reston Publishing Company, Inc.
- Principles of Jig and Tool Design by MHA Kempster, English University Press Ltd.
- Jigs and Fixtures by P. H. Joshi, Tata-McGraw Hill
- Principles of Machine Tools by Senand Bhattacharya, New Central Book Agency Kolkata.
- Machine Tool Design by N. K. Mehta, Tata McGraw Hill

Course Code: PIN14105	Production and Operations Management	Credits: 3-0-0-3

Pre-requisites: Industrial Engineering, Principles of Management.

Course Outcomes:

CO1	Able to understand the concepts of production system, process planning, control of resources and supply chain management using advanced technologies in the context of industrial scenarios.
CO2	Able to run different levels of industrial operations and shop floor management effectively.
CO3	Apply the concepts of modern production technologies and simulations to increase the productivity of the system.
CO4	Identify and analyse the flow of resources and information among the various partners through the knowledge of customer needs.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	1	2	2	1	-	2	1	2	1	2	1	3	1
CO2	-	2	3	3	2	1	1	1	3	1	2	2	2	3
CO3	2	3	2	3	-	-	-	-	2	-	2	2	3	3
CO4	-	1	2	2	-	1	2	3	3	2	2	1	2	2

Unit	Subject Details	No. Hrs
1	**Aggregate Production Planning-** Master scheduling, Bills of materials and MRP, Purpose and scope, Basic strategies, Order and flow control, Routing, Scheduling, and priority dispatching, Operations scheduling. Forecasting.	6
2	**Capacity Planning and Facility Design-**Capacity and Location decisions, Measuring Capacity, Capacity Strategy, Capacity Planning, and Evaluation Methods. Facility location factors, Plant layout, Assembly line balancing.	6
3	**Simulation for Operation Management-**Simulation Models, Steps in Modeling and Simulation, Sample Simulation, Evaluation of Simulation Output.	5
4	**Selection of Process Structure and Technology-** Production Processes Classification: Flow, Job-shop, Cellular, and Project Processes. Modern Production Technologies: Group Technology, Process Automation, and CAD/CAM.	6
5	**Lean Production System-** Kanban and Pull system, JIT and its benefits, Implementation of JIT, JIT Scheduling, Evaluation of JIT Production, Bottleneck Scheduling and Theory of Constraints.	5
6	**Supply Chain Management-** Overview of Supply Chain Management, Competitive Supply chain strategies, Supply chain drives, Customer service, physical distribution planning, inventory, transportation and infrastructure management, Concept of the total cost of ownership, supply stream strategies, measuring the effectiveness of supply management, Sustainable and Green supply chain, Performance of Supply Chain.	8

Text Books:

1	Production and Operations Management	S. N. Chary	McGraw Hill Education
2	Production and Operations Management	Everett E. Adam, Jr. Ronald J. Ebert	Pearson Prentice Hall Publication
3	Modern Production/Operations Management	Elwood S. Buffa and Rakesh K. Sarin	John Wiley & Sons
4	Production and Operations Management	R. Panneerselvam	PHI Learning
5	Supply Chain Management: Strategy, Planning & Operation	Sunil Chopra and Peter Meindle	Pearson Prentice Hall Publication

References:

1	Production and Operations Management	Hamid Noori and Russell Radford	McGraw-Hill Inc., US
2	Operations Management for Competitive Advantage	Chase – Jacobs-Aquilano	McGraw-Hill Education
3	Production and Operations Management	Joseph S. Martinich	John Wiley & Sons
4	World Class Supply Management: The key to Supply Chain Management	Burt, Dobler and Straling	TMH Publication
5	Logistical Management: The integrated Supply Chain Process	Donald J. Bowersox and David J. Closs	TMH Publication

##

Course Code: **HS*****	Principles of Management	Credits: 3-1-0-4

Pre-requisites: NIL

Course Outcomes:

S.N.	Outcomes
CO1	To understand the management concepts and its application with the help of case studies.
CO2	To understand various functional dimensions of management in the business organizations.
CO3	To identify and apply the steps involved in the professional decision making
CO4	To apply managerial and economic concepts in the professional decision making.
C05	To solve case scenarios of real situations in the day-to-day activities

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	-	-	1	2	-	1	-	1	2	2	2	-	-	2
CO2	-	-	1	2	-	1	-	2	3	2	3	-	-	2
CO3	-	-	1	2	-	3	-	3	3	2	3	-	-	2
CO4	-	-	1	2	-	3	-	3	3	2	3	-	-	2
CO5	-	-	1	2	-	3	-	3	2	2	3	-	-	2

Module	Content	Lectures
1	**Introduction to Management:** Definition of Management – Science or Art – Management and Administration, Functions of Management – Types of Business Organisation. Levels of management and Managerial skills. **School of Management Thoughts:** Evolution of Management thoughts, classical approach ,neo- classical approach ,contribution of taylor, weber and fayol, modern approach.	**6**
2	**Planning:** Nature & Purpose – Steps involved in Planning, Objectives, Setting Objectives, Process of Managing by Objectives , Strategies, Policies & Planning Premises Forecasting Decision-making. **Organising:** Nature and Purpose – Formal and informal organization – Organization Chart – Structure and Process – Departmentation by difference strategies – Line and Staff authority – Benefits and Limitations – De-Centralization and Delegation of Authority – Staffing – Selection Process - Techniques – HRD – Managerial Effectiveness.	**8**
3.	**Directing :** Scope – Human Factors – Creativity and Innovation – Harmonizing Objectives – Leadership – Types of Leadership Motivation – Hierarchy of needs – Motivation theories – Motivational Techniques – Job Enrichment – Communication – Process of Communication – Barriers and Breakdown – Effective Communication – Electronic media in Communication. **Organizational Behaviour:** Organizational change, Conflict Management and Stress Management. **Personality:** types, theories and grooming	**8**

	techniques, interpersonal relationship	
4	**Controlling:** System and process of Controlling – Requirements for effective control – The Budget as Control Technique – Information Technology in Controlling – Use of computers in handling the information – Productivity – Problems and Management – Control of Overall Performance ; Coordination and Contemporary international management practices:; MNCSs. TNCs. M&A. **Production concepts and analysis:** Production function, Types of production function, Laws of production: Law of diminishing returns, Law of returns to scale. **Cost concept and analysis:** Types of costs, Cost output relationship in the short-run. Cost output relationship in the Long-run.	**8**
5.	**Introduction to Financial Management** Concept of finance, scope and objectives of finance; Profit maximization vs. Wealth maximization; Functions of Finance Manager in Modern Age; Financial decision areas, Sources of Finance. **Time value of money:** Compounding Techniques, Discounting Techniques Sinking Fund, and Amortization of loan. **Risk and Return analysis:** Return on single securities, portfolio return, Standard deviation, Coefficient of Variation, Systematic risk and Unsystematic Risk.	**10**

Text Books:

1. Tripathy PC And Reddy PN, “Principles of Management”, Tata McGraw-Hill,.
2. Decenzo David, Robbin Stephen A, “Personnel and Human Reasons Management”, Prentice Hall of India,
3. JAF Stomer, Freeman R. E and Daniel R Gilbert, “Management”, Pearson Education, Sixth Edition,
4. Fraidoon Mazda, “Engineering Management”, Addison Wesley,
5. Harold Koontz & Heinz Weihrich “Essentials of Management”, Tata McGraw-Hill,
6. Joseph L Massie “Essentials of Management”, Prentice Hall of India, (Pearson) Fourth Edition,
7. Managerial Economics: Concepts and Applications (SIE), THOMAS& MAURICE, McGraw-Hill Education
8. Van Horne - Financial Management and Policy, Prentice Hall of India

Course Code: **PIN14104**	Metrology and Quality Engineering	Credits: 3-0-0:3

Pre-requisites: Introduction to Manufacturing and basic statistics

Course Outcomes:

CO1	Students will be able to illustrate and apply concepts of Metrology, fits & tolerances, surface texture, concept of flatness, linear, angular and taper measurement devices for measurement of various components.
CO2	Students will be able to illustrate and apply methods of measurement of screw threads and gear tooth profile in field of modern manufacturing.
CO3	Students will be able to illustrate the basic techniques of quality improvement, fundamental knowledge of statistics and probability. Tools and techniques and apply the concepts of six sigma in the manufacturing &service sectors.
CO4	Students will be able to use and plan control charts to describe& analyze for improving the process quality and describe the method of continuous process improvement and
CO5	Students will be able to describe and generate different sampling plans and utilize them in industrial problem solving with case studies.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	-	2	1	-	2	2	2	2	3	3	2
CO2	2	3	3	2	2	2	2	2	3	2	3	3	2	2
CO3	3	2	2	-	2	1	-	2	2	2	2	3	3	3
CO4	2	3	3	2	2	2	2	2	3	2	3	3	2	2
CO5	3	2	3	2	-	3	1	-	2	3	3	2	3	3

UNIT	Details	No. Hrs
1.	Introduction to Metrology: Fundamental Definitions, Types of Standards, Precision and Accuracy, Measurement Errors, System of Limits, Fits, Tolerance and Gauging: Definition of tolerance, Specification in assembly, Principle of interchangeability, linear, measurements by Vernier caliper, micrometer, slip gauges, Angular Measurement: Universal bevel protractor, clinometers, sine bar, angle Comparators : Definition, Classification, Working principle of Mechanical, Opto-mechanical, Pneumatic and Electrical/Electronic comparators with advantages, limitations and uses.	8
2.	Surface Texture measurement: Surface roughness, Waviness, Roughness Parameter Ra, Rz, RMS etc., Surface roughness symbols, Flatness Test measurement by Interference principle: Concept of Flatness, Interferometer principle for measurement, Optical Flats – study of Surface textures under monochromatic light source, fingertip test technique	6
3.	Measurement of tooth thickness: Gear tooth vernier, Constant chord method, Addendum comparator method and Base tangent method, Measurement of tooth profile: Tool maker's microscope or projector, Involute tester, Measurement of pitch, Measurement of run out, Lead and Backlash checking. Measurement of concentricity, Alignment of gears. Screw Thread Measurement: Errors in threads, screw thread gauges, measurement of element of the external and internal threads,	6

	thread caliper gauges.	
4.	Definition of quality, Basic concept of quality, definition of SQC, benefits and limitation of SQC. Comparison of Inspection, Quality control and Quality assurance, concept of quality cost, seven quality control tools and its application, 7 New Quality Improvement Tools and its application	6
5.	Control Charts- General theory of Control Charts, Group Control Charts. Shewhart control chart for process control; Control Charts for variables such as X, R Control Charts for charts for attributes such as c and p charts; Acceptance control chart; Cumulative Sum Control Charts; Subgroup selection; Process Capability,. Six Sigma: The Concept of Six Sigma, Objectives of Six Sigma, The Frame-Work of Six Sigma	6
6.	Acceptance Sampling- Multiple and Sequential Sampling Plans, Multi-Continuous Sampling Plan, Acceptance Sampling by Variables, Advantages & limitations. Sampling plans using different Criteria. Comparison of various types of sampling plans. Introduction to Quality Standards and Quality Circle.	6

Text Books

1. Introduction to Statistical Quality Control Douglas C. Montgomery John Wiley & Sons, Inc.
2. Quality Engineering in Production Systems, by G Taguchi, McGraw Hill, 1989.
3. James R. Evans and William M. Lindsay, "The Management and Control of Quality", 8th Edition, First Indian Edition, Cengage Learning, 2012.
4. Engineering Metrology by R.K.Jain / Khanna Publishers
5. Engineering Metrology and Measurements by NV Raghavendra, L Krishna murthy, Oxford publishers.

Reference Books

1. Juran's Quality Planning and Analysis, by Frank. M.Gryna Jr. McGrawHill
2. Dimensional Metrology, Connie Dotson, Cengage Learning.
3. Engineering Metrology by I.C.Gupta / Dhanpat Rai Publishers.
4. Engineering Metrology by KL Narayana, Scitech publishers.

##

Core Elective Course - 1

Course Code: **PIN14255**	Optimization Methods in Engineering	Credits: 3-0-0: 3

Pre-requisites: Mathematics 1

Course Outcomes:

CO1	Student will be able to understand the terminology and formulation of optimization problems and solve linear programming problems.
CO2	Student will be able to formulate and solve the **s**ingle and multi-variable non linear optimization problemsusing a variety of methods.
CO3	Student will be able to formulate and solve the constrained and specialized multi-variable non linear optimization problemsusing a variety of methods and Matlab software.
CO4	Student will be able to formulate and solve the multi-variable non linear optimization problemsusing a variety of nature inspired optimization methodsand Matlab software.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	1	1	2	1	1	2	1	1	2	3	3
CO2	3	2	2	2	2	1	1	1	2	1	1	3	3	3
CO3	3	2	2	2	1	1	1	1	1	-	1	2	3	3
CO4	3	2	2	3	2	2	1	1	2	1	2	3	3	3

Unit	Details	No. Hrs
1	**Introduction**- Terminology, Design Variables, Constraints, Objective Function, Variable Bounds, Problem Formulation, Engineering Optimization Problems, Calculus Method, Linear Programming- Simplex Method, Concept of Duality.	4
2	**Single Variable Optimization Problems:** Optimality Criterion, Bracketing Methods:Bounding Phase Method. Region Elimination Methods: Golden Section Method. Gradient Based Methods: Newton-Raphson Method. Application to Root finding	4
3	**Multivariable Optimization Algorithms:** Optimality Criteria, Direct Search Methods: Powell's Conjugate Direction Method. Gradient Based Methods: Cauchy's Steepest Descent Method, Newton's method, Powell's Conjugate Gradient Method. Problem solving using Matlab	8
4	**Constrained Optimization Algorithms:** Kuhn Tucker Conditions, Transformation Methods: Penalty Function Method, Method of Multipliers. Sensitivity Analysis.Problem solving using Matlab	6
5	**Specialized Algorithms:** Integer Programming: Branch and Bound Method. Geometric Programming	4
6	**Nature Inspired Optimization Algorithms:** Genetic Algorithms: GAs for multi-variable constrained optimization, Simulated Annealing, Ant Colony Optimization, Particle Swarm Optimization,Multi-Objective optimization. Problem solving using Matlab	10

Text Books:

1	Optimization for engineering design: algorithms and examples	Kalyanmoy Deb	Prentice-HallIndia
2	Optimization - Algorithms and Applications	R. K.Arora	CRC Press, 2015

References:

1.	Engineering optimization - methods and applications	A. M. Natarajan, P. Balasubramani, A. Tamilarasi	Pearson Education, 2013.
2.	Engineering optimization: theory and practice	Singiresu S Rao	4thEdition, New Age Publishers
3.	Introduction to Optimum Design	J. S. Arora	4th Edition – Elsevier, 2016
4.	Operations Research Theory and Applications	J. K. Sharma	MacMillan India Ltd.
5.	https://www.youtube.com/watch?v=aJKuM4U-eYg		
6.	http://www.digimat.in/nptel/courses/video/111105039/L31.html		

##

Course Code: **PIN14254**	Modelling and Simulation in Engineering (MSE)	Credits: 3-0-0: 3

Pre-requisites:

Course Outcomes:

CO1	Understand the importance and principles of mathematical modeling.
CO2	Use advanced system modelling and analysis tools (concepts, methodologies, and abilities) in their research and professional careers.
CO3	Learn to abstract the real-world system into models.
CO4	Analytically derive the relationship of physical model.
CO5	Implementing the model using software.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	-	1	1	-	1	2	1	2	2	3	3	3
CO2	3	3	2	2	1	-	-	1	2	2	2	3	3	3
CO3	3	2	3	3	2	1	1	-	2	1	1	3	3	3
CO4	3	3	3	1	2	1	1	2	2	2	1	3	3	3
CO5	3	3	3	2	3	2	1	2	3	2	2	3	3	3

Module	Content	No. Hr.
1	Introduction to Modelling and Simulation, Concept of System and environment, Continuous and discrete systems, Linear and non-linear systems, stochastic activities, Static and Dynamic models, System analysis, System theory basics, its relation to simulation.	4
2	Physical Modelling: Principles of modelling, Basic Simulation modelling, Role of simulation in model evaluation and studies, Applications and advantages of simulation.	4
3	Mathematical Modelling: Mathematical Model, types of Mathematical models and properties, Procedure of modelling. Graphical method, Basic optimization, Basic probability: Monte-Carlo simulation and applications.	5
4	System Simulation: Techniques of simulation, Monte Carlo method, Experimental nature of simulation, Numerical computation techniques, Continuous system models, Feedback systems, Computers in simulation studies, Simulation software packages.	5
5	Probability Concepts in Simulation: Stochastic variables, Random numbers, Generation of Random numbers, Variance reduction techniques, Determination of length of simulation runs.	4
6	Simulation of Mechanical Systems: Building of Simulation models, Simulation of translational and rotational mechanical systems, Simulation of hydraulic systems.	4
7	Simulation of Dynamic Systems with MATLAB- Simulink, Building a Simulink Model, Simulink of Linear systems, Algebraic loops, subsystems, Mat lab Simulink interface. Concept of Graphical Programming and model building in Lab view. Applications in Mechanical Engineering.	6

Reference Books:

1. Simulation Modeling and Analysis by Averill Law
2. Simulation of Dynamic Systems with MATLAB and Simulink by Harold Klee
3. Dynamic Response of Linear Mechanical Systems: Modeling, Analysis and Simulation by Jorge Angeles
4. System Dynamics: Modeling, Analysis, Simulation, Design by Ernest Doebelin,
5. Mathematical Modeling and Simulation: Introduction for Scientists and Engineers by Kai Velten

Online Course on NPTEL
https://nptel.ac.in/courses/112107214

##

Course Code: PIN14252	Design and Analysis of Experiments	Credits: 3-0-0-3

Pre-requisites: NIL

Course Outcomes:

CO1	Able to understand the concepts of factors associated with experimental design.
CO2	Able to develop appropriate experimental design to run different experiments and analyze the data.
CO3	Apply the concepts of experimental design to develop empirical model and optimize the process parameters.
CO4	Design robust parameters using parametric design approach.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	2	-	-	2	-	-	-	-	-	-	-	2	3
CO2	1	2	3	3	2	-	-	-	-	-	-	2	3	3
CO3	2	3	3	3	2	-	-	-	2	-	-	-	3	3
CO4	1	-	3	2	2	-	-	-	-	-	-	1	2	3

Unit	Subject Details	No. Hrs
1	**Fundamentals of Experimental Design**- Basic Principles, Purpose and Applications of Experimental Design, Perspective of Experimental approaches, Checklist for Design and Planning of Experiments, Steps involved in Experimentation.	6
2	**Simple Comparative Experiments**-Statistical Techniques Concepts, Sampling, Distribution, Replication, Blocking and Randomization in Experiments, Comparison of multiple means and variances, Analysis of Variance (ANOVA), Error Terms.	8
3	**Factorial Designs**-Definition and Principals of Factorial Design, Two-Factor and General Factorial Design, Standard Orthogonal Arrays &Interaction Tables, Modification and Selection of the Orthogonal Arrays, Analysis of Experimental Data.	8
4	**Response Surface Methodology**-Basic Concept, Linear Model, Steepest Ascent, Second Order Model, Fitting Response Surface, Regression Models Fitting, Experiments with Computers.	8
5	**Taguchi's Parameter Design**-Robust Parameter Design, Noise Factors and its Source, Objective Function & Signal to Noise (S/N) Ratios, Inner and Outer Array Design, Data Analysis and Case Study.	6

Text Books:

1	Design and Analysis of Experiments	Douglas C. Montgomery	John Wiley & Sons
2	Design and Analysis of Experiments	Angela M. Dean, Daniel Voss	SPRINGER (SIE)
3	Taguchi Techniques for Quality Engineering	P. J. Ross	McGraw-Hill
4	Quality Engineering using Robust Design	Madhav S. Phadke	Prentice Hall

References:

1	Experiments: Planning, Analysis, and Optimization	C. F. Jeff Wu, Michael S. Hamada	Wiley
2	Introduction to the Design and Analysis of Experiments	Geoffrey M. Clarke, Robert E. Kempson	Wiley
3	Product and Process Design for Quality, Economy and Reliability	Dukkipati, R V and Pradip K Ray	New Age International

##

Course Code: **PIN14251**	Cryogenics	Credits: 3-0-0:3

Pre-requisites: Engineering Thermodynamics, Heat and Mass Transfer, Refrigeration and Air Conditioning.

Course Outcomes:

CO1	Students will understand the fundamentals of the cryogenic systems and will be able to know how to design components of the cryogenic system like heat exchangers, insulation, etc.
CO2	Students will able to analyse the losses in each component of different cycles.
CO3	Students will be able to identify the appropriate refrigeration cycle for a particular application.
CO4	Students will be able to identify the criteria for the selection of materials for the manufacturing of the components used in cryogenic applications.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	3	1	1	0	0	0	0	3	2	3	2
CO2	3	2	2	2	3	0	0	0	0	0	2	2	3	2
CO3	2	2	3	2	1	2	1	0	0	0	0	2	3	2
CO4	3	1	3	2	1	1	1	1	0	0	1	2	3	2

Unit	Details	No. Hrs
1	Introduction: Historical background Current applications. Refrigeration and liquefaction Principles. Joule-Thomson expansion cycles: Simple Linde-Hampson system, Precooled Linde-Hampson system, Cascade system, and Mixed-Refrigerant Cascade Cycles. Isentropic expansion cycles: Simple Gas Expansion Cycle: Simon Helium Liquefier, Kapitza system, Claude system, Collins helium-liquefaction system. Refrigerators for temperatures below 2 K: Magnetic refrigeration systems, Dilution refrigerators. Cold-gas refrigerators: Stirling cycle, Gifford-McMahon cycle and Pulse Tube Refrigerator	8
2	Separation and purification systems: Properties of mixtures, General characteristics of mixtures, Temperature-composition diagrams Principles of gas separation: Simple condensation or evaporation, Principles of rectification, Flash calculations Air-separation systems: Linde single column system, Linde double-column system, Argon-separation systems; Neon-separation system	8
3	Measurement systems: Temperature scales and fixed points, Metallic resistance thermometers, Semiconductor resistance thermometers, Thermocouples Vacuum measurement: McLeod gauge, Knudsen gauge, Momentum Transfer gauge, Pirani gauge, Ionization Gauge Insulations: Expanded-foam insulations, Gas-filled powders, and fibrous insulations, Vacuum insulation, Evacuated-powder, and fibrous insulations, Opacified-powder insulations, Multilayer insulations, Comparison of insulations, Vapor-shielded vessels	8
4	Properties of engineering materials: Mechanical properties: Ultimate and yield strength, Fatigue strength, Impact	8

	strength, Hardness, and ductility, Elastic moduli Thermal properties. Thermal conductivity: Specific heats of solids, Specific heat of liquids and gases, Coefficient of thermal expansion. Electric and magnetic properties: Electrical conductivity, Superconductivity Properties of cryogenic fluids: Helium 4 and Helium 3. Critical components of refrigerators: Heat exchangers: Heat-transfer coefficients and friction factors, Effectiveness-NTU approach in heat-exchanger analysis, Effect of heat-exchanger effectiveness on system performance.	

Text Books:

1	Cryogenic heat transfer	Barron, Randall F., and Gregory F. Nellis	CRC Press.
2	Cryogenic systems	Barron, Randall F	Oxford University Press, and Oxford: Clarendon Press
3	Cryogenic process engineering	Timmerhaus, Klaus D., and Thomas M. Flynn	Springer Science & Business Media

References:

1	Measurement systems: application and design	Doebelin, Ernest O., and Dhanesh N. Manik	Pearson
2	Cryogenic mixed refrigerant processes	Venkatarathnam, Gadhiraju, and Klaus D. Timmerhaus	Springer

##

Course Code: **PIN14253**	**Manufacturing of Non-Metallic Products**	Credits: 3-0-0:3

Prerequisites: Nil

Course Outcomes:

CO1	Students will be able to understand the processing and applications of polymer, rubber, ceramic and composite products.
CO2	Students will be able to select the suitable processing method to manufacture a non-metallic product.
CO3	Students will be able to understand the joining methods of non-metallic products.
CO4	Students will be able to understand and select suitable surface treatment methods for non-metallic products.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	1		1			1	2	1		3	3	3
CO2	3	3	2		2			1	1			3	3	3
CO3	3	3	2		2			1	2			3	3	3
CO4	3	3	3		2			1	2			3	3	3

Unit	Details	No. Hrs
1	**Polymers products:** Classification of Polymers, Polymer melts, Polymer shaping processes to produce tubes, pipes, hose, structural shapes, sheets, films, continuous filaments, coated electrical wires and cables, etc.	8
2	**Rubber products**: Classification of Rubbers, Processing of rubbers; Manufacturing techniques for tires, belts, hoses, foot wears, cellular products and cables. Manufacture of latex based products.	6
3	**Ceramics and glasses products**: Classification of Ceramics; Ceramic processing techniques: hot pressing; hot isostatic pressing (HIP); Sintering, injection molding, Processing of Cemented carbides and other ceramic based materials. Glass forming machines; Manufacturing of hollow wares flat glasses, fiberglass, bulbs, bottles, heat absorbing glasses, amber glass.	8
4	**Composites products:** Requirements of reinforcement and matrix; Manufacturing of composites: Casting, Solid state diffusion, Cladding, HIP, Liquid metal infiltration, Liquid phase sintering; Preparation of molding compounds and prepregs; hand layup method; autoclave method; filament winding method; compression molding; reaction injection molding; knitting; braiding.	8
5	Non-metallic surface treatment and coatings, Joining of non-metallic products, Recent trends in non-metallic products	6

Text Books:

1	Fundamentals of Modern Manufacturing: Materials, Processes, and Systems	Groover, M.P.	Tata-McGraw Hill
2	Polymer Science and Technology- Plastics, Rubber, Blends, and Composites	Ghosh	Tata-McGraw Hill

References:

1. Patton, W.J., Plastic Technology, Theory, Design and Manufacture; Lenton Publishing Company.
2. Rubber Processing Technology, Materials and Principles, J.L. White, Hanser Publishers
3. Glass Engineering Handbook by E. B. Shand, McGraw-Hill
4. Introduction to ceramics by Kingery, Bowen and Uhlmann, John Wiley & Sons publishers
5. Handbook of Composites by George Lubin, Springer

##

Semester-V

Course Code: **PIN15102**	Design of Machine Elements	Credits: **3-0-2:4**

Prerequisites: Material Science and Engineering, Mechanics of Materials

Course Outcomes:

CO1	Students will be able to understand and apply the standards and design data book during a design problem.
CO2	Students will be able to identify the materials and its properties to make the machine component for a particular application
CO3	Students will be able to identify the critical sections of the components and understand its importance during design of a machine component.
CO4	Students will be able to evaluate and apply the concepts of factor of safety and theory of failures for design and creation of a particular machine component under static and cyclic loading conditions.
CO5	Students will be able to apply and analyze the acquired knowledge in design of different machine components such as joints, springs, shafts and gears.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	1	2	3	1	1	-	2	-	1	1	3	3	3
CO2	2	2	3	3	3	2	3	1	1	1	1	2	3	3
CO3	3	3	3	3	1	-	-	2	2	3	-	3	3	3
CO4	3	3	3	3	1	2	2	2	2	3	1	3	3	3
CO5	3	3	3	3	2	2	2	1	2	3	2	3	3	3

Unit	Details	No. Hrs
1	General Introduction: Standards in Design and Selection of Preferred Size, BIS and international system of material designation, Materials for design (such as Cast Iron, Steels and Alloys, Non-ferrous metals, Plastics and Rubbers) and selection methods: Selection strategy, selection procedure, case studies, The statistical significance of material properties, Strength and cold work, Temperature effects.	5
2	Design against Static and variable Load: Static strength, Stress concentration, Failure theories for ductile and brittle materials, Selection of failure criteria, Introduction to fracture mechanics, Factor of Safety and selection criteria, Notch Sensitivity Factor, Design criteria for variable loads, Endurance Limit and fatigue strength, Design for Finite and Infinite Life.	9
3	Shafts and keys: Design of Shafts against Static and Fluctuating Load, Design for Strength and Rigidity, Critical speeds for shafts, Design of Square and Flat Keys and Splines.	4
4	Power Screws and Joints: Form of Threads, Square Threads, Trapezoidal Threads, Stresses in Screw, Design of Screw Jack, Screwed Joints, Welded Joint and Eccentric Loading of above Joints, Design for Fatigue Loading.	9
5	Mechanical Springs: Materials for spring, Design against static and fatigue loading of helical compression and extension springs, *Multi Leaf Springs and Spiral Springs (self study)*	7

6	Spur Gears: Kinematics of gears, Conjugate Action, standard tooth systems for spur gears, Profile shifted gears, Involutometry, gear cutting methods, Modes of gear failure, Spur gear tooth force analysis, Tooth bending stress – AGMA procedure, Bending fatigue strength – AGMA procedure, Buckingham equation for dynamic load on gears, Buckingham contact stress equation, Contact stress – AGMA procedure, Surface fatigue strength – AGMA procedure, Gear materials. *Helical gears (self study)*	8

Text Books:

1	Mechanical Engineering Design (in SI Units)	Joseph E. Shigley and Charles R. Mischke	TATA McGraw Hill

References:

1	Machine Design An Integrated Approach	R. L. Norton	Pearson Prentice Hall
2	Machine Component Design	Juvinall R. C. and Marshek, K. M.,	John Wiley, 5th Edition,
3	Design of Machine Element	V. B. Bhandari	TATA McGraw Hill
4	Design Data sheets	Instructor	

Module	Experiment	No. Hrs.
1	Assembly drawing of threaded Joints using AutoCAD/Solid works.	02
2	Assembly drawing of Cotter and Knuckle joint using AutoCAD/Solid works.	02
3	Assembly drawing of Couplings using AutoCAD/Solid works.	02
4	Assembly drawing of Tailstock using AutoCAD/Solid works.	02
5	Assembly drawing of Plummer block using AutoCAD/Solid works.	02
6	Assembly drawing of Rams bottom safety valve using AutoCAD/Solid works.	02
7	Assembly drawing of Cylinder relief valve using AutoCAD/Solid works.	02
8	Assembly drawing of Blow-off cock using AutoCAD/Solid works.	02
9	Assembly drawing of Tool Post using AutoCAD/Solid works.	02
10	Production drawing of any assembly using AutoCAD/Solid works.	02
11	Assembly drawing of Screw Jack using AutoCAD/Solid works	02

Text Books:

1	Machine Drawing	Ajit Singh	TATA McGraw Hill

References:

1	Machine Drawing	K L Narayana, P Kannaiah, K Venkata Reddy	New Age International Publication
2	Machine Drawing	R K Dhawan	S Chand Publication
3	Machine Drawing	N D Bhatt and V M Panchal	Charotar Publication
4	Production Drawing	K L Narayana, P Kannaiah, K Venkata Reddy	New Age International Publication

Course Code: **PIN15101**	Computer Aided Manufacturing	Credits: **3-0-2:4**

Prerequisites: Workshop and Manufacturing Processes

Course Outcomes:

CO1	Students will be able to understand the automation and its concepts
CO2	Students will be able understand the features of NC and CNC machines, understand the structure and tooling of CNC machine tools.
CO3	Students will be able to learn and write manual part programming, automated part programming for CNC turning and CNC machining center. Also Students will be able to understand the automatic part programming through CAD/CAM software.
CO4	Students will be able to understand Group Technology, FMS and CIM and can perform a case study/ term project

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	-	-	2	-	-	2	2	-	1	1	-	2	3	3
CO2	2	2	2	-	2	-	2	-	1	1	-	2	3	3
CO3	2	2	2	-	3	1	1	-	1	1	-	2	3	3
CO4	2	-	2	-	2	1	1	-	1	1	-	2	3	3

Unit	Details	No. Hrs
1	**Introduction** - Automation need and types of automation, economics of automation. Basics of electro-mechanical automation technologies, Circuit design and applications of hydraulic, pneumatic, electropneumatic, electro-hydraulic and programmable logic control (PLC) systems.	6
2	**NC technology –** Basic components of NC system, NC co-ordinate systems, NC motion control systems, absolute versus incremental positioning, **CNC –** Features of CNC, MCU for CNC, CNC software. **DNC –** DNC (Direct NC), DNC (Distributed NC), Adaptive control, applications of NC, advantages and disadvantages of NC **CNC Hardware basics :** Structure of NC machine tools, Drivers - Actuation system, stepper motor and servo motor, Ball screw and nut with support bearing, open loop and close loop control system, encoders and transducers, linear motion system, engineering analysis of open and closed loop positioning systems. **NC Tooling** - Different tooling used in Milling and Turning centre. ATC (Automatic Tool Changer) in VMC and Turning centre, Work holding	8
3	Computer aided process planning, **CNC programming - *Manual Part Programming*** – G and M coding, Sub routines, scaling, mirror, Do loop features. **Part programming for turning centres:** Zero setting in CNC turning centres, Tool nose radius and tool position offsets in CNC turning centres, diameter programming, Canned (fixed) cycles, manual part programming for turning center. **Part programming for milling and drilling:** Zero setting in CNC machining centres, canned (fixed) cycles, manual part programming for milling and drilling. Tool diameter and length offset (compensation) features.	9
4	**Computer Aided Part Programming** – APT (Automatically Programmed Tool) and Part Program generation through CAD/CAM software	4

5	Group technology, Flexible Manufacturing System (FMS) and Computer Integrated Manufacturing (CIM), **Case study/ term project**	6

Text Books:

1	Automation, Production Systems and Computer Integrated Manufacturing	Mikell P. Groover	Prentice Hall India
2	CAD/CAM/CIM Principles and Applications	P. N. Rao	McGraw Hill Education

References:

1	Numerical Control and Computer Aided Manufacturing	Kundra, Rao and Tiwari	TMH
2	Computer Control of Manufacturing Systems	Yoram Koren	McGraw-Hill Book Company
3	CNC Machining Technology - Vol. 1, 2 & 3	G. T. Smith	Springer-Verlag
4	Principal of Computer Integrated Manufacturing	S. Kant Vajpayee	PHI
5	Machinery's Handbook	Erik Oberg and Franklin D. Jones	Industrial Press, Inc.
6	Computer Aided Design and Manufacturing I https://nptel.ac.in/courses/112102102		NPTEL
7	NPTEL Video Course : Computer Integrated Manufacturing https://www.digimat.in/nptel/courses/video/112104289/L01.html		NPTEL
8	NPTEL Video Course : Computer Aided Design and Manufacturing https://www.digimat.in/nptel/courses/video/112102101/L01.html		NPTEL
9	Computer numerical control CNC of machine tools and processes https://onlinecourses.nptel.ac.in/noc19_me46/preview		Swayam
10	Introduction to CAD, CAM, and Practical CNC Machining https://www.coursera.org/learn/introduction-cad-cam-practical-cnc-machining		Coursera

Unit	Details	No. Hrs
1	Introduction of CNC, its features, required programming concepts and over view of CAM Lab	2
2	Study of HMT CNC TRAINMASTER Lathe and Mach3 controller/ Denford ORAC CNC Lathe and Mach3 controller and study of CNC tooling for Lathe	2
3	Part programming using GM codes for lathe machine (2 programs) and verification on HMT T70/ Denford ORAC CNC Lathe through Mach3 controller **Program1:** Facing, Step Turning, Taper turning, Profile Turning, boring **Program2:** Threading, use of canned (fixed) cycles in lathe operations	2
4	Study of PMT CNC PND-320 turning centre and features of Fanuc O-T controller	2

5	Study of various types of Automatic Tool changers (Fitted in PND-320, Denford ORAC lathe and Denford TRIAC Milling)	2
6	Study of HMT CNC TRAINMASTER Vertical Machining Centre and Mach3 controller/ Denford TRAIC CNC milling machine and Mach3 controller and study of CNC tooling for machining center	2
7	Part programming using GM codes for Drilling/ Milling (2 programs) and verification on software and HMT VMC200/ Denford Traic CNC milling machine through Mach3 controller **Program1:** Drilling, slot milling, pocket milling **Program2:** Profile milling (with tool radius compensation), use of canned (fixed) cycles in milling/drilling operations	2
8	Automatic generation of G-M code from CAD/CAM software and a case study	2

References:

1	Operating and instruction manual of HMT T70 train master lathe	HMT
2	Operating and instruction manual of HMT train master vertical machining centre (VMC200)	HMT
3	Operating and instruction manual of PMT PND 320 CNC turning centre and Fanuc-OT programming manual	PMT Automatics, Pune
4	Mach3 programming manual for CNC Lathe and milling machine	Artsoft

Course Code: **PIN15103**	Introduction to Industry 4.0 and IoT	Credits: 3-0-0:3

Prerequisites: Introduction to Manufacturing, CAM, Robotics and Mechatronics

Course Outcomes:

CO1	Understand basic concepts and Business issues of Industry 4.0 , Smart Business Transformation
CO2	Understand the Concepts of Industrial IOT in various sectors, Components of IIOT - Sensors, Interface, Networks, People &Process and role of IOT in manufacturing, maintenance
CO3	Understand various system components and architecture of IOT
CO4	Able to understand sensors, transducers and actuators. Hardwire the sensors with different protocols and Building Automation Controls
CO5	Learn and understand Opportunities and the Industry 4.0 Era - Strategies for competing in an Industry 4.0 world . . Challenges & Benefits in implementing IIOT - Smart Manufacturing - Smart Devices and Products - Smart Logistics

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	-	2	1	-	2	2	2	2	3	3	3
CO2	2	3	3	2	2	2	2	2	3	2	3	3	2	2
CO3	3	2	3	2	-	3	1	-	2	3	3	2	3	3
CO4	3	3	3	3	3	2	2	2	3	2	2	3	3	2
CO5	3	3	3	3	2	2	1	2	2	3	3	3	2	3

UNIT	Details	No. Hrs
1.	The Various Industrial Revolutions - Digitalization and the Networked Economy - Drivers, Enablers, Compelling Forces and Challenges for Industry 4.0 Comparison of Industry 4.0 Factory and Today's Factory - Trends of Industrial Big Data and Predictive Analytics for Smart Business Transformation	6
2.	Internet of Things (IoT) & Industrial Internet of Things (IIoT) & Internet of Services. Components of IIOT - Sensors, Interface, Networks, People &Process, IOT Market, Trends& future Real life examples, Key terms – IOT Platform, Interfaces, API, clouds, Data Management Analytics, Mining &Manipulation; Role of IIOT in Manufacturing Processes Use of IIOT in plant maintenance practices, Sustainability through Business excellence tools	12
3.	Overview of IOT components, Various Architectures of IOT and IIOT, Advantages & disadvantages, Industrial Internet - Reference Architecture; IIOT System components: Sensors, Gateways, Routers, Modem, Cloud brokers, servers and its integration, WSN, WSN network design for IOT	6
4.	Introduction to sensors, Transducers, Classification, Roles of sensors in IIOT , Various types of sensors , Design of sensors, sensor architecture, special requirements for IIOT sensors, Role of actuators, types of actuators. Hardwire the sensors with different protocols such as HART, MODBUS-Serial &	10

	Parallel, Ethernet, Building Automation Controls Network (BACnet) , Current, M2M etc	
5.	Opportunities and Challenges - Future of Works and Skills for Workers in the Industry 4.0 Era - Strategies for competing in an Industry 4.0 world Application of IIoT: Smart Metering, e-Health Body Area Networks, City Automation, automotive Applications, Home Automation, Smart Cards, Plant Automation, Real life examples of IIOT in Manufacturing Sector. Challenges & Benefits in implementing IIOT - Smart Manufacturing - Smart Devices and Products - Smart Logistics - Smart Cities - Predictive Analytics	6

Text Books:

1. Daniel Minoli, "Building the Internet of Things with IPv6 and MIPv6: The Evolving World of M2M Communications", ISBN: 978-1-118-47347-4, Willy Publications
2. Bernd Scholz-Reiter, Florian 2. Michahelles, "Architecting the Internet of Things", ISBN 978-3-642-19156-5 e-ISBN 978-3-642-19157-2, Springer

Reference Books:

1. Hakima Chaouchi, "The Internet of Things Connecting Objects to the Web" ISBN : 978-1-84821-140-7, Willy Publications
2. Olivier Hersent, David Boswarthick, Omar Elloumi, The Internet of Things: Key Applications and Protocols, ISBN: 978-1-119-99435-0, 2 nd Edition, Willy Publications
3.Inside the Internet of Things (IoT), Deloitte University Press
4. Internet of Things- *From* Research and Innovation to Market Deployment; By Ovidiu & Peter; River Publishers Series
5. Five thoughts from the Father of the Internet of Things; by By Phil Wainewright - Kevin Ashton
6. How Protocol Conversion Addresses IIoT Challenges: White Paper By RedLion.

##

Course Code: PIN15104	Manufacturing Science and Technology-II	Credits: 3-0-2:4

Prerequisites: Workshop and Manufacturing Processes

Course Outcomes

CO1	Student will be able to apply the concept of machining processes to develop a product with required shape, size, accuracy and quality in any manufacturing industry.
CO2	Student will be able to apply the concept of abrasive machining processes for finishing the job of various geometries to get the required finish, accuracy and quality of the product.
CO3	Students will be able to apply the concept of various welding and allied processes for joining parts in any manuafacturing industry.

Course Articulation Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	1	1	-	1	1	1	2	-	1	3	2
CO2	3	3	3	1	1	-	1	1	1	2	-	1	3	2
CO3	3	3	2	1	1	-	1	1	1	2	-	1	3	2

Unit	Details	Hrs
1	**Machining-I:** *Theory of Metal Cutting*- Mechanism of Chip Formation and Types of Chips; Orthogonal and Oblique cutting; Geometry of Orthogonal Cutting- Shear Strain and Shear Strain Rate; Mechanics and Thermodynamics of Orthogonal Cutting-Cutting Forces and Merchant Circle Diagram; Merchant Theory and Shear Angle; Shear Velocity and Chip Velocity; Energy and Power; Chip Tool Contact Length; Heat flux and Temperature in Shear and Friction plane; and Cutting fluid applications; *Technology of Cutting Tools*: Materials- Properties, Development, Composition and Applications; Geometry- Single Point Tool, Twist Drill, Milling Cutter and Broach, and Life- Failure, Wearing, and Evaluation Assessment Evaluation of Machinability	9
2	**Machining-II:** *Single Point Cutting Tool based Machining Operations and Machine Tools*-Turning and Related Operations**;** Lathe Machine: Centre Lathe and Capstan Lathe**;** Shaping and Related Operations; Reciprocating Machines: Shaper Machine and Planer Machine**;** *Multi Point Cutting Tool based Machining Operations and Machine Tools*-Drilling and Related Operations**;** Drilling Machine-Pillar Drilling Machine and Radial Drilling Machine; Milling and Other Operations**;** Milling Machine-Horizontal Milling Machine and Vertical Milling Machine**;** Broaching Operations and Broaching Machine**;** *Evaluation of Machinability*-Index Factor based Evaluation and Other Factor based Evaluation**;** *Analysis of Economics*-Minimum Production Cost based Analysis**;** Minimum Production Time based Analysis. *Introduction to unconventional machining processes.*	15
3	**Abrasive Machining-** Need and Classifications; *Abrasive Grinding Operations*-Technology of Grinding Wheel-Composition, Specification, Selection and Life; Classifications of Grinding Operations; Surface Grinding Operations and Surface Grinder; Cylindrical Grinding Operations and Cylindrical Grinder; Analysis of Grinding Operation: Uncut Chip Size, MRR and Surface Finish; Forces and Temperature; *Abrasive Finishing Operations*-Honing and Lapping; Polishing and	6

	Buffing; Superfinishing; Abrasive Flow Finishing; Magnetic Abrasive Finishing	
4	**Joining Processes:** Need and Classifications of Joining Processes; Solid Welding- Diffusion, Friction, Explosive and Ultrasonic; Fusion Resistance Welding- Spot, Projection and Seam welding; Resistant Butt and Flash Butt welding; High Frequency Resistance and High Frequency Induction welding; Fusion Arc Welding- GTAW, PAW, SMAW, GMAW, SAW and ESW; Fusion Gas Welding: Oxy Acetylene welding; Fusion Thermite Welding; Fusion Beam Welding: LBW and EBW; Welding Defects and Inspection; Characteristics and applications of Brazing and Soldering	**6**

Text/Reference Books:

1. Groover's Principles of Modern Manufacturing: Materials, Processes and Systems by M. P. Groover, John Wiley and Sons, New Delhi (SI Edition)
2. Manufacturing Science by Ghosh and Mallik, East West Press Pvt. Ltd., New Delhi
3. *Introduction to Machining Science by G.K. Lal, New Age International (P) Ltd, New Delhi*

Unit	Details	Hrs
1	Preparation of Single Point Cutting Tool as per the given tool specification. Also write the process sheet for the same.	2
2	To make a job as per drawing on the Capstan Lathe. Write the process sheet and draw the sketches of the machine tool and tools used	2
3	To make a job as per drawing using Radial Drilling Machine. Write the process sheet and draw the sketches of the machine tools and tools used.	2
4	Study of Indexing Mechanism for Gear Cutting and to cut gear on a gear blank using Indexing Mechanism on Horizontal Milling Machine. Write the process sheet and draw the sketches of the machine tool and tools used.	2
5	To make a slot as per the given drawing using Vertical Milling Machine. Write the process sheet and draw the sketches of the machine tool and tools used.	2
6	Study of constructional details and working of Shaper, Planer and Slotter.	2
7	To make a job as per drawing using Cylindrical Grinding Machine. Write the process sheet and draw the Sketches of the machine tool and tools used.	2
8	To make a job as per drawing using Surface Grinding Machine. Write the process sheet and draw the Sketches of the machine tool and tools used.	2
9	Study of DIE SINKING ELECTRICAL DISCHARGE MACHINE and finding the effect of input process parameters on output performance parameters due to machining of hardened steel	2
10	Study of TRAVELLING WIRE ELECTRICAL DISCHARGE MACHINE and finding the effect of input process parameters on output performance parameters due to machining of hardened steel	
11	Study of LASER BEAM MACHINE	2
12	Study of GMAW/GTAW WELDING MACHINE. Also draw the sketches of the tools used	2

Text Books:

1. A Course in Workshop Technology, Vol. II (Machine Tools) by B.S. Raghuwanshi, Dhanpat Rai & Co. (P) Ltd.

2. DeGarmo's Materials and Processes in Manufacturing by J. T. Black, Ronald A. Kohser, Wiley India.

Reference Books:

1. Introduction to Machining Science by G. K. Lal, New Age International Ltd., New Delhi
2. Manufacturing Science by Ghosh and Mallik, East West Press Pvt. Ltd., New Delhi

Semester-VI

Course Code: PIN16102	Advanced Machining Processes	Credits: 3-0-2:4

Pre-requisites: Machining and Joining Technology/ Manufacturing Science and Technology-II

Course Outcomes:

CO1	Identify the need and understand various Advanced Machining Processes
CO2	Apply the basic principles of Advanced Machining Processes for product manufacturing/development.
CO3	Realize the applications of Advanced Machining Processes for product development.
CO4	Prepare for future roles in meeting these requirements in advanced manufacturing environment.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	1	1	-	2	2	1	-	-	1	1	3	3	3
CO2	3	3	3	2	3	1	-	1	3	2	1	3	3	3
CO3	3	3	3	2	3	2	2	3	3	3	3	3	3	3
CO4	3	3	3	3	3	2	2	2	3	3	3	3	3	3

Module	Course Content	Lectures
1	**Introduction:** Limitations of conventional machining processes. Need, characteristics and classification of Advanced Machining Processes (AMPs).	2
2	**Mechanical Energy based AMPs**: Process mechanisms, Parametric effects, Applications and limitations of Jet machining processes such as Abrasive Jet Machining, Water Jet Machining and Abrasive Water Jet Machining. Analysis of Material Removal Rate (MRR) for Abrasive Jet Machining. Process principle, limitations and applications of Ultra-Sonic Machining (USM) process. Analysis of MRR in USM considering throwing and hammering models.	8
3	**Thermal Energy based AMPs:** Working Principles, Parametric effects, Limitations, Applications, process mechanisms and analyses of material removal for Electric Discharge Machining (EDM) and Laser Beam Machining (LBM). Working Principles, Applications and process mechanisms of Electron Beam Machining, Ion Beam Machining and Plasma Arc Machining. Introduction to different variants of EDM and LBM.	8
4	**Chemical Energy based AMPs:** Process principle, limitations and steps involved in Chemical Machining; Introduction to photochemical and biochemical machining. Principle of Electrochemical dissolution. Parametric effect, process limitations and analysis of MRR in Electro-Chemical Machining (ECM), Equilibrium gap and self-regulating feature of ECM.	8
5	**Hybrid Machining and Advanced Finishing Processes:** Limitations of AMPs and concept of Hybrid Machining Processes (HMPs). Classification and characteristics of assisted and mixed type HMPs. Process mechanism and advantages of different HMPs such as Electro-Chemical Grinding (ECG), Electric Discharge Abrasive Grinding (EDAG), Laser-Assisted Turning (LAT), Ultrasonic-Assisted EDM (UAEDM) etc. Micromachining applications of AMPs and HMPs.	8

	Process principle and Applications of Abrasive Flow Finishing, Magnetic Abrasive Flow Finishing, Magnetic Abrasive Finishing, Magneto-Rheological Finishing.	

Text Books:

1. Advanced Machining Processes by V. K. Jain, Allied Publisher Bombay
2. Manufacturing Science by Ghosh and Mallik, EWP Private Ltd.

Reference Books:

1. Non Traditional Manufacturing Processes by G. F. Benedict, Marcel Dekker Inc, New York
2. Advanced Machining Methods by J. A. McGough, Chapman and Hall, London
3. New Technology by Bhattacharaya
4. Modern Machining Process by Aditham
5. Modern Machining Processes by Pandey and Shan, TMH Publication, New Delhi

Web References:

1. http://nptel.ac.in/courses/112105126/36.
2. http://nptel.ac.in/courses/112105127/pdf/LM-40.pdf.

E-Text Books:

1.http://engineeringstudymaterial.net/ebook/advanced-machining-processes.
2.https://books.google.co.in/books/about/Advanced_Machining_Processes.html?id=duBqhj2OlfAC.
3.https://books.google.co.in/books/about/Modern_Machining_Processes.html?id=uC3rHzhogmMC.

Experiment	Content	Practical
1	Study and determination of Material Removal Rate (MRR) on Sinking-Electro-Discharge Machining (Sinking-EDM).	2
2	To perform experiment of drilling a hole of a given diameter using Drilling Electro Discharge Machining (Drilling -EDM)	2
3	Study and measurement of surface roughness of the given job processed on Electro Discharge Abrasive Grinding (EDAG)	2
4	Study and determination of Kerf width of the given job on Wire Electro Discharge Machining (Wire -EDM)	2
5	Study and making of job on 3D printer	2
6	Study and making of job on Hydroforming setup	2
7	Study and perform experiment on hybrid machining setup such as ECG, ECSM	2
8	Study and perform experiment on advanced finishing set up such as MAF, EMAF	2
9	Study the constructional details and working of LBM	2

Course Code: **PIN16101**	Additive Manufacturing	Credits: 3-0-0:3

Pre-requisites: CAD, Manufacturing Science 1 and 2

Course Outcomes:

CO1	Students will be able to apply the basic CAD and Reverse Engineering (RE) concepts for generating solid models of objects using CAD and RE software for AM.
CO2	Students will be able to understand the Additive Manufacturing process chain from CAD to part printing to post processing, and the AM materials and hardware.
CO3	Students will be able to comprehend the various types of Additive Manufacturing processes for printing different materials along with their comparative strengths, limitations and applications.
CO4	Students will be able to familiarize with the basic concepts of Design for Additive Manufacturing (DfAM) including Topology Optimization, Generative Design and Lattice Design in Additive Manufacturing and apply them to execute an application mini project.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	-	3	1	1	1	2	1	-	2	3	3
CO2	3	1	2	1	3	1	1	1	1	1	1	2	3	3
CO3	3	2	2	2	2	2	2	2	2	1	1	2	3	3
CO4	3	3	2	2	3	2	2	1	3	2	2	2	3	3

Unit	Details	Hrs
1	**Introduction to AM:** Evolution of AM/3DP vs CNC and Injection Moulding; CAD for AM: Geometric transformations, curve, surface and solid modeling, Data exchange formats, Reverse engineering, Modeling with point cloud data, 3D Scanning devices;	6
2	**AM process chain:** Tessellation of CAD model, file formats, STL file problems, manipulation and repair, part orientation and support generation, slicing algorithms tool path generation, machine setup and post processing; AM materials and hardware;	8
3	**AM processes:** Liquid polymer based (FDM, SLA), powder based (SLS, MJP, Binder Jetting), molten metal based (DMLS, SLM, EBM, DED, WAAM), solid sheet based (LOM), Bio printing etc.; AM Process selection for targeted applications and case studies including aerospace, medical and commodity products;	12
4	**Basics of Design for Additive Manufacturing (DfAM):**Topology Optimization, Generative Design and Lattice Design; Rapid Tooling; Software application of DfAM and 3DP through a product development mini project; Optimization of AM processes for build time, support material, surface finish and part errors.	10

Text Books:

1	Additive Manufacturing Technologies - 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing (2nd illustrated reprint edition) – 2016	Ian Gibson, D W Rosen and Brent Stucker	Springer
2	Additive Manufacturing: Principles, Technologies and Applications - 2021	C P Paul and A N Jinoop	McGraw Hill

References:

1	3d Printing and Additive Manufacturing: Principles and Applications - Fifth Edition – 2016	C K Chua and K F Leong	World Scientific Publishing
2	Metal Additive Manufacturing - 2021	E Toyserkani, D Sarker, O OIbhadode, F Liravi, P Russo, K Taherkhani	Wiley
3	Additive Manufacturing. 3D Printing for Prototyping and Manufacturing - 2016	Andreas Gebhardt and Jan-Steffen Heotter	Hanser Gardner Publications
4	Rapid prototyping and engineering applications: A toolbox for prototype development – 2nd edition – 2019	Frank W Liou	CRC Press
5	Additive Manufacturing, 2nd Edition 2020	Amit Bandyopadhyay and Susmita Bose	CRC Press
6	CAD/CAM: Theory and Practice (Special Indian Edition – 2nd) – 2009	Ibrahim Zeid and R Sivasubramanian	McGraw Hill Education
7	Engineering Design and Rapid Prototyping– 2010	Ali K Kamrani and Emad Abouel Nasr	Springer

##

Course Code: PIN16103	Product Design and Development	Credits: 3-0-2:4

Prerequisites: NIL

Course Outcomes:

CO1	Students will be able to visualize different products lying in the same category –but that has been designed covering different set of needs.
CO2	Students will be able to feel themselves more knowledgeable- at the end of the course.
CO3	Students will be able to identify needs and be able to suggest different alternative solutions considering cost constraints.
CO4	Students will be able to have a watchful eye on happenings in their surrounding for creative analyses. Possibility of taking up entrepreneurship activity, possibility of coming up with new ideas leading to IPR.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	2	2	2	2	2	-	-	-	2	2	2
CO2	3	3	3	2	2	2	2	2	-	-	-	2	2	2
CO3	3	3	3	2	2	2	2	2	-	-	-	2	2	2
CO4	3	3	3	2	2	2	2	2	-	-	-	2	2	2

Unit	Details	No. Hrs
1	Introduction to Product Design, phases of product design: planning, concept development, system level design, detail design, testing, production ramp up. Characteristics of successful product Development, Who designs & develops products, Industrial & Practical Examples, Development Process & Organization, A Generic Development Process	8
2	Opportunity identification, product planning, Identifying Customer Needs, Product specifications, Concept Generation, Creative thinking- Invention- innovation & inventiveness in a society, Concept Selection, prototyping methods	10
3	Product Architecture, Industrial Design, Design for environment, Design for manufacturing	10
4	Human Factors & System Information Input- Text graphics, symbols and codes, Human Factors Application – case studies, Work Place Design- case studies, Human Errors – accidents and safety. Techno legal issues, Intellectual Property Rights.	7

Text Books:

1	Product Design and Development,	Ulrich K. T, and Eppinger S. D	McGraw Hill

References:

1	Mechanical Design Process	David G Ullman	McGraw Hill
2	Product Design	Otto K, and Wood K	Pearson
3	Engineering of creativity: introduction to TRIZ methodology of inventive Problem Solving	Semyon D. Savransky	CRC Press
4	Human Factors in Engineering Design	Mark S sanders & Ernst J. Mc Cornick	McGraw Hill Publishers.

5	Product Design & Process Engineering	Benjamin W Nishel & Alan B Draker	McGraw Hill Publishers.
6	Any other reference discussed in class for specific topics. Along with the above following is also desired: An open mind to feel the quality in a system. Subscription to a quality National news Paper/ Business news paper /magazines for articles on products technologies/ intellectual property acquired by specific firms etc. - Nationally and internationally.		

Core Elective Courses (2-5)

Course Code: PIN15270/PIN16270	Refrigeration and Air Conditioning	Credits: 3-0-0:3

Prerequisites: Engineering Thermodynamics, Heat and mass Transfer

Course Outcomes:

CO1	Students will be able to identify basic components of a refrigeration systems
CO2	Students will be able to evaluate the performance of various refrigeration systems.
CO3	Students will be able to perform calculations for various psychrometric processes using the psychrometric charts
CO4	Students will be able to explain the functioning of the air conditioning system under different conditions
CO5	Students will be able to calculate load for air conditioning applications

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	-	-	-	-	-	-	-	-	-	-	2	2	1
CO2	3	3	2	3	1	3	3	2	2	2	2	-	3	3
CO3	3	2	2	2	1	2	2	-	-	-	-	-	2	2
CO4	3	2	1	1	1	-	-	-	-	2	-	-	2	1
CO5	3	3	3	3	1	2	2	2	2	-	2	-	2	2

Unit	Details	No. Hrs
1	**Refrigeration**-Introduction, methods of refrigeration, Applications, Carnot refrigeration cycle, Unit of refrigeration capacity, Coefficient of Performance, Heat Pumps	5
2	**Vapour compression system**-Analysis of ideal vapour compression cycle, Use of T-s and p-h charts, Effect of pressure changes, subcooling of condensate and superheating of suction vapour on COP, Actual Vapour-Compression cycle, Cascade refrigeration systems	6
3	**Vapour Absorption system**-Comparison between absorption and compression systems, Water-Lithium Bromide and Ammonia –water absorption systems, Single-effect and double-effect systems.	4
4	**Air refrigeration cycle**:Brayton refrigeration cycle and its analysis, Aircraft refrigeration systems.	4
5	**Refrigerants**-Classification and nomenclature, Desirable properties of refrigerants, conventional and CFC free (ozone friendly) refrigerants.	4
6	**Psychrometry**-Psychrometric terms and definitions, Psychrometric processes, comfort chart.	6
7	**Air-conditioning systems**-Cooling and heating loads calculations, Apparatus Dew Point and By-pass factor of cooling coils, window, split and central air-conditioning systems.	6

Text Books:

1	Refrigeration and Air-conditioning	C.P.Arora	Tata McGraw-Hill
2	Refrigeration and Air-conditioning	Manohar Prasad	New Age International

References:

1	Refrigeration and air conditioning,	W. F.Stoecker, and J. W. Jones	Mc GrawHill Book Co, New York.
2	Principles of refrigeration	Roy J Dossat	Prentice Hall
3	Refrigerant Tables and Charts	Banwait&Laroiya	Birla Publications.

##

Course Code: PIN15260/PIN16260	Finite Element Method in Engineering	Credits: 3-0-0:3

Prerequisites: NIL

Course Outcomes:

CO1	Students will be able to understand the fundamental aspects of finite element method.
CO2	Students will be able to formulate the 1d engineering problems and solve them by hand calculations and FE software.
CO3	Students will be able to formulate the 2d engineering problems and solve them by hand calculations and FE software.
CO4	Students will be able to formulate the 3d engineering problems and solve them by programming and FE software.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	1	1	1	1	1			2	1		2	2	2
CO2	2	2	3	2	3	1			2	2		2	3	3
CO3	2	2	3	2	3	1			2	2		2	3	3
CO4	2	2	3	2	3	1			2	2		2	3	3

Unit	Details	No. Hrs
11	**Introduction:** Basic concept, Historical background, and General applications of finite element method.	1
12	**Approaches of FEM:** Discrete, Variational and Weighted Residual.	5
13	**Direct Problems:** 1-D Rod and Heat conduction, Truss Systems, Solution and its post processing by hand calculations and FE software	6
14	**1-D Thermal and Beam Bending Problem**s: Formulation using Galerkin and Rayleigh-Ritz approaches, Derivation of elemental equations and their assembly, Solution and its post processing by hand calculations and FE software.	6
15	**2-D Thermal and Plane stress, Plane strain and Axi-symmetric Problems-** Formulation using Galerkin and Rayleigh-Ritz approaches, Derivation of elemental equations and their assembly, Solution and its post processing by hand calculations, and FE software.	8
16	**3-D Thermal and Stress Problems-** Formulation using Galerkin and Rayleigh-Ritz approaches, Derivation of elemental equations and their assembly, Solution and its post processing by programming and FE software.	6

Textbooks:

1 A first course in the finite element method — Daryl L. Logan — Cengage Learning India Pvt. Ltd

2 Textbook of Finite Element Analysis — P Seshu — PHI

References:

1.	Introduction to Finite Elements in Engineering	Tirupathi Chandrupatla , Ashok Belegundu	Pearson
2.	The Finite Element Method for Engineers	Kenneth H. Huebner, Donald L. Dewhirst, Doughlas E. Smith	Wiley India Pvt. Ltd
3.	Fundamentals of Finite Element Analysis	David V. Hutton	Tata McGraw Hill Education
4.	The Finite Element Method in Engineering	S. S. Rao	Butterworth-Heinemann
5.	Finite Element Procedure	K. J. Bathe	PHI
6.	Concept and Applications of Finite Element Analysis	Robert D. Cook, David S. Malkus, Michael E. Plesha, Robert J. Witt	John Wiley

##

Course Code: PIN15262/PIN16262	Industrial Safety and Reliability Engineering	Credits:3

Prerequisites: Industrial application and safety Engineering

Course Outcomes:

CO1	Students will be able to understand basic knowledge in failure rate and time between failures.
CO2	Students will be able to formulate the root cause analysis. Explain the different failure distribution and probability plotting techniques.
CO3	Students will be able to analyze and determine the effect of the lifecycle cost and allocation. Express the RBD approach and Fault Tree Analysis.
CO4	Students will be able to predict knowledge on risk assessment techniques. Measure reliability allocations and non-parametric methods.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	3	2	1	1	2	1	3	2	3	2	3	3	2
CO2	3	2	2	1	1	3	2	2	2	3	3	3	2	2
CO3	3	3	2	2	3	2	1	1	3	2	2	2	3	3
CO4	3	3	3	2	3	3	1	2	2	3	3	3	2	3

Unit	Details	No. Hrs
1	Introduction, key concepts, terminologies, and safety quantification, safety by design. Hazard identification techniques (e.g., HAZOP, FMEA, etc.). Fault tree and event tree analysis (qualitative & quantitative). Bow-tie and quantitative risk assessment (QRA).	5
2	Safety function deployment, Safety vs reliability – quantification of basic events (repair to failure, repair-failure-repair, and combined processes) Safety vs reliability – quantification of basic events (contd.), Systems safety quantification (e.g., truth tables, structure functions, minimal cut sets) Human error analysis and safety.	7
3	Accident investigation and analysis, Application of virtual reality, OSHAS 18001 and OSHMS. Rules for combining probabilities of events, Definition of Reliability. Significance of the terms appearing in the definition. Probability distributions: Random variables, probability density and distribution functions.	6
4	Hazard rate, derivation of the reliability function in terms of the hazard rate. Failures: Causes of failures, types of failures (early failures, chance failures and wear-out failures). Bath tub curve. Preventive and corrective maintenance. Modes of failure. Measures of reliability: mean time to failure and mean time between failures.	5
5	Classification of engineering systems: series, parallel and series-parallel systems-Expressions for the reliability of the basic configurations. Reliability evaluation of Non-series-parallel configurations: Decomposition, Path based and cutest based methods, Deduction of the Paths and cut sets from Event tree.	6
6	Approximate system Reliability analysis of Series systems, parallel systems with two and more than two components, Network reduction techniques. Minimal cutest/failure mode approach.	6

Text Books:

1. Probabilistic Risk Assessment For Engineering and Scientist	Komamoto and Henley,IEE Press 1995
2. Industrial Accident Prevention	Heirich et al. Mc Graw Hill,1980
3. Techniques For safety management –A system Approach	Petersen D,ASSE1998
4. Reliability evaluation of Engineering systems	Roy Billinton and Ronald N Allan, BS Publications
5. Reliability Engineering	A. Elsayed, Prentice Hall Publications.

References:

1 Reliability Engineering: Theory and Practice — Alessandro Birolini, Springer Publications.

2 An Introduction to Reliability and Maintainability Engineering — Charles Ebeling, TMH Publications.

3 Reliability Engineering — E. Balaguruswamy, TMH Publications.

4 Reliability Engineering — Srinath L.S Affiliated East-West Press Pvt Ltd, New Delhi, 1998.

5 Reliability and Risk analysis — Modarres Maral Dekker Inc.1993.

6 The Reliability of Mechanical system. — John Davidson published by the Institution of Mechanical Engineers, London, 1988.

7 Introductions to Reliability in Design — Smith C.O McGraw Hill, London, 1976.

##

Course Code: PIN15265/PIN16265	Micro and Nano Manufacturing	Credits: 3-0-0:3

Prerequisites: Workshop Technology, Manufacturing science and technology

Course Outcomes:

S.N.	Outcomes
CO1	Students will be able to understand various traditional/non- traditional micro and nano machining methods.
CO2	Students will be able to understand various Non-conventional micro-nano manufacturing and finishing approaches.
CO3	Students will be able to understand Micro and Nanofabrication Techniques and other processing routes in Micro and nano machining/manufacturing.
CO4	Students will be able to understand various nano finishing techniques used in industries.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	-	-	1	3	1	2	-	2	-	2	1	3	1
CO2	2	3	3	2	3	1	3	-	3	-	2	1	2	2
CO3	2	3	3	2	3	1	3	-	3	-	2	2	3	2
CO4	2	3	3	2	3	2	3	-	2	-	2	2	3	2

Unit	Details	No. Hrs
1	Overview of Micro and Nano Manufacturing Introduction, Micro-Products And Design Considerations For Manufacturing, Material Factors, Considerations On Manufacturing Methods, Manufacturing Methods And Processes, Ductile Mode Cutting of Brittle Materials, Diamond Tools in Micromachining.	6
2	Introduction to Conventional micro machining Processes, Micro-turning, Micro-drilling, Micro-milling, Product quality in micromachining; Ultra-precision Processes- Micro and nano grinding, Nano grinding tools	6
3	Non-traditional Micro Machining- Ultra Sonic Micro Machining, Chemical and Electro Chemical Micro Machining, Electric Discharge Micro Machining, Electron Beam Micro Machining, Laser Beam Micro Machining, Ion Beam Micro Machining.	6
4	Micro and Nano Finishing Processes, Need for Nano finishing, Magnetic abrasive Finishing, Magnetorheological Finish, Elastic, Emission Finishing, Magnetic Float Polishing, Ion Beam finishing.	6
5	Process principles of Micro Forming and Welding, Micro Blanking and Punching, Micro Embossing, Micro Extrusion, LASER Micro Welding, Electron Beam Micro Welding	6
6	Applications of Nano and Micromachining in Industry Typical machining methods- Applications in optical manufacturing, Semiconductor and electronics related applications; Introduction to lithography, RIE, DRIE.	6

Text Books:

1	Nano and Micromachining	J. Paulo Davim, Mark J.Jackson	John Wiley & Sons
2	Micro and Nano-manufacturing	Mark. J. Jackson	Springer

References:

1	Micro-manufacturing Processes	V.K.Jain	CRC Press
2	Micro and Precision Manufacturing	Kapil Gupta	Springer
3	Fundamentals of Microfabrication	Mark Madau	CRC Press

##

Course Code: **PIN15263/PIN16263**	Industrial Tribology	Credits: 3-0-0:3

Prerequisites:

Course Outcomes:

CO1	Students will be able to understand the fundamentals of friction, wear and lubrication with reference to industrial applications
CO2	Students will be able to relate friction and wear of engineering materials
CO3	Students will be able to evaluate friction and wear of various engineering materials with different surface contacts.
CO4	Students will be able to select lubricants and /or surface treatment method to reduce friction and wear

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	1	2	3	1	-	2	-	-	-	2	2	3	3
CO2	3	1	2	3	1	-	2	-	-	-	2	2	3	3
CO3	3	3	3	2	2	-	2	-	-	-	2	3	3	3
CO4	3	3	3	2	3	-	3	-	-	-	2	3	3	3

Unit	Details	No. Hrs
1	Definition and History of Tribology, Industrial Significance of Tribology Surface topography and surfaces in contact: Measurement of surface topography, Quantitative surface roughness, Topography of engineering surfaces, Contact between surfaces.	6
2	Friction: Theories of friction, Friction of metals, ceramics, lamellar solids and polymers, Atomic scale friction, Micro scale friction.	6
3	Wear: Types of wear mechanisms: sliding, erosion, abrasion, etc,; Wear testing methods; Estimation of wear rates; Types of particles present in wear debris. Wear of materials: metals, ceramics, polymers, composites.	6
4	Lubrication: Types of lubricants and their industrial uses, SAE classification, recycling, disposal of oils, properties of liquid and grease lubricants, lubricant additives, general properties and selection. Hydrostatic Lubrication: Principle, general requirement, types and applications. Hydrostatic Lubrication: Principle, Theories of lubrication, types and applications. Air/ Gas Lubricated bearings: Advantages and disadvantages, Hydrodynamic journal bearing, hydrodynamic thrust bearing, Analysis. Effect of lubrication on friction and wear of metals, ceramics, polymers and composites.	12
5	Surface engineering in tribology: Surface treatment methods to reduce friction and wear	3
6	Case studies on friction, wear and lubrication	3

Text Books:

1	Engineering Tribology	G. W. Stachowiak and A. W. Batchelor	Butterworth-Heinemann;4th edition
2	Friction, wear, Lubrication	Ludema, K.C.	CRC Press, NY.
3	Tribology: Friction and Wear of Engineering Materials	Ian Hutchings and Philip Shipway	Butterworth-Heinemann; 2nd edition

References:

1	Introduction to Tribology	Bharat Bhushan	John Wiley and Sons, New York, USA
2	Surface Engineering for Corrosion and Wear Resistance	J. R. Davis and Associates	ASM International, Materials Park, OH, USA, 2001
3	The principles of Lubrication	Cameron A.	Longman, London
4	Industrial Tribology: Tribosystems, Friction, Wear and Surface Engineering, Lubrication	Theo Mang, Kirsten Bobzin, Thorsten Bartels	Wiley-VCH
5	Handbook of Hard Coatings: Deposition Technologies, Properties and Applications	Bunshah, R. F.,	Noyes Pub. Park Ridge, New Jersey, U. S. A./William Andrew Publishing, LLC, Norwich, New York, U.S.A.
6	Standard Handbook of Lubrication Engineering	O' Conner and Royle	McGraw Hills

##

Course Code: **PIN15258/PIN16258**	Energy Management	Credits: 3-0-0-3

Pre-requisites: Physics, Thermodynamics

Course Outcomes:

CO1	Develop an understanding of the energy-economy-environment nexus.
CO2	Use the techniques of energy auditing and benchmarking in the industrial sector.
CO3	Acquire basic knowledge of sustainable energy technologies and their applications.
CO4	To carry out techno-economic feasibility of energy conservation opportunities in different sectors of the economy.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	-	2	-	3	3	-	-	-	-	3	3	-
CO2	3	3	-	3	3	-	-	-	-	-	-	-	3	3
CO3	3	3	-	3	-	-	3	-	-	-	-	-	3	2
CO4	-	-	3	-	3	-	3	-	3	3	3	-	-	3

Unit	Details	No. Hrs
1	Introduction: Energy supply and demand, energy linked environmental crises-causes and options in the present scenario of global warming, Energy classification: renewable and non-renewable forms of energy and their characteristics.	5
2	Energy-economy-environment nexus: energy-economy link and factors affecting it, net energy, gross pollution and growth constraints.	3
3	Energy auditing and benchmarking: Process and gross energy requirements, Carbon Footprint, Energy payback time, Identification of energy conservation opportunities, Benchmarking and its parameters.	5
4	Technical options for emissions mitigation: Combined cycles, Combined heat and power systems (Co-generation and tri-generation systems); Combined cooling and power systems, energy efficiency through heat pumps; cascade refrigeration with V-C and V-A systems, Mechanical Vapor Recompression (MVR) systems, Energy recovery in refrigeration and air-conditioning systems; District Cooling, Geo-thermal heat pumps, Earth-air heat exchangers.	12
5	Case studies from industrial/ commercial/ transport/ agricultural/ residential sectors.	5
6	Non-technical options for emissions mitigation: Energy rebound effect, Life style/attitudinal changes, GDP vs. holistic growth.	3

Text Books:

1	Energy Systems and Sustainability	Boyle et al	Oxford University Press
2	Renewable Energy	Boyle et al	Oxford University Press

References:

1	Energy efficiency	Eastop and Croft	Longman Scientific and Technical
2	Bureau of Energy Efficiency (BEE)	Ministry of Power	Government of India
3	Our Choice	Al Gore	Bloomsbury Publishing
4	An Inconvenient Truth	Al Gore	Oscar winning documentary
5	Before the flood	Leonardo DiCaprio	National Geographic documentary

##

Course Code: **PIN15255/PIN16255**	Concurrent Engineering	Credits: 3-0-0:3

Prerequisites: Industrial Engineering

Course Outcomes:

CO1	Students will be able to understand the concept of concurrent engineering and its applications in the design of products and systems.
CO2	Students will be able to analyze, formulate and apply the concepts of DFM and DFA on the new product development as well as the redesign of existing product.
CO3	Students will be able to understand and determine the product development economics.
CO4	Students will be able to apply the CE techniques in the product development.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	2	2	1	2	2	2	2	2	3	2	2
CO2	3	2	3	2	2	2	2	2	2	2	3	3	3	2
CO3	2	2	3	2	2	2	2	2	2	2	2	2	2	3
CO4	3	3	3	2	2	2	2	2	2	2	2	2	3	3

Unit	Details	No. Hrs
1	**Introduction-** Basic concepts, sequential Engineering, sequential engg Vs CE, why CE, mathematical model for understanding interactions between design and manufacturing, examples, benefits of CE, characterization of CE environment, difficulties associated with performing CE, CE techniques.	**4**
2	**Design for Manufacturing and Assembly-** DFA Guidelines- system guidelines, handling guidelines, insertion guidelines, and joining guidelines, theoretical minimum number of parts, design for piece part production, potential conflicts between DFA and DFM, manufacturing cost analysis, basic DFM part cost method, basic assembly method (adapted Xerox producibility index), Boothroyd DFA analysis.	**8**
3	**Design for Manufacturing-** Estimation of the manufacturing costs, reduction of costs of components, reduction of costs of assembly, reduction of the costs of supporting production; consider the impact of DFM Decisions on other factors.	**4**
4	**Product Development Economics-** Elements of Economic analysis, Build a Base-Case Financial Model, Perform Sensitivity Analysis, Use Sensitivity analysis to understand project Trade-Offs, Consider the influence of the Qualitative factors on project success	**4**
5	**CE Techniques -** Quality Function Deployment, The Taguchi Method for Robust Design, Failure Modes and Effects Analysis (FMEA)	**6**
6	Design for reliability, design for maintainability, design for serviceability and their implementation	**2**

Text Books:

1	Systems Approach to Computer Integrated Design and Manufacturing	Nanua Singh	Wiley India
2	Product Design for Manufacture and Assembly	G. Boothroyd, P. Dewhurst and W. A. Knight	CRC Press

References:

1	Product Design and Development	Karl T. Ulrich, Steven D. Eppinger, and Anita Goyal	McGraw Hill Publication
2	e-Procurement: From Strategy to Implementation	Dale Neef	Prentice Hall Publication.
3	Product Design: Techniques in Reverse Engineering and New Product Development	Kevin Otto and Kristin Wood	Pearson Publication

##

Course Code: **PIN15268/16268**	Precision Engineering	Credits: 3-0-0:3

Prerequisites: Manufacturing Science & Technology –I & II

Course Outcomes:

S.N.	Outcomes
CO1	Students will be able to understand concept of accuracy, dimensional wear of cutting tools, location of rectangular prism alignment tests, the Influence of static stiffness, thermal effects, compliance of work piece, Influence of vibration on accuracy.
CO2	Students will be able to apply the knowledge in various machining operations to achieve high and ultra-precision in the components
CO3	Students will be able to analyse top down and bottom up approach, development of Nanotechnology, precision and micro-machining, Stereo microlithography.
CO4	Students will be able to understand various micro machining and MEMs fabrication methods

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	1	2	1	3	2	-	-	-	-	-	2	3	1
CO2	3	1	3	2	3	3	-	-	-	-	-	3	3	1
CO3	3	2	2	3	3	2	-	-	-	-	-	3	3	2
CO4	2	1	3	3	3	2	-	-	-	-	-	1	1	1

Unit	Details	No. Hrs
1	**Introduction:** Introduction to Precision Engineering, accuracy and Precision, Need of a High Precision, History of machining Precision, Classes of Machining Accuracy – Normal Vs Precision Machining. Concept of Accuracy of Machine Tools – Spindle ad Displacement Accuracies – Accuracy of numerical Control Systems – Errors due to Numerical Interpolation Displacement Measurement System and Velocity Lags. Geometric Dimensioning and Tolerancing: Tolerance Zone Conversions – Surfaces, Features, Features of Size, Datum Features – Datum Oddly Configured and Curved Surfaces as Datum Features, Equalizing Datums – Datum Feature of Representation – Form Controls, Orientation Controls – Logical Approach to Tolerancing.	8
2	**Static stiffness and thermal Considerations in Precision Engineering:** Influence of static stiffness, thermal effects: Static stiffness, nature of deformation in a machine tool, compliance of work piece, errors due to the variation of the cutting force and total compliance, accuracies due to thermal effects, methods of decreasing thermal effects-Influence of vibration on accuracy.	7
3	**Precision Machining:** Introduction**,** Ultra-Precision Grinding, Various Ultra-precision Machines and Their Development, Some Applications of Ultra-precision Machining. Top down and bottom up approach, development of Nanotechnology, precision and micro-machining, diamond turning of parts to nanometer accuracy. Stereo microlithography, machining of micro-sized components, mirror grinding of ceramics, ultraprecision block gauges.	8
4	**Nano measuring systems:** In-process measurement of position of processing point, post process and online measurement of dimensional features, mechanical	6

	measuring systems, optical measuring systems, electron beam measuring systems, pattern recognition and inspection systems.	
5	**Micro electro-Mechanical Systems (MEMS)** Introduction, Advances in Microelectronics, Characteristics and Principles of MEMS, Design of MEMS, Application of MEMS in Automobiles, Health-care Industry, Defence, Aerospace Industry, Industrial Products, Consumer Products, Telecommunications, Materials for MEMS, MEMS Fabrication and Micromanufacturing Processes, Bulk Micromachining, Surface Micromachining, MEMS and Microsystem Packaging, Future of MEMS, Clean Rooms- Effects of Various Parameters, Design and Construction	7

Text Books:

1	Precision Engineering	Venkatesh V.C. and Izman S.,	Tata McGraw Hill
2	Precision Engineering	Murthy R.L.	New Age International

References:

1	Elements of precision engineering	R Raman	Oxford & IBH
2	Principles of Precision Engineering	Nakazawa H.	Oxford University Press
3	Basics of precision engineering	Leach, R. K. and Smith, Stuart T.	CRC Press
4	Initiatives of Precision Engineering at the Beginning of a Millennium	Ichiro I.	Springer
5	Nanotechnology	Norio Taniguchi	Oxford university press
6	http://nptel.ac.in/courses/112106138/		

##

Course Code: PIN15257/PIN16257	Design for Manufacturing and Assembly	Credits: 3-0-0:3

Prerequisites: Workshop and Manufacturing Processes, Manufacturing Science and Technology

Course Outcomes:

CO1	Students will be able to understand the significance of Design for Manufacture and Assembly.
CO2	Students will be able to apply the concept of DFM for casting and machining
CO3	Students will be able to apply the concept of DFM for forming, sheet metal work and assembly
CO4	Students will be able to apply the concept of DFMA for a given product

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	2	-	1	1	2	-	1	1	-	2	3	2
CO2	2	2	2	-	1	1	2	-	1	1	-	2	3	2
CO3	2	2	2	-	1	1	2	-	1	1	-	2	3	2
CO4	2	2	2	-	1	1	2	-	1	1	-	2	3	2

Unit	Details	No. Hrs
1	**Introduction:** How Does DFMA Work?, Reasons for Not Implementing DFMA, What Are the Advantages of Applying DFMA During Product Design?, Typical DFMA Case Studies, Overall Impact of DFMA on Industry. **Selection of Materials and Processes:** General Requirements for Early Materials and Process, Selection, Selection of Manufacturing Processes, Process Capabilities, Selection of Materials, Primary Process/Material Selection, Systematic Selection of Processes and Materials	6
2	**Design for Manual Assembly**: General design guidelines for manual assembly, development of the systematic DFA methodology, assembly efficiency, Effect of Part Symmetry, Thickness, Weight on Handling Time, Effects of Combinations of Factors, estimation of insertion time.	5
3	**Design for Machining:** General design rules for machining - Dimensional tolerance and surface roughness — Design for machining — Ease — Redesigning of components for machining ease with suitable examples. General design recommendations for machined parts.	4
4	**Design for Sand Casting and Die Casting:** Sand Casting Alloys, Basic Characteristics and Mold Preparation, Sand Cores, Melting and Pouring of Metal, Cleaning of Castings, Cost Estimating, Design Rules for Sand Castings. The Die Casting Cycle, Auxiliary Equipment for Automation, Determination of the Optimum Number of Cavities, Determination of Appropriate Machine Size, Die Casting Cycle Time Estimation, Die Cost Estimation, Design Principles.	5
5	**Design for Forging, Extrusion and Sheet Metal Working:** Design factors for Forging — Closed die forging design — parting lines of die, drop forging die design — general design recommendations. Design guidelines for extruded sections - Dedicated Dies and Press-working, Press Selection, Turret Press working, Press Brake Operations, Design Rules	6

6	Design for other Misc Processes; Design for Human Factors; Design for X – Reliability, Serviceability, Environment, Disassembly **Design for Assembly Automation:** Fundamentals of automated assembly systems, System configurations, parts delivery system at workstations, various escapement and placement devices used in automated assembly systems, Quantitative analysis of Assembly systems, Multi station assembly systems, single station assembly lines.	7

Text Books:

1	Product Design for Manufacture and Assembly	Geoffrey Boothroyd, Peter Dewhurst, Winston A. Knight	CRC Press
2	Assembly Automation and Product Design	Geoffrey Boothroyd	Book World Enterprises

References:

1	Design for Manufacturability Handbook	James Bralla	McGraw-Hill Professional
2	Design for Manufacturing and Assembly: Concepts, architectures and implementation	O. Molloy, E. A. Warman, S. Tilley	Chapman & Hall
3	Handbook of Product Design	Geoffrey Boothroyd	Marcel and Dekken
4	Engineering Design – Material and Processing Approach	George E. Deiter	McGraw Hill Intl

##

Course Code: **PIN15253/PIN16253**	Composite Materials	Credits: 3-0-0:3

Pre-requisites: Material Science and Engineering, Mechanics of Materials

Course Outcomes:

CO1	Student will be able to understand the basics, design and mechanics of the composites.
CO2	Student will be able to understand the various testing and characterization techniques for the composites.
CO3	Student will be able to design and develop the composites.
CO4	Student will be able to apply the appropriate characterization techniques for the analysis of composites.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	2	1	1	1	1	-	-	1	3	3	3
CO2	3	2	2	1	1	1	1	1	-	-	1	3	3	3
CO3	3	3	3	3	3	2	1	1	-	-	3	3	3	3
CO4	3	3	3	2	3	2	1	1	-	-	2	3	3	3

Unit	Details	No. Hrs
1	**Introduction to Composite Materials**: Definition, Role of matrix and reinforcement, Classification and characteristics, Advantages and limitations and applications in various fields.	4
2	**Introduction to Composite Design:** Ply properties, Framework for composite design, Ply Orientation and arrangement, Use of failure criterion, Sizing of the laminates.	4
3	**Macro and micro-mechanical Analysis of Lamina**: Definitions of stress, strain, Elastic moduli & strain energy, Hooke's law for different types of materials, Hooke's law for two-dimensional unidirectional lamina, Hooke's law for two-dimensional angle lamina, Engineering constants for an angle lamina, Hydrothermal stresses and strains in lamina.	8
4	**Micromechanical Analysis of Laminates:** Volume and mass fractions, density and void content, laminate code, stress-strain relationship for a laminate, in-plane and flexural modulus of a laminate, hydrothermal effects in a laminate.	6
5	**Fabrication of composites**: Polymer matrix composites (classification, hand lay-up technique, compression molding, injection molding, resin transfer molding, pultrusion, filament winding, vacuum bag molding and autoclave molding) Metal matrix composites (stir Casting, Infiltration, In - Situ fabrication, diffusion bonding and powder metallurgy).	6
6	**Testing and Characterization Techniques**: Mechanical Testing: tension, compression, shear, flexure, fracture toughness, hardness, and impact, Thermal analysis: thermogravimetric analysis (TGA), differential scanning calorimeter (DSC), dynamic mechanical analysis (DMA) and Optical Microscope.	6

Text Books:

1	Principles of Composite Material Mechanics	R. F. Gibson	Taylor & Francis, 4th Edition, 2016
2	Analysis and Performance of Fibre Composites	Bhagwan D Agrawal, L J Broutman, K Chandrashekhara	Wiley, ISBN-10: 1119389984

References:

1	Mechanics of Composite Materials:	R. M. Jones
2	Mechanics of Composite Materials:	Autar K kaw
3	Composite Structures-Testing, Analysis and Design:	J. N. Reddy and A.V. Krishna Moorty.
4	Composite Materials - Design and Applications:	D. Gay, S. V. Hoa, S. W. Tsai.
5	Introduction to Composite Materials Design:	E J. Barbero.
6	https://www.youtube.com/watch?v=VMH6qbED7pg	
7	https://www.youtube.com/watch?v=CF6uHm-KSIM	
8	https://onlinecourses.nptel.ac.in/noc22_me51/preview	

##

Course Code: PIN15269/PIN16269	Product Lifecycle Management	Credits: 3-0-0:3

Pre-requisites: Industrial Engineering [Basic] and Introduction to Design and Manufacturing

Course Outcomes:

CO1	Students will be able to understand the concept of product lifecycle management
CO2	Students will be able to explain the integration and deployment of PLM System with other system
CO3	Students will be able to recognize the benefits of PLM in conventional and e-business.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	1	2	2	1	3	3	3	3	3	3	3
CO2	3	2	2	1	2	2	1	3	3	3	3	3	3	3
CO3	3	3	3	3	3	2	1	3	3	3	3	3	3	3

Unit	Details	No. Hrs
1	**Introduction to PLM** – background, Product data or product information, Product lifecycle management concept, Product lifecycle management systems, Reasons for the deployment of PLM systems, Information models and product structures.	7
2	**Product lifecycle management systems** – Functionality, Use of product lifecycle management systems in different organization verticals, Product development and engineering, Production, Sales and marketing, After sales, Sourcing and procurement.	7
3	**Integration of the PLM system with other applications**– Different ways to integrate PLM systems, Database integration, System roles, ERP, CAD, Configurators	6
4	**Deployment of the PLM system –** Different stages of deployment, Leading a PLM project, Choosing a system, Realization stage of the project, Start up, Steering group, Project group, Project manager, Accomplishing change in the organization, Problems	7
5	**Business benefits of a PLM system –** Factors leading to product lifecycle management, Benefits of the PLM system in product lifecycle management, Measuring the business benefits in daily operations, Improving the productivity of labor, Costs of quality	7
6	**Electronic business and PLM** - Preconditions for electric business, Significance of product management, collaboration and electronic business for the manufacturing industry.	2

Text Books:

1	Product Lifecycle Management	Antti Saaksvuori and AnselmiImmonen	Springer Publications

References:

1	Product LifecycleManagement	John Stark	Springer
2	Product Designand Development	Karl T. Ulrich and Steven D. Eppinger	Mc. Graw Hill, Irwin

##

Course Code: PIN15266/PIN16266	Noise and Vibration	Credits: 3-0-0:3

Prerequisites: Basic knowledge of science and engineering

Course Outcomes:

CO1	Students will be able to understand the concept of noise and vibration in the design of products and systems.
CO2	Students will be able to formulate the analytical and numerical model for noise and vibration in the system.
CO3	Students will be able to analyze and determine the effect of system parameters on noise and vibration.
CO4	Students will be able to acquire the noise and vibration of the machine and will provide the solution to minimize it.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	1	1	1	1	1	-	-	-	3	3	3
CO2	3	2	2	1	1	1	1	1	-	-	-	3	3	3
CO3	3	3	3	2	3	2	1	1	-	-	-	3	3	3
CO4	3	3	3	2	3	2	1	1	-	-	-	3	3	3

Unit	Details	No. Hrs
1	Random aspects of noise, traffic noise, community noise, automobile noise, jet noise, aircraft noise, Signal Analysis and Fast Fourier Transform (FFT)	5
2	Sonic bang, acoustic fatigue, industrial noise, noise in piping system.	5
3	Identification of noise sources and control, Automotive noise control principles, Sound in enclosures, Sound energy absorption, Sound transmission through barriers.	5
4	Noise control: types and design of exhaust mufflers, sound absorbing materials.	5
5	Noise measurement and instrumentation, Effect of noise on human beings, auditory/non-auditory effects of noise, Noise standards and limits, Noise standards in India	5
6	Vibration-Systems with one degree of freedom, Free and forced vibration, torsional vibration. Analysis by Rayleigh's method. Stodola method and iterative method of Holtzer. Analysis and application of forced vibration in steady state as well as transient state, self excited vibrations. Free vibrations of systems with several degrees of freedom. Free vibration of elastic bodies, Free longitudinal vibrations of Prismatic bar, orthogonality principle. vibration absorbers, case studies, vibration measurement and instrumentation	10

Text Books:

1	Mechanical Vibrations	Singiresu S.Rao	Pearson Education.
2	Noise and Vibration Control	Munjal M L	World Scientific Publishers

References:

1	Fundamentals of Sound and Vibrations	Frank Fahy and David Thompson	CRC Press
2	Elements of Vibration Analysis	Leonard Meirovitch	Tata McGrmv-Hill, New York.

##

Course Code: PIN15254/PIN16254	Computational Fluid Dynamics	Credits: 3-0-0:3

Prerequisites: Engineering Thermodynamics,

Course Outcomes:

CO1	To understand various discretization methods for solving PDE problems
CO2	To understand fundamental matrix algebra concepts to solve simultaneous linear equations numerically
CO3	To apply numerical methods to obtain approximate solutions of General Transport equations

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	1	1	1	1	1	-	-	-	3	3	3
CO2	3	2	2	1	1	1	1	1	-	-	-	2	3	2
CO3	2	3	3	2	3	2	1	1	-	-	-	3	2	3

Unit	Details	No. Hrs
1	**Mathematical Description of the Physical Phenomena**-Governing equations—mass, momentum, energy, species, General form of the scalar transport equation, Elliptic, parabolic and hyperbolic equations, Behaviour of the scalar transport equation with respect to these equation type.	5
2	**Discretization Methods-** Methods for deriving discretization equations- Introduction to finite difference, finite volume and finite element methods, Method for solving discretization equations – iterative methods, Consistency, stability and convergence - Von-Neumann stability analysis.	6
3	**Diffusion Equation-** 1D-2D steady and transient diffusion, Treatment of source terms, non-linearity, Boundary conditions, interface diffusion coefficient, Under-relaxation, Unsteady diffusion, Explicit, Implicit and Crank-Nicolson scheme, Two dimensional conduction, Boundeness, accuracy, stability and convergence for diffusion problems.	7
4	**Convection and Diffusion-** Steady and transient one-dimensional convection and diffusion, Upwind, exponential, hybrid, power, QUICK scheme, Two-dimensional convection-diffusion, Accuracy of Upwind scheme; false diffusion and dispersion, Boundary conditions.	6
5	**Flow Field Calculation-** Incompressibility issues and pressure-velocity coupling, Primitive variable versus other methods, Vorticity-stream function formulation, Staggered grid, SIMPLE family of algorithms.	7
6	Latest Developments in CFD Techniques and newer applications	3

Text Books:

1	Numerical Heat Transfer and Fluid Flow	Suhas V. Patankar	CRC Press.
2	Computational Fluid Dynamics - The basics with applications	Jr. Anderson	TATA McGraw-Hill

References:

1	An Introduction to Computational Fluid Dynamics: The Finite Volume Method	H. Versteeg, Malalasekera	W. Pearson

##

Course Code: **PIN15261/PIN16261**	Fracture Mechanics in Manufacturing	Credits: 3-0-0:3

Prerequisites: Material Science and Engineering, Mechanics of Materials, Additive Manufacturing

Course Outcomes:

CO1	Students will be able to understand the concept of fracture mechanics in manufacturing processes
CO2	Students will be able to formulate the effect of cracks, flaws on the mechanical behaviour of manufactured components.
CO3	Students will be able to analyze the fracture parameters of manufactured components under different load conditions both analytically and experimentally.
CO4	Students will be able to predict the condition of the tool tip touching the crack tip during which energy is transferred directly to the fracture process

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	1	1	1	1	1	-	1	-	3	3	3
CO2	3	2	2	1	1	1	1	1	-	-	-	3	3	3
CO3	3	3	3	2	3	2	1	1	-	-	-	3	3	3
CO4	3	3	3	2	3	2	1	1	1	-	-	3	3	3

Unit	Details	No. Hrs
1	**Introduction:** Background; Griffith theory of fracture, energy release rate (ERR), conditions for stable and unstable crack growth, crack arrest	4
2	**Linear elastic fracture mechanics:** Williams analysis of stress field at the tip of a crack, Solution of stress and displacement field for plane cracks using complex methods in plane elasticity (Westergaards or Kolosov-Muskhelishvili approach), Stress intensity factor (SIF) for plane and penny shaped cracks, Equivalence of SIF and ERR, fracture toughness.	10
3	**Elasto-plastic fracture mechanics:** First order estimate of crack tip plastic zone using Irwin's and Dugdle's approach, Plastic zone for plane stress and plane strain situation and effect on fracture toughness, Review of small strain plasticity, Crack tip fields in an elasto-plastic material (Discussion on HRR fields), J-integral as a fracture parameter and crack tip opening displacement.	10
4	**Mixed-mode fracture:** Prediction of crack path and critical condition for crack extension under mixed-mode loading using Maximum tensile stress, Minimum strain energy density and Maximum energy release rate criteria	6

5	**Experimental measurement of SIF and fracture toughness:** SIF measurement using strain gages, optical techniques, Evaluation of fracture toughness	6
6	Fracture mechanics analysis of cutting and machining, Defects in Metal Additive Manufacturing Processes, fusion-based processes and solid-state/sintering processes.	6

Text Books:

1	Fracture Mechanics	Michael Janssen, Jan Zuidema and Russell Wanhill	Spon Press (Taylor & Francis Group)
2	Metal Fatigue in Engineering	R.I. Stephens , A.Fatemi, R.R. Stephens and H.O. Fuchs	John Wiley

References:

1	Fracture Mechanics: Fundamentals and Applications	T.L. Anderson	CRC Press
2	Fundamentals of Fracture Mechanics	J.F. Knott	Butterworths
3	Fatigue Damage, Crack Growth and Life Prediction	F. Ellyin	Chapman & Hall
4	Elementary Engineering Fracture Mechanics	D. Broek	Kluwer Academic
5	Fracture Mechanics with an introduction to micromechanics	Gross and Seelig	Springer
6	Elements of Fracture Mechanics	Prashant Kumar	Tata McGraw Hill
7	Deformation and Fracture Mechanics of Engineering, Materials	R.W. Hertzberg	John Wiley
8	Fatigue and Fracture Behaviour of Additively Manufactured Mechanical Components	Roberto Citarella, Paulo M. S. T. de Castro, Angelo Malign	MDPI, Multidisciplinary Digital Publishing Institute, 2021
9	Fracture Properties of Thermoplastic Composites Manufactured Using Additive Manufacturing	Manush Ravi Prame	Youngstown State University, 2017

10	Fundamentals of cutting.	JG Williams, Y. Patel	Interface Focus 6: 20150108. http://dx.doi.org/10.1098/rsfs.2015.0108
11	A fracture mechanics model to study indentation cutting	M. Terzano, A. Spagnoli, P. Ståhle	Fatigue and Fracture of Engineering Materials and Structures DOI: 10.1111/ffe.12750
12	A fracture mechanics analysis of cutting and machining,	J.G. Williams, Y. Patel, B.R.K. Blackman	Engineering Fracture Mechanics 77 (2010) 293–308
13	Fracture toughness and cutting	A.G. Atkins	International Journal of Production Research, 12 (1974), pp. 263-274

##

Course Code: **PIN15252/PIN16252**	Automobile Engineering	Credits: 3-0-0

Pre-requisites: Engineering Thermodynamics, Engineering mechanics, Material Science, Strength of Materials.

Course Outcomes:

CO1	Students will able to understand the different types of auto vehicles and transmission system.
CO2	Students will able to acquire knowledge on the steering system, suspension system, braking system and wheels and tyre assembly.
CO3	Student will able to evaluate various resistances and aerodynamics drag force on auto vehicle body.
CO4	Students will able to acquire knowledge on lubricating and cooling systems, Lighting system in automobile and exhaust System.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	2	1	1	2	2	1	-	2	-	2	2	2
CO2	2	2	2	1	1	2	2	2	-	1	-	2	3	3
CO3	3	2	2	1	2	3	2	2	-	1	-	2	3	3
CO4	2	2	3	1	1	2	3	2	-	2	-	2	2	3

Unit	Details	No. Hrs
1	**Introduction to Auto Vehicles:** History of automobile, Classification of automobile, Types of chassis layout and type of drive, Types of chassis- fully forward, semi forward, Truck or bus chassis, two & three wheeler chassis layout.	4
2	**Power Transmissions: (Manual, Semi-automatic and Fully Automatic)** Clutches and its types, Gear Box and its types, Fluid Couplings, Torque convertors, Semi Automatic & Automatic Transmission, Continuous Variable Transmission (CVT), Telescopic joint and Propeller Shaft, Differential and its types, Axles and its types and Traction Control.	8
3	**Steering and Suspension System** Steering linkages, functions of steering mechanism, steering gear box types, wheel geometry, and power steering systems. Suspension geometry, Dependent and independent suspension systems, coil and leaf spring suspension, Shock Absorbers and Torsion Bar	8
4	**Braking System and Wheels and Tyre Assembly:** Mechanical Brakes, Hydraulic Brakes, constructional and operation of ABS, Pneumatic Brakes and Vacuum Brakes and hand brake. Wheel quality, assembly, types of wheels, wheel rims. Construction of tyres and tyre specifications.	8
5	**Automotive Body and Road Safety:** Vehicle body styles, Aerodynamic considerations in body profiling, resistance calculation. Road Safety, seat belt, air bags, bumper, anti lock brake system (ABS), wind shield, suspension sensors, traction control, mirrors, central locking and electric windows, speed control.	6
6	**Miscellaneous:** Lubricating system and cooling systems, Air-conditioning and Lighting system in automobile and exhaust System.	4

Text Books:

1	The Motor Vehicle	**Newton** & **Steeds** & Garrot	Butterworth-Heinemann
2	Advanced Vehicle Technology	Heinz Heisler	Butterworth-Heinemann
3	Automotive Engineering	David A Crolla.	Elsevier collection

References:

1	Tire and Vehicle Dynamics	Hans B Pacejka	Elsevier Ltd
2	Road Vehicle Dynamics	Rao V Dukkipati	Springer
3	Ground Vehicle Dynamics	Werner and Karl	Berlin Heidelberg
4	Theory of Ground Vehicles	Wong H.	McGraw Hill, Second edition

##

Course Code: **PIN15256/PIN16256**	Condition Monitoring and Diagnostics	Credits: 3-0-0:3

Pre-requisites: Basic knowledge of science and engineering

Course Outcomes:

CO1	Students will be able to understand the concept of condition monitoring and diagnostics of the systems.
CO2	Students will be able to select appropriate condition monitoring and diagnostics technique in a given system/plant.
CO3	Students will be able to explore the data acquisition system, sensors, signal processing required for condition monitoring of the system.
CO4	Students will be able to analyze and identify the faults in the system.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	1	1	1	1	1	-	-	-	3	3	3
CO2	3	2	2	1	1	1	1	1	-	-	-	3	3	3
CO3	3	3	3	2	3	2	1	1	-	-	-	3	3	3
CO4	3	3	3	2	3	2	1	1	-	-	-	3	3	3

Unit	Details	No. Hrs
1	**Principles of Maintenance:** Reactive Maintenance, Preventive Maintenance, Predictive Maintenance, Enterprise Resource Planning, Bath Tub Curve, Failure Modes Effects and Criticality Analysis (FMECA)	5
2	**Digital Signal Processing:** Classification of Signals, Signal Analysis, Frequency Domain Signal Analysis, Fundamentals of Fast Fourier Transform, Computer-Aided Data Acquisition, Signal Conditioning, Signal Demodulation, Cepstrum Analysis	5
3	**Vibration Monitoring:** Principles of Vibration Monitoring, Misalignment Detection, Eccentricity Detection, Cracked Shaft, Bowed and Bent Shaft, Unbalanced Shaft, Looseness, Rub, Bearing Defects, Gear Fault, Faults in Fluid Machines, Case studies.	10
4	**Electrical Machinery Faults:** Construction of an Electric Motor, Faults in Electric Motor, Fault Detection in Electric Motors, MCSA for Fault Detection in Electrical Motors, Instrumentation for Motor Current Signature Analysis, Fault Detection in Mechanical Systems by MCSA, MCSA for Fault Detection in any Rotating Machine, Fault Detection in Power Supply Transformers, Fault Detection in Switchgear Devices, Case studies.	5
5	**Thermography and Wear Debris Analysis :** Thermal Imaging Devices, Use of IR Camera, Industrial Applications of Thermography, Applications of Thermography in Condition Monitoring, Mechanisms of Wear, Detection of Wear Particles, Common Wear Materials, Oil Sampling Technique, Oil Analysis, Limits of Oil Analysis, Case studies.	5
6	**Machine Tool Condition Monitoring:** Tool Wear, Sensor Fusion in Tool Condition Monitoring, Sensors for Tool Condition Monitoring, A Tool Condition Monitoring System	5

Text Books:

1 Machinery Condition Monitoring: Principles and Practices — Mohanty, A. R — Taylor and Francis, CRC Press

References:

1	Mechanical fault diagnosis and condition monitoring	Collacott, R.A.	John Wiley
2	Handbook of condition monitoring	Davis, A.	Springer
3	Machinery malfunction diagnosis and correction	Eisenmann, R. C	Prentice Hall

##

Course Code: PIN15267/PIN16267	Non-conventional Energy Resources	Credits: 3-0-0:3

Pre-requisites: Basic knowledge of Heat Transfer, Thermodynamic.

Course Outcomes:

CO1	Understand the concept of energy crisis, non-conventional energy resources, availability and their importance.
CO2	Understand various methods to harness non-conventional energy resources.
CO3	Apply the methods for better harness, conversion techniques, and utilization of non-conventional energy resources.
CO4	Analyse various problems, limitations, complexities and performances of power plants based on non-conventional energy resources.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	2	2	3	3	3	2	2	2	3	3	2
CO2	3	3	2	2	2	3	3	3	2	2	2	3	3	2
CO3	3	3	3	3	3	3	3	3	3	3	2	3	3	3
CO4	3	3	3	3	3	3	3	3	3	3	3	3	3	3

Unit	Details	No. Hrs
1	Introduction: The energy crisis – causes and options, various conventional and non-conventional forms of energy and their characteristics, availability of non-conventional energy and land area requirements.	4
2	Solar energy: Introduction, Solar radiation, Sun-Earth angles, Measurement of solar radiation at the earth's surface, Types of collectors such as flat-plate and concentrating collectors, solar thermal power generation, solar ponds and energy storage. Principle of Solar photovoltaic, materials, mono-crystalline, polycrystalline and amorphous silicon cells and their production technology, I-V characteristics, parameters of performance, modules, array and PV plant configurations and power generation.	6
3	Biomass energy: Introduction, Incineration, Thermo-chemical and biochemical conversion to solid, liquid and gaseous fuels; Production technologies for bio-ethanol, biogas and producer gas, Urban waste to energy processes.	5
4	Ocean, Wave and Tidal energy: Introduction, Ocean thermal energy conversion (OTEC) – closed and open cycles and their limitations, Wave energy and its conversion processes, Tidal energy – nature of the tides and tidal barrages for power generation.	5
5	Wind energy: Fundamentals, power in the wind, site selection, maximum power coefficient, wind turbine and its types – horizontal axis and vertical axis machines, performance of wind machines, wind energy farms.	5
6	Geothermal energy: Introduction, Geothermal energy resources, Hot aquifers and hot dry rock systems, geothermal electric power plants.	4
7	Other Technologies: Magnetohydrodynamics (MHD) Energy conversion, Fuel Cells, Nuclear Energy, Hydrogen, Methanol, Energy Storage.	4

Text Books:

1	Renewable Energy Sources and Emerging Technologies	D.P. Kothari, K.C. Singal and R. Ranjan	PHI Learning Pvt. Ltd., New Delhi
2	Solar Energy-Fundamentals, Design, Modeling & Applications'	G.N. Tiwari	Narosa Publishing House, New Delhi, India

References:

1	Advanced Renewable Energy Sources	G.N. Tiwari and R.K. Mishra	RSC Publishing, Cambridge, U.K
2	Biogas Systems: Principles and Applications	K.M Mittal	New Age International Limited Publishers.
3	Wind Energy Come of Age	Gipe P	John Wiley and sons, New York.
4	Solar Energy Fundamentals	S. Kalogirou	Academic Press
5	Solar Photovoltaics: FundamentalsTechnologies and Applications	C.S. Solanki	PHI Learning Pvt. Ltd., New Delhi
6	Energy Technology (Non Conventional, Renewable And Conventional)	S. Rao, BB Parulekar	Khanna Publishers

##

Course Code: PIN15259/PIN16259	Failure Mode and Effect Analysis	Credits: 3-0-0:3

Prerequisites: Mechanics of Materials, Design of Machine Elements, Industrial Engineering

Course Outcomes:

CO1	Students will be able to understand and recognize failure modes in a system
CO2	Students will be able to identify corrective actions resulting from proper FMEA development
CO3	Students will be able to demonstrate the FMEA's role in developing Special Characteristics and Design and Process Controls
CO4	Students will be able to apply the method of FMEA in a design, system or process for betterment of the society

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	3	2	1	1	3	3	3	2	3	3	3
CO2	3	2	2	3	2	1	1	1	3	3	2	3	3	3
CO3	3	3	3	2	3	2	1	1	3			3	3	3
CO4	3	3	3	2	3	3	1	1	3			3	3	3

Units	Title	Lectures
1	**FMEA:** A General overview and purpose, Critical or Significant Characteristics or Key Indicators, Types of FMEAs, Relationships of FMEA and other Tools, Quantitative Techniques, Qualitative Techniques	5
2	**System/Subsystem/Component Design FMEA**: Material Properties (Strength, Lubricity, Viscosity, Elasticity, Plasticity, Malleability, Machinability etc.), The Geometry of the Product (Shape, Position, Flatness, Parallelism),Tolerances/Stack-Ups, Interfaces with other Components and/or Systems; Manufacturing and Assembly Process FMEA, Machinery and Equipment FMEA (Logistics Support),	7
3	**Process FMEA**: Man - Human Factors / Human Error, Methods - Methods involved in processes of product/service including assembly lines, supply chains and communications standards, Materials - Materials used in the process, Machinery- Machines utilized to do the work, Measurement - Measurement systems and impact on acceptance, Environment- Mother Earth: The Links between Design and Process FMEA, Special characteristics (critical and significant), Collaboration on special characteristics, Characteristics as inputs to PFMEA	8
4	**Steps for an FMEA:** Review the Process of Product, Brainstorm Potential Failure Modes, List Potential Effects for Each Failure Mode, Assigning Severity, Occurrence, and Detection Rankings, Assigning a Severity Ranking for Each Effect, Assign an Occurrence Ranking for Each Effect, Assigning a Detection Ranking for Each Failure Mode, and/or Effect, Calculating the Risk Priority Number (RPN) for Each Failure Mode, Prioritizing the Failure Modes for Action, Taking Action to Eliminate or Reduce the High-Risk Failure Modes, Calculating the Resulting RPN as the Failure Modes are Reduced	8
5	**Case studies:** FMEA and the Automotive Industry: Definition of FMEA, The FMEA Form, Special Automotive Characteristics, Driving the Action Plan, Getting the Most form FMEA, After the FMEA; FMEA and the Electromechanical Industry etc. **FMEA and Robustness**	8

Text Books:

1. The basics of FMEA, Robert E McDermott, Raymond J. Mikulak, and Michael R. Beauregard, CRC Press

References:

1. Failure Mode and Effect Analysis: FMEA form theory to execution, D H Stamatis, ASQ Quality Press
2. Failure Mode Effects Analysis: A practical Approach, IanMcAndrew and Elena Vishnevskaya, Lambert
3. FMEA Failure Modes Effects Analysis A Complete Guide, Gerardus Blokdyk (Author) , 5STARCooks
4. NPTEL: https://www.youtube.com/watch?v=7bFjH_ZVARI

##

Course Code: PIN15272/PIN16272	Total Quality Management	Credits: 3-0-0:3

Pre-requisites: Quality Engineering

Course Outcomes:

CO1	Student able to understand the concept of quality management, techniques, frameworks and models
CO2	Students able to understand the TQM philosophies and implementation
CO3	Students able to attain knowledge on TQM principles, team work and continuous improvement process
CO4	Students able to apply the modern quality management tools in developing the business strategy
CO5	Students able to understand the implications of quality management standards and systems

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	-	1	-	-	2	2	2	1	1	1	2	2	2
CO2	1	-	-	-	-	1	2	2	2	1	2	1	2	2
CO3	1	-	2	-	-	1	2	2	2	1	2	2	2	2
CO4	1	-	1	-	-	1	2	2	1	1	1	1	2	2
CO5	1	-	1	-	-	2	2	2	1	1	1	2	2	2

Unit	Details	No. Hrs
1	Introduction: Basic concepts of TQM, TQM approach, Models and Frame works for TQM.Quality award models and new model for TQM.	6
2	TQM Philosophies: Deming Philosophy, Juran Trilogy, Crosby zero Defect Philosophy, Barriers to TQM Implementation, Benefits of TQM, Characteristics of successful quality leader, Contributions of Gurus of TQM, Case studies.	6
3	TQM Principles:Leadership theory and practices, Creating the leadership system, strategy and organization structure, leadership for Quality creating or changing the culture – effective leadership – excellence in leadership. Strategic quality planning, Quality councils-employee involvement, motivation, Empowerment, training and development, Team and Teamwork, Quality circles, recognition and reward, performance appraisal, Continuous process improvement, PDCE cycle, 5S, Kaizen, Improvement Strategies, Types of Problems, Problem solving Methods, Reengineering.	7
4	**TQM Tools and Techniques:**Design, innovation and improvement – the design process – quality function deployment (QFD) – the house of quality (HOQ), building a HOQ, QFD process – specifications and standards. Bench marking and POKA YOKE.	6
5	TQM quality systems: Quality and environment management systems: Introduction to IS/ISO 9004:2000 – – Elements, implementation and documentation of Quality system. Guidelines for performance improvements, Quality Audits - registration - ISO 14000 series standards – concepts of ISO 14001 – requirements of ISO 14001 – benefits of EMS – integrating ISO 14000 with ISO 9000 – relationship between health and safety.	7

Text Books:

1	Besterfiled D. H.	'Total Quality Management'	Pearson Education Asia – 2005
2	SubburajRamasamy	Total Quality Management	Tata McGraw Hill Publishing Company Ltd., New Delhi, 2005

References:

1	Joel E. Ross	Total Quality Management	Taylor and Franscis Limited
2	James R. Evans and William M. Lindsay	"The Management and Control of Quality"	8th Edition, First Indian Edition, Cengage Learning, 2012.
3	ISO 9000: Concepts, Methods and Implementation,		Tapan P Bagchi, A.H.Wheeler, 1999
4	L. Suganthi, Anand A. Samuel,	Total Quality Management 1st Edition	PHI Learning, 2009
5	R. Ashley Rawlins,	Total Quality Management	Autherhouse, 2008

##

Course Code: **PIN15251/PIN16251**	Automatic Control	Credits: 3-0-0:3

Pre-requisites: Mathematics – I and Mathematics – II

Course Outcomes:

CO1	Students will be able toapply the modelling fundamentals to obtain state-space and transfer function models of linear control systems.
CO2	Students will be able tocompute the time response of linear control systems.
CO3	Students will be able tocompute the frequency response of linear control systems.
CO4	Students will be able toanalyse the linear control systems to identify the characteristics of the systems.
CO5	Students will be able todesign the linear controller based on the desired characteristics of the systems.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	2	3	-	-	2	2	2	1	2	3	2
CO2	3	3	3	2	3	-	-	2	2	2	1	2	3	2
CO3	3	3	3	2	3	-	-	2	2	2	1	2	3	2
CO4	3	3	3	2	3	-	-	2	2	2	1	2	3	2
CO5	3	3	3	3	3	1	-	2	2	3	1	3	3	2

Unit	Details	No. Hrs
1	Introduction to control, open-loop control, feedback control, Modelling of mechanical, electrical and hydraulic dynamic systems, Properties of Laplace transform, Transfer function modelling, Representation of multiple subsystems: Block diagrams, Signal flow graphs, State-space representation, State-space model solution.	8
2	Time response of first order system, time-constant, Time response of second order systems, Pole locations and Time Response, Transient Response Analysis, Stability analysis using the Routh-Hurwitz test, Relative Stability, Steady state error, PID Controller Design.	7
3	Root locus analysis: Sketching a root locus, Selection of gain from the root locus, Design of Lead and Lag Compensators using the root locus.	6
4	Frequency response analysis: Bode plot, Nyquist plot, Stability Analysis: Nyquist theorem, Stability Margins, Closed loop frequency response, Design of Lead and Lag Compensators using Frequency Domain Techniques.	8
5	Linear discrete time systems: z-transform, mathematical modelling, stability analysis, steady-state error, dynamic performance of discrete time systems	6

Text Books:

1	Automatic Control Systems	B C Kuoand F Golnaraghi	Wiley
2	Modern Control Engineering	K Ogata	Pearson Education.
3	Discrete-Time Control Systems	K Ogata	Pearson Education

References:

1	Control Systems: Principles and Design	M Gopal	Tata McGraw-Hill
2	Automatic Control Engineering	F H Raven	McGraw-Hill
3	Control Systems Engineering	I J Nagrath and M Gopal	New Age International
4	Feedback Control of Dynamic Systems	G F Franklin, J D Powell and A Emami-Naeini	Prentice-Hall
5	Automatic Control	https://nptel.ac.in/courses/112107240	
6	Control engineering	https://nptel.ac.in/courses/108106098	

##

Course Code: PIN15264/PIN16264	Mechanical Micromachining Technology	Credits: 3-0-0-3

Prerequisites: Material Science and Engineering, Manufacturing Science and Technology-I, Manufacturing Science and Technology-II.

Course Outcomes:

CO1	Able to understand the fundamental concepts of modern mechanical micromachining technology.
CO2	Apply the concepts of micro turning, micro drilling, micro milling and micro grinding for fabrication and finishing of micro-featured products.
CO3	Utilize the in-process monitoring tool in micromachining to improve the tool life and product quality.
CO4	Identify and apply the possibilities of mechanical micromachining techniques in the emerging areas.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	-	-	-	1	-	2	1	2	-	-	-	3	1
CO2	2	3	3	3	3	3	2	1	2	1	-	2	3	3
CO3	2	3	3	2	2	2	2	-	-	-	-	2	3	3
CO4	-	1	2	2	2	1	2	-	-	-	-	3	3	2

Unit	Subject Details	No. Hrs
1	**Fundamentals of Micromachining**- Introduction, Materials in Micromachining, Experimental Observation and Theoretical Prediction of an Atom, Micromachining Mechanics: Size Effect, Minimum Chip Thickness, Specific Cutting Energy, Surface Generation and Burrs, Surface Roughness, Cutting Fluid, Issues and Challenges, Mechanical Micromachining Processes, Ductile Mode Machining of Brittle Materials, Machined Surface Quality with Chip Formation Mode.	7
2	**Micro Turning and Diamond Turning**-Basics of Micro Turning, Mechanics of Micro Turning, Size Effect in Micro Turning, Diamond Technology, Ultra-precision Diamond Turning, Material Perspective and Micro-structuring, Surface Quality in Micro Turning.	6
3	**Micro Drilling**-Introduction to Micro Drilling, Issues and Challenges, Cutting Mechanics, Tool Selection, Burr Elimination, Hole Quality and Roundness Error, Process ParameterSelection.	5
4	**Micro Milling**-Introduction, Elements in Micro Milling, Micro Milling Mechanics of chip Removal, Scientific and Technological Challenges, Surface Quality and Burr Removal, Hybrid Micro Milling Process, Freeform Milling, Process Parameter Selection.	7
5	**Micro Grinding**- Introduction, Chip Removal Mechanism, Interaction between Diamond Abrasive and Work material, Implementation Perspective: Truing and Dressing, Tool Topography and Edge Distribution, Profile Grinding.	5
6	**In-ProcessMonitoring, Product Quality and Industrial Applications**-In-Process Monitoring of Cutting Force, Tool Wear and Surface Form, Online Measurement by Machine Vision and Integrate Probe, Surface Integrity and Other Related Measurements, Product Quality, Industrial Applications of Micromachining: Semiconductor, Electronics, Optics, Heat Transfer, Medical, Aerospace and Automotive Industry.	6

Text Books:

1	Micromachining of Engineering Materials	J.A. McGeough	CRC Press
2	Micromachining Techniques for Fabrication of Micro and Nano Structures	Mojtaba Kahrizi	InTech
3	Micro-Cutting Fundamentals and Applications	Kai Cheng, Dehong Huo	Wiley
4	Nano and Micromachining	J. Paulo Davim, Mark J. Jackson	John Wiley & Sons

References:

1	Comprehensive Materials Processing	M.S.J. Hashmi	Elsevier
2	Micromachining with Nanostructured Cutting Tools	Mark J. Jackson	Springer
3	Advanced Machining and Finishing	Kapil Gupta, Alokesh Pramanik	Elsevier
4	Control of Cutting Vibration and Machining Instability	C. Steve Suh, Meng-Kun Liu	Wiley
5	An Introduction to Surface-Micromachining	Robert W. Johnstone, M. Parameswaran	Kluwer Academic Publishers

##

Course Code: PIN15271/PIN16271	Surface Treatment and Characterization	Credits: 3-0-0:3

Prerequisites: NIL

Course Outcomes:

CO1	Students will be able to know the surface treatment and characterization methods for the newly developed materials and also would be able to conduct the failure analysis of the materials.
CO2	Students will be able to obtain the mechanical and metallurgical properties of the engineering materials
CO3	Students will be able to prepare the specimen for a particular material and characterization technique.
CO4	Students will be able to understand the surfaces, properties, structures and phases of the engineering materials

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	2	3	3	1	2	1	-	-	-	2	3	3
CO2	2	2	2	3	3	1	2	1	-	-	-	2	3	3
CO3	3	2	3	3	3	1	2	1	-	-	-	3	3	3
CO4	3	2	3	3	3	1	2	1	-	-	-	3	3	3

Unit	Details	No. Hrs
1	**Property enhancing and surface processing operations:** Surface cleaning methods; Mechanical cleaning, chemical cleaning **Surface treatment methods:** Surface engineering to change the surface metallurgy, surface engineering to change the surface chemistry, surface engineering to add a surface layer or coating, Process comparisons.	12
2	**Mechanical Property characterization:** Principles and characterization techniques related to Tensile, compressive, hardness, fatigue and fracture toughness properties.	4
3	**Characterization: Optical/Electron Microscopy Techniques**: Surface topography, specimen and surface preparation, mounting, elements of phase identification, grain size determination, inclusion analysis, Image analysis, etc. **Scanning Electron Microscopy**: Theory and principles, construction, controls & operation of scanning electron microscopy, Environmental scanning electron microscopy, High resolution SEM imaging, EDS / EDAX analysis. **Transmission Electron Microscopy**: Theory and principles, construction and controls.	8
4	**XRD**: Principle, Crystallography and Rietveld analysis, Quantitative and qualitative analysis, Residual stress analysis, Determination of layer thicknesses, Small Angle X-ray Scattering (SAXS) **Scanning Probe Microscopy**: STM & AFM- Principle, scanning techniques, image capturing and manipulation, and analysis techniques.	6
5	**Thermal Analysis:** Principles and applications of thermal analysis; Dynamic Mechanical Analyzer	2

6	**Case studies on characterization of Engineering Materials :** Metals and Alloys; Polymers; Composites; ceramics; glasses; Superalloys; Piezoelectric materials (PZT); Shape memory alloys (SMA); Micro-electro-mechanical (MEMS) materials; Nano-structured materials; etc.	4

Text Books:

1	Introduction to Physical Metallurgy	**Avner**, **S.H.**	McGraw-Hill Education, 2017
2	Surface Engineering for corrosion and wear resistance	J. R. Davis	ASM International

References:

1. Speyer, R.F., Thermal Analysis of Materials, Marcel Decker, 1994.
2. Surface Engineering, Vol. 5, ASM Hand book, 1994.
3. Materials Characterization, Vol. 10, ASM Hand book, ASM International, 2019.

##

Semester-VII

Course Code: **PIN17101**	Supply Chain Management	**Credits:** 3-1-0-4

Pre-requisites: Industrial Engineering

Course Outcomes:

CO1	Understand how each functional component and its processes become one integrated operation to satisfy customer's needs.
CO2	Develop an understanding of how to manage the interaction of business functions across companies in the supply chain.
CO3	Develop an understanding of how to manage the impact of demand on the supply chain and the considerable competitive advantages that can result from managing demand across companies.
CO4	Effectively manage the flow of resources and information among the various partners of the supply chain.
CO5	Develop an understanding of how logistics and supply chain strategies can create value generation and utilise IT applications

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	3	3	3	3	2	2	2	2	2	3	3	3	2
CO2	1	3	3	3	3	2	3	3	2	2	3	3	3	2
CO3	2	3	3	3	3	3	2	2	2	3	3	3	2	3
CO4	2	3	3	3	3	3	2	2	3	2	3	3	2	3
CO5	1	3	3	2	2	3	2	2	2	2	3	3	3	3

Module	Content	Lectures
1	**Basics of Supply Chain:** Introduction to Supply Chain Management, Understanding the Supply Chain, Supply Chain Performance: Competitive and Supply Chain Strategies, achieving Strategic Fit and Scope of Strategic Fit	**08**
2	**Design of Supply Chain Drivers:** Supply Chain Drivers and Metrics: Drivers of Supply Chain Performance, Framework for structuring Drivers, Facilities, Inventory, Transportation, Information, Sourcing and Pricing, Case Study: : Seven-Eleven Japan Company, Planning Demand and Supply In a Supply Chain: Demand Forecasting in a Supply Chain, Aggregate Planning in a Supply Chain	**08**
3	**Design of Distribution Network and Network Design:** Designing Distribution Networks and Application to E-Business- Role of distribution, factors influencing distribution network design, design options for a distribution network, E-Business and the distribution network, Network Design in the Supply Chain- Role of network design in the supply chain, factors influencing network design decisions, framework for network design decisions	**08**
4	Role of Information Technology in supply chain, coordination in a supply chain, Bullwhip Effect, Effect on performance due to lack of coordination, obstacles to coordination in a supply chain, Factors influencing logistics and decisions, Benchmarking and performance measurement, Internal Supply Chain Management and its drivers, External Supply Chain Management and its	**10**

	drivers.	
5	Sustainable Supply Chain Management, Digital Supply Chain Management and Smart Supply Chain Management	**04**

Text Books:

1. Supply Chain Management: Strategy, Planning & Operation- Sunil Chopra and Peter Meindle- Pearson Prentice Hall Publication.
2. Supply Chain Management in the 21st Century- B. S. Sahay- MacMillan Publication.

Reference Books:

1. Logistical Management: The integrated Supply Chain Process- Donald J. Bowersox and David J. Closs- TMH Publication.
2. Supply Chain Management – Maretin Christopher
3. World Class Supply Management: The key to Supply Chain Management- Burt, Dobler and Straling – TMH Publication.
4. Logistics and Supply Management – D K Agarwal – MacMillan Publication
5. Supply Chain Management: Theories & Practices – R P Mohanty and S. G. Deshmukh- Biztantra Publication.
6. e-Procurement: From Strategy to Implementation- Dale Neef- Prentice Hall Publication.

Core Elective Courses (6)

Course Code: PIN17267	Solar Energy and Applications	Credits: 3-0-0:3

Prerequisites: Heat and Mass Transfer, Energy Science.

Course Outcomes:

CO1	Understand the basics of solar energy including its production at the Sun, and collection at Earth surface.
CO2	Understand various methods to collect the solar energy and its measurement.
CO3	Applysolar energy to solve various technical problems overcoming their conventional methods for safely realization, betterment of mankind and to protect our planet from effects of climate change such as global warming.
CO4	Analyse the performances of various solar energy applications e.g. Thermal, Photovoltaic and Daylight..

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	2	2	2	2	2	2	2	2	3	3	2
CO2	3	2	2	2	3	3	3	3	2	2	2	3	3	2
CO3	3	3	3	3	3	3	3	3	3	3	2	3	3	3
CO4	3	3	3	3	3	3	3	3	3	3	2	3	3	3

Unit	Details	No. Hrs
1	Introduction: Energy saving and Protection of Environment, The Sun, The Earth, Solar spectrum. Global warming and it's effect, Importance of Solar Energy. Solar energy systems and It's types: Active and Passive. A brief overview of various applications of solar energy.	4
2	Solar Radiation: Types of Solar radiation (Terrestrial and Extra-terrestrial regions, Beam radiation, Diffuse radiation), Air mass, Albedo, Irradiance. Attenuation, Sun-Earth Angles, Solar time, Solar radiation on inclined surface and horizontal surface, Measuring Instruments for solar radiation e.g. Pyrheliometer, Pyranometer, Sun-shine recorder.	4
3	Solar Water Heating: Introduction (need & working principle), Heat and mass transfer mechanism, Types of solar water heating systems, Basic energy balance equations, Efficiency and Performance. Solar Air Heating/Cooling: Introduction (need & working principle), Heat and mass transfer mechanism, Types of solar air heating and cooling systems, Basic energy balance equations, Efficiency and Performance.	6
4	Solar Distillation: Introduction (need & working principle), Heat and mass transfer mechanism, Types of solar distillation systems, Basic energy balance equations, Efficiency and Performance. Solar Passive house: Concept of passive house, Solar architecture, Principles of making a solar passive house. Daylight and its Use.	6

5	Photovoltaics: Introduction, Materials and Doping, Fermi level, p-n junction & its characteristics, Photovoltaic effect, Solar Cell, Module, Array and PV Plant, Solar cell efficiency, Fill factor, Packing factor, Hybrid PV-T applications- a brief study.	6
6	Other applications of solar energy: A brief study of Solar cooking, Solar Aquaculture, Solar Greenhouse, Solar cooling, Solar Thermal Power Generation plant etc.	4

Text Books:

1	Solar Energy – Fundaments, Design, Modeling & Applications	G.N. Tiwari	Narosa Publications.
2	Solar Energy	S P Sukhatme, J K Nayak	McGraw-Hill Publications
3	Solar Photovoltaics: Fundamentals, Technologies And Applications	C. S. Solanki	PHI Publications

References:

1	Solar Energy Engineering	S. Kalogirou	Academic Press
2	Solar Photovoltaic Technology and Systems-A manual for technicians, Trainers and Engineers	S. Solanki	PHI Publications
3	Solar Engineering of Thermal Processes	John A. Duffie, William A. Beckman	John Wiley and sons, New York.
4	Principles of Solar Energy	Frank Krieth& John F Kreider	John Wiley and sons, New York.

##

Course Code: PIN17259	Energy Management	Credits: 3-0-0-3

Prerequisites: Physics, Thermodynamics

Course Outcomes:

CO1	Develop an understanding of the energy-economy-environment nexus.
CO2	Use the techniques of energy auditing and benchmarking in the industrial sector.
CO3	Acquire basic knowledge of sustainable energy technologies and their applications.
CO4	To carry out techno-economic feasibility of energy conservation opportunities in different sectors of the economy.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	-	2	-	3	3	-	-	-	-	3	3	-
CO2	3	3	-	3	3	-	-	-	-	-	-	-	3	3
CO3	3	3	-	3	-	-	3	-	-	-	-	-	3	2
CO4	-	-	3	-	3	-	3	-	3	3	3	-	-	3

Unit	Details	No. Hrs
1	Introduction: Energy supply and demand, energy linked environmental crises-causes and options in the present scenario of global warming, Energy classification: renewable and non-renewable forms of energy and their characteristics.	5
2	Energy-economy-environment nexus: energy-economy link and factors affecting it, net energy, gross pollution and growth constraints.	3
3	Energy auditing and benchmarking: Process and gross energy requirements, Carbon Footprint, Energy payback time, Identification of energy conservation opportunities, Benchmarking and its parameters.	5
4	Technical options for emissions mitigation: Combined cycles, Combined heat and power systems (Co-generation and tri-generation systems); Combined cooling and power systems, energy efficiency through heat pumps; cascade refrigeration with V-C and V-A systems, Mechanical Vapor Recompression (MVR) systems, Energy recovery in refrigeration and air-conditioning systems; District Cooling, Geo-thermal heat pumps, Earth-air heat exchangers.	12
5	Case studies from industrial/ commercial/ transport/ agricultural/ residential sectors.	5
6	Non-technical options for emissions mitigation: Energy rebound effect, Life style/attitudinal changes, GDP vs. holistic growth.	3

Text Books:

1 Energy Systems and Sustainability — Boyle et al — Oxford University Press

2 Renewable Energy — Boyle et al — Oxford University Press

References:

1	Energy efficiency	Eastop and Croft	Longman Scientific and Technical
2	Bureau of Energy Efficiency (BEE)	Ministry of Power	Government of India
3	Our Choice	Al Gore	Bloomsbury Publishing
4	An Inconvenient Truth	Al Gore	Oscar winning documentary
5	Before the flood	Leonardo DiCaprio	National Geographic documentary

##

Course Code: PIN17266	Smart Materials	Credits: 3-0-0:3

Prerequisites: Material Science and Engineering, Mechanics of Materials & Composite materials

Course Outcomes:

CO1	Student will be able to understand the basics, role, types, design and mechanics of the smart materials.
CO2	Student will be able to understand the various characterization techniques for the smart materials.
CO3	Student will be able to design and develop the smart materials.
CO4	Student will be able to design the novel smart materials for advance applications.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	2	1	1	1	1			1	3	3	3
CO2	3	2	2	1	1	1	1	1			1	3	3	3
CO3	3	3	3	3	3	2	1	1			3	3	3	3
CO4	3	3	3	2	3	2	1	1			2	3	3	3

Unit	Details	No. Hrs
1	**Introduction to Smart Materials:** Overview of Smart Materials, Advantages and limitations, Applications, Types of smart materials, Piezoelectric Materials, Elecrostrictive Materials, Magnetostrictive Materials, Magneto electric Materials. Magnetorheological Fluids, Electroheological Fluids, Shape Memory Materials, Fiber-Optic Sensors.	6
2	**Fabrication and characterization:** Additive manufacturing, injection moulding, vapor deposition (PVD), vacuum bag molding process. X-ray diffraction (XRD), Raman scattering spectroscopy (RS), Secondary Ion Mass Spectrometer (SIMS), Transmission electron Microscopy (TEM), Fourier-transform infrared reflection (FTIR), Ultraviolet–visible (UV–Vis), Atomic force microcopy (AFM).	6
3	**Ferroelectric materials:** Piezoelectric materials- piezoelectric effect, Direct and converse, parameter definitions, Piezoceramics, Piezopolymers, Piezoelectric materials as sensors, Actuators and bimorphs	5
4	**Shape memory materials**: Shape memory alloys (SMAs), Shape memory effect, Martensitic transformation, One way and two-way SME, training of SMAs, binary and ternary alloy systems, Functional properties of SMAs.	5
5	**Smart polymers and hydrogels**: Thermally responsive polymers, Electroactive polymers microgels, Synthesis, Properties and Applications, Protein-based smart polymers, pH-responsive and photo-responsive polymers, Self-assembly, Molecular imprinting using smart polymers, Approaches to molecular imprinting, Drug delivery using smart polymers, Synthesis, Fast responsive hydrogels,	5

	Molecular recognition, Smart hydrogels as actuators, Controlled drug release, Artificial muscles, Hydrogels in microfluidics.	
6	**Smart systems for sustainable applications**: Elastic memory composites, Smart corrosion protection coatings, Self-healing materials, Sensors, Actuators, Transducers, MEMS, Deployment devices, Molecular machines, Nuclear Industries	5

Text Books:

1	Smart Structure and Materials	Brain Culshaw	Artech House – Borton. London
2	Smart Materials and Structures	M. V. Gandhi and_B.So Thompson	Chapman & Hall, London; New York

References:

1.	Electro ceramics: Materials, Properties	A.J. Moulson and J.M-Herbert	Wiley/ 2nd Edition, (ISBN: 0471497479).
2.	Piezoelectric Sensories: Force, Strain, Pressure, Acceleration and Acoustic Emission Sensors: Materials and Amplifiers	G. Gautschi	Springer, Berlin; New York, 2002 (ISBN:3540422595)
3.	Piezoelectric Actuators and wtrasonic Motors	K.Uchino	Academic Publishers, Boston, 1997 (ISBN: 0792398114)
4.	https://archive.nptel.ac.in/courses/112/104/112104251/		
5.	https://www.youtube.com/watch?v=yXHlIowQntk		

##

Course Code: PIN17260	Green Hydrogen and Alternative Fuels	Credits: 3-0-0:3

Prerequisites: Concepts of Thermodynamics, Fluid Mechanics and Heat Transfer

Course Outcomes:

CO1	Students will be able to explain basic concepts of hydrogen energy and advances in this technology
CO2	Students will be able to explain the different formation methods of hydrogen production and its associated challenges in its storage, transportation and safety.
CO3	Students will be able to explain the importance of bio energy in near future along with the conversion techniques of bio energy from biomass and bio waste.
CO4	Students will be able to identify the challenges in the dissemination of bio-energy to the mass and its design and technical aspects.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	1	1	1	1	1	-	-	2	1	-	3	3
CO2	3	2	2	1	-	-	1	-	-	2	-	-	2	1
CO3	2	3	1	3	2	-	2	-	-	3	1	-	2	2
CO4	3	3	2	3	1	1	3	1	1	2	1	2	3	3

Unit	Details	No. Hrs
1	Basics and types of hydrogen, its production technologies, hydrogen generation from fossil fuels, biomass and renewables by different methods, selection criteria for choosing the Electrolyzers. Hydrogen production from electrolysis method, its working principle, classification, criteria for choosing the materials, and different materials used in this method.	8
2	Hydrogen storage and transport, methods of hydrogen storage, characterization methods, challenges of materials and their solutions, selection criteria of nanomaterials, and different nanomaterials used in hydrogen storage. Safety issues associated with Hydrogen energy.	6
3	Biomass, Broad Classifications, Compositions, Characteristics, Properties, Structural Components, Biomass Residues, Utilization through Conversion Routes: Bio-chemical and Thermo Chemical, Bioconversion into Biogas, Mechanism	7
4	Bioconversion of Substrates into Alcohols and Bio diesels; Thermo-Chemical Conversion of Biomass, Conversion to Solid, Liquid and Gaseous Fuels, Pyrolysis, Gasification, Combustion, Chemical Conversion Processes.	6
5	Biogas Production and Characterization, Biogas Digesters, Parameters influencing the biogas production, challenges with biogas technologies, Biogas Purification and upgradation techniques, compressed biogas technologies	6

Text Books:

1	Hydrogen and Fuel Cells: Emerging Technologies and Applications	Bent Sorensen	Academic Press
2	Biomass Gasification, Pyrolysis and Torrefaction,	Prabir Basu,	Elsevier
3	Renewable Energy Resources	Twidell, J. and Tony W.,	Taylor & Francis

References:

1	Hydrogen Energy Challenges and Solutions for a Cleaner Future	Bahman Zohuri	Springer Singapore
2	Biomass Gasification and Pyrolysis Practical Design	Prabir Basu	Elsevier
3	Biogas Technology	Liangwei Deng, Yi Liu, Wenguo Wang	Springer Singapore

##

Course Code: PIN17264	Mechanics of Composite Materials	Credits: 3-0-0:3

Prerequisites: Mechanics of Materials, Material science and engineering

Course Outcomes:

CO1	Students will be able to analyze the mechanical behaviour of composite materials over isotropic materials.
CO2	Students will be able to apply constitutive equations of composite materials and understand mechanical behaviour at micro and macro levels.
CO3	Students will be able to determine the stresses and strains relation in composites materials.
CO4	Students will be able to predict the failure of the lamina and laminates composites

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	1	2	1	1	1	-	-	-	3	3	3
CO2	3	2	2	1	1	1	2	1	-	-	-	3	3	3
CO3	3	3	3	2	3	2	1	1	-	-	-	3	3	3
CO4	3	3	3	2	3	2	1	1	-	1	-	3	3	3

Unit	Details	No. Hrs
1	INTRODUCTION TO COMPOSITE MATERIALS: Introduction, Classification: Polymer Matrix Composites, Metal Matrix Composites, Ceramic Matrix Composites, nature-made composites, and applications. Fibres- Glass, Silica, Kevlar, carbon, boron, silicon carbide, and born carbide fibres. Particulate composites, Polymer composites, Thermoplastics, Thermosetts, Metal matrix and ceramic composites.	**9**
2	ELASTIC BEHAVIOR OF COMPOSITE LAMINA USING MICROMECHANICS: Introduction, Strength of Materials Approach, Semi-Empirical Models, Elasticity Approach, Volume and Mass Fractions, Density, and Void Content, Evaluation of the Four Elastic Moduli, Ultimate Strengths of a Unidirectional Lamina	**6**
3	ELASTIC BEHAVIOR OF COMPOSITE LAMINA USING MACROMECHANICS: Introduction, Definitions: Stress, Strain, Elastic Moduli, Strain Energy, stress-	**6**

	strain relations for general anisotropic materials, specially orthotropic materials, transversally isotropic materials, orthotropic material under plane stress and isotropic materials, relations between mathematical and engineering constants.	
4	ELASTIC BEHAVIOR OF MULTIDIRECTIONAL LAMINATES: Basic assumptions, laminate code, strain-displacement relations, stress-strain relations of a layer within a laminate, force and moment resultants, Laminate stiffness and laminate compliance, symmetric laminates, balance laminates	**6**
5	FAILURE ANALYSIS AND DESIGN OF LAMINA: Strength Failure Theories of an Angle Lamina: Maximum Stress Failure Theory Strength Ratio, Failure Envelopes, Maximum Strain Failure Theory, Tsai–Hill Failure Theory, Tsai–Wu	**7**
6	FAILURE ANALYSIS AND DESIGN OF LAMINATES: Introduction, Special Cases of Laminates, and Failure Criterion for a Laminate, and Design of a Laminated Composite	**6**

Text Books:

1	Engineering Mechanics of Composite Materials	Isaac and M Daniel,	Oxford University Press
2	Analysis and performance of fibre Composites	B. D. Agarwal and L. J. Broutman	John Wiley & sons, New York

References:

1	Mechanics of Composite Materials	R. M. Jones	Mc Graw Hill Company, New York
2	Analysis of Laminated Composite Structures	L. R. Calcote	Van Nostrand Rainfold, New York
3	Mechanics of Composite Materials	Autar K. Kaw	CRC Publication

##

Course Code: PIN17257	Design against Fatigue and Fracture	Credits: 3-0-0:3

Prerequisites: Material Science and Engineering, Mechanics of Materials

Course Outcomes:

CO1	Students will be able tounder stand the concept of fracture mechanics in the design of products and systems.
CO2	Students will be able to formulate the effect of cracks, flaws on mechanical behavior of components.
CO3	Students will be able to analyze and determine the effect of inherent/nucleated cracks and flaws under monotonic and fluctuating load conditions both analytically and experimentally.
CO4	Students will be able to predict the life of components under cyclic loading conditions and apply the knowledge in research and development activity for betterment of the society.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	1	1	1	1	1				3	3	3
CO2	3	2	2	1	1	1	1	1				3	3	3
CO3	3	3	3	2	3	2	1	1				3	3	3
CO4	3	3	3	2	3	2	1	1				3	3	3

Unit	Details	No. Hrs
1	Stress concentration effect of flaws, Cracks as stress raisers; The Griffith energy balance, The energy release rate, Crack growth instability analysis and R-curve.	5
2	Stress analysis of cracks: Generalised In-plane Loading (Williams approach), Westergaard stress function, Behaviour at Crack Tips in Real Materials; Effects of Cracks on Strength; Effect of Cracks on Brittle versus Ductile Behaviors, The stress Intensity factor K, Crack tip plasticity, Fracture toughness, K as a failure criterion, Trends of K_{IC} with material	7
3	Crack tip opening displacement (CTOD), The J-contour integral, J as a nonlinear energy release rate, J as a Path-Independent Line Integral, J as a Stress Intensity Parameter, Laboratory measurement of K_{IC}	6
4	Micro-mechanism of fatigue, Introduction, Fatigue Design Criteria : Infinite life design, safe life design, fail-safe design, Damage Tolerant Design, Fatigue Tests and the stress-life (S-N) Approach.	5
5	Cyclic deformation and the strain-life (ε-N) approach, Fundamentals of LEFM and application to fatigue crack growth : LEFM concepts, Cyclic plastic zone size, fatigue crack growth, mean stress effect, Experimental measurement of fatigue crack growth.	6
6	Fatigue from variable amplitude loading: Spectrum loading, Cumulative damage theories, Load interaction and sequence effects, cyclic counting method, crack growth and life estimation methods.	6

Text Books:

1	Fracture Mechanics	Michael Janssen, Jan Zuidema and Russell Wanhill	Spon Press (Taylor & Francis Group)
2	Metal Fatigue in Engineering	R.I. Stephens , A.Fatemi, R.R. Stephens and H.O. Fuchs	John Wiley

References:

1	Fracture Mechanics: Fundamentals and Applications	T.L.Anderson	CRC Press
2	Fundamentals of Fracture Mechanics	J.F.Knott	Butterworths
3	Fatigue Damage, Crack Growth and Life Prediction	F.Ellyin	Chapman & Hall
4	Elementary Engineering Fracture Mechanics	D. Broek	Kluwer Academic
5	Fracture Mechanics with an introduction to micromechanics	Gross and Seelig	Springer
6	Elements of Fracture Mechanics	Prashant Kumar	Tata McGraw Hill
7	Deformation and Fracture Mechanics of Engineering, Materials	R.W. Hertzberg	John Wiley

##

Course Code: PIN17258	Electric Vehicle Technology	Credits: 3-0-0:3

Prerequisites: Basic Electrical Engineering

Course Outcomes:

S.N.	Outcomes
CO1	Students will be able to understand about basics of electric vehicle.
CO2	Students will be able to understand about drives and control systems of electric vehicles.
CO3	Students will be able to select motor, battery, battery indication system for EV applications.
CO4	Students will be able to design battery charger for an EV.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	-	-	1	1	3	1	-	-	-	-	1	2	1
CO2	3	-	-	1	1	3	1	-	-	-	-	2	2	1
CO3	1	3	3	3	2	3	1	1	-	-	2	2	3	2
CO4	1	2	3	2	3	2	2	1	-	-	1	2	3	3

Unit	Details	No. Hrs
1	**Introduction to Electric Vehicle:**Types and working mechanisms of Electric Vehicles, Components of Electric Vehicles, Chassis /Battery/Charger/etc., Standard Materials and its properties for components used in ElectricVehicles, Frame and Chassis of Electric Vehicles, braking systems in EVs, planetary gears, clutches, differentials, all-wheel drive regenerative braking mechanisms, Brake strategies (Series and Parallel), Braking torque distribution principle, electro-mechanical hybrid braking system.	10
2	**Energy Storage Systems (ESS):** Types of Batteries, their working mechanisms and characteristics, Applications of Batteries and ultracapacitors in Electric Vehicles, Comparison between different cell chemistry w.r.t. specific power, specific energy, safety, lifespan, performance, cost etc.	7
3	**Analysis of ESS:**Battery design parameters for several Electric Vehicles, Battery Architecture, Battery passive components sizing, Isolation requirements, Manufacturing of batteries, Battery modelling, form cell to pack, Battery pack and design issues, Failures of batteries, Battery Pack Performance & Safety testing standards, Battery management systems, Overview of safety circuits like over voltage and under voltage protection, pre-charge circuit, isolation monitoring, HVIL (high voltage interlock loop), MSD (manual service disconnect), Fuses etc., Overview of favorable and unfavorable storage conditions, impact of temperature on batteries.	8
4	**Mobility and Connectors:**Various types of chargers and energy management strategies, Connected Mobility and Autonomous Mobility- Emobility. Connectors-Types of EV charging connector, North American EV Plug Standards, DC Fast	6

	Charge EV Plug Standards in North America, CCS (Combined Charging System), CHAdeMO, Tesla, European EV Plug Standards,	
5	**Drives for EV:**Introduction to Electromagnetic Energy Conversion; Electric drivetrain system; System design considerations, rating and sizing of electric drivetrain components; Machines and drives for traction and EVs: Permanent Magnet Synchronous Motor (PMSM), Permanent Magnet Brushless DC motors(PMBLDCM), Switched reluctance motors, synchronous reluctance motor, induction motor (IM); Control of Electric Drives; Bidirectional DC-DC converters.	5

Text Books:

1	Electric Vehicle Technology Explained	James Larminie, John Lowry	John Wiley & Sons, Ltd.
2	Electric and Hybrid Vehicles: Design Fundamentals	Iqbal Husain	Iqbal Husain

References:

1	Electric Vehicles: Modern Technologies and Trends	Nil Patel, Akash Kumar Bhoi, Sanjeevkumar Padmanaban, Jens Bo Holm-Nielsen	Springer Singapore
2	Battery Management Systems of Electric and Hybrid Electric Vehicles	Nicolae Tudoroiu (editor)	MDPI AG
3	Heavy-Duty Electric Vehicles: From Concept to Reality	Shashank Arora, Alireza Tashakori Abkenar, Shantha Gamini Jayasinghe, Kari Tammi	Butterworth-Heinemann
4	Rechargeable Lithium-Ion Batteries: Trends and Progress in Electric Vehicles	Thandavarayan Maiyalagan (editor), Perumal Elumalai (editor)	CRC Press

##

Course Code: PIN17251	Advanced Automobile Engineering	Credits: 3-0-0:3

Prerequisites: Engineering Thermodynamics, Engineering Mechanics, Automobile engineering (basic course)

Course Outcomes:

CO1	Students will be able to identify different types of automobile structures, body components and body interiors and how their design differ.
CO2	Students will able to understand and analyze various chassis design and stability of automobiles.
CO3	Students will be able to identify various modern steering and suspension systems and will able to analyze load associated with these systems.
CO4	Students will able to analyze vehicle safety related issues and vehicle design parameters that leads to increased safety and methods to reduce vehicle noise.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	1	2	3	3	2	1	2	-	2	2	2
CO2	3	2	2	2	2	3	3	2	1	2	-	2	3	3
CO3	3	2	2	2	2	3	3	2	1	2	-	2	3	3
CO4	3	2	2	1	2	3	3	2	1	2	-	2	3	2

Unit	Details	No. Hrs
1	**Introduction and overview** –Beginnings Growth and refinement	4
2	**Vehicle Structure, Body Components and Body Interiors:** Basic requirement of stiffness and strength Vehicle structure types, Demonstration of Simple Structural Surfaces (SSS), Bumpers, Grilles, Sill covers and side air bags, outer moldings, Weather strips, Glass and Mirrors, Seat Belt Restraint system-Air-Bag, components of Air- Bag, Dash Board	8
3	**Chassis**: Vehicle and body centre of gravity and handling properties, axle weight and axle centre of gravity, body weight and body centre of gravity, Braking behavior –stability, anti dive control, traction behavior.	8
4	**Steering and Suspension systems:** types-limitations. Hydraulic, electro hydraulic and electrical power steering, steering column, steering damper. Vehicle weights and axle loads, Shock absorbers, spring damper units, roll center analysis, load due to gyroscopic force on suspension, total load on suspension.	8
5	**Automotive vehicle safety, Testing and Noise Control:** basic concepts of vehicle safety, techno legal issues- ethics, testing of automotive components, failure investigations, safety factors, designs for uncertainty, crash testing. Interior noise, Engine noise, Road noise, wind noise, brake noise, Interior noise: Assessment and control	8

Text Books:

1 The Motor Vehicle Newton and Steed Butterworth-Heinemann

2	Vehicle Body Engineering	J. Powloski	Business Books Ltd
3	Tire and Vehicle Dynamics	Hans B Pacejka	Elsevier Ltd
4	Automotive vehicle safety	George A Peters & Barbara J Peters	CRC Press

References:

1	Advanced Vehicle Technology	Heinz Heisler	Butterworth-Heinemann
2	The Automotive Chassis	J. Reimpell, H Stoll	SAE International
3	Automotive Engineering Fundamentals	Richard Stone and J K Ball	SAE International
4	Automotive Body	Lorenzo Morello	Springer
5	Automotive Engineering (Power Train, Chassis system and Vehicle Body)	David A Crolla	Elsevier collection
6	Road Vehicle Dynamics	Rao V Dukkipati	Springer
7	Highway Design & Traffic Safety Engineering Handbook	Ruediger Lamm	McGraw-Hill Education
8	The handbook of road safety measures	Rune Elvik, Truls Vaa, Alena Hoye, Michael Sorensen	Emerald Group Publishing

##

Course Code: PIN17271	Vehicle Management System	Credits: 3-0-0:3

Prerequisites: Engineering Thermodynamics, Engineering Mechanics, Electrical Engineering and Automobile Engineering.

Course Outcomes:

CO1	Students will able to acquire an overview of automotive components, subsystems, and basics of Electronic Engine Control in today's automotive industry
CO2	Students will able to use available automotive sensors and actuators while interfacing with microcontrollers / microprocessors during automotive system design
CO3	Student will able to understand the networking of various modules in automotive systems, communication protocols and diagnostics of the sub systems.
CO4	Students will able to design and implement the electronics that attribute the reliability, safety, and smartness to the automobiles, providing add-on comforts and get fair idea on future Automotive Electronic Systems.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	1	1	1	3	2	1	2	1	3	2	2
CO2	3	3	3	2	2	2	2	2	1	2	1	3	3	2
CO3	3	3	3	2	2	2	3	3	1	1	1	3	3	3
CO4	3	3	3	2	2	2	3	3	1	1	1	3	3	3

Unit	Details	No. Hrs
1	**Automotive Sensors & Actuators:** Hall Effect, hot wire, thermistor, piezo electric, piezoresistive, based sensors. Introduction, basic sensor arrangement, types of sensors, oxygen concentration sensor, lambda sensor, crankshaft angular position sensor, cam position sensor, Mass air flow (MAF) rate, Manifold absolute pressure (MAP), Throttle plate angular position, engine oil pressure sensor, vehicle speed sensor, stepper motors, relays, detonation sensor, emission sensors.	**10**
2	**Digital Engine Control System:** Open loop and close loop control system, engine cooling and warm up control, idle speed control, acceleration and full load enrichment, deceleration fuel cutoff. Fuel control maps, open loop control of fuel injection and closed loop lambda control exhaust emission control, on-board diagnostics, diagnostics, future automotive electronic systems, Electronic dash board instruments – Onboard diagnosis system.	**8**
3	**SI Engine Management:** Feedback carburetor system, throttle body injection and multi point fuel injection system, injection system controls, advantage of electronic ignition systems, three way catalytic converter, conversion efficiency versus lambda. Layout and working of SI engine management systems like Bosch Monoj etronic, L-Jetronic and LH-Jetronic. Group and sequential injection techniques. Working of the fuel system components. Advantages of electronic ignition systems. Types of solid state ignition systems and their principle of operation, Contactless electronic ignition system, Electronic spark timing control.	**10**
4	**CI Engine Management:** Fuel injection system, parameters affecting combustion, noise and emissions in CI engines. Pilot, main, advanced, post injection and retarded post injection. Electronically controlled Unit Injection system. Layout of the common rail fuel injection system. Working of components like fuel injector,	**10**

	fuel pump, rail pressure limiter, flow limiter, EGR valve control in electronically controlled systems.	

Text Books:

1	Automobile Electrical & Electronic Equipments	Young, Griffitns	Butterworths, London.
2	Understanding Automotive Electronics	Wiliam B. Ribbens	Butterworth–Heinemann
3	Gasoline Engine Management	Robert Bosch	SAE Publications
4	Diesel Engine Management	Robert Bosch	SAE Publications

References:

1	Understanding Automotive Electronics	Bechfold	SAE
2	Automobile Electronics	Eric Chowanietz	SAE
3	Automotive Computer & Control System	Tomwather J. R., Cland Hunter	Prentice Inc. NJ
4	Automobile Electrical & Electronic Systems	Tom Denton	Allied Publishers Pvt. Ltd

##

Course Code: PIN17261	Hybrid Electric and Fuel Cell Vehicles	Credits: 3-0-0:3

Prerequisites: Engineering Thermodynamics, Material Science, Internal Combustion Engines, Automobile Engineering, Advanced Automobile Engineering

Course Outcomes:

CO1	Students will be able to understand and analyze different types of Fuel cells, its operation, and performance
CO2	Students will be able to quantify fuel cell processing using codes and standards.
CO3	Students will be able to comprehend basic concept of Hybrid and Electric traction.
CO4	Students will be able to understand the need and environmental importance of Hybrid technology and analyze it.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	3	3	3	3	2	3	3	2	2	3	3	3	3
CO2	3	2	3	3	3	2	3	3	2	2	2	3	3	3
CO3	3	2	3	3	2	2	3	3	2	2	2	3	3	3
CO4	3	3	3	3	3	3	3	3	2	2	3	3	3	3

Unit	Details	No. Hrs
1	**Fuel Cell Technology**-Introduction to Electrochemistry, Unit Cells, Fuel cell stacking, Fuel cell Types (Polymer Electrolyte Fuel cell, Alkaline Fuel cell, Phosphoric acid Fuel cell, Molten carbonate fuel cell, and Solid oxide fuel cell), and Timeline of introduction of fuel cell technology in automobiles.	**8**
2	**Fuel Cell Performance**-Role of Gibbs free energy and Nernst Potential, Cell Energy balance, Cell efficiency, Performance variables, various mathematical models. Polymer Electrolyte Fuel cell-Cell Components, PEFC system Performance, Alkaline Fuel Cell-Cell component, Performance.	**6**
3	**Introduction to Fuel cell Hybrids:** Fuel cell Auxiliary Power Systems, Sample Calculations-Fuel cell Calculations, Fuel Processing Calculations for PEFC, AFC. Fuel cell related codes and Standards	**6**
4	**Hybrid Electric Technology and Electric drive trains**-Introduction, History, Environmental importance, Basic concept of Hybrid Traction, Basic concept of electric traction, Introduction of electric components used in electric vehicles. Principles of Hybrid Electric Drive trains, Architectures, Hybrid control Strategies – Parallel Hybrid, Series Hybrid – (Charge Sustaining, Charge Depleting), Low-Voltage Storage System.	**8**
5	**Hybrid Vehicle Technology**-Sizing the drive system: Matching the electric machine and the Internal combustion engine (ICE), Sizing the propulsion motor, sizing the power electronics, selecting the energy storage technology, Communications, and supporting subsystems. Energy Management Strategies in hybrid and electric vehicles, Case Studies: Design of a Hybrid Electric Vehicle (HEV), Design of a Battery Electric Vehicle (BEV).	**8**

Text Books:

1	Fuel Cell Technology Handbook	Hoogers, G., Edr.	CRC Press
2	Fuel Cell Systems Explained	Larminie, J. and Dicks, A.	John Wiley & Sons, Ltd
3	Vehicular Electric Power Systems	Ali Emadi, Mehrdad Ehsani, John M. Miller	Marcel Dekker, Inc.

References:

1	Fuel Cell Handbook	EG&G Technical Services, Inc.	National Energy Technology Laboratory
2	Electric and Hybrid Vehicles	Tom Denton	Institute of the Motor Industry

##

Course Code: PIN17253	Automotive Electronics	Credits: 3-0-0

Prerequisites: Automobile Engineering

Course Outcomes:

CO1	Understand the need of safety of electronics in automobiles, electronic circuit fundamentals and basic test equipment.
CO2	Analyse vehicle electronic circuits.
CO3	Outline the working of batteries, starting systems, charging systems, ignition systems and auxiliaries.
CO4	Understand the working of sensors and ECU

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	1	2	2	1	3	3	2	1	1	1	3	2	3
CO2	2	2	3	3	2	3	3	2	1	2	1	3	3	3
CO3	2	2	3	3	2	3	3	2	1	2	1	3	3	3
CO4	2	2	3	3	2	3	3	2	1	2	1	3	3	3

Unit	Details	No. Hrs
1	**Introduction:** Overview of the course, Examination and Evaluation patterns, History of Automotive electronics. **Safety and Communication:** Safe working practices-work cloths, eye protection, fire protection, battery safety. Working as an electricity / electronics technician-your toolbox, access to wiring diagrams and repairs information, communicating with the customer, working around air bags. **Circuit fundamentals and basic test equipment:** voltage, current, resistance, circuits components, series and parallel circuits, purpose of voltmeters, measuring voltage drop, connecting the voltmeter, types of ammeters, current probes, reading and interpreting ohmmeter readings, continuity testing.	**6**
2	**Vehicle circuits:** circuit components, analysing series and parallel circuits, control circuits, diagnosing open and short circuits. **Digital Storage Oscilloscope:** voltage and time setting, DSO trigger and slope, using a current probe with DSO, using the DSO‟s multiple-trace capability. **Electronic fundamentals:** solid state devices, electronic control input devices, diagnosing and servicing electronic control input devices, integrated circuits as input devices, diagnosing and servicing ICs, oxygen sensors, diagnosing and servicing oxygen sensors.	**8**
3	**Wiring diagrams and Batteries:** wiring diagram symbols, using the wiring diagram as aservice tool, automotive batteries, diagnosing batteries, servicing batteries. **Starting and charging systems:** starting circuits, solenoid shift starters, diagnosing and servicing solenoid shift starters systems, positive engagement starters, diagnosing and servicing positive engagement starting system, gear-reduction starters, diagnosing gearreduction starters, charging system overview, field circuits, diagnosing and servicing the charging system.	**6**
4	**Ignition systems and accessories:** secondary ignition systems, servicing the secondary ignition system, primary ignition system, diagnosing and servicing	**8**

	distributed primary ignition systems, distributor less ignition secondary circuits, diagnosing and servicing the secondary ignition system on a distributor less vehicles, distributor less ignition primary circuits, diagnosing and servicing the primary circuit on a distributor less ignition system. Lighting circuits, diagnosing lighting circuits, defogger, horn, and windshield wiper circuits, diagnosing defogger, horn, and windshield wiper circuits, motor driven accessories, diagnosing motor driven accessories	
5	**Cooling of Electronics Equipment:** Cooling load of electronics equipment, thermal environment, Electronics cooling in automotive systems, air cooling, liquid cooling, and immersion cooling. **Electronic control units and sensors:** Vehicle sensors-speed, temperature, fuel level, battery condition, emissions, feedback circuits.	**8**

Text Books:

1	Automotive Technology, Electricity and Electronics	Al Santini	Cengage Publishers, 2011
2	Understanding Automotive Electronics, 6th Edition	William Ribbens	Elsevier

Course Code: PIN17252	Alternative Fuels Technology	Credits: 3-0-0

Prerequisites: Engineering Thermodynamics, Internal Combustion Engines

Course Outcomes:

CO1	Students will able to understand about the various alternative fuels available and its properties
CO2	Students will able to determine various properties of bio fuels and their significance in IC engines.
CO3	Student will able to analyze the various gaseous alternative fuels for IC engine applications
CO4	Students will able to explain the concepts of Electric, Hybrid and Fuel Cell Vehicles.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	1	2	2	1	3	3	2	1	1	1	3	2	3
CO2	2	2	3	3	2	3	3	2	1	2	1	3	3	3
CO3	2	2	3	3	2	3	3	2	1	2	1	3	3	3
CO4	2	2	3	3	2	3	3	2	1	2	1	3	3	3

Unit	Details	No. Hrs
1	**Need for alternate fuel:** Availability and properties of alternate fuels, general use of alcohols, LPG, hydrogen, ammonia, CNG and LNG, vegetable oils and biogas, merits and demerits of various alternate fuels, introduction to alternate energy sources. Like EV, hybrid, fuel cell and solar cars	**6**
2	**Alcohols as Fuels**: Production methods of alcohols. Properties of alcohols as fuels. Methods of using alcohols in CI and SI engines. Blending, dual fuel operation, surface ignition and oxygenated additives. Performance emission and combustion characteristics in CI and SI engines.	**8**
3	**Vegetable Oils and Biodiesel as Fuels:** Various vegetable oils and their important properties. Different methods of using vegetable oils engines – Blending, preheating Transesterification and emulsification of Vegetable oils - Performance in engines – Performance, Emission and Combustion Characteristics in diesel engines.	**6**
4	**Hydrogen, Biogas, Natural Gas and LPG as Fuels:** Production methods of hydrogen. Combustive properties of hydrogen. Problems associated with hydrogen as fuel and solutions. Different methods of using hydrogen in SI and CI engines. Performance, emission and combustion analysis in engines. Hydrogen storage - safety aspects of hydrogen. Production methods of Biogas, Natural gas and LPG. Properties studies. CO_2 and H_2S scrubbing in Biogas., Modification required to use in SI and CI Engines- Performance and emission characteristics of Biogas, NG and LPG in SI and CI engines.	**8**
5	**Electric, Hybrid and Fuel Cell Vehicles:** Layout of Electric vehicle and Hybrid vehicles – Advantages and drawbacks of electric and hybrid vehicles. System components, Electronic control system – Different configurations of Hybrid vehicles. Power split device. High energy and power density batteries – Basics of Fuel cell vehicles.	**8**

Text Books:

1	Handbook of Alternative Fuel Technologies	Sunggyu Lee James G. Speight Sudarshan K. Loyalka	CRC Press, Taylor and Francis Group
2	Biodiesel Handbook	Gerhard Knothe, Jon Van Gerpen, Jargon Krahl	AOCS Press Champaign
3	Alternative Fuels: The Future of Hydrogen	Michael F. Hordeski	The Fairmont Press
4	Hybrid, Electric and Fuel-cell Vehicles	Delmar Cengage Learning	Delmar Cengage Learning

References:

1	Alternative Fuels and Advanced Combustion Techniques as Sustainable Solutions for Internal Combustion Engines	Akhilendra Pratap Singh, Dhananjay Kumar, Avinash Kumar Agarwal	Springer
2	Electric, Hybrid, and Fuel Cell Vehicles	Dr. Amgad Elgowainy	Springer Science
3	Transactions of SAE on Biofuels (Alcohols, vegetable oils, CNG, LPG, Hydrogen, Biogas etc.).		SAE Publication

##

Course Code: PIN17263	Machine Learning	Credits: 3-0-0:3

Prerequisites: NIL

Course Outcomes:

CO1	Student will be able to understand the fundamental issues and challenges of machine learning
CO2	Student will be able to understand a wide variety of learning algorithms
CO3	Student will be able to formulate and evaluate models generated from data
CO4	Student will be able to understand the strengths and weaknesses of various machine learning approaches.
CO5	Student will be able to design and implement various machine learning algorithm for real world problems

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	2	2	1	1	1	2	1	-	2	3	2
CO2	3	3	2	3	3	1	1	1	2	1	-	2	3	3
CO3	3	3	3	3	3	2	2	3	2	2	2	3	3	3
CO4	3	3	2	2	3	-	-	-	2	-	-	2	2	2
CO5	3	3	3	3	3	2	2	3	3	3	3	3	3	3

Unit	Details	No. Hrs
1	Basic Concepts: Machine Learning, Supervised learning, Unsupervised learning	3
2	Linear Regression with One Variable: Model representation, Cost function formulation, gradient descent for linear regression, Linear Regression with Multiple Variables: Model representation, Cost function formulation, gradient descent for multiple variables, features and polynomial regression, Logistic Regression: Classification, Hypothesis Representation, Decision Boundary, Cost Function, Simplified Cost Function and Gradient Descent, Multiclass Classification Regularization: Over fitting, Regularized linear and logistic regression	7
3	Neural Network Representation : Physiology of Human Brain, Models of Neuron, Network Architecture, Artificial Intelligence & Neural Network Single Layer Perceptrons: Least mean square algorithm, learning curves learning rate annealing techniques, Perceptron, Perceptron Convergence Theorem. Multi-Layer Feed forward Neural Networks: Multi-Layer Perceptrons, Back Propagation Algorithm, Generalization, Cross Validation, Network Pruning Techniques, Accelerated Convergence of Back Propagation Learning.	7
4	Radial Basis Function Networks: Radial Basis Function Networks, Cover's Theorem; Regularization Theory, Regularization Networks, Comparison of RBF Networks & Multilayer Perceptron.	4
5	Dimensionality Reduction: Hebbian based Principal Component Analysis Adaptive Principal Component Analysis using lateral inhibition; Kernel based Principal Component Analysis. Self Organizing Maps: Self Organizing Map, Properties of the feature Map; Learning Vector Quantization, Contextual maps.	5
6	Support Vector Machine: Large Margin Classification, Kernels, Using an SVM	5

7	Anomaly Detection: Developing and Evaluating an Anomaly Detection System, Anomaly Detection vs. Supervised Learning, Choosing What Features to Use, Multivariate Gaussian Distribution Anomaly Detection using the Multivariate Gaussian Distribution	4

Text Books:

1	Neural Networks: A comprehensive Foundation	S. Haykin	Pearson Education, Inc.
2	Machine Learning: A Probabilistic Perspective	Kevin P. Murphy	MIT Press

References:

1	Introduction to artificial neural systems	Jacek M. Zurada	Jaico Publishing House
2	The Elements of Statistical Learning	T. Hastie, R. Tibshirani, and J. Friedman	Springer
3	Pattern Recognition and Machine Learning	Christopher M. Bishop	Springer

##

Course Code: PIN17256	Computer Integrated Manufacturing	Credits: 3-0-0:3

Pre-requisites: NIL

Course Outcome

S.N.	Outcomes
CO1	Understand and apply the basics of CAD-CAM to link with the present industrial requirement.
CO2	Identify the levels of integration and required devices for industrial automation and up graduation requirements.
CO3	Identify the parameters of capacity planning, manufacturing resource planning and their effects on current market trends.
CO4	Evaluate and apply the concepts of industry 4.0 environment and to develop business strategy on the basis of studied parameters.
CO5	Apply and analyse the required knowledge in developing business competencies, ethics and to develop strategy for dynamic customer's requirement.

Course Articulation Matrix:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	2	2	3	1	1	-	2	-	1	1	3	3	3
CO2	2	2	3	3	3	2	3	1	1	1	1	2	3	3
CO3	3	3	3	3	1	-	-	2	2	3	-	3	3	3
CO4	3	3	3	3	1	2	2	2	2	3	1	3	3	3
CO5	3	3	3	3	2	2	2	1	2	3	2	3	3	3

Module	Content	No. Hr
1	CIM Concepts: Manufacturing Enterprise: External and Internal Challenges, world-class order-winning criteria, CIM- definition, SME manufacturing wheel, CIM benefits and implementation steps; Manufacturing Systems: Classification, elements or sections of a typical manufacturing organization. Functions and Components of CIM System: Design process, concurrent engineering, Concept of CAD/CAM and CIMS.	**10**
2	Database and Communication in CIM System: Data Communication technologies, Database Management technologies, Automated data collection in shop floor.	**6**
3	Planning and Scheduling Functions in CIM System: Aggregate Production Planning (APP), Master Production Schedule (MPS), Material Requirement Planning (MRP), Capacity Requirement Panning (CRP), Manufacturing Resource Planning (MRP-II), Just-In-time Production Systems and Concept of Enterprise Resource Planning (ERP).	**7**
4	Group Technology and Cellular Manufacturing: Concept of Group Technology and its Application, Classification and Coding Techniques; Clustering Techniques and Cellular Manufacturing, Flexible Manufacturing Systems.	**9**

	Computer-Aided Process Planning: Approaches – Variant and Generative, Feature Classification and Recognition; Process Classifications and Selections, Machines and Tool Selection, Setting Process Parameters, Process Sheet Documentation.	
5	Automated Material Handling Systems Industrial Robots, Conveyors, AGVs, Automatic Storage and Retrieval Systems. Introduction to Advanced Manufacturing Systems Introduction to Lean Manufacturing systems, Agile Manufacturing systems, Quick Response Manufacturing, Reconfigurable Manufacturing Systems, Holonic Manufacturing Systems, Agent-Based Manufacturing Systems, Web-based manufacturing, Virtual Manufacturing.	**8**

Reference Books:

1. James A. Rehg and Henry W. Kraebber, 2005. Computer-Integrated Manufacturing. Second Edition, Pearson Education (Singapore) private Ltd., Delhi.
2. Mikell P. Groover, 2005. Automation, Production Systems and Computer-Integrated Manufacturing. Second Edition, Pearson Education (Singapore) private Ltd., Delhi.
3. Nanua Singh, 1995, Systems Approach to Computer Integrated Design and manufacturing, John Wiley & Sons.

##

Course Code: PIN17265	Microelectromechanical Systems (MEMS)	Credits: 3-0-0

Prerequisites: Basic knowledge of science and engineering

Course Outcomes:

CO1	Students will be able to understand the concept of micro-electro-mechanical systems, its working principles and applications.
CO2	Students will be able to design, simulate and analyse the basic micro sensors and actuators in the micro system.
CO3	Students will gain the knowledge of the MEMS fabrication and manufacturing processes.
CO4	Students will be able to explore new design and applications of MEMS

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	1	1	1	1	1				1	2	2
CO2	3	2	2	1	1	1	1	1				3	3	3
CO3	3	3	3	2	3	2	1	1				1	1	1
CO4	3	3	3	2	3	2	1	1				2	2	1

Unit	Details	No. Hrs
1	**Overview of Micro Electro Mechanical systems (MEMS):** MEMS and Microsystem products: Microgears, Micromotors, Microturbines, Mirco-optical Components, Application of Microsystems in Automotive Industry, Application of Microsystems in other Industries: Health care, Aerospace, Industrial Products, Consumer Products, Telecommunications; Scaling Laws in Miniaturization	5
2	**Working Principles of Microsystems:** Microsensors, Microactuation, MEMS with Microactuators, Microactuators with Mechanical Inertia, Microfluidics, Case studies.	5
3	**Engineering Science for Microsystems Design and Fabrication:** Atomic structure of matter, Ions and Ionization, Molecular theory of matter and Intermolecular forces, Doping of semiconductor, Diffusion process, Plasma Physics, Electrochemistry, Case studies.	5
4	**Materials for MEMS:** Substrates and Wafers, Active substrate materials, Silicon and its compounds, polymers, packaging materials, Case studies.	5
5	**Engineering Mechanics and thermo-fluid Engineering for Microsystems Design:** Static bending of thin plates, Design theory of accelerometer, micro accelerometer, thin film mechanics: thermo mechanics, Fluid flow in micro conduits, Heat conduction in multilayered thin films and in solids at sub-micrometer scale, Case studies.	7
6	**Fabrication and manufacturing Processes for Microsystems:** Photolithography, Ion implantation, Diffusion, Oxidation, Chemical Vapour Deposition, Physical Vapour Deposition, Etching, Bulk micro manufacturing, Surface micro machining LIGA process, Case studies.	8

Text Books:

1 MEMS and Microsystems: Design, Manufacture, and Nanoscale — Hsu, T.R — John Wiley & Sons, Inc. New Jersey

Engineering

References:

1	Fundamentals of Microfabrication	Madau, M. J.,	Taylor &Francis
2	Handbook of MEMS: Introduction and Fundamentals	Gad-el-Hak, M.	Taylor &Francis

Course Code: PIN17262	Industrial Automation	Credits: 3-0-0

Prerequisites: Workshop and Manufacturing Process, Industrial Engineering

Course Outcomes:

CO1	Students able to understand the concepts of automations, automation strategy and advanced automation functions.
CO2	Students able understand the different components and tools for automation process
CO3	Students able to understand performances of different automated material handling and storage system
CO4	Students able to understand about the automated production and assembly lines, cellular and flexible manufacturing systems.
CO5	Students able to understand advanced manufacturing production planning and capacity planning system.

Course Articulation Matrix:

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2
CO 1	1	1				1	2	1	1	1	2	2	1	2
CO 2	1	2	2	1	1	2	2	2	2	2	2	2	2	2
CO 3	1	1	1	1	1	2	2	2	1	2	2	2	2	2
CO 4	1		2	2	1	1	2	2	1	1	2	2	2	2
CO 5	1	1	1	1		2	2	2	1	1	2	2	2	2

Unit	Details	No. Hrs.
1	Introduction: – need for automation – automation in production systems – automation principles and strategies - hard and soft automation production system - elements of advanced automation functions - levels of automation - modeling of manufacturing systems.	4
2	Introduction to hydraulic, pneumatic, electric controls system. – majorcomponents, symbols and accessories functions of hydraulic system - Design and application of hydraulic circuits of machine tool, press, Mobile hydraulic. Pneumatic system - pneumatic components and function- pneumatic components symbols- Design and application of pneumatic circuits of machine tool. Semi automats-automated-transfer lines - automatic assembly - transfer devices and feeders' classifications and applications-job orienting and picking devices- setting of automats and transfer lines. Introduction to Microprocessors and their applications, Sensors and Principles, PLC system	7
3	Material handling: Introduction, material handling systems and equipment - principles and design, material transport system: transfer mechanisms and equipments – automated feed cut of components, performance analysis, uses of various types of handling systems including AGV and its various guiding technologies. Overview of automatic identification methods.	7
4	Storage system: introduction - storage system performance - location strategies -	4

	conventional storage methods and equipments - automated storage systems – analysis of storage systems.	
5	Automated manufacturing systems: Components, classification, overview of automated production lines – automated assembly systems, group technology and cellular manufacturing – flexible manufacturing cells and systems - components and applications.	6
6	Manufacturing support system: Process planning and concurrent engineering- process planning, CAPP, CE and design for manufacturing, advanced manufacturing planning, production planning and control system, master production schedule, MRP. Capacity planning, shop floor control, inventory control, MRP-II, J.I.T production systems. Lean and agile manufacturing	6
	Total Hours	34

Text Books:

1	Automation, Production Systems and Computer Integrated Manufacturing	Mikell P. Groover	Prentice Hall India
2	Introduction to industrial automation	Manesis, S., & Nikolakopoulos, G	CRC Press

References:

1	Power Hydraulics	Michael J. Pinches and John G	Prentice Hall
2	Basic Fluid Power	DudleytA. Pease and John, J. Pippenge	Prentice Hall
3	Assembly Automation and Product Design	Geoffrey Boothroyd	
4	Product Design for manufacture and Assembly	Joffrey Boothroyd, Peter Dewhurst and Winston A. Knight	CRC Press
5	Industrial Automation: Hands On	Frank Lamb	
6	Industrial Automation and Control https://archive.nptel.ac.in/courses/108/105/108105062		Nptel

Course Code: PIN17268	Sustainable Engineering	Credits: 3-0-0

Prerequisites:

Course Objectives

- To have an increased awareness among students on issues in areas of sustainability.
- To understand the role of engineering and technology within sustainable development.
- To know the methods, tools, and incentives for sustainable product-service system development.
- To establish a clear understanding of the role and impact of various aspects of engineering and engineering decisions on environmental, societal, economic problems.

Expected outcome:

CO1	The student will be The student will be able to understand the different types of environmental pollution problems and their sustainable solutions.
CO2	The student will be The student will be able to work in the area of sustainability for research and education.
CO3	Students will have a broader perspective in thinking for sustainable practices by utilizing the engineering knowledge and principles gained from this course.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	1	2	3	1	1	-	2	-	1	1	3	3	3
CO2	2	2	3	3	3	2	3	1	1	1	1	2	3	3
CO3	3	3	3	3	1	-	-	2	2	3	-	3	3	3

Unit	Details	No. Hrs
17	Sustainability- Introduction, Need and concept of sustainability, Social-environmental and economic sustainability concepts, Sustainable development, Nexus between Technology and Sustainable development, Challenges for Sustainable Development. Multilateral environmental agreements and Protocols-Clean Development Mechanism (CDM), Environmental legislations in India-Water Act, Air Act.	4
18	Air Pollution, Effects of Air Pollution- sources, Sustainable waste water treatment, Solid waste- sources, impacts of solid waste, Zero waste concept, 3R concept, Global environmental issues-Resources degradation, Climate change, Global warming, Ozone layer depletion, Regional and Local Environmental Issues. Carbon credits and	6

	carbon trading, carbon foot prints.	
19	Environmental management standards, ISO 14000 series, Life Cycle Analysis (LCA) – Scope and Goal, Bio-mimicking, Environment Impact Assessment (EIA) – Procedures of EIA in India.	4
20	Basic concepts of sustainable habitat, Green buildings, green materials for building construction, material selection for sustainable design, green building certification, Methods for increasing energy efficiency of buildings. Sustainable cities, Sustainable transport.	5
21	Energy sources: Basic concepts-Conventional and non-conventional, solar energy, Fuel cells, Wind energy, Small hydro plants, bio-fuels, Energy derived from oceans, Geothermal energy.	5
22	Green Engineering, Sustainable Urbanization, industrialization and poverty reduction; Social and technological change, Industrial Processes: Material selection, Pollution Prevention, Industrial Ecology, Industrial symbiosis.	5

Text Books:

Allen, D. T. and Shonnard, D. R., Sustainability Engineering: Concepts, Design and Case Studies, Prentice Hall.

References:

1 Engineering applications in sustainable Design and Development — Bradley. A. S; Adebayo, A. O., Maria, P. — Cengage learning

2 Basic Concepts in Environmental Management — Mackenthun, K. M. — Lewis Publication, London, 1998

3 Environment Impact Assessment Guidelines, Notification of Governments of India, 2006.

4 ECBC Code 2007, Bureau of Energy Efficiency, New Delhi Bureau of Energy Efficiency Publications-Rating System, TERI Publications- GRIHA Rating System.

5 System Analysis of Sustainable Engineering Theory and Applications — Ni bin Chang — McGraw-Hill Professional

6 Renewable Energy Resources — Twidell, J. W. and Weir, A. D. — English Language Book Society (ELBS).

7 An approach for sustainable environment — Purohit, S. S — Green Technology

Course Code: PIN17269	Sustainable Materials and Green Buildings	Credits: 3-0-0

Prerequisites: Basics concepts of green technology and sustainability, introduction to civil engineering building materials.

Course Outcomes:

CO1	Expose the students to the concepts of sustainability
CO2	Understand the concept of building and conventional engineered building materials
CO3	Understand the concept of conventional engineered building materials
CO4	Make student aware of various green building councils

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	2	2	2	1	2	3	2	1	1	1	3	3	3
CO2	2	2	2	2	2	2	2	2	1	2	1	3	2	3
CO3	2	1	2	3	2	2	3	2	1	2	1	3	3	2
CO4	2	2	3	3	2	3	3	2	1	2	1	3	3	3

Unit	Details	No. Hrs
1	**Introduction to sustainability and green building:** Introduction to sustainable materials and the concept of green building, Embodied energy and Operational energy in Building and Life cycle energy, Ecological footprint, Bio- capacity and calculation of planet equivalent.	**8**
2	**Sustainable materials:** Role of Material: Carbon from Cement, alternative cements and cementitious material, Alternative fuel for cements for reduction in carbon emission, Sustainability issues for concrete, Role of quality, minimization of natural resource utilization, High volume fly ash concrete, geo-polymer concrete etc. concrete with alternative material for sustainability.	**8**
3	**Energy and resources consumption:** Reduction in water consumption in concrete, recycled aggregate, Energy for grinding and crushing of cement, aggregate etc. and reduction. Operational energy in building role of materials and thermal conductivity. Clay Bricks, Types of kilns, Comparative energy performance, emission performance and financial performance, Indoor air quality.	**8**
4	**Operational energy consumption:** Paints, Adhesive and sealants for use in building, Volatile organic content (VOC) emission issues and indoor air quality for Sustainability and Health hazard. Operational energy reduction and net zero building, Optimization for design of building for energy efficiency and example of optimization through use of Evolutionary genetic algorithm.	**8**
5	**Energy and resources balance:** Radiation budget, Surface water balance, Effects of trees and microclimatic modification through greening. Use of Building Integrated Photo Voltaic (BIPV) and other renewable energy in buildings, basic concepts and efficiency.	**8**
6	**Energy codes:** ECBC requirement, Concepts of Overall Thermal Transfer Value (OTTV), Green Performance rating, requirements of Leadership in Energy and Environmental Design (LEED), Green Rating for Integrated Habitat Assessment (GRIHA) and Indian Green Building Council (IGBC).	**8**

Text Books:

1 Sustainability Engineering: Allen, D. T. and Shonnard, Prentice Hall

	Concepts, Design and Case Studies	D. R.	
2	Engineering applications in sustainable design and development	Bradley. A.S; Adebayo, A.O., Maria	Cengage learning
3	Environment Impact Assessment Guidelines	Notification of Government of India	
4	Basic Concepts in Environmental Management	Mackenthun, K.M.	Lewis Publication London
5.	GRIHA Rating System	New Delhi Bureau of Energy Efficiency	Publications- Rating System TERI Publications

Course Code: PIN17254	Automotive Materials	Credits: 3-0-0

Prerequisites: Automobile Engineering

Course Outcomes:

CO1	Understand and select suitable materials for automotive applications
CO2	Distinguish between the materials requirements for automobiles interior and exterior
CO3	Understand and Select advanced materials for specific automobile components.
CO4	Comprehend Ashby charts for material selection

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	2	2	1	2	2	2	1	1	1	3	2	2
CO2	2	2	2	2	2	2	2	1	1	2	1	3	3	3
CO3	2	2	2	3	2	2	3	1	1	2	1	3	3	2
CO4	2	2	3	3	2	2	3	2	1	2	1	3	3	3

Unit	Details	No. Hrs
1	**Introduction to Automotive Materials:** Introduction to common engineering materials; metallic and non-metallic automotive materials. Materials and processes with relevance to automotive applications. Advanced materials, light weight material, nano material, and synthesis and in-situ materials for automotive applications, corrosion, Standards for automotive materials.	**6**
2	**Materials For The Interior:** Various high performance plastics and composites used in making of dashboards and their processing. Materials used in Flooring, dashboard silencer, headliner, door trim, baffles, rear shelf and their functionality. Car seat-considerations and materials used. Air bag materials used and their testing. Fabrics used in upholstery and their properties requirements	**8**
3	**Materials For The Exterior:** Application of various new materials including various types of composites in making of car bodies, bonnet, Alloy wheels and the processing method/s used to shape these parts. Reinforcement of fibres in composites - Woven fabrics - Non woven random mats - Various types of fibres in PMC processes - Hand lay-up processes - Spray up processes - Compression moulding - Reinforced reaction injection moulding -Resin transfer moulding - Filament winding - Injection moulding. Fibre reinforced plastics(FRP), Glass fibre reinforced plastics (GFRP)	**8**
4	**Smart Concepts for Automobiles:** Relevance of smart materials in the automobile industry, Recent developments in smart automobiles and Smart engines, Use of Electro- or magneto-rheological engine mounts. Engine blocks-cast iron, aluminium alloys. New trends in engines. Suspension systems: Use of MR fluids and ER fluids in dampers. Fuel Injector materials: high melting point materials-Use of ceramics as fuel injectors. Sintered Friction materials: Powder metallurgy process for making disc brake pads	**6**
5	**Selection Of Materials:** Introduction to Ashby charts for making a good selection of materials for different systems in automobiles. Case studies for materials developments by Ferrari, Land Rover, Honda, and FIAT in the making of a automobiles.	**4**

Text Books:

1	Material Selection in Mechanical Design	Michel F Ashby	Butterworth Heinemann
2	Automotive Engineering: Lightweight, Functional and Novel Materials	Cantor B, Johnston, Colin Grant and Patrick	Taylor & Francis
3	Composite materials	K.K Chawla	Springer - Verlag

Reference Books:

1	Material and Design: The Art and Science of Material Selection in Product Design	Michel F Ashby	Butterworth Heinemann
2	Composite materials: Engineering and Science	F.L. Mathews and R.D Rawlings	Chapman and Hall, London, England, 1st edition
3	Composite materials	K.K Chawla	Springer - Verlag

Course Code: PIN17255	Automotive Safety	Credits: 3-0-0

Prerequisites: Automobile Engineering

Course Outcomes:

CO1	Identify safety systems necessary for automobiles
CO2	Understand active and passive safety systems
CO3	Design and develop automobile safety systems
CO4	Design and develop automobile comfort and convenience systems.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	1	2	2	1	3	3	2	1	1	1	3	2	3
CO2	2	2	3	2	2	2	2	2	1	2	1	3	3	3
CO3	2	2	2	3	2	2	3	2	1	2	1	3	3	3
CO4	2	2	3	3	2	3	3	2	1	2	1	3	3	3

Unit	Details	No. Hrs
1	**Introduction:** Design of the body for safety, energy equation, engine location, deceleration of vehicle inside passenger compartment, deceleration on impact with stationary and movable obstacle, concept of crumble zone, safety sandwich construction.	**6**
2	**Safety Concepts:** Active safety, driving safety, conditional safety, perceptibility safety, operating safety, passive safety: exterior safety, interior safety, deformation behaviour of vehicle body, speed and acceleration characteristics of passenger compartment on impact.	**8**
3	**Safety Equipment's:** Seat belt, regulations, automatic seat belt tightener system, collapsible steering column, tiltable steering wheel, air bags, electronic system for activating air bags, bumper design for safety	**6**
4	**Collision Warning And Avoidance:** Collision warning system, causes of rear end collision, frontal object detection, rear vehicle object detection system, object detection system with braking system interactions	**8**
5	**Comfort And Convenience System:** Steering and mirror adjustment, central locking system , Garage door opening system, tyre pressure control system, rain sensor system, environment information system.	**8**

Text Books:

1 Automotive Handbook Bosch SAE publication
2 Automotive Mechanics Volume One Ed May McGraw Hill Publications
3 Automotive Mechanics Volume Two Ed May McGraw Hill Publications

Course Code: PIN17270	Vehicle Maintenance	Credits: 3-0-0

Prerequisites: Automobile Engineering

Course Outcomes:

CO1	Understand and diagnose engine maintenance and its trouble shooting.
CO2	Understand and diagnose the transmission and driveline maintenance
CO3	Understand and diagnose the steering, braking, suspension and wheel maintenance and its trouble shooting.
CO4	Understand and diagnose air conditioning and electrical systems maintenance

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	2	2	2	1	2	3	2	1	1	1	3	3	3
CO2	2	2	2	2	2	2	2	2	1	2	1	3	2	3
CO3	2	1	2	3	2	2	3	2	1	2	1	3	3	2
CO4	2	2	3	3	2	3	3	2	1	2	1	3	3	3

Unit	Details	No. Hrs
1	**Engine And Engine Subsystem Maintenance :** Service of basic engine parts, cooling and lubricating system, fuel system, Intake and Exhaust system, electrical system - Electronic fuel injection and engine management service - fault diagnosis- servicing emission controls	**6**
2	**Transmission And Driveline Maintenance:** Clutch- general checks, adjustment and service- Dismantling, identifying, checking and reassembling transmission, transaxle- road testing- Removing and replacing propeller shaft, servicing of cross and yoke joint and constant velocity joints- Rear axle service points- removing axle shaft and bearings- servicing differential assemblies- fault diagnosis.	**8**
3	**Steering, Brake and Suspension Maintenance:** Inspection, Maintenance and Service of Hydraulic brake, Drum brake, Disc brake, Parking brake. Bleeding of brakes. Inspection, Maintenance and Service of Mc person strut, coil spring, leaf spring, shock absorbers. Dismantling and assembly procedures. Maintenance and Service of steering inkage, steering column, Rack and pinion steering, Recirculating ball steering service- Worm type steering, power steering system	**6**
4	**Wheel Maintenance:** Wheel alignment and balance, removing and fitting of tyres, tyre wear and tyre rotation. Inspection.	**4**
5	**Auto Electrical And Air Conditioning Maintenance:** Maintenance of batteries, starting system, charging system and body electrical -Fault diagnosis using Scan tools. Maintenance of air conditioning parts like compressor, condenser, expansion valve, evaporator - Replacement of hoses- Leak detection- AC Charging- Fault diagnosis Vehicle body repair like panel beating, tinkering, soldering, polishing, painting.	**8**

Text Books:

1	Automotive Handbook	Bosch	SAE publication
2	Automotive Mechanics Volume One	Ed May	McGraw Hill Publications
3	Automotive Mechanics Volume Two	Ed May	McGraw Hill Publications
4	Crashworthiness of Vehicles	W. Johnson and A.G Mamalis	MEP, London

Open Elective Course

Course Code: MEN17403	Non-conventional Energy Sources	Credits: 3-0-0:3

Pre-requisites: NIL

Course Outcomes:

CO1	Understand the concept of energy crisis, non-conventional energy resources, availability and their importance.
CO2	Understand various methods to harness non-conventional energy resources.
CO3	Apply the methods for better harness, conversion techniques, and utilization of non-conventional energy resources.
CO4	Analyse various problems, limitations, complexities and performances of power plants based on non-conventional energy resources.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	2	2	3	3	3	2	2	2	3	3	2
CO2	3	3	2	2	2	3	3	3	2	2	2	3	3	2
CO3	3	3	3	3	3	3	3	3	3	3	2	3	3	3
CO4	3	3	3	3	3	3	3	3	3	3	3	3	3	3

Unit	Details	No. Hrs
1	Introduction: The energy crisis – causes and options, various conventional and non-conventional forms of energy and their characteristics, availability of non-conventional energy and land area requirements.	4
2	Solar energy: Introduction, Solar radiation, Sun-Earth angles, Measurement of solar radiation at the earth's surface, Types of collectors such as flat-plate and concentrating collectors, solar thermal power generation, solar ponds and energy storage. Principle of Solar photovoltaic, materials, mono-crystalline, polycrystalline and amorphous silicon cells and their production technology, I-V characteristics, parameters of performance, modules, array and PV plant configurations and power generation.	6
3	Biomass energy: Introduction, Incineration, Thermo-chemical and biochemical conversion to solid, liquid and gaseous fuels; Production technologies for bio-ethanol, biogas and producer gas, Urban waste to energy processes.	5
4	Ocean, Wave and Tidal energy: Introduction, Ocean thermal energy conversion (OTEC) – closed and open cycles and their limitations, Wave energy and its conversion processes, Tidal energy – nature of the tides and tidal barrages for power generation.	5
5	Wind energy: Fundamentals, power in the wind, site selection, maximum power coefficient, wind turbine and its types – horizontal axis and vertical axis machines, performance of wind machines, wind energy farms.	5
6	Geothermal energy: Introduction, Geothermal energy resources, Hot aquifers and hot dry rock systems, geothermal electric power plants.	4

7	Other Technologies: Magnetohydrodynamics (MHD) Energy conversion, Fuel Cells, Nuclear Energy, Hydrogen, Methanol, Energy Storage.	4

Text Books:

1	Renewable Energy Sources and Emerging Technologies	D.P. Kothari, K.C. Singal and R. Ranjan	PHI Learning Pvt. Ltd., New Delhi
2	Solar Energy-Fundamentals, Design, Modeling & Applications'	G.N. Tiwari	Narosa Publishing House, New Delhi, India

References:

1	Advanced Renewable Energy Sources	G.N. Tiwari and R.K. Mishra	RSC Publishing, Cambridge, U.K
2	Biogas Systems: Principles and Applications	K.M Mittal	New Age International Limited Publishers.
3	Wind Energy Come of Age	Gipe P	John Wiley and sons, New York.
4	Solar Energy Fundamentals	S. Kalogirou	Academic Press
5	Solar Photovoltaics: Fundamentals Technologies and Applications	C.S. Solanki	PHI Learning Pvt. Ltd., New Delhi
6	Energy Technology (Non Conventional, Renewable And Conventional)	S. Rao, BB Parulekar	Khanna Publishers

##

Course Code: MEN17402	Energy Management	Credits: 3-0-0-3

Pre-requisites: NIL

Course Outcomes:

CO1	Develop an understanding of the energy-economy-environment nexus.
CO2	Use the techniques of energy auditing and benchmarking in the industrial sector.
CO3	Acquire basic knowledge of sustainable energy technologies and their applications.
CO4	Undertake case studies in energy management in different sectors of the economy.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	-	2	-	3	3	-	-	-	-	3	3	-
CO2	3	3	-	3	3	-	-	-	-	-	-	-	3	3
CO3	3	3	-	3	-	-	3	-	-	-	-	-	3	2
CO4	-	-	3	-	3	-	3	-	3	3	3	-	-	3

Unit	Details	No. Hrs
1	Introduction: Energy supply and demand, energy linked environmental crises-causes and options in the present scenario of global warming, Energy classification: renewable and non-renewable forms of energy and their characteristics.	5
2	Energy-economy-environment nexus: energy-economy link and factors affecting it, net energy, gross pollution and growth constraints.	3
3	Energy auditing and benchmarking: Process and gross energy requirements, Carbon Footprint, Energy payback time, Identification of energy conservation opportunities, Benchmarking and its parameters.	5
4	Technical options for emissions mitigation: Combined cycles, Combined heat and power systems (Co-generation and tri-generation systems); Combined cooling and power systems, energy efficiency through heat pumps; cascade refrigeration with V-C and V-A systems, Mechanical Vapor Recompression (MVR) systems, Energy recovery in refrigeration and air-conditioning systems; District Cooling, Geo-thermal heat pumps, Earth-air heat exchangers.	12
5	Case studies from industrial/ commercial/ transport/ agricultural/ residential sectors.	5
6	Non-technical options for emissions mitigation: Energy rebound effect, Life style/attitudinal changes, GDP vs. holistic growth.	3

Text Books:

1 Energy Systems and Sustainability — Boyle et al. — Oxford University Press

2 Renewable Energy — Boyle et al. — Oxford University Press

References:

1	Energy efficiency	Eastop and Croft	Longman Scientific and Technical
2	Bureau of Energy Efficiency (BEE)	Ministry of Power	Government of India
3	Our Choice	Al Gore	Bloomsbury Publishing
4	An Inconvenient Truth	Al Gore	Oscar winning documentary
5	Before the flood	Leonardo DiCaprio	National Geographic documentary

##

Course Code: MEN17404	Product Design and Development	Credits: 3-0-0: 3

Prerequisites: NIL

Course Outcomes:

CO1	Students will be able to visualize different products lying in the same category –but that has been designed covering different set of needs.
CO2	Students will be able to feel themselves more knowledgeable- at the end of the course.
CO3	Students will be able to identify needs and be able to suggest different alternative solutions considering cost constraints.
CO4	Students will be able to have a watchful eye on happenings in their surrounding for creative analyses. Possibility of taking up entrepreneurship activity, possibility of coming up with new ideas leading to IPR.

Course Articulation Matrix:

	PO 1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO 11	PO1 2	PSO 1	PSO2
CO1	3	3	3	2	2	2	2	2	-	-	-	2	2	2
CO2	3	3	3	2	2	2	2	2	-	-	-	2	2	2
CO3	3	3	3	2	2	2	2	2	-	-	-	2	2	2
CO4	3	3	3	2	2	2	2	2	-	-	-	2	2	2

Unit	Details	No. Hrs
1	Introduction to Product Design, phases of product design: planning, concept development, system level design, detail design, testing, production ramp up. Characteristics of successful product Development, Who designs & develops products, Industrial & Practical Examples, Development Process & Organization, A Generic Development Process	8
2	Opportunity identification, product planning, Identifying Customer Needs, Product specifications, Concept Generation, Creative thinking- Invention- innovation & inventiveness in a society, Concept Selection, prototyping methods	10
3	Product Architecture, Industrial Design, Design for environment, Design for manufacturing	10
4	Human Factors & System Information Input- Text graphics, symbols and codes, Human Factors Application – case studies, Work Place Design- case studies, Human Errors – accidents and safety. Techno legal issues, Intellectual Property Rights.	7

Text Books:

1 Product Design and Development, Ulrich K. T, and Eppinger S. D McGraw Hill

References:

1	Mechanical Design Process	David G Ullman	McGraw Hill
2	Product Design	Otto K, and Wood K	Pearson
3	Engineering of creativity: introduction to TRIZ methodology of inventive Problem Solving	Semyon D. Savransky	CRC Press
4	Human Factors in Engineering Design	Mark S sanders & Ernst J. Mc Cornick	McGraw Hill Publishers.
5	Product Design & Process Engineering	Benjamin W Nishel & Alan B Draker	McGraw Hill Publishers.
6	Any other reference discussed in class for specific topics. Along with the above following is also desired: An open mind to feel the quality in a system. Subscription to a quality National news Paper/ Business news paper /magazines for articles on products technologies/ intellectual property acquired by specific firms etc. - Nationally and internationally.		

##

Course Code: MEN17401	Electric Vehicle Technology	Credits: 3-0-0:3

Prerequisite: NIL

Course Outcomes:

CO1	Students will be able to understand about basics of electric vehicle.
CO2	Students will be able to understand about drives and control systems of electric vehicles.
CO3	Students will be able to select motor, battery, battery indication system for EV applications.
CO4	Students will be able to design battery charger for an EV.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	-	-	1	1	3	1	-	-	-	-	1	2	1
CO2	3	-	-	1	1	3	1	-	-	-	-	2	2	1
CO3	1	3	3	3	2	3	1	1	-	-	2	2	3	2
CO4	1	2	3	2	3	2	2	1	-	-	1	2	3	3

Unit	Details	No. Hrs
1	**Introduction to Electric Vehicle:** Types and working mechanisms of Electric Vehicles, Components of Electric Vehicles, Chassis /Battery/Charger/etc., Standard Materials and its properties for components used in ElectricVehicles, Frame and Chassis of Electric Vehicles, braking systems in EVs, planetary gears, clutches, differentials, all-wheel drive regenerative braking mechanisms, Brake strategies (Series and Parallel), Braking torque distribution principle, electro-mechanical hybrid braking system.	10
2	**Energy Storage Systems (ESS):** Types of Batteries, their working mechanisms and characteristics, Applications of Batteries and ultracapacitors in Electric Vehicles, Comparison between different cell chemistry w.r.t. specific power, specific energy, safety, lifespan, performance, cost etc.	7
3	**Analysis of ESS:** Battery design parameters for several Electric Vehicles, Battery Architecture, Battery passive components sizing, Isolation requirements, Manufacturing of batteries, Battery modelling, form cell to pack, Battery pack and design issues, Failures of batteries, Battery Pack Performance & Safety testing standards, Battery management systems, Overview of safety circuits like over voltage and under voltage protection, pre-charge circuit, isolation monitoring, HVIL (high voltage interlock loop), MSD (manual service disconnect), Fuses etc., Overview of favorable and unfavorable storage conditions, impact of temperature on batteries.	8
4	**Mobility and Connectors:** Various types of chargers and energy management strategies, Connected Mobility and Autonomous Mobility- Emobility. Connectors- Types of EV charging connector, North American EV Plug Standards, DC Fast Charge EV Plug Standards in North America, CCS (Combined Charging System), CHAdeMO, Tesla, European EV Plug Standards,	6

5	**Drives for EV:** Introduction to Electromagnetic Energy Conversion; Electric drivetrain system; System design considerations, rating and sizing of electric drivetrain components; Machines and drives for traction and EVs: Permanent Magnet Synchronous Motor (PMSM), Permanent Magnet Brushless DC motors(PMBLDCM), Switched reluctance motors, synchronous reluctance motor, induction motor (IM); Control of Electric Drives; Bidirectional DC-DC converters.	5

Text Books:

1	Electric Vehicle Technology Explained	James Larminie, John Lowry	John Wiley & Sons, Ltd.
2	Electric and Hybrid Vehicles: Design Fundamentals	Iqbal Husain	Iqbal Husain

References:

1	Electric Vehicles: Modern Technologies and Trends	Nil Patel, Akash Kumar Bhoi, Sanjeevkumar Padmanaban, Jens Bo Holm-Nielsen	Springer Singapore
2	Battery Management Systems of Electric and Hybrid Electric Vehicles	Nicolae Tudoroiu (editor)	MDPI AG
3	Heavy-Duty Electric Vehicles: From Concept to Reality	Shashank Arora, Alireza Tashakori Abkenar, Shantha Gamini Jayasinghe, Kari Tammi	Butterworth-Heinemann
4	Rechargeable Lithium-Ion Batteries: Trends and Progress in Electric Vehicles	Thandavarayan Maiyalagan (editor), Perumal Elumalai (editor)	CRC Press

##

Course Code: MEN17406	Solar Photovoltaics	Credits: 3-0-0:3

Prerequisites: NIL

Course Outcome

CO1	Understand the basics of solar energy and solar photovoltaics.
CO2	Understand the principle of solar cells, materials, types of solar cells.
CO3	Analyse the performances of photovoltaic systems.
CO4	Apply the solar PV technology for power generation and other use.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	2	2	2	2	2	2	2	2	3	3	2
CO2	3	2	2	2	3	3	3	3	2	2	2	3	3	2
CO3	3	3	3	3	3	3	3	3	3	3	2	3	3	3
CO4	3	3	3	3	3	3	3	3	3	3	2	3	3	3

Unit	Content	Lectures
1.	**Introduction:** Basics of energy and electricity, DC and AC Power, Measurement of electrical quantities, The Sun, The Earth, Solar spectrum. Importance of Solar Energy, Types of Solar radiation (Terrestrial and Extra-terrestrial regions, Beam radiation, Diffuse radiation), Air mass, Albedo, Irradiance. Attenuation, Sun-Earth Angles, Solar time, Solar radiation on inclined surface and horizontal surface, Measuring Instruments for solar radiation e.g. Pyrheliometer, Pyranometer, Sun-shine recorder.	**8**
2.	**Solar photovoltaics:** Introduction and history of solar photovoltaics: Direct Energy Conversion, Advantages and Disadvantages of PV, PV system configurations.	**6**
3.	**Solar cell materials and battery:** Types of Solar cell, materials and their generation, intrinsic and extrinsic material, p- & n- type materials, Organic solar cells, Perovskite solar cells, fabrication of solar cells, Losses in PV cells, Basics of Battery and its parameters.	**6**
4.	**Performance parameters of PV:** Module and Array, fill factor, conversion efficiency, packing factor, open circuit voltage (V_{oc}), Short circuit current (I_{sc}), Standard Test Condition, I-V characteristics, P-V characteristics, factors affecting performance of solar cell, PV module, PV array.	**6**
5.	**Solar PV Systems:** Types of Solar PV power plants, Stand alone system, grid connected system, Hybrid Solar PV system. Other Applications of PV (Urban, Rural and Remote location use of PV such as BiPV, Solar PV vehicles, solar PV water pump, Street light etc.), National and International programmes for promotion of solar photovoltaic**.**	**6**

Text Books:

1. Solar Photovoltaics: Fundamentals, Technologies and Applications C. S.Solanki, PHI Publications.
2. Solar Energy, S P Sukhatme, J K Nayak, McgrawHill Publications.
3. Solar Energy – Fundaments, Design, Modeling & Applications – G.N. Tiwari, Narosa Publications.

REFERENCES:

1. Solar Photovoltaic Technology and Systems-A manual for technicians, Trainers and Engineers -C. S. Solanki, PHI Publications.
2. Principles of Solar Energy, Frank Krieth& John F Kreider, John Wiley, New York.
3. Solar Energy Engineering – S. Kalogirou, Academic Press.

##

Course Code: MEN17405	Quality Engineering	Credits: 3-0-0:3

Pre-requisites: Measurement and Metrology

COURSE OUTCOME:

S.N.	Outcomes
CO1	Understand control charts for the analysis of observational data. Apply control charts for the real world industry or service organisations problems
CO2	Understand types of sampling plan and apply different sampling plans during the inspection of lots of products.
CO3	Understand and apply the concept of Reliability, Availability and Maintainability
CO4	Apply Quality Design concept for Parameter and Tolerance Design

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	3	3	3	2	3	3	2	2	3	3	**3**
CO2	3	3	3	3	3	3	2	3	3	2	2	3	3	**3**
CO3	3	3	3	3	3	3	2	3	3	2	2	3	3	**3**
CO4	3	3	3	3	3	3	2	3	3	2	2	3	3	**3**

Unit	Details	No. of hours
1	**Introduction**-Concept of quality, basic statistical concepts, Control of accuracy and precision, Process capability, standardization and interchangeability; Statistical Quality Control: Objectives, Applications, organization, cost aspects, theory of statistical tolerance.	**4**
2	**Control Charts**- General theory of Control Charts, Shewhart control chart for process control; Control Charts for variables such as X, R Control Charts for charts for attributes such as c and p charts; Acceptance control chart; Cumulative Sum Control Charts; Process Capability, Cause- Effect and Pareto diagrams.	**12**
3	**Acceptance Sampling-** Multiple and Sequential Sampling Plans, Multi-Continuous Sampling Plan, Acceptance Sampling by Variables, Advantages limitations. Sampling plans using different Criteria. Comparison of various types of sampling plans. Rectifying Inspection..	**8**
4	**Reliability, Availability and Maintainability**- Introduction to reliability, Bathtub curve, Series and Parallel system; MTBF, Evaluation of Availability and Maintainability.	**6**
5	**Quality Design**- Design of experiment concept, System, Parameter and Tolerance Design; Concept of Robust Design, Taguchi Concept - Orthogonal Arrays and S/N ratio.	**6**

Text/Reference Books:

1. Statistical Quality Control; Eugene L. Grant, Richard S. Leavenworth, Tata Mc Graw Hill, 2000
2. Introduction to quality control, Jamieson A, Reston, 2004.

Reference Books:

1. Statistical Quality control; A Modern Introduction 6th Edition, Douglas C. Montgomery, 2010
2. Juran's Quality Planning and Analysis, by Frank. M.Gryna Jr. McGrawHill
3. Reliability Engineering, (3rdEdition), by LS Srinath, Affiliated East West Pvt Ltd, 1991.
4. Reliability Engineering, by E Bala Guruswamy, Tata McGraw Hill, 1994.
5. Quality Engineering Using Robust Design, Madhav S. Phadke, Pearson, 2008.
6. Handbook of Reliability, Availability, Maintainability and Safety in Engineering Design. Stapelberg Rudolph Frederick, ISBN: 9781848001749, 9781848001749.
7. James R. Evans and William M. Lindsay, "The Management and Control of Quality", 8th Edition, First Indian Edition, Cengage Learning, 2012.

##

Course Code: MEN17407	Total Quality Management	Credits: 3-0-0:3

Prerequisites: NIL

Course Outcomes:

CO1	Student able to understand the concept of quality management, techniques, frameworks and models
CO2	Students able to understand the TQM philosophies and implementation
CO3	Students able to attain knowledge on TQM principles, team work and continuous improvement process
CO4	Students able to apply the modern quality management tools in developing the business strategy
CO5	Students able to understand the implications of quality management standards and systems

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	**1**		**1**			**2**	**2**	**2**	**1**	**1**	**1**	**2**	**2**	**2**
CO2	**1**					**1**	**2**	**2**	**2**	**1**	**2**	**1**	**2**	**2**
CO3	**1**		**2**			**1**	**2**	**2**	**2**	**1**	**2**	**2**	**2**	**2**
CO4	**1**		**1**			**1**	**2**	**2**	**1**	**1**	**1**	**1**	**2**	**2**
CO5	**1**		**1**			**2**	**2**	**2**	**1**	**1**	**1**	**2**	**2**	**2**

Unit	Details	No. Hrs
1	Introduction: Basic concepts of TQM, TQM approach, Models and Frame works for TQM. Quality award models and new model for TQM.	6
2	TQM Philosophies: Deming Philosophy, Juran Trilogy, Crosby zero Defect Philosophy, Barriers to TQM Implementation, Benefits of TQM, Characteristics of successful quality leader, Contributions of Gurus of TQM, Case studies.	6
3	TQM Principles: Leadership theory and practices, Creating the leadership system, strategy and organization structure, leadership for Quality creating or changing the culture – effective leadership – excellence in leadership. Strategic quality planning, Quality councils-employee involvement, motivation, Empowerment, training and development, Team and Teamwork, Quality circles, recognition and reward, performance appraisal, Continuous process improvement, PDCE cycle, 5S, Kaizen, Improvement Strategies, Types of Problems, Problem solving Methods, Reengineering.	7
4	**TQM Tools and Techniques:** Design, innovation and improvement – the design process – quality function deployment (QFD) – the house of quality (HOQ), building a HOQ, QFD process – specifications and standards. Bench marking and POKA YOKE.	6
5	TQM quality systems: Quality and environment management systems: Introduction to IS/ISO 9004:2000 – – Elements, implementation and documentation of Quality system. Guidelines for performance improvements, Quality Audits - registration - ISO 14000 series standards – concepts of ISO 14001 – requirements of ISO 14001 – benefits of EMS – integrating ISO 14000 with ISO 9000 – relationship between health and safety.	7

Text Books:

1	Besterfiled D. H.	'Total Quality Management'	Pearson Education Asia – 2005
2	SubburajRamasamy	Total Quality Management	Tata McGraw Hill Publishing Company Ltd., New Delhi, 2005

References:

1	Joel E. Ross	Total Quality Management	Taylor and Franscis Limited
2	James R. Evans and William M. Lindsay	"The Management and Control of Quality"	8th Edition, First Indian Edition, Cengage Learning, 2012.
3	ISO 9000: Concepts, Methods and Implementation,		Tapan P Bagchi, A.H.Wheeler, 1999
4	L. Suganthi, Anand A. Samuel,	Total Quality Management 1st Edition	PHI Learning, 2009
5	R. Ashley Rawlins,	Total Quality Management	Autherhouse, 2008

##

Course Code: ME*****	Minor Project	Credits: 0-0-6:3

Prerequisites: NIL

Course Outcomes:

CO1	Student will be able to apply the knowledge of the subjects studied to solve and analyze the real world problems.
CO2	Apply the knowledge of the subjects studied to fabricate or model the solutions for the real world problems.
CO3	Student will be able interact and work coherently in a team environment, and manage projects in multidisciplinary environments.
CO4	Student will be able to make presentation and write report effectively.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	3	3	3	3	2	3	1	1	3	3	3
CO2	3	3	3	3	3	1	2	2	3	1	2	3	3	3
CO3	-	-	-	-	-	2	-	3	3	3	3	3	3	3
CO4	-	-	-	-	2	1	1	2	2	3	2	3	3	3

##

Semester VIII

Course Code: ME*****	Major Project	Credits: 0-0-24-12

Prerequisites: NIL

Course Outcomes:

CO1	Student will be able to apply the knowledge of the subjects studied to solve and analyze the real world problems.
CO2	Apply the knowledge of the subjects studied to fabricate or model the solutions for the real world problems.
CO3	Student will be able interact and work coherently in a team environment, and manage projects in multidisciplinary environments.
CO4	Student will be able to make presentation and write report effectively.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	3	3	3	3	2	3	1	1	3	3	3
CO2	3	3	3	3	3	1	2	2	3	1	2	3	3	3
CO3	-	-	-	-	-	2	-	3	3	3	3	3	3	3
CO4	-	-	-	-	2	1	1	2	2	3	2	3	3	3

##