Dr. Babasaheb Ambedkar Technological University

(Established as a University of Technology in the State of Maharashtra)

(under Maharashtra Act No. XXIX of 2014)

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Department of Mechanical Engineering

Course Contents for

B. Tech. in Mechanical Engineering

From 3rd Semester - 8th Semester

Vision

The vision of the Department is to achieve excellence in teaching, learning, research and transfer of technology for the overall development of students.

Mission

Imparting quality education, looking after holistic development of students, and conducting need-based research and extension activities.

Graduate Attributes

The Graduate Attributes are the knowledge skills and attitudes which the students have at the time of graduation. These Graduate Attributes identified by National Board of Accreditation are as follows:

1. **Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems.
2. **Problem analysis:** Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences.
3. **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5. **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6. **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. **Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8. **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **Communication:** Communicate effectively on complex 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.
11. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
12. **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Educational Objectives

PEO1	Graduates should excel in engineering positions in industry and other organizations that emphasize design and implementation of engineering systems and devices.
PEO2	Graduates should excel in best post-graduate engineering institutes, reaching advanced degrees in engineering and related discipline.
PEO3	Within several years from graduation, alumni should have established a successful career in an engineering-related multidisciplinary field, leading or participating effectively in interdisciplinary engineering projects, as well as continuously adapting to changing technologies.
PEO4	Graduates are expected to continue personal development through professional study and self-learning.
PEO5	Graduates are expected to be good citizens and cultured human beings, with full appreciation of the importance of professional, ethical and societal responsibilities.

Program Outcomes

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

PO1	Apply knowledge of mathematics, science and engineering to analyze, design and evaluate mechanical components and systems using state-of-the-art IT tools.
PO2	Analyze problems of mechanical engineering including thermal, manufacturing and industrial systems to formulate design requirements.
PO3	Design, implement and evaluate mechanical systems and processes considering public health, safety, cultural, societal and environmental issues.
PO4	Design and conduct experiments using domain knowledge and analyze data to arrive at valid conclusions.
PO5	Apply current techniques, skills, knowledge and computer based methods and tools to develop mechanical systems.
PO6	Analyze the local and global impact of modern technologies on individual organizations, society and culture.
PO7	Apply knowledge of contemporary issues to investigate and solve problems with a concern for sustainability and eco-friendly environment.
PO8	Exhibit responsibility in professional, ethical, legal, security and social issues.
PO9	Function effectively in teams, in diverse and multidisciplinary areas to accomplish common goals.
PO10	Communicate effectively in diverse groups and exhibit leadership qualities.
PO11	Apply management principles to manage projects in multidisciplinary environment.
PO12	Pursue life-long learning as a means to enhance knowledge and skills.

Abbreviations

PEO:	Program Educational Objectives
PO:	Program Outcomes
CO:	Course Outcomes
L:	No. of Lecture hours (per week)
T:	No. of Tutorial hours (per week)
P:	No. of Practical hours (per week)
C:	Total number of credits
BSH:	Basic Science and Humanity
BSC:	Basic Sciences Course
PCC:	Program Core Course
POE:	Program Open Elective
PCE:	Program Core Elective
BHC:	Basic Humanity Course
ESC:	Engineering Science Course
NCC:	National Cadet Corps
NSS:	National Service Scheme

B. Tech. Mechanical Engineering
Semester-III
Effective from 2017-2018

Course Code	Course Name	L	T	P	C
BSH 301	Engineering Mathematics-III	3	1	0	4
ME 302	Machine Drawing and Computer-aided Drafting	2	0	0	2
ME 303	Thermodynamics	3	1	0	4
ME 304	Fluid Mechanics	3	1	0	4
ME 305	Materials Science and Metallurgy	3	0	0	3
BSH 306	Basic Human Rights	2	0	0	2
BSH 307	Elective – I	3	0	0	3
ME 308	Fluid Mechanics Lab	0	0	2	1
ME 309	Machine Drawing and Computer-aided Drafting Lab	0	0	4	2
ME 310	Materials Science and Metallurgy Lab	0	0	2	1
ME 311	NCC/NSS/Sports/Arts	0	0	0	0
		19	3	8	26

Elective-I (From Humanities and Basic Sciences)

BSH 307A	Physics of Engineering Materials
BSH 307B	Applied Chemistry
BSH 307C	Interpersonal Skills

Semester-IV

Course Code	Course Name	L	T	P	C
ME 401	Theory of Machines and Mechanisms-I	4	0	0	4
ME 402	Strength of Materials	3	1	0	4
ME 403	Manufacturing Processes-I	3	0	0	3
ME 404	Applied Thermodynamics	3	1	0	4
ME 405	Numerical Methods in Engineering	2	1	0	3
ME 406	Elective – II	3	0	0	3
ME 407	Theory of Machines and Mechanisms Lab-I	0	0	2	1
ME 408	Manufacturing Processes Lab-I	0	0	2	1
ME 409	Strength of Materials Lab	0	0	2	1
ME 410	Thermal Engineering Lab-I	0	0	2	1
ME 411	NCC/NSS/Sports/Arts	0	0	0	0
		18	3	8	25

Elective - II

ME 406A	NSS-I
ME 406B	Biology for Engineers
ME 406C	Value Education
ME 406D	Renewable Energy Sources

B. Tech. Mechanical Engineering
Semester V
Effective from 2018-2019

Course Code	Course Name	L	T	P	C
ME 501	Machine Design-I	3	1	0	4
ME 502	Manufacturing Processes-II	3	0	0	3
ME 503	Theory of Machines & Mechanisms-II	4	0	0	4
ME 504	Heat Transfer	3	1	0	4
ME 505	Metrology and Quality Control	4	0	0	4
ME 506	Elective – III	3	0	0	3
ME 507	Machine Design Practice-I	0	0	2	1
ME 508	Theory of Machines and Mechanisms Lab II	0	0	2	1
ME 509	Metrology and Quality Control Lab	0	0	2	1
ME 510	Heat Transfer Lab	0	0	2	1
ME 511	NCC/NSS/Sports/Arts	0	0	0	0
		20	2	8	26

Elective – III

ME 506A	NSS – II
ME 506B	Sheet Metal Processes and Products
ME 506C	Knowledge Management
ME 506D	Sustainable Development
ME 506E	Non-Conventional Machining
ME 506F	Mechanical Measurements

Semester VI

Course Code	Course Name	L	T	P	C
ME 601	Manufacturing Processes-III	3	0	0	3
ME 602	IC Engines and Refrigeration and Air-conditioning	4	0	0	4
ME 603	Machine Design-II	3	1	0	4
ME 604	Fluid Machinery	2	1	0	3
ME 605	Elective – IV	3	0	0	3
ME 606	Elective – V	3	0	0	3
ME 607	Manufacturing Processes Lab-II	0	0	2	1
ME 608	Machine Design Practice-II	0	0	2	1
ME 609	Thermal Engineering Lab - II	0	0	2	1
ME 610	Technical Project for Community Services	0	0	3	2
ME 611	Summer Vacation Training *	0	0	0	0
ME 612	NCC/NSS/Sports/Arts	0	0	0	0
		18	2	9	25

*Six weeks in Industry

Elective–IV

ME 605A	Design of Experiments
ME 605B	Wind Energy
ME 605C	Engineering Economics
ME 605D	Entrepreneurship Development
ME 605E	Quantitative Techniques in Project Management
ME 605F	Development Engineering

Elective–V

ME 606A	Manufacturing Automation
ME 606B	Steam and Gas Turbines
ME 606C	Industrial Product Design
ME 606D	Nanotechnology
ME 606E	Intellectual Property Rights
ME 606F	Additive Manufacturing Processes

B. Tech. Mechanical Engineering
Semester VII
Effective from 2019-2020

Course Code	Course Name	L	T	P	C
ME 701	Mechatronics	3	0	0	3
ME 702	Industrial Engineering & Management	4	0	0	4
ME 703	CAD/CAM	3	0	0	3
ME 704	Power Plant Technology	3	0	0	3
ME 705	Elective – VI	3	0	0	3
ME 706	Mechatronics Lab	0	0	2	1
ME 707	CAD/CAM Lab	0	0	2	1
ME 708	Seminar	0	0	3	2
ME 709	Summer Vacation Training *	0	0	0	2
ME 710	Project Stage–I **	0	0	4	2
		16	0	11	24

*Evaluation of Six weeks Summer Vacation Training
**In case of students opting for Internship in the eighth semester, the Project must be industry-based

Elective–VI

ME 705A	Finite Element Analysis
ME 705B	Mechanical Vibrations
ME 705C	Surface Engineering
ME 705D	Human Resource Management
ME 705E	Design of Heat Exchangers

Semester VIII

Course Code	Course Name	L	T	P	C
ME 801	Elective – VII*	3	0	0	3
ME 802	Elective – VIII*	3	0	0	3
ME 803	Elective – IX*	3	0	0	3
ME 804	Elective – X*	3	0	0	3
ME 805	Elective – XI*	3	0	0	3
ME 806	Project Stage-II	0	0	8	4
		15	0	8	19

* In lieu of these Electives, Six months Internship in the industry including project

Elective–VII

ME 801A	Biomechanics
ME 801B	Failure Analysis and Design
ME 801C	Automobile Engineering
ME 801D	Engineering Tribology
ME 801E	Heating Ventilation Air Conditioning and Refrigeration (HVAC and R)

Elective–VIII

ME 802A	Robotics
ME 802B	Tool Condition Monitoring
ME 802C	Experimental Stress Analysis
ME 802D	Energy Conservation and Management
ME 802E	Modeling of Thermal Systems And Optimization
ME 802F	Utilization of Solar Energy

Elective–IX

ME 803A	Plant Maintenance
ME 803B	Design of Air Conditioning Systems
ME 803C	Process Equipment Design
ME 803D	Analysis and Synthesis of Mechanisms
ME 803E	Alternative Fuels for IC Engines

Elective–X

ME 804A	Design of Piping System
ME 804B	Product Life Cycle Management (PLM)
ME 804C	Advanced IC Engines
ME 804D	Machine Tool Design
ME 804E	Numerical Heat Transfer

Elective–XI

ME 805A	Tool Design
ME 805B	Advanced Refrigeration
ME 805C	Cryogenic Systems
ME 805D	Material Handling Systems
ME 805E	Advanced Methods in Engineering Design

Semester III

Engineering Mathematics-III

BSH 301	Engineering Mathematics-III	BSC	3-1-0	4 Credits

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Comprehend the fundamental knowledge of the Laplace and inverse Laplace transforms and their derivatives for elementary functions
CO2	Apply the properties of Laplace and inverse Laplace transforms to solve simultaneous linear and linear differential equations with constant coefficients
CO3	Conceptualize the definitions and properties of Fourier transforms
CO4	Solve boundary value problems using Fourier transforms
CO5	Find the series solutions of the linear differential equations using Frobenius method
CO6	Find the solutions of partial differential equations governing real-world problems
CO7	Conceptualize limit, continuity, derivative and integration of complex functions
CO8	Evaluate complex integrals useful in real-world problems

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1		1	2		1			1		1
CO2	3	2		2	2		2	1	2	1	1	2
CO3	2	1		1	2		1			1		1
CO4	3	2		2	2		2	1	1	1	1	2
CO5	3	1		1	2		1					1
CO6	3	2	1	2	2	1	2	1	3	1	1	2
CO7	2				1							1
CO8	3				1					1	1	2

Course Contents:

Unit 1: Laplace Transform

Definition: conditions for existence; Transforms of elementary functions; Properties of Laplace transforms: Linearity property, first shifting property, second shifting property, transforms of functions multiplied by t^n, scale change property, transforms of functions divided by t, transforms of integral of functions, transforms of derivatives; Evaluation of integrals by using Laplace transform; Transforms of some special functions: periodic function, error function, unit step function .

Unit 2: Inverse Laplace Transform

Introductory remarks; Inverse transforms of some elementary functions; General methods of finding inverse transforms; Partial fraction method and Convolution Theorem for finding inverse Laplace transforms.

Applications to find the solutions of linear differential equations and simultaneous linear differential equations with constant coefficients.

Unit 3: Fourier Transform
Definitions: integral transforms; Fourier integral theorem (without proof); Fourier sine and cosine integrals; Complex form of Fourier integrals; Fourier sine and cosine transforms; Properties of Fourier transforms; Convolution theorem for Fourier Transforms; Application to boundary value problems.

Unit 4: Series Solutions of Differential Equations and Special Functions
Validity of series solution, Series solutions about ordinary and singular point, Frobenius method, Series solution of Bessel equation, Recurrence relations for Bessel function, Generating function for Bessel function, Orthogonality of Bessel function.

Unit 5: Partial Differential Equations and Their Applications
Formation of Partial differential equations; Solutions of Partial differential equations-direct integration, linear equations of first order (Lagrange's linear equations), homogeneous linear equations with constant coefficients; Method of separation of variables-application to find solutions of wave equation, one dimensional heat equation and Laplace equation.

Unit 6: Calculus of Complex Functions
Limit and continuity of f(z), Derivative of f(z), Cauchy-Riemann equations, Analytic functions, Harmonic functions-orthogonal system, Conformal transformations, complex integration-Cauchy's theorem, integral formula, Residue theorem.

Texts:

1. B. S. Grewal, "Higher Engineering Mathematics", Khanna Publishers, New Delhi.
2. P. N. Wartikar, J. N. Wartikar, "A Text Book of Applied Mathematics", Vol. I and II, Pune Vidyarthi Griha Prakashan, Pune.
3. Erwin Kreyszig, "Advanced Engineering Mathematics", John Wiley and Sons, New York.
4. Dr. B. B. Singh, "A course in Engineering Mathematics", Vol. III, Synergy Knowledgeware, Mumbai.

References:

1. B. V. Ramana, "Higher Engineering Mathematics", Tata McGraw-Hill Publications, New Delhi.
2. N. P. Bali, N. Ch. Narayana Iyengar, "A Text Book of Engineering Mathematics", Laxmi Publications (P) Ltd., New Delhi.
3. Peter O' Neil, "A Text Book of Engineering Mathematics", Thomson Asia Pvt. Ltd., Singapore.
4. C. R. Wylie, L. C. Barrett, "Advanced Engineering Mathematics", Tata McGraw Hill Publishing Company Ltd., New Delhi.
5. Dr. B. B. Singh, "Integral Transforms and their Engineering Applications", Synergy Knowledgeware, Mumbai.

Machine Drawing and Computer Aided Drafting

ME 302	Machine Drawing and Computer Aided Drafting	PCC	2-0-0	2 Credits

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Interpret the object with the help of given sectional and orthographic views.
CO2	Construct the curve of intersection of two solids
CO3	Draw machine element using keys, cotter, knuckle, bolted and welded joint
CO4	Assemble details of any given part. i. e. valve, pump , machine tool part etc.
CO5	Represent tolerances and level of surface finish on production drawings
CO6	Understand various creating and editing commands in Auto Cad

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2								3	2		1
CO2	2	1							2	1		1
CO3	2								2	1		
CO4	2	2			1				2	1		1
CO5	1	1			1				2	1		1
CO6	1	1			1				2	2		1

Course Contents:

Unit 1: Sectional Views
Full section, half section, partial section, off-set section, revolved sections, removed sections, auxiliary section, guidelines for hatching, examples on all above types of sections of machine elements.

Unit 2: Study of Machine Elements
Study of simple machine elements and components such as screwed fasteners, shaft couplings, pipe joints, riveted and welded joints, bearings, gears, etc.

Unit 3: Interpenetration of Surfaces (Emphasis on Applied Cases)
Line or curve of intersection of two penetrating cylinders, Cone and cylinder, prism and a cylinder, cone and prism, Forged ends, etc.

Unit 4: Drawing of Assembly and Details
Part drawing of standard machine components such as valves, components of various machine tools, pumps, shaft couplings, joints, pipe fittings, engine parts, etc.

Unit 5: Production Drawing and Reading Blue Prints
Types of production drawings, size, shape and description; limits, fits and tolerances, surface roughness and surface roughness symbols, reading the blue prints.

Unit 6: Computer Aided Drafting
Introduction to Computer Aided Design and Drafting, Advantaged of CADD, study of preliminary AutoCAD commands like drawing, dimensioning, viewing commands. Drawing 3D views in AutoCAD, Introduction to AutoLISP programming.

Texts:
1. N. D. Bhatt, "Engineering Drawing", Charotar Publishing House, Anand, India.
2. N. D. Bhatt, "Machine Drawing", Charotar Publishing House, Anand, India
3. Ajeet Sing, "Working with AutoCAD 2000", Tata McGraw Hill, New Delhi.
4. George Omura, "ABC of AutoLISP", BPB Publications, New Delhi.

References:
1. Narayana, Kannaiah, Reddy, "Machine Drawing", New Age International Publishers.
2. AutoCAD and AutoLISP manuals from Autodesk Corp. U.S.A.
3. IS Code: SP 46-1988, Standard Drawing Practices for Engineering Institutes.

Thermodynamics

ME 303	Thermodynamics	PCC	3-1-0	4 Credits

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Define the terms like system, boundary, properties, equilibrium, work, heat, ideal gas, entropy etc. used in thermodynamics.
CO2	Study different laws of thermodynamics and apply these to simple thermal systems like balloon, piston-cylinder arrangement, compressor, pump, refrigerator, heat exchanger, etc. to study energy balance.
CO3	Study various types of processes like isothermal, adiabatic, etc. considering system with ideal gas and represent them on p-v and T-s planes.
CO4	Apply availability concept to non-flow and steady flow type systems.
CO5	Represent phase diagram of pure substance (steam) on different thermodynamic planes like p-v, T-s, h-s, etc. Show various constant property lines on them.

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1										
CO2	1	2	1									
CO3		1	1									
CO4	2				1							
CO5	1	1										

Course Contents:

Unit 1: Fundamental Concepts and Definitions
Thermodynamic systems; properties, processes and cycles. Thermodynamic equilibrium, Quasi-static process, Macroscopic vs. Microscopic viewpoint, Work and heat Transfer:

Work transferred and other types of work, Heat transfer, temperature and its measurement (principle of measurement, various instruments etc.). Zeroth law of thermodynamics, specific heat and latent heat, point function, path function.

Unit 2: First Law of Thermodynamics
First law of thermodynamics for a closed system undergoing a cycle and change of state, Energy, different forms of energy, Enthalpy, PMM-I control volume.
Application of first law of steady flow processes (nozzle, turbine, compressor pump, boiler, throttle valve etc.)

Unit 3: Second Law of Thermodynamics
Limitation of first law of thermodynamics, cycle heat engine, refrigerator and heat pump, Kelvin- Plank and Clausius statements and their equivalence, Reversibility and Irreversibility, Carnot cycle, Carnot theorem, Absolute thermodynamic temperature scale.

Unit 4: Entropy
Introduction, Clausius theorem, T-s plot, Clausius inequality, Entropy and Irreversibility, Entropy principle and its application, combined I and II law, Entropy and direction, Entropy and disorder.

Unit 5: Availability
Available energy pertaining a cycle, Quality of energy, law of degradation of energy, maximum work in a reversible process, Dead state, Availability in steady flow and non-flow processes, Second law efficiency.

Unit 6: Ideal Gas
Avogadro's law, Equation of state, ideal gas and process, relation between C_p and C_v, other equation of states.

Properties of Pure Substance: Phase change of pure substance, phase diagram of pure substance, p-v, T-s, and h-s diagrams properties of steam, property table, representation of processes of steam on p-v, T-s, and diagrams, Dryness fraction and its measurement.

Texts:

1. P. K. Nag, " Engineering Thermodynamics", Tata McGraw Hill, New Delhi, 3rd edition, 2005.
2. Y. A. Cengel, M. A. Boles, "Thermodynamics-An Engineering Approach", Tata McGraw Hill, 5th edition, 2006.

References:

1. G. J. Van Wylen, R. E. Sonntag, " Fundamental of Thermodynamics", John Wiley and Sons, 5th edition, 1998.
2. M. J. Moran, H. N. Shaprio, "Fundamentals of Engineering Thermodynamics", John Wiley and Sons, 4th edition, 2004.

Fluid Mechanics

ME 304	Fluid Mechanics	PCC	3-1-0	4 Credits

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Define fluid, define and calculate various properties of fluid
CO2	Calculate hydrostatic forces on the plane and curved surfaces and explain stability of floating bodies
CO3	Explain various types of flow. Calculate acceleration of fluid particles
CO4	Apply Bernoulli's equation and Navier-Stokes equation to simple problems in fluid mechanics
CO5	Explain laminar and turbulent flows on flat plates and through pipes
CO6	Explain and use dimensional analysis to simple problems in fluid mechanics
CO7	Understand boundary layer, drag and lift

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	1							1
CO2	3	3	1	1	1							1
CO3	3	3	1	1	1							1
CO4	3	3										1
CO5	3	3										1
CO6	2	3										1
CO7	2	3										1

Course Contents:

Unit 1: Basics

Definition of fluid, fluid properties such as viscosity, vapour pressure, compressibility, surface tension, capillarity, Mach number etc., pressure at a point in the static mass of fluid, variation of pressure, Pascal's law, pressure measurement by simple and differential manometers using manometric expression.

Unit 2: Fluid Statics

Hydrostatic forces on the plane and curved surfaces, centre of pressure, Buoyancy, centre of buoyancy, stability of floating bodies, metacentre and metacentric height its application in shipping.

Unit 3: Fluid Kinematics

Velocity of fluid particle, types of fluid flow, description of flow, continuity equation, Coordinate free form, acceleration of fluid particle, rotational and irrotational flow, Laplace's equation in velocity potential and Poisson's equation in stream function, flow net.

Unit 4: Fluid Dynamics

Momentum equation, development of Euler's equation, Introduction to Navier-Stokes equation, Integration of Euler's equation to obtain Bernoulli's equation, Bernoulli's

theorem, Application of Bernoulli's theorem such as venture meter, orifice meter, rectangular and triangular notch, pitot tube, orifices etc.

Unit 5: Types of Flow

a) **Laminar Flow:** Flow through circular pipe, between parallel plates, Power absorbed in viscous flow in bearings, loss of head due to friction in viscous flow.
b) **Turbulent Flow:** Reynolds's experiment, frictional loss in pipe flow, shear stress in turbulent flow, major and minor losses, HGL and TEL, flow through series and parallel pipes.

Unit 6: Dimensional Analysis

a) **Dimensional Analysis:** Dimensional homogeneity, Raleigh's method, Buckingham's theorem, Model analysis, similarity laws and dimensionless numbers.
b) **Introduction** to boundary layer theory and its analysis.
c) **Forces on Submerged bodies:** Drag, lift, Drag on cylinder, Development of lift in cylinder.

Texts:

1. P. N. Modi, S. M. Seth, "Fluid Mechanics and Hydraulic Machinery", Standard Book House, 10th edition, 1991.
2. Robert W. Fox, Alan T. McDonald, "Introduction to Fluid Mechanics", John Wile and Sons, 5th edition.

References:

1. V. L. Streeter, K.W. Bedford and E. B. Wylie, "Fluid Dynamics", Tata McGraw-Hill, 9th edition, 1998.
2. S. K. Som, G. Biswas, " Introduction to Fluid Mechanics and Fluid Machines", Tata McGraw Hill, 2nd edition, 2003.

Materials Science and Metallurgy

ME 305	Materials Science and Metallurgy	PCC	3-0-0	3 Credits

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Analyze the structure of materials at different levels
CO2	Understand mechanical properties of materials and calculations of same using appropriate equations
CO3	Evaluate phase diagrams of various materials
CO4	Suggest appropriate heat treatment process for a given application
CO5	Prepare samples of different materials for metallography
CO6	Recommend appropriate NDT technique for a given application

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	1									
CO2	3	2	2	3	2							
CO3	2	1	2	1	1							
CO4	1	2	2	1	2	1	2	1	1	1		
CO5	1	1	1	3	2		1		1			
CO6	1	1	2	2	2	1	2		1	1		

Course Contents:

Unit 1: Structure of Materials
Crystal structures, indexing of lattice planes, Indexing of lattice directions, Imperfections in crystals-point defects, line defects, surface and bulk defects, Mechanism of plastic deformation, deformation of single crystal by slip, plastic deformation of polycrystalline materials.

Unit 2: Mechanical Properties and Their Testing
Tensile test, engineering stress-strain curve, true stress-strain curve, types of stress-strain curves, compression test, bend test, torsion test, formability, hardness testing, different hardness tests-Vickers, Rockwell, Brinnel, Impact test, fatigue test, creep test.

Unit 3: Equilibrium Diagrams
Definitions of terms, rules of solid-solubility, Gibb's phase rule, solidification of a pure metal, plotting of equilibrium diagrams, lever rule, Iron-iron carbide equilibrium diagram, critical temperatures, solidification and microstructure of slowly cooled steels, non-equilibrium cooling of steels, property variation with microstructures, classification and application of steels,, specification of steels, transformation products of austenite, TTT diagram, critical cooling rate, CCT diagram.

Unit 4: Heat Treatment
Heat treatment of steels, cooling media, annealing processes, normalizing, hardening, tempering, quenching and hardenability, surface hardening processes-nitriding, carbo-nitriding, flame hardening, induction hardening.

Unit 5: Metallography
Microscopy, specimen preparation, polishing abrasives and cloths, specimen mounting, electrolytic polishing, etching procedure and reagents, electrolytic etching, optical metallurgical microscope, macroscopy, sulphur printing, flow line observations, examination of fractures, spark test, electron microscope

Unit 6: Strengthening Mechanisms and Non-destructive Testing
Refinement of grain size, cold working/strain hardening, solid solution strengthening, dispersion strengthening, Precipitation hardening. Magnetic particle inspection, dye penetrant inspection, ultrasonic inspection, radiography, eddy current testing, acoustic emission inspection.

Texts:

1. V. D. Kodgire, S.V. Kodgire, "Material Science and Metallurgy for Engineers", Everest Publishing House, Pune, 24th edition, 2008.
2. W. D. Callister, "Materials Science and Engineering: An Introduction", John Wiley and Sons, 5th edition, 2001.
3. V. Raghvan, "Material Science Engineering", Prentice Hall of India Ltd., 1992.
4. S. H. Avner, "Introduction to Physical Metallurgy", Tata McGraw Hill, 2nd edition, 1997.
5. R. A. Higgins, "Engineering Metallurgy: Part I", ELBS, 6th edition, 1996.

References:

1. V. B. John, "Introduction to Engineering Materials", ELBS, 6th edition, 2001.
2. G. F. Carter, D. E. Paul, "Materials Science and Engineering", ASM International, 3rd edition, 2000.
3. T. E. Reed-Hill, R. Abbaschian, "Physical Metallurgy Principles", Thomson, 3rd edition, 2003.

Basic Human Rights

BSH 306	Basic Human Rights	BHC	2-0-0	2 Credits

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Understand the history of human rights.
CO2	Learn to respect others caste, religion, region and culture.
CO3	Be aware of their rights as Indian citizen.
CO4	Understand the importance of groups and communities in the society.
CO5	Realize the philosophical and cultural basis and historical perspectives of human rights.
CO6	Make them aware of their responsibilities towards the nation.

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1						2						
CO2												
CO3												
CO4									3			
CO5								2		2		
CO6												1

Course Contents:

Unit 1: The Basic Concepts
Individual, group, civil society, state, equality, justice. Human Values, Human rights and Human Duties: Origin, Contribution of American bill of rights, French revolution. Declaration of independence, Rights of citizen, Rights of working and exploited people

Unit 2: Fundamental Rights and Economic Program
Society, religion, culture, and their inter-relationship. Impact of social structure on human behavior, Social Structure and Social Problems: Social and communal conflicts and social harmony, rural poverty, unemployment, bonded labour.

Unit 3: Workers and Human Rights
Migrant workers and human rights violations, human rights of mentally and physically challenged. State, Individual liberty, Freedom and democracy.

Unit 4: NGOs and Human Rights in India
Land, Water, Forest issues.

Unit 5: Human Rights in Indian Constitution and Law
i) The constitution of India: Preamble
ii) Fundamental rights.
iii) Directive principles of state policy.
iv) Fundamental duties.
v) Some other provisions.

Unit 6: UDHR and Indian Constitution
Universal declaration of human rights and provisions of India; Constitution and law; National human rights commission and state human rights commission.

References:
1. Shastry, T. S. N., "India and Human Rights: Reflections", Concept Publishing Company India (P Ltd.), 2005.
2. C. J. Nirmal, "Human Rights in India: Historical, Social and Political Perspectives (Law in India)", Oxford India.

Elective I

Physics of Engineering Materials

BSH 307A	Physics of Engineering Materials	POE	3-0-0	3 Credits

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Understand the different types of structures of solid, defects in solids and analysis of crystal structure by X-ray diffraction technique.
CO2	Understand the origin and types of magnetism, significance of hysteresis loo in different magnetic materials and their uses in modern technology
CO3	Understand the band structure of solids and conductivity, categorization of solids on the basis of band structure, significance of Fermi-Dirac probability functions
CO4	Understand the principles of superconductivity, their uses in modern technology
CO5	Understand the position of Fermi level in intrinsic and extrinsic semiconductors, Semiconductor conductivity
CO6	Understand the electric field in dielectric
CO7	Understand basics of Nano materials, synthesis methods and characterization techniques

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2		3	3		1					3
CO2	3	3			1		2		2		1	2
CO3	2	2			1		1					3
CO4	3	3			1		3		1		1	2
CO5	3	2		2	1		1					1
CO6	3	2			2		2		3		1	2
CO7	2	3	1		3	1	3	1				1

Course Contents:

Unit 1: Crystallography
Crystal directions and planes, Diatomic Crystal (CsCl, NaCl, Diamond, $BaTiO_3$) Crystal imperfection, Point defects, Line defects, Surface and Volume defects, Structure properties relationship, structure determination by X-ray diffraction.

Unit 2: Magnetic Materials
Origin of magnetization using atomic theory, classification of magnetic materials and properties, Langevin's theory of Dia, Para and ferromagnetism, Soft and Hard magnetic materials and their uses, Domain theory of ferromagnetism, Hysteresis loss, Antiferromagnetic and Ferrimagnetic materials, Ferrites and Garnets, magnetic bubbles, magnetic recording.

Unit 3: Conducting and Superconducting Materials
Band theory of solids, Classical free electron theory of metals, Quantum free electron theory, Density of energy states and carrier concentration, Fermi energy, Temperature and Fermi energy distribution, Superconductivity, Factor affecting Superconductivity, Meissner effect, Type-I and Type-II superconductors, BCS theory, Josephson effect, High temperature superconductors, Application of superconductors (Cryotron, magnetic levitation)

Unit 4: Semiconducting Materials
Band structure of semiconductor, Charge carrier concentration, Fermi level and temperature, Electrical conductivity, Hall effect in semiconductors, P-N junction diode, Preparation of single crystals, LED, Photovoltaic Cell

Unit 5: Dielectric Materials
Dielectric constant and polarizability, types of polarization, temperature and frequency dependences of Dielectric parameter, internal fields in solids, Clausius-Mosotti equation, dielectric loss, dielectric breakdown, ferroelectric, pyroelectric and piezoelectric materials, applications of dielectric materials

Unit 6: Nano Materials
Nano materials: Introduction and properties, synthesis of nano materials, Carbon Nano Tubes, Characterization techniques of nano materials - SEM, TEM, EDAX, FMR, XRD. Applications of Nano materials.

Texts:

1. Kittle, “Introduction to Solid state Physics”, John Wiley and Sons, 8th edition, 2004.
2. M. Srivastava, C. Srinivasan, “Science of Engineering Materials and Carbon Nanotubes”, New Age International Publication, 3rd edition, 2010.
3. A. J. Dekker, “Solid State Physics”, Pan Macmillan and Co. Ltd., London, 01st July, 1969.

References:

1. V. Raghavan, “Material Science and Engineering”, Prentice Hall Publication, 5th edition, 2007.
2. A. J. Dekker, “Electrical Engineering Materials”, Prentice Hall Publication, 1st edition, 1959.

Elective I

Applied Chemistry

BSH 307B	Applied Chemistry	POE	3-0-0	3 Credits

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Classify and explain various types of Corrosion and should apply methods to minimize the rate of corrosion.
CO2	Understand and apply the concepts of Photochemical and Thermal reactions.
CO3	Understand the basic concepts of Polymers, Polymerization and Moulding techniques; Determine molecular weight of High-Polymers.
CO4	Understand and apply the basic techniques in Chemistry and capable to explain the concepts of Solvent Extraction.
CO5	Understand and apply various types of Spectroscopic, Chromatographic techniques and also able to explain the concepts of Thermo-Gravimetric Analysis (TGA).

Mapping of course outcomes with program outcomes

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

Course Contents:

Unit 1: Corrosion and Its Control
Introduction, Fundamental reason, Electrochemical Corrosion, Direct Chemical Corrosion, Factors affecting the rate of corrosion, types of corrosion-Galvanic, Pitting Corrosion, Microbiological corrosion, Stress corrosion, methods to minimise the corrosion: Proper design, Cathodic and Anodic protection.

Unit 2: Metals and Alloys
Metals: Introduction, Properties of metals and alloys. Occurrence, extraction, properties and uses of Ni, Cr and Ti Alloys: Introduction, Need for alloying Steel, Application of Alloy Steel.

Unit 3: Polymers and Its Characterization
Introduction, molecular weight determination by osmotic pressure and viscosity method, polymers in medicines and surgery, inorganic polymers: silicones. Classes of polymerization (Synthesis and Characterization). Plastic, Moulding of plastic.

Unit 4: Basic Techniques in Chemistry
Preparing substances for analysis, dissolving the samples, Precipitation, Filtration, Washing

Precipitate, Drying and Igniting precipitate. Solvent Extraction: Aqueous and Organic phase liquid – liquid extraction.

Unit 5: Spectroscopy

Brief introduction to spectroscopy, UV–Visible Spectroscopy: Laws of absorption, instrumentation and application. IR spectroscopy: introduction, theory, instrumentation and application. Brief discussion on NMR Spectroscopy and its Applications. Brief introduction of AAS (Atomic Absorption Spectroscopy)

Unit 6: Instrumental Methods of Analysis

Introduction to Chromatography, Types of Chromatography (Adsorption and partition chromatography), Paper and Thin Layer Chromatography, Gas Chromatography – introduction, theory, instrumentation. Brief discussion of Thermo gravimetric analysis (TGA).

Texts:

1. Bhal and Bhal, "Advance Organic Chemistry", S. Chand and Company, New Delhi, 1995.
2. P. C. Jain, Monica Jain, "Engineering Chemistry", Dhanpat Rai and Sons, Delhi, 1992.
3. Bhal, Tuli, "Text book of Physical Chemistry", S. Chand and Company, New Delhi, 1995.
4. Chatwal Anand, "Instrumental Methods of analysis", Himalaya Publication.

References:

1. L. Finar, "Organic Chemistry", Vol. I and II, Longman Gr. Ltd and English Language Book Society, London.
2. G. M. Barrow, "Physical Chemistry", Tata McGraw Hill Publication, New Delhi.
3. Shikha Agarwal, "Engineering Chemistry-Fundamentals and applications", Cambridge Publishers, 2015.
4. O. G. Palanna, "Engineering Chemistry", Tata McGraw Hill Publication, New Delhi.
5. WILEY, Engineering Chemistry, Wiley India, New Delhi 2014.
6. Willard, "Instrumental Methods of analysis", Merrit, Tata McGraw Hill Publications.
7. Glasstone, "Physical Chemistry", D. Van Nostrand Company Inc., 2nd edition, 1946.
8. Peter Atkins, "Physical Chemistry", W. H. Freeman and Co., 9th edition, 2009.

Elective I

Interpersonal Skills

ME 307C	Interpersonal skills	POE	3-0-0	3 Credits

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Acquire interpersonal communication skills
CO2	Develop the ability to work independently.
CO3	Develop the qualities like self-discipline, self-criticism and self-management.
CO4	Have the qualities of time management and discipline.
CO5	Present themselves as an inspiration for others
CO6	Develop themselves as good team leaders

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1								1				
CO2										2		
CO3												2
CO4									1			
CO5										2		
CO6											3	

Course Contents:

Unit 1: Development of Proficiency in English
Speaking skills, Feedback & questioning technique, Objectivity in argument (Both one on one and in groups). 5 Ws and 1 H and 7 Cs for effective communication.
Imbibing etiquettes and manners. Study of different pictorial expressions of non-verbal communication and their analysis

Unit 2: Self-Management
Self-Management, Self-Evaluation, Self-discipline, Self-criticism; Recognition of one's own limits and deficiencies, dependency, etc.; Self-Awareness, Self-Management, Identifying one's strengths and weaknesses, Planning & Goal setting, Managing self-emotions, ego, pride. Leadership and Team Dynamics

Unit 3: Time Management Techniques
Practice by game playing and other learning strategies to achieve the set targets Time Management Concept; Attendance, Discipline and Punctuality; Acting in time, Quality /Productive time.

Unit 4: Motivation/Inspiration
Ability to shape and direct working methods according to self-defined criteria, Ability to think for oneself, Apply oneself to a task independently with self-motivation.
Motivation techniques: Motivation techniques based on needs and field situations

Unit 5: Interpersonal Skills Development
Positive Relationship, Positive Attitudes, Empathise: comprehending others' opinions, points of views, and face them with understanding, Mutuality, Trust, Emotional Bonding, Handling Situations (Interview), Importance of interpersonal skills.

Unit 6: Effective Computing Skills
Designing an effective Presentation; Contents, appearance, themes in a presentation, Tone and Language in a presentation, Role and Importance of different tools for effective presentation.

References:

1. Mitra, Barun, "Personality Development and Soft Skills", Oxford University Press, 2016.
2. Ramesh, Gopalswamy, "The Ace of Soft Skills: Attitude, Communication and Etiquette for Success", Pearson Education, 2013.
3. Stephen R. Covey, "Seven Habits of Highly Effective People: Powerful Lessons in Personal Change", Free Press Publisher, 1989.
4. Rosenberg Marshall B., "Nonviolent Communication: A Language of Life" 3rd edition, Puddle dancer Press, 1st September, 2003.

Fluid Mechanics Lab

ME 308	Fluid Mechanics Lab	PCC	0-0-2	1 Credits

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Understand laminar and Turbulent flow and determine Critical Reynolds number using Reynolds Apparatus
CO2	Verify Bernoulli's theorem
CO3	Determine pressure drop in flow though pipes and pipe fittings
CO4	Verify momentum equation using impact of jet apparatus
CO5	Determine viscosity using viscometer
CO6	Do calibration of pressure gauges, rotameter
CO7	Use manometers for pressure measurement

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1	1	3	1				1	2		1
CO2	1	1	1	3	1				1	2		1
CO3	1	1	1	3	1				1	2		1
CO4	1	1	1	3	1				1	2		1
CO5	1	1	1	3	1				1	2		1
CO6	1	1	1	3	1				1	2		1
CO7	1	1	1	3	1				1	2		1

List of Practicals/Experiments/Assignments (any eight experiments from the list)

1. Flow visualization technique: characteristics of laminar and turbulent flow patterns using Helleshaw Apparatus.
2. Verification of Bernoulli's theorem
3. Determination of Critical Reynolds number using Reynolds Apparatus
4. Determinations of pressure drop in pipes of various cross-sections
5. Determinations of pressure drop in pipes of various pipe fittings etc.
6. Viscosity measurement using viscometer (at least one type)
7. Verification of momentum equation using impact of jet apparatus
8. Determination of metacentric height of a floating body
9. Calibration of a selected flow measuring device and Bourdon pressure gauge
10. Gauge and differential pressure measurements using various types of manometers, Bourdon type pressure gauge. Demonstration of measurement using these instruments Lab.
11. Experiment to study hydraulic jump.

Machine Drawing and Computer Aided Drafting Lab

ME 309	Machine Drawing and Computer-aided Drafting Lab	PCC	0-0-4	2 Credits

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Draw Conventional representation of standard machine components, welds, materials etc.
CO2	Draw sectional view of a given machine component.
CO3	Develop Assemble view from details of given component i.e. valve, pump, machine tool part, etc.
CO4	Combine details of given machine component and draw assembled view.
CO5	Use various Auto-Cad commands to draw orthographic projection
CO6	Draw sectional view from pictorial view of given machine component using Auto-Cad

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1	1		1				1			
CO2	2	1	1		1				1			1
CO3	3	1	1		1				2	1		2
CO4	3	1	1		1				2	1		1
CO5	2	1	1		2				2	2		1
CO6	1	1	1		1				1	1		1

List of Practicals / Experiments / Assignments (minimum six assignments should be completed)

1. One full imperial drawing sheet consisting the drawing/ sketches of representation of standard components, symbols of pipe joints, weld joints, rivet joint etc., surface finish symbols and grades, limit, fit and tolerance sketches.
2. Two full imperial drawing sheets, one consisting of assembly and the other consisting of details of any one standard component such as valves, components of various machine tools, pumps, joints, engine parts, etc.
3. Two assignment of AutoCAD: Orthographic Projections of any one simple machine component such as bracket, Bearing Housing or Cast component for Engineers such as connecting rod, Piston, etc.; with dimensioning and detailing of three views of components.
4. 3-D model at least one simple machine component.

Materials Science and Metallurgy Lab

ME 310	Materials Science and Metallurgy Lab	PCC	0-0-2	1 Credits

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Measure hardness of given material using Brinell and Rockwell tests
CO2	Evaluate stretchability of given sheet metal samples of different thicknesses
CO3	Demonstrate the application of various non-destructive tests
CO4	Prepare specimen for observing the microstructure of the material
CO5	Sort out plain carbon steel samples based on their carbon percentages
CO6	Carry out hardening and hardenability test of the given sample.

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1			3		1	1		1	1		
CO2	1			3		1	1		1	1		
CO3	1			3		1	1		1	1		
CO4	1			3		1	1		1	1		
CO5	1			3		1	1		1	1		
CO6	1			3		1	1		1	1		

List of Practicals/Experiments/Assignments (any eight experiments from the list):

1. Brinell Hardness Test
2. Rockwell Hardness test
3. Erichson Cupping Test
4. Magnaflux Test
5. Dye Penetrant Test
6. Specimen Preparation for Microscopy
7. Sulphur Print Test
8. Spark Test
9. Study and drawing of microstructures of plain carbon steels of varying carbon percentage
10. Study and drawing of microstructures of heat treated steels
11. Jominy End Quench Test
12. Study and drawing of microstructures of cast irons
13. Study and drawing of microstructures of non-ferrous alloys
14. Hardening of steels of varying carbon percentage

Semester IV

Theory of Machines and Mechanisms-I

ME 401	Theory of Machines and Mechanisms-I	PCC	4-0-0	4 Credits

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Define basic terminology of kinematics of mechanisms
CO2	Classify planar mechanisms and calculate its degree of freedom
CO3	Perform kinematic analysis of a given mechanism using ICR and RV methods
CO4	Perform kinematic analysis of a given mechanism analytically using vector or complex algebra method
CO5	Perform kinematic analysis of slider crank mechanism using Klein's construction and analytical approach

Mapping of course outcomes with program outcomes

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

Course Contents:

Unit 1: Introduction

Definition of link, pair, kinematics chain, inversions, inversions of single and double slider crank chain, kinematic diagrams of mechanisms, equivalent linkage of mechanism, degree of freedom.

Study of various mechanisms such as straight line mechanisms, pantograph, Geneva mechanism, steering gear mechanisms and Hooke's joint.

Instantaneous centre of rotation, body and space centrodes and their applications, Kennedy's theorem and its applications.

Unit 2: Velocity Acceleration Analysis

Velocity and acceleration analysis and its purpose, velocity and acceleration diagrams using relative velocity method, Corioli's component of acceleration, Velocity and acceleration analysis by vector methods, coordinate system, Loop closure equation, Chase solutions, velocity and acceleration by vector and complex algebra.

Velocity and acceleration of slider crank mechanism by analytical method and Klein's construction.

Unit 3: Friction and Lubrication

Dry friction, friction between nut and screw with different types of threads, Uniform wear

theory and uniform pressure theory, Frication at pivot and collars, Friction in turning pair, Friction circle and friction axis, Friction in mechanisms.
Lubrication, Viscosity, Viscous flow, Boundary lubrication, Thick film lubrication, Hydrostatic and hydrodynamic lubrications.

Unit 4: Clutch, Brakes and Dynmometers
Friction Clutches: Single plate and multiplate clutch, Cone clutch, Centrifugal clutch, Torque transmitting capacity, Clutch operating mechanism.
Brakers: Shoe brake, Internal and external shoe brakes, Block brakes, Band brakes, Band and block brakes, Braking torque.
Dynamometers: Different types of absorption and transmission type dynamometers, Construction and working of eddy current dynamometer, Torque measurement.

Unit 5: Cams and Followers
Types of cams and followers, Analysis of motion, Jump and ramp of cam, Determination of cam profiles for a given follower motion, Circular arc cam, Tangent cam, Cycloidal cam.

Unit 6: Balancing
Balancing of rotating masses in one and several planes, Balancing of reciprocating, masses in single and multi-cylinder engine viz., inclined, radial and v-type engines, Primary and secondary balancing analysis, Concept of direct and reverse cranks, Balancing of locomotive engines, Effect of partial balancing, Static and dynamic balancing.

Texts:

1. A. Ghosh, A. K. Malik, "Theory of Mechanisms and Machines", Affiliated East-West Press Pvt. Ltd., New Delhi.
2. S. S. Rattan, "Theory of Machines", Tata McGraw Hill, New Delhi.

References:

1. Thomas Beven, "Theory of Machines", CBS Publishers and Distributors, Delhi.
2. J. E. Shigely, J. J. Uicker, "Theory of Machines and Mechanisms", Tata McGraw Hill Publications, New York, International Student Edition, 1995.

Strength of Materials

ME 402	Strength of Materials	PCC	3-1-0	4 Credits

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	State the basic definitions of fundamental terms such as axial load, eccentric load, stress, strain, E, μ, etc.
CO2	Recognise the stress state (tension, compression, bending, shear, etc.) and calculate the value of stress developed in the component in axial/eccentric static and impact load cases.
CO3	Distinguish between uniaxial and multiaxial stress situation and calculate principal stresses, max. shear stress, their planes and max. normal and shear stresses on a given plane.
CO4	Analyse given beam for calculations of SF and BM
CO5	Calculate slope and deflection at a point on cantilever /simply supported beam using double integration, Macaulay's , Area-moment and superposition methods
CO6	Differentiate between beam and column and calculate critical load for a column using Euler's and Rankine's formulae

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												
CO5												
CO6												

Course Contents:

Unit 1: Simple Stresses and Strains

Mechanical properties of materials, analysis of internal forces, simple stress and strain, stress-strain curve, Hooke's law, modulus of elasticity, shearing, thermal stress, Hoop stress, Poisson's ratio, volumetric stress, bulk modulus, shear modulus, relationship between elastic constants.

Unit 2: Principal Stresses and Strains

Uni-axial stress, simple shear, general state of stress for 2-D element, ellipse of stress, principle stresses and principal planes, principal strains, shear strains, strain rosettes, Mohr's circle for stresses and strains.

Strain energy and resilience: Load deflection diagram, strain energy, proof resilience, stresses due to gradual, sudden and impact loadings, shear resilience, strain energy in terms of principal stresses.

Unit 3: Combined Stresses

Combined axial and flexural loads, middle third rule, kernel of a section, load applied off the axes of symmetry.

Shear and Moment in Beams: Shear and moment, interpretation of vertical shear and bending moment, relations among load, shear and moment.

Unit 4: Stresses in Beams
Moment of inertia of different sections, bending and shearing stresses in a beam, theory of simple bending, derivation of flexural formula, economic sections, horizontal and vertical shear stress, distribution shear stress for different geometrical sections-rectangular, solid circular, I-section, other sections design for flexure and shear.

Unit 5: Beam Deflections
Differential equation of deflected beam, slope and deflection at a point, calculations of deflection for determinate beams by double integration, Macaulay's method, theorem of area-moment method (Mohr's theorems), moment diagram by parts, deflection of cantilever beams, deflection in simple supported beams, mid-span deflection, conjugate beam method, deflection by method of superstition.

Unit 6: Torsion
Introduction and assumptions, derivation of torsion formula, torsion of circular shafts, stresses and deformation in determinate solid/homogeneous/composite shafts, torsional strain energy.
Columns and Struts: Concept of short and long Columns, Euler and Rankine's formulae, limitation of Euler's formula, equivalent length, eccentrically loaded short compression members.

Texts:

1. S. Ramamrutham, "Strength of Materials", Dhanpat Rai and Sons, New Delhi.
2. F. L. Singer, Pytle, "Strength of Materials", Harper Collins Publishers, 2002.
3. S. Timoshenko, "Strength of Materials: Part-I (Elementary Theory and Problems)", CBS Publishers, New Delhi.

References:

1. E. P. Popov, "Introduction to Mechanics of Solid", Prentice Hall, 2nd edition, 2005.
2. S. H. Crandall, N.C. Dahl, T. J. Lardner, "An introduction to the Mechanics of Solids", Tata McGraw Hill Publications, 1978.
3. S. B. Punmia, "Mechanics of Structure", Charotar Publishers, Anand.
4. B. C. Punmia, Ashok Jain, Arun Jain, "Strength of Materials", Laxmi Publications.

Manufacturing Processes-I

ME 403	Manufacturing Processes-I	PCC	3-0-0	3 Credits

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Identify castings processes, working principles and applications and list various defects in metal casting
CO2	Understand the various metal forming processes, working principles and applications
CO3	Classify the basic joining processes and demonstrate principles of welding, brazing and soldering.
CO4	Study center lathe and its operations including plain, taper turning, work holding devices and cutting tool.
CO5	Understand milling machines and operations, cutters and indexing for gear cutting.
CO6	Study shaping, planing and drilling, their types and related tooling's

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1	1		1	1				1		1
CO2	2	2	1		1	1				1		1
CO3	2	1	1		1	1				1		1
CO4	1		1		1	1				1		1
CO5	2		1		1	1				1		1
CO6	1				1	1				1		1

Course Contents:

Unit 1: Introduction and Casting Processes

What is manufacturing? Selection of manufacturing processes

Introduction to casting; solidification of metals: Pure metals, Alloys; fluid flow; fluidity of molten metal; heat transfer: Solidification time, Shrinkage; defects: Porosity; Metal casting processes: Introduction; sand casting, shell molding, investment casting; Permanent-mold casting, vacuum casting, die casting, centrifugal casting; Inspection of casting; melting practice and furnaces, general design considerations for casting.

Unit 2: Rolling and Forging Processes

Introduction to Rolling; Flat-rolling Process: Roll Force, Torque, and Power Requirements, Geometric Considerations; Flat-rolling Practice: Defects in Rolled Plates and Sheets; Rolling Mills; Various Rolling Processes and Mills.

Introduction to forging, Open-die forging; Impression-die and Closed-die forging; various forging Operations; Forgeability of Metals: Forging Defects; Die Design, Die Materials, and Lubrication; Forging Machines.

Unit 3: Extrusion, Drawing and Sheet Metal Forming

Introduction; Extrusion Process; Hot Extrusion; Cold Extrusion: Impact extrusion, Hydrostatic Extrusion; Extrusion Defects; Extrusion Equipment; Drawing Process; Drawing Practice; Drawing Defects and Residual Stresses; Drawing Equipment.

Introduction to sheet metal forming; Shearing: Shearing operations, Characteristics and Type of Shearing Dies; Sheet-metal Characteristics and Formability, Formability Tests for Sheet Metals; Bending Sheets, Plates, and Tubes; Deep Drawing: Deep Drawability, Deep-drawing Practice; Spinning; Design Considerations in Sheet-metal Forming; Equipment for Sheet-metal Forming.

Unit 4: Joining Processes

Oxy-fuel-gas Welding; Arc-Welding Processes: Non consumable Electrode; Arc-welding Processes: Consumable Electrode, Shielded Metal-arc Welding, Submerged-arc Welding, Gas Metal-arc Welding; Electrodes for Arc Welding; The Weld joint, Quality, and Testing: Weld Quality, Weldability, Testing of Welds; Joint Design and Process Selection.
Introduction to solid state welding, Friction Welding, Resistance Welding: Spot, Seam, Projection Welding. Introduction to brazing and soldering; Brazing: Brazing Methods, Design for Brazing; Soldering: Types of Solders and Fluxes, Solderability, Soldering Techniques, Soldering Applications and Design Guidelines; Mechanical Fastening, Design for Mechanical Fastening.

Unit 5: Machining Processes: Turning and Hole Making

Introduction; The Turning Process; Lathes and Lathe Operations: Lathe Components, Workholding Devices and Accessories, Lathe Operations, Types of Lathes, Turning-process Capabilities, Design Considerations and Guidelines for Turning Operations, Chip Collection Systems, Cutting Screw Threads; Boring and Boring Machines; Drilling, Drills, and Drilling Machines: Drills, Material-removal Rate in Drilling, Thrust Force and Torque, Drill Materials and Sizes, Drilling Practice, Drilling Machines, Design Considerations for Drilling; Reaming and Reamers; Tapping and Taps.

Unit 6: Machining Processes: Milling, Broaching and Gear Manufacturing

Introduction, Milling and Milling Machines: Peripheral Milling, Face Milling, End Milling, Other Milling Operations and Milling Cutters, Toolholders, Milling Process Capabilities, Design and Operating Guidelines for Milling, Milling Machines; Planing and Shaping; Broaching and Broaching Machines; Gear Manufacturing by Machining: Form Cutting, Gear Generating, Cutting Bevel Gears, Gear-finishing Processes, Design Considerations and Economics of Gear Machining.

Text:

1. Serope Kalpakjian and Steven R. Schmid, "Manufacturing Engineering and Technology", Addison Wesley Longman (Singapore) Pte. India Ltd., 6th edition, 2009.

References:

1. Milkell P. Groover, " Fundamentals of Modern Manufacturing: Materials, Processes, and Systems", John Wiley and Sons, New Jersey, 4th edition, 2010.
2. Paul DeGarmo, J. T. Black, Ronald A. Kohser, " Materials and Processes in Manufacturing", Wiley, 10th edition, 2007.

Applied Thermodynamics

ME 404	Applied Thermodynamics	PCC	3-1-0	4 Credits

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Define the terms like calorific value of fuel, stoichiometric air-fuel ratio, excess air, equivalent evaporation, boiler efficiency, etc. Calculate minimum air required for combustion of fuel.
CO2	Study and Analyze gas power cycles and vapour power cycles like Otto, Diesel, dual, Joule and Rankine cycles and derive expressions for the performance parameters like thermal efficiency, P_m
CO3	Classify various types of boiler, nozzle, steam turbine and condenser used in steam power plant.
CO4	Classify various types of IC engines. Sketch the cut section of typical diesel engine and label its components. Define the terms like TDC, BDC, r_c, etc.
CO5	Draw P-v diagram for single-stage reciprocating air compressor, with and without clearance volume, and evaluate its performance. Differentiate between reciprocating and rotary air compressors.

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1										
CO2	1	2										
CO3	1											
CO4			1		1							
CO5		2										

Course Contents:

Unit 1: Fuels and Combustion

Types of fuels, calorific values of fuel and its determination, combustion equation for hydrocarbon fuel, determination of minimum air required for combustion and excess air supplied conversion of volumetric analysis to mass analysis, fuel gas analysis.

Unit 2: Steam Generators

Classification of boilers, boiler details, requirements of a good boiler; merits and demerits of fire tube and water tube boilers, boiler mountings and accessories.

Boiler Draught: Classification of draught, natural draught, efficiency of the chimney, draught losses, types of boiler draught.

Performance of Boilers: Evaporation, equipment evaporation, boiler efficiency, boiler trial and heat balance, Introduction to IBR.

Unit 3: Vapor and Gas Power Cycles

Carnot cycle, ideal Rankine cycle, Reheat and Regeneration, Stirling cycle, Joule-Brayton cycle. Calculation of thermal efficiency, specific steam/fuel consumption, work ratio for above cycles.

Unit 4: Steam Nozzles

Types of Nozzles, flow of steam through nozzles, condition for maximum discharge, expansion of steam considering friction, super saturated flow through nozzles, General relationship between area, velocity and pressure.

Unit 5: Steam Turbines
Advantages and classification of steam turbines, compounding of steam turbines, velocity diagrams, work one done and efficiencies, losses in turbines.
Condensers and Cooling Towers: Elements of steam condensing plants, advantages of using condensers, types of condensers, thermodynamic analysis of condensers, efficiencies, cooling towers.

Unit 6: Reciprocating Air Compressor
Classification constructional details, theoretical and actual indicator diagram, FAD, multi staging, condition for maximum efficiency, capacity control.
Rotary Compressor- Concepts of: Rotary compressors, Root blower and vane type compressors, Centrifugal compressors. Velocity diagram construction and expression for work done, introduction to slip factor, power input factor.

Texts:
1. T. D. Eastop, A. McConkey, "Applied Thermodynamics", Addison Wesley Longman.
2. Rayner Joel, "Basic engineering Thermodynamics", Addison Wesley Longman.

References:
1. Yunus A. Cengel, "Thermodynamics- An Engineering Approach", Tata McGraw Hill Publications.
2. P. K. Nag, "Basic and Applied Thermodynamics", Tata McGraw Hill Publications.
3. P. K. Nag, "Power Plant Engineering", Tata McGraw Hill Publications, 2nd edition.
4. Sharma and Mathur, "Internal Combustion Engines", Tata McGraw Hill Publications.

Numerical Methods in Engineering

ME 405	Numerical Methods in Engineering	PCC	2-1-0	3 Credits

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Describe the concept of error
CO2	Illustrate the concept of various Numerical Techniques
CO3	Evaluate the given Engineering problem using the suitable Numerical Technique
CO4	Develop the computer programming based on the Numerical Techniques

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3		1	3							
CO2	3	3		1	3							
CO3	3	3		1	3							
CO4	3	3		1	3							

Course Contents:

Unit 1: Error Analysis
Significant figures, round-off, precision and accuracy, approximate and true error, truncation error and Taylor series, machine epsilon, data uncertainties, error propagation, importance of errors in computer programming.

Unit 2: Roots of Equations
Motivation, Bracketing methods: Bisection methods, Open methods: Newton Raphson method, Engineering applications.

Unit 3: Numerical Solution of Algebraic Equations
Motivation, Cramer's rule, Gauss-Elimination Method, pivoting, scaling, engineering applications.

Unit 4: Numerical Integration and Differentiation
Motivation, Newton's-Cotes Integration Formulas: Trapezoidal Rule, Simpson's rule, engineering applications Numerical differentiation using Finite divide Difference method

Unit 5: Curve Fitting and Interpolation
Motivation, Least Square Regression: Linear Regression, Polynomial regression.
Interpolation: Newton's Divide Difference interpolation, engineering applications.
Solution to Ordinary Differentiation Equations: Motivation**,** Euler's and Modified Euler's Method, Heun's method, Runge – Kutta Method, engineering applications.

Unit 6: Computer Programming
Overview of programming language, Development of at least one computer program based on each unit.
Texts:

1. Steven C Chapra, Reymond P. Canale, "Numerical Methods for Engineers", Tata McGraw Hill Publications, 2010.
2. E. Balagurusamy, "Numerical Methods", Tata McGraw Hill Publications, 1999.

References:

1. V. Rajaraman, "Fundamental of Computers", Prentice Hall of India, New Delhi, 2003.
2. S. S. Sastri, "Introductory Methods of Numerical Methods", Prentice Hall of India, New Delhi, 3rd edition, 2003.
3. K. E. Atkinson, "An Introduction to Numerical Analysis", Wiley, 1978.
4. M.J. Maron, "Numerical Analysis: A Practical Approach", Macmillan, New York, 1982.

Elective II

NSS-I

ME 403	NSS-I	POE	3-0-0	3 Credits

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Understand the concept of NSS
CO2	Analyze the methods of mobilization of peoples and its management
CO3	Recognize the role of youth in leadership, peace building and conflict resolution
CO4	Improve the qualities like Problem solving and decision making, Positive thinking etc.
CO5	Study the Indian history and identify the youth development programs in the country

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1								2	2	1		1
CO2			1			1	2	2	1	1		1
CO3						1	2	2	2	2		2
CO4			1			1	1	1	1	1		2
CO5						1	1	1	1	2		1

Course Contents:

Unit 1: Introduction and Basic Concepts of NSS
History, Philosophy, Aims & objectives of NSS Organizational structure, Concept of regular activities, Special camping, Day Camps. Basis of adoption village/slums, Methodology of conducting Survey

Unit 2: Youth and Community Mobilization
Definition, Profile of youth, Categories of youth, Issues, Challenges and opportunities for youth, Youth as an agent of social change, Youth-adult partnership, Mapping of community stakeholders, Identifying methods of mobilization, Needs and importance of volunteerism**.**

Unit 3: Importance and Role of Youth Leadership
Meaning and types of leadership, Qualities of good leaders; Traits of leadership, Importance and role of youth leadership

Unit 4: Life Competencies and Skill
Definition and importance of life competencies, Communication, Inter Personal, Problem solving and decision making, Positive thinking, Self-confidence and self-esteem, Life goals, Stress and time management

Unit 5: Social Harmony and National Integration
Indian history and culture, Role of youth in peace-building and conflict resolution, Role of youth in Nation building

Unit 6: Youth Development Programs in India
National Youth Policy, Youth development programs at the National Level, State Level and voluntary sector, Youth-focused and Youth-led organizations

Elective II

Biology for Engineers

ME 406B	Biology for Engineers	POE	3-0-0	3 Credits

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Explain origin of life and Evolution, Cells, Biomolecules-Lipids
CO2	Understand Biomolecules
CO3	Understand Cell structure and function and cell cycle
CO4	Explain Mendelian genetics
CO5	Understand and Explain DNA structure, DNA replication, Transcription, Translation

Mapping of course outcomes with program outcomes

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

Course Contents:

Unit 1: Introduction
Origin of life and Evolution, Cells, Biomolecules-Lipids

Unit 2: Biomolecules
Carbohydrates, water, Amino acids and proteins, Enzymes, Nucleotides

Unit 3: Cell structure
Cell structure and function, Prokaryotes, Eukaryotes

Unit 4: Cell cycle
Cell division, mitosis, meiosis, culture growth,

Unit 5: Genetics
Mendelian genetics, genetic disorders, Mendelian inheritance principle, pedigree analysis, Non- Mendelian inheritance

Unit 6: DNA
Chromatin, DNA structure, DNA replication, Transcription, Translation.

Texts:
1. Arthur T. Johnson, “Biology for Engineers”, CRC Press.

References:

1. N. A. Campbell, J. B. Reece, "Biology", International edition, Benjamin Cummings, New York, 7th edition or later, 2007 or later.
2. G. Karp, "Cell and Molecular Biology: Concepts and Experiments", Wiley, New York, 7th edition, 2013.

Elective II

Value Education

ME 406C	Value Education	POE	3-0-0	3 Credits

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Give an understanding of life in all its complexities and to provide practical opportunities and mould students to meet the needs of the people
CO2	Sharpen the capacity to make right moral and ethical choices
CO3	Develop social concern reaching out to the nation as leaders and serving the needy with divine grace and power
CO4	Analyze the economic, political and social situations with respect to values
CO5	Identify the changes that must be done to thrust the society towards moral recovery

Mapping of course outcomes with program outcomes

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

Course Contents:

Unit 1: Introduction

Definition, definition of values, why values? Need for inculcation of values, object of value education, sources of value, types: personal values, social values, professional values, moral and spiritual values, behavioral (common) values.

Unit 2: Personal Values

Definition of person, self-confidence, self-discipline, self-assessment, self-restraint, self-motivation, determination, ambition, contentment humility and simplicity, sympathy and compassion, gratitude, forgiveness, honesty, courtesy.

Unit 3: Social Values

Definition of society, units of society, individual, family, different groups, community, social

consciousness, equality and brotherhood, dialogue, tolerance, responsibility, co-operation, freedom repentance and magnanimity.

Unit 4: Professional Values
Definition, competence, confidence, devotion to duty, efficiency, accountability, respect for learning/learned, willingness to learn, open and balanced mind, team spirit, professional ethics, willingness for discussion, aims, efforts, avoidance of procrastination and slothfulness, alertness.

Unit 5: Moral Values
Detachment, Faith, Loyalty, Non-violence, Obedience, Prayer, Purity, Renuciation, Truthfulness; Inculcation of values: Direct and indirect approaches; process of inculcation: Being sensitive, identifying the appropriate values, internalizing the values, practicing the values.

Unit 6: Behavioral Values
Individual values and group values, good manners at home and outside, equality, purity of thoughts, speech and action, understanding the role of religion, faith, understanding commonness of religions, respect for other faiths, unity, diversity, living together, tolerance, non-violence, truthfulness, common aim, unified efforts towards peace, patriotism.

Text:

1. Dr. S. Ignacimuthu, S. J., "Values for life", Better Yourself Books, Bandra, Mumbai, 1999.
2. R. P. Dhokalia, "Eternal Human Values", NCRT Campus, Sri Aurobindo Marg, New Delhi.
3. Ramakrishna Math, "Values: Collection of Essays", Chennai, 1996.

Elective II

Renewable Energy Sources

ME 406D	Renewable Energy Sources	PCE	3-0-0	3 Credits

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Explain the difference between renewable and non-renewable energy
CO2	Describe working of solar collectors
CO3	Explain various applications of solar energy
CO4	Describe working of other renewable energies such as wind, biomass

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	2	3		2	3	3	3	2	2		2
CO2	1	1	3	1	2	3	3	3	2	2		2
CO3	2	1	1				3	2		1		2
CO4	3	3			2	3	3	2				1

Course Contents:

Unit 1: Introduction

Energy resources, Estimation of energy reserves in India, Current status of energy conversion technologies relating to nuclear fission and fusion, Solar energy.

Unit 2: Solar Radiations

Spectral distribution, Solar geometry, Attenuation of solar radiation in Earth's atmosphere, Measurement of solar radiation, Properties of opaque and transparent surfaces.

Unit 3: Solar Collectors

Flat Plate Solar Collectors: Construction of collector, material, selection criteria for flat plate collectors, testing of collectors, Limitation of flat plate collectors, Introduction to ETC.

Concentrating type collectors: Types of concentrators, advantages, paraboloid, parabolic trough, Heliostat concentrator, Selection of various materials used in concentrating systems, tracking.

Unit 4: Solar Energy Applications

Air/Water heating, Space heating/cooling, solar drying, and solar still, Photo-voltaic conversion.

Unit 5: Wind Energy and Biomass

Types of wind mills, Wind power availability, and wind power development in India. Evaluation of sites for bio-conversion and bio-mass, Bio-mass gasification with special reference to agricultural waste.

Unit 6: Introduction to Other Renewable Energy Sources

Tidal, Geo-thermal, OTEC; Mini/micro hydro-electric, Geo-thermal, Wave, Tidal. System design, components and economics.

Texts:

1. Chetansingh Solanki, "Renewable Energy Technologies", Prentice Hall of India, 2008.

References:

1. S. P. Sukhatme, "Solar Energy: Principles of Thermal Collection and Storage", Tata McGraw Hill Publications, New Delhi, 1992.
2. G. D. Rai, "Solar Energy Utilization", Khanna Publisher, Delhi, 1992.

Theory of Machines and Mechanisms Lab-I

ME 407	Theory of Machines and Mechanisms Lab-I	PCC	0-0-2	1 Credits

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Perform graphically kinematic analysis of any planar mechanism using ICR and RV methods.
CO2	Perform graphically kinematic analysis of slider crank mechanism using Klein's construction.
CO3	Demonstrate use of graphical differentiation method for kinematic analysis of slider crank mechanism or any other planar mechanism with a slider.
CO4	Sketch polar diagram for a Hooke's joint.

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												

List of Practicals/Experiments/Assignments

1. **Four sheets** (half imperial size)
   Graphical solution of problems on velocity, acceleration in mechanisms by relative velocity method, instantaneous center of rotation method and Klein's construction. Atleast one problem containing Corioli's component of acceleration.
2. **Experiments (any 2)**
   a) Experimental determination of velocity and acceleration of Hooke's joint.
   b) Determination of displacement of slider-crank mechanism with the help of model and to plot velocity and acceleration curves from it.
   c) Experiment on Corioli's component of acceleration.
3. **Assignment**
   Develop a computer program for velocity and acceleration of slider crank mechanism.

Manufacturing Processes Lab-I

ME 408	Manufacturing Processes Lab-I	PCC	0-0-2	1 Credits

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Perform plain turning, step turning, knurling, eccentric turning, chamfering and facing operations on lathe.
CO2	Prepare setup and fabricate composite job using milling, shaping and drilling machine.
CO3	Making spur gears on a milling machine.
CO4	Prepare sand casting setup using split pattern for simple component.
CO5	Perform joining of two plate using TIG/MIG welding.
CO6	Demonstrate cutting of a sheet metal using flame cutting.

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1		3	1		1		1	2		1
CO2	1	1		3	1		1		1	2		1
CO3	1	1		3	1		1		1	2		1
CO4	2	1		3	1		1		1	2		1
CO5	2	1		3	1		1		1	2		1
CO6	1	1		3	1		1		1	1		1

List of Practicals/Experiments/Assignments

Each student shall be required to submit any six jobs from the following:

1. Making a job with a process plan involving plain, step and taper turning operations on a Centre lathe.
2. Preparation of process planning sheet for a job including operations such as milling, drilling and shaping.
3. Making a spur gear using universal dividing head on milling machine.
4. Making a simple component by sand casting using a split pattern.
5. Cutting of a steel plate using oxyacetylene flame cutting /plasma cutting.
6. Making a butt joint on two stainless steel plates using TIG Welding.
7. An experiment on shearing operation.
8. An experiment on blanking operation.
9. An experiment on drawing operation.

Strength of Materials Lab

ME 409	Strength of Materials Lab	PCC	0-0-2	1 Credits

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Perform tension, compression, shear and torsion tests for various metals and alloys
CO2	Perform flexure, impact and deflection tests for various materials such as timbar, cast iron, etc.
CO3	Measure stress and strain experimentally using photo-elasticity, strain gauges, etc.
CO4	Carry out experiments to demonstrate thermal stresses.

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												

List of Practicals/Experiments/Assignments (any 8 experiments from the list)

1. Tension test on ferrous and non-ferrous alloys (mid steel/cast iron/aluminum, etc.
2. Compression test on mild steel, aluminum, concrete, and wood
3. Shear test on mild steel and aluminum (single and double shear tests)
4. Torsion test on mild steel and cast iron solid bars and pipes
5. Flexure test on timber and cast iron beams
6. Deflection test on mild steel and wooden beam specimens
7. Graphical solution method for principal stress problems
8. Impact test on mild steel, brass, aluminum, and cast iron specimens
9. Experiments on thermal stresses
10. Strain measurement in stress analysis by photo-elasticity
11. Strain measurement involving strain gauges/ rosettes
12. Assignment involving computer programming for simple problems of stress, strain computations.

Thermal Engineering Lab-I

ME 410	Thermal Engineering Lab-I	PCC	0-0-2	1 Credits

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Conduct test on Bomb calorimeter, nozzle, steam turbine, condenser, compressor etc. to study their performance.
CO2	Draw performance curves of these machines.
CO3	Analyze the results obtained from the tests.
CO4	Draw conclusions based on the results of the experiments
CO5	Based on your visit to Industry, sketch its layout and write specifications.

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1			2								
CO2	2	1		1								
CO3	1	2	1	2	1	1						
CO4				2								
CO5		1				1				2		2

List of Practicals/Experiments/Assignments

Experiment Number 10 and any seven experiments from 1-9 experiments from the list:

1. Determination of calorific value by Bomb calorimeter
2. Measurement of dryness fraction of steam using separating & throttling calorimeter.
3. Trial on boiler
4. Trial on convergent/convergent-divergent type nozzle
5. Performance evaluation of steam turbine (Reaction / Impulse).
6. Performance evaluation of surface condenser.
7. Flue gas analysis using emission measuring instruments
8. Study & trial on single stage/two-stage reciprocating air compressor
9. Trial on centrifugal blower
10. Visit to appropriate industry to study and experience some of the above listed systems **(Compulsory).**

Semester V
Machine Design-I

ME 501	Machine Design-I	PCC	3-1-0	4 Credits

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Formulate the problem by identifying customer need and convert into design specification
CO2	Understand component behavior subjected to loads and identify failure criteria
CO3	Analyze the stresses and strain induced in the component
CO4	Design of machine component using theories of failures
CO5	Design of component for finite life and infinite life when subjected to fluctuating load
CO6	Design of components like shaft, key, coupling, screw and spring

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1						1				1
CO2	3	2		1		1		1		1		1
CO3	1	1				1		1		1		1
CO4	3	3	2	1		2		1		1		1
CO5	1	1				1		1		1		1
CO6	2	2	2	1		1		1		1		1

Course Contents:

Unit 1: Mechanical Engineering Design Process
Traditional design methods, general industrial design procedure, design considerations, phases in design ,creativity in design, use of standardization, preferred series, introduction to ISO 9000, use of design data book, aesthetic and ergonomic considerations in design.

Unit 2: Design of Machine Elements against Static Loading
Theories of Failure (Yield and Fracture Criteria): Maximum normal stress theory, Maximum shear stress theory, Maximum distortion energy theory, comparison of various theories of failure, Direct loading and combined loading, Joints subjected to static loading e.g. cotter and knuckle joint, turnbuckle, etc. introduction to fluctuating loads.

Unit 3: Design against Fluctuating Loads
Stress concentration, stress concentration factors, fluctuating stresses, fatigue failure, endurance limit, notch sensitivity, approximate estimation of endurance limit, design for finite life and finite life under reversed stresses, cumulative damage in fatigue, Soderberg and Goodman diagrams, fatigue design under combined stresses.

Unit 4: Design of Shafts Keys and Couplings
Various design considerations in transmission shafts, splined shafts, spindle and axles strength, lateral and torsional rigidity, ASME code for designing transmission shaft.

Types of Keys: Classification and fitment in keyways, Design of various types of keys.
Couplings: Design consideration, design of rigid, muff and flange type couplings, design of flexible couplings.

Unit 5: Design of Threaded Joints
Stresses in screw fasteners, bolted joints under tension, torque requirement for bolt tightening, preloading of bolt under static loading, eccentrically loaded bolted joints.
Power Screws: Forms of threads used for power screw and their applications, torque analysis for square and trapezoidal threads, efficiency of screw, collar friction, overall efficiency, self-locking in power screws, stresses in the power screw, design of screw and nut, differential and compound screw, re-circulating ball screw.
Welded Joints: Type of welded joints, stresses in butt and fillet welds, strength of welded joints subjected to bending moments.

Unit 6: Mechanical Springs
Stress deflection equation for helical spring, Wahl's factor, style of ends, design of helical compression, tension and torsional spring under static loads, construction and design consideration in leaf springs, nipping, strain energy in helical spring, shot peening.

Texts:

1. V. B. Bhandari, "Design of Machine Elements", Tata McGraw Hill Publications, New Delhi, 2008.
2. R. L. Nortan, "Machine Design: An Integrated Approach", Pearson Education Singapore, 2001.

References:

1. R. C. Juvinall, K. M. Marshek, "Fundamental of machine component design", John Wiley & Sons Inc., New York, 3rd edition, 2002.
2. B. J. Hamrock, B. Jacobson and Schmid Sr., "Fundamentals of Machine Elements", International Edition, New York, 2nd edition, 1999.
3. A. S. Hall, A. R. Holowenko, H. G. Langhlin, "Theory and Problems of Machine Design", Schaum's Outline Series, Tata McGraw Hill book Company, New York, 1982.
4. J. E. Shigley and C. Mischke, "Mechanical Engineering Design", Tata McGraw Hill Publications, 7th edition, 2004.
5. M. F. Spotts, "Design of Machine Elements", Prentice Hall of India, New Delhi.

Manufacturing Processes-II

ME 502	Manufacturing Processes-II	PCC	3-0-0	3 Credits

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Understand the process of powder metallurgy and its applications
CO2	Calculate the cutting forces in orthogonal and oblique cutting
CO3	Evaluate the machinability of materials
CO4	Understand the abrasive processes
CO5	Explain the different precision machining processes
CO6	Design jigs and fixtures for given application

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	1	1			2					1
CO2	3	3										1
CO3	3	3	1	2	3							1
CO4	3	3	2									1
CO5	3	3	1	3								1
CO6	3	1	3	3	3			2				1

Course Contents:

Unit 1: Abrasive Machining and Finishing Operations
Introduction; Abrasives and Bonded Abrasives: Grinding Wheels, Bond Types, Wheel Grade and Structure; Grinding Process: Grinding-wheel wear, Grinding Ratio, Dressing, Truing and Shaping of Grinding Wheels, Grindability of Materials and Wheel Selection; Grinding Operations and Machines; Design Considerations for Grinding; Finishing Operations

Unit 2: Mechanics of Metal Cutting
Geometry of single point cutting tools, terms and definitions; chip formation, forces acting on the cutting tool and their measurement; specific cutting energy; plowing force and the "size effect"; mean shear strength of the work material; chip thickness: theory of Ernst and merchant, theory of Lee and Shaffer, friction in metal cutting

Unit 3: Thermal aspects, Tool wear, and Machinability
Temperature in Metal Cutting: Heat generation in metal cutting; temperature distribution in metal cutting, effect of cutting speed on temperatures, measurement of cutting temperatures
Tool life and tool Wear: progressive tool wear; forms of wear in metal cutting: crater wear, flank wear, tool-life criteria,
cutting tool materials: basic requirements of tool materials, major classes of tool materials: high-speed steel, cemented carbide, ceramics, CBN and diamond, tool coatings; the work material and its machinability
Cutting fluids: Action of coolants and application of cutting fluids.

Unit 4: Processing of Powder Metals
Introduction; Production of Metal Powders: Methods of Powder Production, Particle Size, Shape, and Distribution, Blending Metal Powders; Compaction of Metal Powders: Equipment, Isostatic Pressing, Sintering; Secondary and Finishing Operations; Design Considerations.

Unit 5: Processing of Ceramics and Glasses
Introduction; Shaping Ceramics: Casting, Plastic Forming, Pressing, Drying and Firing, Finishing Operations; Forming and Shaping of Glass: Flat-sheet and Plate Glass, Tubing and Rods, Discrete Glass Products, Glass Fibers; Techniques for Strengthening and Annealing Glass: Finishing Operations; Design Considerations for Ceramics and Glasses

Unit 6: Processing of Plastics

Introduction; Extrusion: Miscellaneous Extrusion Processes, Production of Polymer Reinforcing Fibers; Injection Moulding: Reaction-injection Molding; Blow Moulding; Rotational Moulding; Thermoforming; Compression Moulding; Transfer Moulding; Casting; Foam Moulding; Cold Forming and Solid-phase Forming; Processing Elastomers

Texts:

1. Serope Kalpakjian and Steven R. Schmid, "Manufacturing Engineering and Technology", Addison Wesley Longman (Singapore) Pte. India Ltd., 6th edition, 2009.
2. Geoffrey Boothroyd, Winston Knight, "Fundamentals of Machining and Machine Tools", Taylor and Francis, 3rd edition, 2006.

References:

1. Milkell P. Groover, " Fundamentals of Modern Manufacturing: Materials, Processes, and Systems", John Wiley and Sons, New Jersey, 4th edition, 2010.
2. Paul De Garmo, J. T. Black, Ronald A. Kohser, " Materials and Processes in Manufacturing", Wiley, 10th edition, 2007.
3. M. C. Shaw, "Theory of Metal Cutting", Oxford and I.B.H. Publishing, 1st edition, 1994.

Theory of Machines and Mechanisms-II

ME 503	Theory of Machines and Mechanisms-II	PCC	4-0-0	4 Credits

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Identify and select type of belt and rope drive for a particular application
CO2	Evaluate gear tooth geometry and select appropriate gears, gear trains
CO3	Define governor and select/suggest an appropriate governor
CO4	Characterize flywheels as per engine requirement
CO5	Understand gyroscopic effects in ships, aero planes, and road vehicles.
CO6	Understand free and forced vibrations of single degree freedom systems

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	3	1		2		1			2		2
CO2	2	3					1					3
CO3		2										2
CO4		2		1								
CO5	2	3		2								3
CO6	2	3		3								3

Course Contents:

Unit 1: Belt and Rope Drives
Flat belts, Effect of slip, Centrifugal tension, Creep, Crowing of pulley, Initial tension in belts. V- Belts, Virtual coefficient of friction, Effect of V-groove on torque transmitted. Rope drives, Rope constructions, Advantages of rope drives.

Unit 2: Toothed Gears
Classification of gears, Terminology of spur gears, Conjugate action, Involute and cycloidal profiles, Path of contact, Contact ratio, Interference, Undercutting, Rack shift, Effect of center distance variations, Friction between gear teeth, Internal gears.
Helical gear terminology, Normal and transverse module, Virtual number of teeth, Torque transmitted by helical gears, Spiral gears, Efficiency of spiral gears, Worm gears, Bevel gear terminology, Tooth forces and geometric relationship, Torque capacities.

Unit 3: Gear Trains
Velocity ratios, Types of gear trains, Tooth load, Torque transmitted and holding torque.

Unit 4: Governor and Flywheel
Governors: Function of governor, Inertia and centrifugal type of governors, Controlling force analysis, Governor Effort and governor power, Sensitivity, stability, Isochronisms and Hunting, Friction insensitiveness.
Flywheel: Turning moment diagram, Fluctuation of energy and speed, Determination of flywheel size for different types of prime movers and machines.

Unit 5: Gyroscope
Gyroscope: Principles of gyroscopic action, Precession and gyroscopic acceleration, gyroscopic couple, Effect of the gyroscopic couple on ships, aeroplanes and vehicles, inclined rotating discs, gyroscopic stabilization.

Unit 6: Vibration
Basic concepts and definitions; vibration measuring parameters- displacement, velocity, and acceleration.
Mechanical Vibration: Single degree of freedom system, SHM, Undamped free vibrations, damped free vibrations, Types of damping.
Forced Vibration: Effect of excitation, Excitation due to reciprocating and rotating unbalance, Vibration isolation and transmissibility.
Critical Speeds: Whirling of vertical and horizontal shaft carrying single rotor with damped and un-damped system, Whirling speed of multi rotor shafts.
Torsional Vibrations: Single degree of freedom system Forced an free damped and undamped vibratins, Two rotor and three rotor system, Geared rotor system , Natural frequency , Modes of vibrations, Torsional dampers, Introduction to Holzer's method for multi rotor system.

Texts:

1. S. S. Rattan, "Theory of Machines", Tata McGraw Hill Publications, New Delhi.
2. Thomas Beven, "Theory of machines", CBS Publishers, Delhi, 1984.
3. Kelly, Graham S., "Mechanical Vibrations", Schaum's Outline Series, McGraw Hill, New York, 1996.

4. Rao, J.S., "Introductory Course on Theory and Practice of Mechanical Vibration", New age International (P) Ltd, New Delhi, 2nd edition, 1999.

References:

1. Rao Singiresu, "Mechanical Vibrations", Pearson Education, New Delhi, 4th edition 2004.
2. J. E. Shigley, J. J. Vicker, "Theory of Machines and Mechanisms", Tata McGraw Hill International.

Heat Transfer

ME 504	Heat Transfer	PCC	3-1-0	4 Credits

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Explain the laws of heat transfer and deduce the general heat conduction equation and to explain it for 1-D steady state heat transfer in regular shape bodies
CO2	Describe the critical radius of insulation, overall heat transfer coefficient, thermal conductivity and lumped heat transfer
CO3	Interpret the extended surfaces
CO4	Illustrate the boundary layer concept, dimensional analysis, forced and free convection under different conditions
CO5	Describe the Boiling heat transfer, mass transfer and Evaluate the heat exchanger and examine the LMTD and NTU methods applied to engineering problems
CO6	Explain the thermal radiation black body, emissivity and reflectivity and evaluation of view factor and radiation shields

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1			1				1			
CO2	3	2			1							
CO3	3	1			2		2		1			
CO4	3	3		1	1				1			
CO5	3	3	3		1		2					
CO6	2	3		2	2		2		1			

Course Contents:

Unit 1: Introduction

Heat transfer mechanism, conduction heat transfer, Thermal conductivity, Convection heat transfer, Radiation heat transfer, laws of heat transfer

Steady State Conduction: General heat conduction equation, Boundary and initial conditions, One-dimensional steady state conduction: the slab, the cylinder, the sphere, composite systems.

Unit 2: Overall Heat Transfer and Extended Surfaces

Thermal contact resistance, Critical radius of insulation, Electrical analogy, Overall heat transfer coefficient, Heat source systems, Variable thermal conductivity, Extended surfaces.
Unsteady State Conduction: Lumped system analysis, Biot and Fourier number, Heisler chart **(No numerical examples)**.

Unit 3: Principles of Convection

Continuity, Momentum and Energy equations, Hydrodynamic and Thermal boundary layer for a flat plate and pipe flow. Dimensionless groups for convection, relation between fluid friction and heat transfer, turbulent boundary layer heat transfer.

Unit 4: Forced Convection

Empirical relations for pipe and tube flow, flow across cylinders, spheres, tube banks. **Free Convection:** Free convection from a vertical, inclined and horizontal surface, cylinder and sphere.

Unit 5: Boiling and Condensation

Film-wise and drop-wise condensation, pool boiling regimes, forced convection boiling (Internal flows).
Introduction to Mass Transfer: Introduction, Mechanism of diffusion, Fick's law of mass transfer, mass diffusion coefficient.
Heat Exchangers: Types of heat exchangers, the overall heat transfer coefficient, Analysis of heat exchangers, the log mean temperature difference (LMTD) method, the effectiveness-NTU method, selection of heat exchangers, Introduction to TEMA standard.

Unit 6: Radiation Heat Transfer

Introduction, Thermal radiation, Black body radiation, radiation laws, Radiation properties, Atmospheric and Solar radiation, The view factor, Radiation heat transfer from black surfaces, gray surfaces, diffuse surfaces, Radiation shields and the radiation effect.

Texts:

1. F. P. Incoropera, D. P. Dewitt, "Fundamentals of Heat and Mass Transfer", John-Wiley, 5th edition, 1990.
2. S. P. Sukhatme, "A Textbook on Heat Transfer", Tata McGraw Hill Publications, 3rd edition.

References:

1. Y. A. Cengel, "Heat Transfer- A Practical Approach", Tata McGraw Hill Publications, 3rd edition, 2006.
2. J. P. Holman, "Heat Transfer", Tata McGraw Hill Publications, 9th edition, 2004.

Metrology and Quality Control

ME 505	Metrology and Quality Control	PCC	4-0-0	4 Credits

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Identify techniques to minimize the errors in measurement
CO2	Identify methods and devices for measurement of length, angle, and gear and thread parameters, surface roughness and geometric features of parts.
CO3	Choose limits for plug and ring gauges.
CO4	Explain methods of measurement in modern machineries
CO5	Select quality control techniques and its applications
CO6	Plot quality control charts and suggest measures to improve the quality of product and reduce cost using Statistical tools.

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1				3								2
CO2		2	2		2							
CO3			2	3	2							
CO4						3						
CO5	1					2		3	3		3	2
CO6	1					2		3	3		2	2

Course Contents:

Unit 1: Measurement Standard and Comparators
Measurement Standard, Principles of Engineering Metrology, Line end, wavelength, Traceability of Standards. Types and Sources of error, Alignment, Temperature, Plastic deformation, Slip gauges and gauge block, Linear and Angular Measurement (Sine bar, Sine center, Autocollimator, Angle Décor and Dividing head), Calibration. Comparator: Mechanical, Pneumatic, Optical, Electronic (Inductive), Electrical (LVDT).

Unit 2: Interferometry and Limits, Fits, Tolerances
Principle, NPL Interferometer, Flatness measuring of slip gauges, Parallelism, Laser Interferometer, Surface Finish Measurement: Surface Texture, Measuring Surface Finish by Stylus probe, Tomlinson and Talysurf, Analysis of Surface Traces: Methods.
Design of Gauges: Types of Gauges, Limits, Fits, Tolerance; Terminology for limits and Fits. Indian Standard (IS 919-1963) Taylor's Principle.

Unit 3: Metrology of Screw Thread
Gear Metrology: Gear error, Gear measurement, Gear Tooth Vernier; Profile Projector, Tool marker's microscope. Advancements in Metrology: Co-ordinate Measuring Machine, Universal Measuring Machine, Laser in Metrology.

Unit 4: Introduction to Quality and Quality Tools
Quality Statements, Cost of Quality and Value of Quality, Quality of Design, Quality of Conformance, Quality of Performance, Seven Quality Tools: Check sheet, Flow chart, Pareto analysis, cause and effect diagram, scatter diagram, Brain storming, Quality circles.

Unit 5: Total Quality Management
Quality Function Deployment, 5S, Kaizan, Kanban, JIT, Poka yoke, TPM, FMECA, FTA, Zero defects.

Unit 6: Statistical Quality Control
Statistical Quality Control: statistical concept, Frequency diagram, Concept of Variance analysis, Control chart for variable & attribute, Process Capability.
Acceptance Sampling: Sampling Inspection, OC curve and its characteristics, sampling methods.
Introduction to ISO 9000: Definition and aims of standardizations, Techniques of standardization, Codification system, Varity control and Value Engineering.

Texts:

1. I. C. Gupta, "Engineering Metrology", Dhanpat ana Rai Publications, New Delhi, India.
2. M. S. Mahajan, "Statistical Quality Control", Dhanpat and Rai Publications.

References:

1. R. K. Jain, "Engineering Metrology", Khanna Publications, 17th edition, 1975.
2. K. J. Hume, "Engineering Metrology", McDonald Publications, 1st edition, 1950.
3. A. W. Judge, "Engineering Precision Measurements", Chapman and Hall, London, 1957.
4. K. L. Narayana, "Engineering Metrology", Scitech Publications, 2nd edition.
5. J. F. Galyer, C. R. Shotbolt, "Metrology for Engineers", Little-hampton Book Services Ltd., 5th edition, 1969.
6. V. A. Kulkarni, A. K. Bewoor, "Metrology & Measurements", Tata McGraw Hill Co. Ltd., 1st edition, 2009.
7. Amitava Mitra, "Fundamental of Quality Control and Improvement", Wiley Publication.
8. V. A. Kulkarni, A. K. Bewoor, "Quality Control", Wiley India Publication, 01st August, 2009.
9. Richard S. Figliola, D. E. Beasley, "Theory and Design for Mechanical Measurements", Wiley India Publication.
10. E. L. Grant, "Statistical Quality Control", Tata McGraw Hill Publications.
11. J. M. Juran, "Quality Planning and Analysis", Tata McGraw Hill Publications.

Elective III

NSS-II

ME 506A	NSS-II	POE	3-0-0	3 Credits

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Understand features of Indian constitution, fundamental rights and duties of citizen
CO2	Explain importance of Health, Hygiene & Sanitation
CO3	Summarize yoga a tool for healthy lifestyle
CO4	Conclude environmental issues and organize its management
CO5	Classify the disasters and youth role in its management

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1			1			1	1	1	1	2	1	
CO2			1				2	1	1	1	1	1
CO3			1			1		1	1	1	1	1
CO4			2			1	1	1	1	1	1	1
CO5	1		1			1	1	1	1	1	1	1

Course Contents:

Unit 1: Citizenship
Basic Features of Constitution of India, Fundamental Rights and Duties, Human Rights, Consumer awareness and the legal rights of the consumer, RTI.

Unit 2: Health, Hygiene and Sanitation
Definition, Needs and scope of health education , Food and Nutrition , Safe drinking water, Water borne diseases and sanitation, National Health Program, Reproductive health , Healthy Lifestyles ,HIV AIDS, Drugs and Substance abuse, Home Nursing , First Aid.

Unit 3: Youth and Yoga
History, Philosophy and concept of Yoga , Myths and misconceptions about yoga , Different Yoga traditions and their Impacts, Yoga as a preventive, promotive and curative method, Yoga as a tool for healthy lifestyle.

Unit 4: Environment Issues
Environment conservation, Enrichment and Sustainability, Climate change, Waste management, Natural resource management, Rain water harvesting, Energy conservation, Waste land development, Soil conservations and forestation.

Unit 5: Disaster Management
Introduction to Disaster Management, Classification disaster, Role of youth in Disaster Management

Unit 6: Youth and crime
Sociological and psychological factors influencing youth crime, Peer mentoring in preventing crime, Awareness about anti-ragging, Cybercrime and its prevention, Juvenile justice.

Elective III

Sheet Metal Processes and Products

ME 506B	Sheet Metal Processes and Products	POE	3-0-0	3 Credits

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Recognize common manufacturing processes of Sheet Metal Fabrication
CO2	Understand the principles of design and fabricate of sheet metal products and recognize common material used in the industry
CO3	Distinguish Shearing, Drawing and Pressing etc. processes.
CO4	Know types of dies and formability.
CO5	Select mechanical or hydraulic presses for the given process

Mapping of course outcomes with program outcomes

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

Course Contents:

Unit 1: Introduction
Importance of sheet metal engineering, materials used, desirable properties of materials in sheet metal products

Unit 2: Basic Applications
Shearing processes like blanking, piercing, and punching.

Unit 3: Drawing Processes
Shallow and deep drawing of cylindrical and rectangular bodies, forming and bending including spring-back.

Unit 4: Types of Dies
Compound dies, progressive dies, and combination dies

Unit 5: Mechanical Presses
Mechanical and hydraulic presses, modern developments in press tools, formability.

Unit 6: Case Studies
Case studies for manufacturing of sheet metal products in various engineering applications

Texts:

1. Donaldson et al., "Tool Design", Tata McGraw-Hill Publications, New Delhi, 1998.

References:

1. P. N. Rao, "Manufacturing Technology, Foundry, Forming and Welding", Vol. I, Tata McGraw Hill Publishing Co. Ltd, New Delhi, 3rd edition, 2004.
2. ASM Handbook, "Metal Forming", Vol. XV, ASM Publication, Metals Park, Ohio, 10th edition, 1989.
3. A. S. Deshpande, "Die Design Handbook", ASTME.
4. Sheet Metal Engineering Notes, IIT Bombay, 1999.

Elective III

Knowledge Management

ME 506C	Knowledge Management	POE	3-0-0	3 Credits

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Define KM, learning organizations, intellectual capital and related terminologies in clear terms and understand the role of knowledge management in organizations.
CO2	Demonstrate an understanding of the history, concepts, and the antecedents of management of knowledge and describe several successful knowledge management systems.
CO3	Identify and select tools and techniques of KM for the stages of creation, acquisition, transfer and management of knowledge.
CO4	Analyze and evaluate tangible and intangible knowledge assets and understand current KM issues and initiatives.
CO5	Evaluate the impact of technology including telecommunications, networks, and internet/intranet role in managing knowledge.
CO6	Identify KM in specific environments: managerial and decision making communities; finance and economic sectors; legal information systems; health information systems

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1						1						3
CO2												3
CO3												3
CO4								2				3
CO5					3				2			3
CO6												3

Course Contents:

Unit 1: Introduction
Definition, evolution, need, drivers, scope, approaches in Organizations, strategies in organizations, components and functions, understanding knowledge.

Unit 2: Learning Organization
Five components of learning organization, knowledge sources and documentation.

Unit 3: Essentials of Knowledge Management
Knowledge creation process, knowledge management techniques, systems and tools.

Unit 4: Organizational Knowledge Management
Architecture and implementation strategies, building the knowledge corporation and implementing knowledge management in organization.

Unit 5: Knowledge Management System
Knowledge management system life cycle, managing knowledge workers, knowledge audit, and knowledge management practices in organizations, few case studies.
Unit 6: Futuristic KM
Knowledge engineering, Theory of computation, data structure.

Texts:
1. Thohothathri Raman, "Knowledge Management: A resource book", Excel, 2004.
2. M. Elias, Awad Hasan, M. Ghazri, "Knowledge Management", Pearson Education.

References:
1. Amrit Tiwana, "Strategy & Knowledge Platforms", The KM Toolkit–Orchestrating IT, Pearson, PHI, 2nd edition.
2. Peter Senge et al., "The Fifth Discipline Field Book–Strategies and Tools for Building A learning Organization", Nicholas Brealey, 1994.
3. Sudhir Warier, "Knowledge Management", Vikas Publications.
4. Madanmohan Rao, "Leading with Knowledge", Tata McGraw Hill Publications.

Elective III

Sustainable Development

ME 605B	Sustainable Development	POE	3-0-0	3 Credits

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Explain the difference between development and sustainable development
CO2	Explain challenges of sustainable development and climate change
CO3	Explain sustainable development indicators
CO4	Analyze sustainable energy options
CO5	Understand social and economic aspects of sustainable development

Mapping of course outcomes with program outcomes

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

Course Contents:

Unit 1: Introduction
Status of environment, Environmental, Social and Economic issues, Need for sustainability, nine ways to achieve sustainability, population, resources, development and environment.

Unit 2: Global Warming and Climate Change
Global Warming and climate Change since industrial revolution, Greenhouse gas emission, greenhouse effect, Renewable energy, etc.

Unit 3: Challenges of Sustainable Development and Global Environmental Issues
Concept of sustainability, Factors governing sustainable development, Linkages among sustainable development, Environment and poverty, Determinants of sustainable development, Case studies on sustainable development, Population, income and urbanization Health care, Food, fisheries and agriculture , Materials and energy flows.

Unit 4: Sustainable Development Indicators
Need for indicators, Statistical procedures Aggregating indicators, Use of principal component analysis, Three environmental quality indices.

Unit 5: Environmental Assessment
National environmental policy act of 1969, Environmental Impact Assessment, Project categories based on environmental impacts, Impact identification methods, Environmental impact assessment process.

Unit 6: Environmental Management and Social Dimensions
Revisiting complex issues, Sector policies concerning the environment, Institutional framework for environmental management, Achievements in environmental management, People's perception of the environment, Participatory development, NGOs, Gender and development, Indigenous peoples, Social exclusion and analysis.

Texts:

1. J. Sayer, B. Campbell, "The Science of Sustainable Development: Local Livelihoods and the Global Environment", Biological Conservation, Restoration and Sustainability, Cambridge University Press, London, 2003.
2. J. Kirkby, P. O"Keefe, Timberlake, "Sustainable Development", Earth scan Publication, London, 1993.
3. Peter P. Rogers, Kazi F. Jalal, John A. Boyd, "An introduction to sustainable development", Glen Educational Foundation, 2008.

References:

1. Jennifer A. Elliott, "An introduction to sustainable development". London: Routledge: Taylor and Francis group, 2001.
2. Low, N. "Global ethics and environment", London, Rout ledge, 1999.
3. Douglas Muschett, "Principles of Sustainable Development", St. Lucie Press, 1997.

Elective III

Non-Conventional Machining

ME 506E	Non-Conventional Machining	PCE	3-0-0	3 Credits

Pre-Requisites: Engineering mathematics-I, Manufacturing processes

Course Outcomes: At the end of the course, students will be able to:

CO1	Classify Non-conventional machining processes.
CO2	Understand working principle and mechanism of material removal in various non-conventional machining processes.
CO3	Identify process parameters their effect and applications of different processes.
CO4	Summarized merits and demerits of non-conventional machining processes.
CO5	Explain the mechanism to design hybrid processes such as ELID grinding, EDCG, EDCM, etc.
CO6	Understand mechanism and working principle of micro machining using non-conventional processes.

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1	1	1	1	1				1		1
CO2	2	2	1		2	1	1			1		1
CO3	2	2	1	1	2	1	1			1		1
CO4	2	2	1		2	1	1			1		1
CO5	3	2	1	1	2	2	1			1		1
CO6	2	2	1	1	1	2	1			1		1

Course Contents:

Unit 1: Introduction to Non-Conventional Machining Processes

An overview, Trends in manufacturing, Classification of Non-Conventional Machining processes.

Unit 2: Chemical and Electrochemical Processes

Introduction, Types: CHM, ECM, Electrochemical grinding, electrochemical deburring, electrochemical honing, Mechanism of material removal, Process characteristics, Process parameters, Equipment and Tooling (maskant sand etchants), Advantages, applications and limitations.

Unit 3: Thermo-Electrical Processes
Electrical discharge machining, Electron beam machining, Ion beam machining, Plasma arc machining, Hot machining, Mechanism of material removal, Process characteristics, Process parameters, Equipment and Tooling, Advantages, applications and limitations.

Unit 4: Mechanical Processes
Ultrasonic machining, Abrasive jet machining, Abrasive flow machining, Water Jet cutting, Mechanism of material removal, Process characteristics, Process parameters, Equipment and Tooling, Advantages, applications and limitations.

Unit 5: Laser Based Machining Processes
Types of lasers, Laser beam generation, Equipment and machining procedure, Process characteristics, Process parameters, Advantages and limitations of LBM, Applications.

Unit 6: Hybrid Processes
Concept, Mechanism of material removal, Process characteristics, Process parameters, Equipment and Tooling, classification, applications, advantages, Shaped tube electrolytic machining, Electrical discharge wire cutting, ELID grinding, Micro machining: Micro EDM, Micro ECM, Electro discharge chemical grinding (EDCG).

Texts:

1. P. C. Pande, H. S. Shan, "Modern Machining Process", Tata McGraw-Hill Publications, New Delhi, 1980.
2. V. K. Jain, "Advanced Machining Processes", Allied Publishers Pvt. Ltd., New Delhi, 2002.
3. P. K. Mishra, "Non-Conventional Machining", Narosa Publishing House, New Delhi, 2007

References:

1. P. C. Wellar, "Non-Traditional Machining Processes", SME, Michigan, 1984.
2. Gary F. Benedict, "Non-traditional Manufacturing Processes", Marcel Dekker, 1987.

Elective III

Mechanical Measurements

ME 506F	Mechanical Measurement	PCE	3-0-0	3 Credits

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Define measurement parameters, and Identify errors in measurement
CO2	Identify methods and devices for measurement of length, angle
CO3	Identify methods and devices for measurement of pressure, flow, force, torque, strain, velocity, displacement, acceleration, temperature

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1		1	3	3	1							2
CO2	1	2	2	1	1							2
CO3	1	1	3	2	1							1

Course Contents:

Unit 1: Mechanical Measurement
Need of mechanical measurement, Basic definitions: Hysteresis, Linearity, Resolution of measuring instruments, Threshold, Drift, Zero stability, loading effect and system response. Measurement methods, Generalized Measurement system, Static performance characteristics, Errors and their classification.

Unit 2: Linear and Angular Measurements
Linear Measurement Instruments, Vernier calliper, Micrometer, Interval measurements: Slip gauges, Checking of slip gauges for surface quality, Optical flat, Limit gauges, Problems on measurements with gauge.

Unit 3: Measurement of Pressure
Gravitational, directing acting, elastic and indirect type pressure transducers. Measurement of very low pressures (high vacuum). Flow Measurement: Measurement of fluid velocity, Hot Wire Anemometry, Laser Doppler Velocimetry. Flow measuring devices, Rotameter.

Unit 4: Measurement of Force, Torque and Strain
Force measurement: load cells, cantilever beams, proving rings, differential transformers. Measurement of torque: Torsion bar dynamometer, servo controlled dynamometer, absorption dynamometers. Power measurements.
Measurement of strain: Mechanical strain gauges, electrical strain gauges, strain gauge: materials, gauge factors, theory of strain gauges and method of measurement, bridge arrangement, temperature compensation.

Unit 5: Displacement, Velocity/Speed and Acceleration Measurement
Working principal of Resistive Potentiometer, Linear variable differential transducers, Electro Magnetic Transducers, Mechanical, Electrical and Photoelectric Tachometers, Piezoelectric Accelerometer, Seismic Accelerometer,

Unit 6: Temperature Measurement
Temperature Measuring Devices: Thermocouples, Resistance Temperature Detectors, Thermistor, Liquid in glass Thermometers, Pressure Thermometers, Pyrometer, Bimetallic strip. Calibration of temperature measuring devices, Numerical Examples on Flow Measurement.

Texts:
1. I. C. Gupta, “Engineering Metrology”, Dhanpat Rai and Sons.
2. R. K. Jain, “Mechanical & Industrial Measurements”, Khanna Publishers.

References:

1. E. O. Doebelin, “Measurement Systems, Application and Design”, Tata McGraw Hill Publications.
2. G. Beckwith and G. Thomas, “Mechanical Measurements”, Pearson Education.

Machine Design Practice-I

ME 507	Machine Design Practice-I	PCC	0-0-2	1 Credits

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Apply design process to an open ended problem
CO2	Determine suitable material and size for structural component of machine/system
CO3	Apply iterative technique in design including making estimate of unknown values for first computation and checking or revisiting and re-computing
CO4	Choose logically and defend selection of design factors
CO5	Design of components for given part/system i.e. shaft, keys, coupling, links, screws, springs etc.
CO6	Work effectively as a part of design group/team
CO7	Have good communication skill, orally, graphically as well as in writing

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1	2	2			2	1				
CO2	1	3	2	1			1	1				1
CO3	3	2	2	1			1	1				1
CO4	2	2	2	2			1	1				1
CO5	3	3	2	1			2	1				1
CO6						1	1	1	2	2		2
CO7								1	1	2	2	3

List of Practicals/Experiments/Assignments

1. The term work shall consist of two design projects based on the syllabus of Machine Design I. Each design project shall consist of two imperial size sheets- on e involving assembly drawings with a part list and overall dimensions and other sheet involving drawings of individual components. Manufacturing tolerances, surface finish symbols and geometric tolerances should be specified, wherever necessary, so as to make it working drawing
2. A design report giving all necessary calculations for the design of components and assembly should be submitted in a separate file.
3. Two assignments based on topics of syllabus of Machine Design I.

Theory of Machines and Mechanisms Lab-II

ME 508	Theory of Machines and Mechanisms Lab-II	PCC	0-0-2	1 Credit

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Explain various types of gear boxes, gear trains, belt and rope drives
CO2	Interpreting physical principles and phenomenon of governor, gyroscopic, flywheel
CO3	Measure vibration parameters in single degree of freedom systems
CO4	Evaluating natural frequency of 1 dof

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	1	2	2		2					
CO2	2	2	1	2	2							3
CO3	3	3		3	3							3
CO4	2	3		3	3							3

List of Practicals/Experiments/Assignments

Term work should consist of total 10 experiments from the below given list.

1. Study of various types of gear boxes such as Industrial gear box, Synchromesh gear box, Differential gear box, etc.
2. To draw conjugate profile for any general shape of gear tooth
3. To generate gear tooth profile and to study the effects under cutting and rack shift using models
4. To draw cam profile for various types of follower motions
5. To study various types of lubricating systems
6. To study various types of dynamometers
7. To determine speed vs. lift characteristic curve of a centrifugal governor and to find its coefficient of insensitiveness and stability.
8. Verification of principle of gyroscope and gyroscopic couple using motorized gyroscope
9. Study of any tow gyro-controlled systems
10. To study the dynamic balancing machine and to balance a rotor such as a fan or the rotor of electric motor or disc on the machine
11. To determine the natural frequency of damped vibration of a single degree of freedom system and to find its damping coefficient
12. To verify natural frequency of torsional vibration of two rotor system and position of node
13. To determine critical speed of a single rotor system
14. To determine transverse natural frequency of a beam experimentally using frequency measurement setup
15. To determine the frequency response curve under different damping conditions for the single degree of freedom system
16. To study shock absorbers and to measure transmissibility of force and motion.
17. Study of epicyclic gear train and its dynamic behaviour.

Metrology and Quality Control Lab

ME 509	Metrology and Quality Control lab	PCC	0-0-2	1 Credit

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Measure linear, angular circular features, dimensional and geometric features
CO2	Measure surface roughness of components
CO3	Calibration of metrological equipment

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1	1	3	1							2
CO2			2	2		1		1				2
CO3			3	2		1						2

List of Practicals/Experiments/Assignments

A] Any Four from experiment No. 1 to 5 and Any Four from experiment No. 6 to 10

1. Determination of linear and angular dimensions of given composite part using precision/non precision measuring instruments.
2. Error determination with linear / angular measuring instruments.
3. Calibration of measuring instrument. Example – Dial gauge, Micrometer, Vernier (any one)
4. Verification of dimensions & geometry of given components using Mechanical & Pneumatic comparator.
5. Machine tool alignment testing on any two machines.
6. Identification of surfaces using optical flat/interferometers and measure surface roughness using surface roughness tester.
7. Determination of geometry & dimensions of given composite object using profile projector and measurement of various angles of single point cutting tool using tool maker's microscope.
8. Measurement of thread parameters using floating carriage diameter measuring machine.
9. Measurement of spur gear parameters using Gear Tooth Vernier, Span, Gear Rolling Tester.
10. Determination of given geometry using coordinate measuring machine (CMM).

B] Statistical Quality Control (SQC) (Any Two)
Note - Use of computational tools are recommended

1. Analyze the fault in given batch of specimens by using seven quality control tools for engineering application.
2. Determination of process capability from given components and plot variable control chart/ attribute chart.
3. Case study on various tools in Total Quality Management (TQM).

C] Industrial visit to Calibration lab /Quality control lab / Gear manufacturing unit / Automotive Industry / Engineering Industry.

Heat Transfer Lab

ME 510	Heat Transfer Lab	PCC	0-0-2	1 Credit

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Understand the various heat transfer mode of heat transfer and its application and verify
CO2	Learn the experimental methodology
CO3	Describe the concept the terms like least count, calibration of the instruments

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	3		3	2							
CO2	3	3		3	2		2					
CO3	3	3		3	2		2					

List of Practicals/Experiments/Assignments

Any eight experiments from the list:

1. Determination of thermal conductivity of a metal rod.
2. Determination of thermal conductivity of insulating powder.
3. Determination of conductivity of a composite slab.
4. Temperature distribution on a fin surface.
5. Determination of film heat transfer coefficient for nature convection.
6. Determination of film heat transfer coefficient for forced convection.
7. Determination of heat transfer coefficient for cylinder in cross flow in forced convection.
8. Performance of Double pipe Heat Exchanger / Shell and Tube Heat Exchanger.
9. Determination of emissivity of a metal surface.
10. Determination of Stefan Boltzman's constant.
11. Determination of critical heat flux.
12. Calibration of measuring instruments pressure gauge, thermocouple, flow-meter etc.

Semester VI

Manufacturing Processes-III

ME 601	Manufacturing Processes-III	PCC	3-0-0	3 Credits

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Differentiate clearly between NC and CNC machines
CO2	Prepare and execute a part program for producing a given product
CO3	Select appropriate non-traditional machining process for a given application
CO4	Compare different surface coating techniques
CO5	Explain different rapid prototyping techniques
CO6	Illustrate the working principle of various micro-manufacturing processes

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1	1									
CO2	1	1			1							
CO3	2	2	2									
CO4	2	2	1			1	1					1
CO5	1	1	1			1	1					
CO6	1	1	1			1						

Course Contents:

Unit 1: Introduction to CNC System
Numerical Control, CNC, Classification of NC/CNC systems, Basic components of CNC system: Design considerations, structure, Antifriction LM guideways, spindles, ball screws; CNC Drives and controls: DC motors, AC motors, Stepper motors, Feedback devices: Encoders, tachometers; Servo motors, Linear motors

Unit 2: CNC Tooling and Programming
CNC Tooling, Tool and work holding devices, Automatic Tool Changers, Automatic Pallet Changers. Part programming: Introduction, Part Program and its elements, Methods of Programming: Manual and Computer Assisted Part programming, APT language.

Unit 3: Advanced Machining Processes
Introduction; Chemical Machining; Electrochemical Machining: Pulsed, Electrochemical Machining; Electrochemical Grinding; Electrical-discharge Machining: Wire EDM, Electrical-discharge Grinding; Laser-beam Machining; Electron-beam Machining; Water-jet Machining; Abrasive-jet Machining; Hybrid Machining Systems

Unit 4: Surface Treatments and Coatings
Introduction; Mechanical Surface Treatments; Mechanical Plating and Cladding; Thermal Spraying, Vapour Deposition: Physical Vapor Deposition, Chemical Vapor Deposition; Ion

Implantation and Diffusion Coating; Laser Treatments; Electroplating, Electroless Plating, and Electroforming; Conversion Coatings, Hot Dipping, Porcelain Enamelling: Ceramic and organic coatings; Diamond Coating and Diamond like Carbon; Surface Texturing

Unit 5: Rapid Prototyping
Introduction; subtractive processes; additive processes: Fused-deposition Modeling, Stereolithography, Multijet/Polyjet Modeling, Selective Laser Sintering, Electron-beam Melting, Three-dimensional Printing, Laminated-object Manufacturing, Solid-ground Curing, Laser-engineered Net Shaping; virtual prototyping; direct manufacturing and rapid tooling

Unit 6: Micromanufacturing Technology
Introduction to fabrication of MEMS, micromachining of MEMS devices: Bulk Micromachining, Surface Micromachining; LIGA microfabrication process; Solid free-form fabrication of devices; Nanoscale manufacturing.

Texts:
1. HMT Ltd, "Mechatronics", Tata McGraw Hill Publications, New Delhi, 1998.
2. Serope Kalpakjian and Steven R. Schmid, "Manufacturing Engineering and Technology", Addison Wesley Longman (Singapore) Pte. India Ltd., 6th edition, 2009

References:
1. James Madison, "CNC Machining Handbook", Industrial Press Inc., 1996.
2. Gibbs and Crandell, CNC Machining and Programming: An Introduction, Industrial Press Inc, 2003.
3. Gary F. Benedict, "Non Traditional Manufacturing Processes", Marcel Dekker, 1987.

IC Engines and Refrigeration-Air Conditioning

ME 602	IC Engine and RAC	PCC	4-0-0	4 Credits

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Describe and explain different types of reciprocating internal combustion engines (ICE), their typical design features and performance characteristics.
CO2	Describe and analyze the power cycle of internal combustion engines using ideal gas cycles, air cycles, and fuel-air cycles. Compute indicated power and thermal efficiency.
CO3	Understand various engine combustion parameters, generation of undesirable combustion and exhaust emissions and primitive measures,
CO4	Study various engine systems and performance improvement techniques. Testing performance analysis of IC engines.
CO5	State the importance, applications, methods of cooling and refrigeration(Domestic and Industrial).Understand Thermodynamics behind various refrigeration cycles
CO6	Describe and analyze vapor compression and vapor absorption system

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2										
CO2	1	2										
CO3		1			1		1					
CO4	1	1		2								
CO5	2	1			1							
CO6	1	2										

Course Contents:

Unit 1: Fundamentals of IC Engines

Applications, nomenclature, engine components, Engine classification, two and four stroke cycle engines; fundamental difference between SI and CI engines; valve timing diagrams.

Power Cycles: Air standard Otto, Diesel and Dual cycles; Valve timing diagrams, Fuel-Air cycles and deviation of actual cycles from ideal cycles.

Combustion: Introduction, important qualities and ratings of SI Engines fuels; qualities and ratings of CI Engine fuels.

Combustion in S.I. Engines, flame speed, ignition delay, normal and abnormal combustion, effect of engine variables on flame propagation and ignition delay, Combustion in C.I. Engines, combustion of a fuel drop, stages of combustion, ignition delay, combustion knock; types of SI and CI Engine combustion chambers.

Unit 2: Various Engine Systems

Starting systems, fuel supply systems, engine cooling system, ignition system, engine friction and lubrication systems, governing systems.

Unit 3: Engine Testing and Performance of SI and CI Engines

Parameters, Type of tests and characteristic curves.

Super charging in IC Engine: Effect of attitude on power output, types of supercharging.

Engine Emissions and control: Pollutants from SI and CI engines and their control, emission regulations such as Bharat and Euro.

Alternate fuels for SI and CI engines: Alcohols, Biodiesels, vegetable oil extraction, Trans-esterification process, properties of alternative fuels and fuel blends.

Unit 4: Introduction to Refrigeration

Fundamental of refrigeration, Unit, Applications, Methods of cooling, Refrigeration systems, Thermodynamics of Refrigeration, Air refrigeration system

Unit 5: Vapour Compression System

Theoretical and actual cycle, use for P-h and T-s charts for problem solving, various effects on system performance. Refrigerants

Vapour Absorption System: Introduction, comparison with vapour compression system Aqua-ammonia system, lithium bromide-water system.

Unit 6: Air Conditioning
Properties of moist air, psychometric chart, Sensible and latent heat loads SHF, GSHF, RSHF, bypass factor, air conditioning processes. Refrigeration and air conditioning controls.

Texts:

1. V. Ganeshan, "Internal Combustion Engines", Tata McGraw Hill Publications, New Delhi, 3rd edition.
2. C. P. Arora, "Refrigeration and Air Conditioning", Tata McGraw Hill Publications, New Delhi, 2nd edition, 2000.
3. W. F. Stoeker, J. P. Jones, "Principles of Refrigeration and Air Conditioning", Tata McGraw Hill Publications, New York, 2nd edition, 1982.

References:

1. J. B. Heywood, "Internal Combustion Engine Fundamentals", Tata McGraw Hill Publications, New York, International Edition, 1988.
2. ASHRAE Handbook, "Fundamentals and Equipment", 1993.
3. ASHRAE Handbook – Applications, 1961.
4. ISHRAE Handbook
5. Prof. Ram Gopal, NPTL Lectures, www.nptel.com, IIT Kharagpur.
6. Carrier Handbook
7. R.C. Jordan, G. B. Priester, "Refrigeration and Air Conditioning", Prentice Hall of India Ltd., New Delhi, 1969.
8. J. L. Threlkeld, "Thermal Environmental Engineering", Prentice Hall, New York, 1970.

Machine Design-II

ME 603	Machine Design-II	PCC	3-1-0	4 Credits

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Define function of bearing and classify bearings.
CO2	Understanding failure of bearing and their influence on its selection.
CO3	Classify the friction clutches and brakes and decide the torque capacity and friction disk parameter.
CO4	Select materials and configuration for machine element like gears, belts and chain
CO5	Design of elements like gears, belts and chain for given power rating
CO6	Design thickness of pressure vessel using thick and thin criteria

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1						1				1
CO2	3	2		1		1		1		1		1
CO3	1	1				1		1		1		1
CO4	3	3	2	1		2		1		1		1
CO5	1	1				1		1		1		1
CO6	3	2	2	1		1		1		1		1

Course Contents:

Unit 1: Rolling Contact Bearings

Types, Static and dynamic load carrying capacities, Stribeck's Equation, Equivalent load, load and life relationship, selection of bearing life, Load factor, selection of bearing from manufacturer's catalogue, Taper roller bearings and their selection, Cyclic loads and speeds, Design for probability of survival other than 90% Lubrication and mountings of rolling contact bearings.

Sliding Contact Bearings: Methods of lubrication, Viscosity and its measurement, Effect of temperature, viscous flow through rectangular slot, Hydrostatic step bearing, Load capacity and energy losses, Reynolds equation, Raimondi and Boyd method, temperature rise, Constructional details of bearing, Bearing material, Lubrication oils, Additives and greases, Sintered metal bearings, Comparison of rolling and sliding contact bearings.

Unit 2: Spur Gear

Gear drives, Classification of gears, Law of gearing, Terminology of spur gear, Standard system of gear tooth force analysis, gear tooth failures, Selection of materials Constructional, Number of teeth, Face with, Beam strength equation, Effective load on gear tooth, Estimation of module based on beam strength.

Design for maximum power capacity, Lubrication of gears.

Helical Gears: Terminology, Virtual number of teeth, Tooth proportions, Force analysis, Beam strength equation, Effective load on gear tooth, Wear strength equation.

Unit 3: Bevel Gears

Types of bevel gears, Terminology of straight bevel, force analysis, Beam and Wear strength, Effective load on gear tooth.

Worm Gears: Terminology, Proportions, Force analysis, Friction in worm gears, Vector method, Selection of materials, Strength and wear rating, Thermal considerations

Unit 4: Belt and Chain Drives

Flat and V belts, Geometric relationship, analysis of belt tensions, condition for maximum power, Selection of flat and V belts from manufacturer's catalogue, Adjustment of belt tensions. Roller chains, Geometric relationship, polygonal effect, power rating of roller chain, sprocket wheels, and Silent chains.

Flywheel: Introduction, types of flywheel, stresses in disc and armed flywheel.

Unit 5: Brakes and Clutches

Types of clutches, torque capacity, single and multi-plate clutches, cone clutch, centrifugal clutch, friction materials.

Types of brakes, energy equation, block with shoe brake, pivoted brake with long shoe, internal expanding shoe brake, thermal considerations.

Unit 6: Pressure Vessel
Thin cylinders, thick cylinders, principal stresses, Lame's equation, Clavirino and Birnie's equation, cylinder with external pressure, autofrettage, compounding of cylinders, gasketed joint, unfired pressure vessel, thickness of cylindrical and spherical pressure shells, end closure, opening in pressure vessel, area compensation method

Texts:

1. V. B. Bhandari, "Design of machine Elements", Tata McGraw Hill Publications, New Delhi, 1998
2. R. L. Nortan, "Machine Design: An Integrated Approach", Pearson Education.

References:

1. J. E. Shigley, C. Mischke, "Mechanical Engineering Design", Tata McGraw Hill Inc, New York, 6th edition, 2003.
2. R. C. Juvinall, K. M. Marshek, "Fundamentals of Machine Component Design", John Wiley & Sons, Inc, New York, 2002.

Fluid Machinery

ME 604	Fluid Machinery	PCC	2-1-0	3 Credits

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Understand and apply momentum equation
CO2	Understand and explain Hydrodynamic Machines
CO3	Explain difference between impulse and reaction turbines
CO4	Find efficiencies, draw velocity triangles
CO5	Explain governing mechanisms for hydraulic turbines
CO6	Explain working of various types of pumps, draw velocity diagrams, do simple calculations
CO7	Design simple pumping systems

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1									1
CO2	3		3				2					1
CO3	3	2										1
CO4	3	3	2									1
CO5			3									1
CO6	3	3	3	1	1							1
CO7	3	3		3								1

Course Contents:

Unit 1: Momentum Equation and its Applications
Impulse momentum, Principle, Fixed and moving flat inclined plates, Curved vanes, Series of plates and vanes, Velocity triangle and their analysis, Water wheels. Hydrodynamic Machines: Classification, General theory, Centrifugal head, Fundamental equations, and Euler's equation, Degree of reaction, Head on machine, various efficiencies, Condition for maximum hydraulic efficiency.

Unit 2: Impulse Turbines
Impulse principle, Construction of Pelton wheel, Velocity diagrams and its analysis, Number of buckets, Jets, Speed ratio, Jet ratio.
Reaction Turbines: Constructional details of Francis, Kaplan and Propeller turbine, Deciaz turbine, and Draft tube types, Efficiencies, Cavitation.

Unit 3: Governing of Turbines
Methods of governing, Performance characteristics, Safety devices, Selection of turbines, Unit quantities, Specific speed, Principles of similarity and model testing.

Unit 4: Centrifugal Pump
Construction, Classification, Terminology related to pumps, Velocity triangle and their analysis, Cavitation, NPSH, Thoma's cavitation factor, Priming, Methods of priming, Specific speed, Performance characteristics, Actual thrust and its compensation, Troubleshooting.
Multistage Pumps: Pump H-Q characteristics and system H-Q Characteristics, Series and parallel operation of pumps, Systems in series and parallel, Principle of model testing and similarity.

Unit 5: Special Purpose Pumps
Chemical pumps, nuclear pumps, Sewage pumps, Submersible deep well pumps, Pump installation, Energy efficient pumps.
Failure of Pumping System: Pump failures, Remedies, Source failure, Causes and remedies, Trouble shooting.

Unit 6: Design of Pumping System
Principles of line layout, Estimation of pressure drops across pipes, Fittings, etc.
Miscellaneous Pumps: Reciprocating pump, Gear pump, Vane pump, Lobe pump, etc., Application field (no mathematical treatment).

Texts:

1. P. N. Modi, S. M. Seth, "Hydraulics and Fluid Mechanics including Hydraulic Machines", Standard Book House, Rajsons Publications Pvt. Ltd., 20th edition.
2. R. K. Bansal, "A Text Book of Fluid Mechanics and Hydraulic Machines", Lakshmi Publications Pvt. Ltd., 9th edition.

References:

1. Yunus A. Çengel, John M. Cimbala, Fluid Mechanics: Fundamentals and Applications", McGraw Hill, 3rd edition, 2014.

Elective IV

Design of Experiments

ME 605A	Design of Experiments	POE	3-0-0	3 Credits

Pre-Requisites: Engineering mathematics-I

Course Outcomes: At the end of the course, students will be able to:

CO1	Define Taguchi, factorial experiments, variability, orthogonal array, quality loss.
CO2	Plan and design the experimental investigations efficiently and effectively.
CO3	Understand strategy in planning and conducting experiments.
CO4	Evaluate variability in the experimental data using ANOVA.
CO5	Practice statistical software to achieve robust design of experiments.

Mapping of course outcomes with program outcomes

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

Course Contents:

Unit 1: Introduction
Modern quality control, quality in engineering design, history of quality engineering, The Taguchi Approach to quality: Definition of quality, loss function, offline and online quality control, Taguchi`s quality philosophy.

Unit 2: Full Factorial Designs
traditional scientific experiments, two factor design, three factor design, replicating experiments, factoring reactions, normal plots of estimated effects, mechanical plating experiments, four factor design, Taguchi design and western design.

Unit 3: Fractional Factorial Design
Fractional factorial design base done ightrun experiments, folding over an eight run experimental design, Fractional factorial design in sixteen run, folding over sixteen run experimental design, blocking two level designs, other two level designs, Necessity to use more than two level, factors at three and four levels.

Unit 4: Taguchi Robust Design
Construction of orthogonal array, Additive model for factor effects, Signal to noise ratios, linear graphs, Taguchi Inner and outer arrays: Noise factors, experimental designs for control and noise factors.

Unit 5: Evaluating Variability
Necessity to analyze variability, measures of variability, the normal distribution, Analysis of variance in engineering design, using estimated effects as test statistics, analysis of variance for two level designs

Unit 6: Computer Software for Experimental Design
Role of computer software in experimental design, summery of statistical packages, example of use of software packages.

Texts:
1. M. S. Phadke, "Quality Engineering using Robust Design", Prentice Hall, Englewood Cliffs, NewJersey,1989.
2. R.H. Lochner and J.E. Matar, "Designing for Quality: An Introduction to the Best of Taguchi and Western Methods of Statistical Experimental Design", Chapmanand Hall, London, 1983.

References:

1. D.C. Montgomery, "Design and Analysis of Experiments", John Wiley and Sons, New York, 5th edition, 2004.
2. Peter Goos, Bradley Jones, "Optimal Design of Experiments: A Case Study Approach", Wiley Publishers, July 2011.
3. Raymond H. Myers, Douglas C. Montgomery, Christine M. Anderson-Cook, "Response Surface Methodology: Process and Product Optimization Using Designed Experiments", 4th Edition, Wiley, January 2016.
4. D. C. Montgomery, "Design and Analysis of Experiments", John Wiley and Sons, New York, 5th edition, 2004.
5. R. H. Lochner, J. E. Matar, "Designing for Quality: An Introduction to the Best of Taguchi and Western Methods of Statistical Experimental Design", Chapman and Hall, London, 1983.
6. M. S. Phadke, "Quality Engineering using Robust Design", Prentice Hall, Engle wood Cliffs, New Jersey, 1989.

Elective IV

Wind Energy

ME 605B	Wind Energy	POE	3-0-0	3 Credits

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Understand historical applications of wind energy
CO2	Understand and explain wind measurements and wind data
CO3	Determine Wind Turbine Power, Energy and Torque
CO4	Understand and explain Wind Turbine Connected to the Electrical Network AC and DC
CO5	Understand economics of wind energy

Mapping of course outcomes with program outcomes

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

Course Contents:

Unit 1: Introduction
Historical uses of wind, History of wind electric generations

Wind Characteristics: Metrology of wind, World distribution of wind, Atmospheric stability, Wind speed variation with height, Wind speed statistics, Weibull statistics, Weibull parameters, Rayleigh and normal distribution

Unit 2: Wind Measurements
Biological indicators, Rotational anemometers, other anemometers, Wind direction

Unit 3: Wind Turbine Power, Energy and Torque
Power output from an ideal turbine, Aerodynamics, Power output from practical turbines, Transmission and generation efficiency, Energy production and capacity factor, Torque at constant speeds, Drive train oscillations, Turbine shaft power and torque at variable speeds.

Unit 4: Wind Turbine Connected to the Electrical Network
Methods of generating synchronous power, AC circuits, The synchronous generator, Per unit calculations, The induction machine, Motor starting, Capacity credit features of electrical network

Unit 5: Wind Turbines with Asynchronous Electric Generators
Asynchronous systems, DC shunt generator with battery load, Per unit calculation, Self excitation of the induction generators, Single phase operation the induction generator, Field modulated generators, Roesel generator.
Asynchronous Load: Piston water pumps, Centrifugal pumps, Paddle wheel heaters, Batteries, Hydrogen economy, and Electrolysis cells.

Unit 6: Economics of Wind Systems
Capital costs, Economic concepts, Revenues requirements, Value of wind generated electricity

Texts:
1. S. Ahmad, “Wind Energy: Theory and Practice”, Prentice Hall of India Pvt. Ltd.

References:
1. Garg L. Johnson, “Wind Energy Systems” Prentice Hall Inc., New Jersey, 1985.
2. Desire Le Gouriers, “Wind Power Plants: Theory and Design” Pergamon Press, 1982.

Elective IV

Engineering Economics

ME 605C	Engineering Economics	POE	3-0-0	3 Credits

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Apply the appropriate engineering economics analysis method(s) for problem solving: present worth, annual cost, rate-of-return, payback, break-even, Benefit-cost ratio.
CO2	Evaluate the cost effectiveness of individual engineering projects using the methods learned and draw inferences for the investment decisions.
CO3	Compare the life cycle cost of multiple projects using the methods learned, and make a quantitative decision between alternate facilities and/or systems.
CO4	Compute the depreciation of an asset using standard Depreciation techniques to assess its impact on present or future value.
CO5	Apply all mathematical approach models covered in solving engineering economics problems: mathematical formulas, interest factors from tables, Excel functions and graphs. Estimate reasonableness of the results.
CO6	Examine and evaluate probabilistic risk assessment methods.
CO7	Compare the differences in economic analysis between the private and public sectors. Recognize the limits of mathematical models for factors hard to quantify.
CO8	Develop and demonstrate teamwork, project management, and professional communications skills

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1											3	
CO2											3	
CO3											3	
CO4											3	
CO5					3						3	
CO6											3	
CO7											3	
CO8									2		3	

Course Contents:

Unit 1: Introduction to Economics

Introduction to Economics: Flow in an economy, Law of supply and demand, Concept of En**g**ineering Economics: Engineering efficiency, Economic efficiency, Scope of engineering economics - Element of costs, Marginal cost, Marginal Revenue, Sunk cost, Opportunity cost, Break-even analysis: V ratio, Elementary economic Analysis: Material selection for product Design selection for a product, Process planning.

Unit 2: Value Engineering
Make or buy decision, Value engineering: Function, aims, and Value engineering procedure. Interest formulae and their applications: Time value of money, Single payment compound amount factor, Single payment present worth factor, Equal payment series sinking fund factor, Equal payment series payment Present worth factor: equal payment series capital recovery factor:
Uniform gradient series annual equivalent factor, Effective interest rate, Examples in all the methods.

Unit 3: Cash Flow
Methods of comparison of alternatives: present worth method (Revenue dominated cash flow diagram), Future worth method (Revenue dominated cash flow diagram, cost dominated cash flow diagram), Annual equivalent method (Revenue dominated cash flow diagram, cost dominated cash flow diagram), rate of return method, Examples in all the methods.

Unit 4: Replacement and Maintenance Analysis
Replacement and Maintenance analysis: Types of maintenance, types of replacement problem, determination of economic life of an asset, Replacement of an asset with a new asset: capital recovery with return and concept of challenger and defender, Simple probabilistic model for items which fail completely.

Unit 5: Depreciation
Depreciation: Introduction, Straight line method of depreciation, declining balance method of depreciation, sum of the years digits method of depreciation, sinking fund method of depreciation/annuity method of depreciation, service output method of depreciation-

Unit 6: Evaluation of Public Alternatives
Introduction, Examples, Inflation adjusted decisions: procedure to adjust inflation, Examples on comparison of alternatives and determination of economic life of asset.

Texts:

1. Panneer Selvam R, “Engineering Economics”, Prentice Hall of India Ltd, New Delhi, 2001.

References:

1. Chan S. Park, “Contemporary Engineering Economics”, Prentice Hall of India, 2011.
2. Donald G. Newman, Jerome P. Lavelle, “Engineering Economics and analysis”, Engineering Press, Texas, 2010.
3. E. P. Degarmo, W. G. Sullivan and J. R. Canada, “Engineering Economy”, Macmillan, New York, 2011.
4. Zahid A. Khan, "Engineering Economy", Dorling Kindersley, 2012.

Elective IV

Entrepreneurship Development

ME 605D	Entrepreneurship Development	POE	3-0-0	3 Credits

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	enlarge the supply of entrepreneurs for rapid industrial development
CO2	Develop small and medium enterprises sector which is necessary for generation of employment
CO3	Industrialize rural and backward regions
CO4	Provide gainful self-employment to educated young men and women
CO5	Diversify the sources of entrepreneurship.

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1									2			
CO2									2			
CO3											2	
CO4											2	3
CO5												3

Course Contents:

Unit 1: Introduction to Entrepreneurship
Evolution of the Concept of Entrepreneur Functions of Entrepreneur, Characteristics of an Entrepreneur, Types of Entrepreneur, Concept of Entrepreneurship, Growth of Entrepreneurship, Barriers of Entrepreneurship, Role of Entrepreneurship in India, Entrepreneurial Motivation, Major Entrepreneurial Competencies.

Unit 2: Small Scale Industries (SSI)
Characteristics of Small Scale Industry, Basis for Classification of Small Scale Industry: Resource Based, Demand Based, Ancillary, Subsidiary Based or Sub-Controlled Type, Technology Based etc. Government Policy for Small Scale Industry, Growth of SSI in Developing Countries, Role of National and State Agencies Providing Assistance To SSI's, Relationship between Small and Big Industries, Ownership Structure, Registration of SSI.

Unit 3: Project Identification and Project Formulation
Meaning of Project, Project Identification and Selection, Elements of Project Formulation, Concept and Significance of Project Formulation, Meaning, Significance and Contents of Project Report.
Accounting for Small Enterprises: Objective of Accounting, Accounting Process, Journal, Ledger, Preparation of Balance Sheet and Assessment of Economic Viability

Unit 4: Project Appraisal
Concept of Project Appraisal, Project Appraisal Methods, Cash Flows as Costs and Benefits, Payback Period, Average Rate of Return. Discounted Cash Flow Techniques, Working Capital Management, Cost of Capital, Financing of Enterprises, Project Sickness & Corrective Measures.

Unit 5: Marketing Management
Market Segmentation, Marketing Mix, and Packaging, Pricing Policy, Distribution Channels, and Govt. Purchases from SSIS.
Laws Concerning Entrepreneur: Income Tax Laws, Excise Duty ,The Central Sales Tax Act, Professional Tax, Value Added Tax (VAT), Service Tax, The Workmen Compensation Act, The Minimum Wages Act, The Maternity Benefit Act, The Payment of Bonus Act

Unit 6: Institutional Support
Government Policies for Small Scale Entrepreneurs, Institutional Setup, District Industries Centers, Industrial Estates , SIDCO, NSIC, Directorate of Industries, Commercial Banks, New Entrepreneurial Development Agencies.
Women Entrepreneurship: Growth, Problems, Recent Trends.

References:

1. S. S. Khanka, "Entrepreneurial Development", S. Chand and Company Ltd.
2. C. B. Gupta, N. P. Srinivasan, "Entrepreneurship Development in India", S. Chand and Sons.
3. B. Badhai, "Entrepreneurship Development Programme", Mansell Publishing Ltd.
4. V. Desai, "Dynamics of Entrepreneurial Development and Management", Hindustan Publishing House.
5. David H. Holt, "Entrepreneurship", PHI Learning.
6. Roy Rajeev, "Entrepreneurship", Oxford University Press.

Elective IV
Quantitative Techniques in Project Management

ME 605E	Quantitative Techniques in Project Management	POE	3-0-0	3 Credits

Pre-Requisites: Engineering Mathematics-I/II/III

Course Outcomes: At the end of the course, students will be able to:

CO1	Define and formulate research models to solve real life problems for allocating limited resources by linear programming.
CO2	Apply transportation and assignment models to real life situations.
CO3	Apply queuing theory for performance evaluation of engineering and management systems.
CO4	Apply the mathematical tool for decision making regarding replacement of items in real life.
CO5	Determine the EOQ, ROP and safety stock for different inventory models.
CO6	Construct a project network and apply CPM and PERT method.

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1	1	3	2				3	1	3	1
CO2	3	1	1	3	2				3	2	3	1
CO3	3	1	1	3	2				3	2	3	1
CO4	3	1	1	3	2	1			3	2	3	1
CO5	3	1	1	3	2	1			3	2	3	1
CO6	3	1	1	3	2	2			3	2	3	1

Course Contents:

Unit 1: Introduction

Introduction to Operations Research, Stages of Development of Operations Research, Applications of Operations Research, Limitations of Operations Research Linear programming problem, Formulation, graphical method, Simplex method, artificial variable techniques.

Unit 2: Assignment and Transportation Models

Transportation Problem, North west corner method, Least cost method, VAM, Optimality check methods, Stepping stone, MODI method, Assignment Problem, Unbalanced assignment problems, Travelling salesman problem.

Unit 3: Waiting Line Models and Replacement Analysis

Queuing Theory: Classification of queuing models, Model I (Birth and Death model) M/M/I (∞, FCFS), Model II - M/M/I (N/FCFS).

Replacement Theory, Economic Life of an Asset, Replacement of item that deteriorate with time, Replacement of items that failed suddenly.

Unit 4: Inventory Models

Inventory Control, Introduction to Inventory Management, Basic Deterministic Models, Purchase Models and Manufacturing Models without Shortages and with Shortages, Reorder level and optimum buffer stock, EOQ problems with price breaks.

Unit 5: Project Management Techniques

Difference between project and other manufacturing systems. Defining scope of a project, Necessity of different planning techniques for project managements, Use of Networks for planning of a project, CPM and PERT.

Unit 6: Time and Cost Analysis

Time and Cost Estimates: Crashing the project duration and its relationship with cost of project, probabilistic treatment of project completion, Resource allocation and Resource leveling.

Texts:

1. P. K. Gupta, D. S. Hira, “Operations Research”, S. Chand and Company Ltd., New Delhi, 1996.
2. L. C. Jhamb, “Quantitative Techniques for managerial Decisions”, Vol. I and II, Everest Publishing House, Pune, 1994.
3. N. D. Vohra, “Operations Research”, Tata McGraw Hill Co., New Delhi.

References:
1. H. Taha, "Operations Research–An Introduction", Maxwell Macmillan, New York.
2. J. K. Sharma, "Operations Research–An Introduction", Maxwell Macmillan, New Delhi.
3. Harvey M. Wagner, "Principles of Operations Research with Applications to Managerial Decisions", Prentice Hall of India Pvt. Ltd., New Delhi, 2nd edition, 2005.
4. Rubin and Lewin, "Quantitative Techniques for Managers", Prentice Hall of India Pvt. Ltd., New Delhi.

Elective IV

Development Engineering

ME 605F	Development Engineering	POE	3-0-0	3 Credits

Pre-Requisites:

Course Outcomes: At the end of the course, students will be able to:

CO1	Explain the technology for development intervention cycle
CO2	Integrate the principles and elements of Development Engineering
CO3	Distinguish appropriate, affordable and robust devices, technologies or technological interventions for development
CO4	Compare different approaches to technological development
CO5	Identify sustainable solutions to complex problems
CO6	Apply the sustainable and socially responsible value chain canvas to specific contexts

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												
CO5												
CO6												

Course Contents:

Unit 1: Introduction

Introduction to the course and to Development Engineering
Context analysis and identification of challenges and opportunities
Technological Development and Innovation for sustainable development and poverty reduction

Unit 2: Development Technologies
Intervention design (human-centered design) and management: quantitative research methods for project design and management. Experimental and quasi-experimental designs
Intervention design and management; Qualitative research methods for project design and management

Unit 3: Technological Development and Innovation-I
The sustainable and socially responsible value chain canvas: From engineering to marketing,
The sustainable and socially responsible value chain canvas: From assembly to commissioning

Unit 4: Technological Development and Innovation-II
The sustainable and socially responsible value chain canvas: From training to recycling and decommissioning.

Unit 5: Deployment, Adopting/Mainstreaming and Scale-Up
Technology/technological intervention and innovation deployment, adopting/mainstreaming and scale-up; Sustainable business models;

Unit 6: Evaluation of Development Engineering and Innovation Interventions
Evaluation of Development Engineering Interventions: From theory to practice

Elective V

Manufacturing Automation

ME 606A	Manufacturing Automation	PCE	3-0-0	3 Credits

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Understand the concept of automation
CO2	Design a Pneumatic and Hydraulic system for a given application
CO3	Demonstrate the use of different sensors for automation
CO4	Design an AGV system
CO5	Understand the transfer mechanisms in automation

Mapping of course outcomes with program outcomes

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

Course Contents:

Unit 1: Introduction
Concept of automation, mechanization and automation, Concept of automation in industry, mechanization and automation, classification Types of automation, Degree of automation, Technical, economic and human factors in automation,

Unit 2: Automation using Hydraulic Systems
Design aspects of various elements of hydraulic systems such as pumps, valves, filters, reservoirs, accumulators, actuators, intensifiers etc. Selection of hydraulic fluid, practical case studied on hydraulic circuit design and performance analysis. Servo valves, electrohydraulic valves, proportional valves and their applications.

Unit 3: Automation using Pneumatic systems
Pneumatic fundamentals, control elements, position and pressure sensing, logic circuits, switching circuits, fringe conditions modules and these integration, sequential circuits, cascade methods, mapping methods, step counter method, compound circuit design combination circuit design, Pneumatic equipment's, selection of components, design calculations, application, fault finding, hydro pneumatic circuits, use of microprocessors for sequencing PLC, Low cost automation, Robotic circuits.

Unit 4: Automation using Electronic Systems
Introduction, various sensors, transducers, signal processing, servo systems, programming of microprocessors using 8085 instruction, Industrial logic control systems Logic diagraming, programmable logic controllers.

Unit 5: Automation in Work Handling
Working principles and techniques, job orienting and feeding devices, Transfer mechanisms automated feed cut of components, performance analysis, Uses of various types of handling systems including AGV and its various guiding technologies

Unit 6: Applications of Automation
Development of small automation systems using mechanical devices, Circuit optimization techniques, Illustrative examples of the above types of systems as well as hybrid systems

Texts:

1. F. Kay, "Pneumatics for Industry", The Machining Publication Co., London, 1959.
2. Asphal Ray, "Robots and Manufacturing Automation", John Wiley, New York, 1985.
3. Andrew Parr, "Hydraulic and Pneumatics (HB)", Jaico Publishing House, 1999.

References:

1. M. G. Pippenger, "Industrial Hydraulics", MGH, New York, 1979.
2. G. Boothroyd, C. Poli, "Automatic Assembly", Marcel Dekker, New York, 1982.
3. Antony Espossito, "Fluid power with Applications", Prentice Hall, 1980.
4. Dudleyt, A. Pease, John J. Pippenger, "Basic Fluid Power", Prentice Hall, 1987.
5. W. Bolton, "Pneumatic and Hydraulic Systems", Butterworth, Heineman, 1997.

Elective V

Steam and Gas Turbines

ME 606B	Steam and Gas Turbine	PCE	3-0-0	3 Credits

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	State Various properties of Steam, Draw P-V, T-s, H-s (Mollier) diagrams for steam, Describe Theoretical steam turbine cycle.
CO2	Define and Understand Various Types of Design of Turbines.
CO3	Perform analysis of given steam and gas Turbine power plant (Efficiencies, Power Output, Performance)
CO4	Study and apply various Performance improvement Techniques in steam and gas Turbines
CO5	Assess factors influencing performance of thermal power plants,
CO6	Apply various maintenance procedures and trouble shootings to Turbines.

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1										
CO2	1	1										
CO3		2			2							
CO4	1				1	2	2					
CO5	1	2										
CO6	1	1		3								

Course Contents:

Unit 1: Introduction
Properties of steam, Theoretical steam turbine cycle. The flow of steam through Impulse and Impulse–Reaction turbine blades

Unit 2:
Vortex flow in steam turbines, Energy lines, State point locus, Reheat factor and Design procedure. Governing and performance of steam turbine

Unit 3: Gas Turbine
Introduction, simple open cycle gas turbine, Actual Brayton cycle, Means of Improving the efficiency and the specific output of simple cycle,

Unit 4: Gas Turbine Cycle Modifications and Performance
Regeneration, Reheat, Intercooling, closed-cycle gas turbine, turbine velocity diagram and work done.

Unit 5: Turbine Cooling
Turbine blade cooling, material, protective coating, Performance of turbine, Application of turbine.

Unit 6:
Lubrication, cooling, fuel supply and control, Maintenance and trouble shooting.

Texts:
1. W. J. Kearton, "Steam Turbine Theory and Practice", ELBS.

References:
1. R. Yadav, "Steam and Gas Turbine", Central Publishing Home, Allahabad.
2. Jack D. Mattingly, "Elements of Gas Turbine propulsion", Tata McGraw Hill Publications.

Elective V

Industrial Product Design

ME 606C	Industrial Product Design	PCE	3-0-0	3 Credits

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Identify design and development process of industrial products, considering ergonomic requirements
CO2	Explain market requirements and manufacturing aspects of industrial design
CO3	Identify consumer products, functions and use
CO4	Explain aesthetic concept, symmetry
CO5	Explain economic considerations, value analysis and cost reduction
CO6	Employ standard organization structure, standardization, record keeping

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	1		2							2
CO2		3	2	1	3							2
CO3		1	2		1							2
CO4	1		2		2							2
CO5		2	1	3								
CO6								1	2	2	3	2

Course Contents:

Unit 1: Introduction-Approach to Industrial Design

a. Approach to industrial product based on idea generation and innovations to meet the needs of the developing society. Design and development process of industrial products, various steps such as creative process involved in idea marketing, designers, mind-criticism, design process, creation.
b. Ergonomics and aesthetic requirements of product design, quality and maintainability consideration in product design, Use of modeling technique, prototype designs, conceptual design.

Unit 2: Industrial Product Design

a. General design situations, setting specifications, requirements and ratings, their importance in the design, Study of market requirements and manufacturing aspects of industrial designs.
b. Aspects of ergonomic design of machine tools, testing equipment, instruments, automobiles, process equipment etc. Convention of style, from and color of industrial design.

Unit 3: Design of Consumer Product

a. Functions and use, standard and legal requirements, body dimensions.
b. Ergonomic considerations, interpretation of information, conversions for style, forms, colors

Unit 4: Aesthetic Concepts

a. Concept of unity order with variety, concept of purpose, style and environment, Aesthetic expression of symmetry, balance, contrast and continuity, proportion, rhythm, radiation.
b. Form and style of product: visual effect of line and form, mechanics of seeing, psychology of seeing, influence of line and form, Components of style, Basic factors, effect of color on product appearance, color composition, conversion of colors of engineering products.

Unit 5: Economic Considerations

Selection of material, Design for production, use of standardization, value analysis and cost reduction, maintenance aspects in design.

Unit 6: Design Organization

Organization Structure, Designer position, Drawing office procedure, Standardization, record keeping, legal procedure of Design patents.

Reference Books:

1. W. H. Mayall, “Industrial Design for Engineers”, London Hiffee books Ltd, 1967.
2. Hearn Buck, “Problems of Product Design and Development”, Pergamon Press.
3. Charles H. Fluerichem, “Industrial Designs in Engineering”
4. Ezio Manzini, “Material of Invention: Materials and Design”, The MIT Press, 1989.
5. Percy H. Hill, “The Science of Engineering Design”, Holt, Rinehart and Winston Publication, 1970.

Elective V

Nanotechnology

ME 606D	Nanotechnology	POE	3-0-0	3 Credits

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Demonstrate the understanding of length scales concepts, nanostructures and nanotechnology.
CO2	To impart basic knowledge on various synthesis and characterization techniques involved in Nanotechnology
CO3	To educate students about the interactions at molecular scale
CO4	Evaluate and analyze the mechanical properties of bulk nanostructured metals and alloys, Nano-composites and carbon nanotubes.
CO5	To make the students understand about the effects of using nanoparticles over conventional methods

Mapping of course outcomes with program outcomes

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

Course Contents:

Unit 1: Scientific Revolutions
Types of Nanotechnology and Nano machines: the Hybrid nanomaterial. Multiscale hierarchical structures built out of Nano sized building blocks (nano to macro).Nanomaterials in Nature: Nacre, Gecko, Teeth. Periodic table, Atomic Structure, Molecules and phases, Energy, Molecular and atomic size, Surfaces and dimensional space: top down and bottom up.

Unit 2: Forces between Atoms and Molecules
Particles and grain boundaries, strong Intermolecular forces, Electrostatic and Vander Waals forces between surfaces, similarities and differences between intermolecular and inter particle forces covalent and coulomb interactions, interaction polar molecules.
Thermodynamics of self-assembly.

Unit 3: Opportunity at the Nano Scale
Length and time scale in structures, energy landscapes, Inter dynamic aspects of inter molecular forces, Evolution of band structure and Fermi surface.

Unit 4: Nano Shapes
Quantum dots, Nano wires, Nano tubes, 2D and 3D films, Nano and mesopores, micelles, bilayer, vesicles, bionano machines, biological membranes.

Unit 5: Influence of Nano Structuring
Influence of Nano structuring on mechanical, optical, electronic, magnetic and chemical properties-gram size effects on strength of metals- optical properties of quantum dots.

Unit 6: Nano Behaviour
Quantum wires, electronic transport in quantum wires and carbon nano-tubes, magnetic behavior of single domain particles and nanostructures, surface chemistry of Tailored monolayer, self-assembling.

Texts:
1. C. Koch, "Nanostructured materials: Processing, Properties and Potential Applications", Noyes Publications, 2002.
2. C. Koch, I. A. Ovidko, S. Seal and S. Veprek, "Structural Nano crystalline Materials: Fundamentals & Applications", Cambridge University Press, 2011.

References:
1. Bharat Bhushan, "Springer Handbook of Nanotechnology", Springer, 2nd edition, 2006.
2. Laurier L. Schramm, "Nano and Microtechnology from A-Z: From Nano-systems to Colloids and Interfaces", Wiley, 2014.

Elective V

Intellectual Property Rights

ME 606E	Intellectual Property Rights	POE	3-0-0	3 Credits

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	State the basic fundamental terms such as copyrights, Patents, Trademarks etc.,
CO2	Interpret Laws of copy-rights, Patents, Trademarks and various IP registration Processes.
CO3	Exhibit the enhance capability to do economic analysis of IP rights, technology and innovation related policy issues and firms commercial strategies.
CO4	Create awareness at all levels (research and innovation) to develop patentable technologies.
CO5	Apply trade mark law, copy right law, patent law and also carry out intellectual property audits.
CO6	Manage and safeguard the intellectual property and protect it against unauthorized use.

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1											
CO2								1				
CO3		1						1				
CO4										1		
CO5	1							1				
CO6								2				

Course Contents:

Unit 1: Introduction to Intellectual Property
Introduction, types of intellectual property, international organizations, agencies and treaties, importance of intellectual property rights.

Unit 2: Trade Marks
Purpose and function of trademarks, acquisition of trade mark rights, protectable matter, selecting and evaluating trade mark, trade mark registration processes.

Unit 3: Law of Copy Rights
Fundamental of copy right law, originality of material, rights of reproduction, rights to perform the work publicly, copy right ownership issues, copy right registration, notice of copy right, international copy right law.

Unit 4: Law of Patents
Foundation of patent law, patent searching process, ownership rights and transfer.

Unit 5: Trade Secrets
Trade secretes law, determination of trade secretes status, liability for misappropriations of trade secrets, protection for submission, trade secrete litigation.
Unfair competition: Misappropriation right of publicity, false advertising.

Unit 6: New Development of Intellectual Property
New developments in trade mark law; copy right law, patent law, intellectual property audits. International overview on intellectual property, international trade mark law, copy right law, international patent law, and international development in trade secrets law.

Texts:

1. Deborah, E. Bouchoux, “Intellectual Property Right”, Cengage learning.
2. Prabuddha Ganguli, “Intellectual property right: Unleashing the knowledge economy”, Tata McGraw Hill Publishing Company Ltd.

References:

1. Ajit Parulekar, Sarita D’Souza, “Indian Patents Law-Legal and Business implications”, Macmillan India Ltd., 2006.
2. B. L. Wadhera, “Law related to patents, Trademarks, Copyrights, Designs and Geographical indications”, Universal law Publishing Pvt. Ltd., India, 2000.
3. P. Narayanan, “Law of copyright and Industrial Designs”, Eastern Law house, Delhi, 2010.

Elective V

Additive Manufacturing Processes

ME 606F	Additive Manufacturing Processes	PCE	3-0-0	3 Credits

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Understand the importance of Additive Manufacturing
CO2	Classify the different AM processes
CO3	Design for AM processes
CO4	Understand the applications of AM
CO5	Differentiate the post processing processes

Mapping of course outcomes with program outcomes

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

Course Contents:

Unit 1: Introduction to Additive Manufacturing (AM)
Introduction to AM, AM evolution, Distinction between AM and CNC machining, Advantages of AM.
AM process chain: Conceptualization, CAD, conversion to STL, Transfer to AM, STL file manipulation, Machine setup, build , removal and clean up, post processing.
Classification of AM processes: Liquid polymer system, discrete particle system, molten material systems, and solid sheet system.

Unit 2: Design for AM
Motivation, DFMA concepts and objectives, AM unique capabilities, Exploring design freedoms, Design tools for AM, Part Orientation, Removal of Supports, Hollowing out parts, Inclusion of Undercuts and Other Manufacturing Constraining Features, Interlocking Features, Reduction of Part Count in an Assembly, Identification of markings/ numbers etc.

Unit 3: Guidelines for Process Selection
Introduction, selection methods for a part, challenges of selection, example system for preliminary selection, production planning and control

Unit 4: AM Applications
Functional models, Pattern for investment and vacuum casting, Medical models, art models, Engineering analysis models, Rapid tooling, new materials development, Bi-metallic parts,

Re-manufacturing. Application examples for Aerospace, defence, automobile, Bio-medical and general engineering industries

Unit 5: Post Processing of AM Parts
Support material removal, surface texture improvement, accuracy improvement, aesthetic improvement, preparation for use as a pattern, property enhancements using non-thermal and thermal techniques.

Unit 6: Future Directions of AM
Introduction, new types of products, employment and digiproneurship.

Texts:
1. Chua Chee Kai, Leong Kah Fai, "Rapid Prototyping: Principles and Applications", World Scientific, 2003.
2. Ian Gibson, David W. Rosen, Brent Stucker, "Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing", Springer, 2nd edition, 2010.

References:
1. Ali K. Kamrani, Emand Abouel Nasr, "Rapid Prototyping: Theory and Practice", Springer, 2006.
2. D. T. Pham, S. S. Dimov, "Rapid Manufacturing: The Technologies and Applications of Rapid Prototyping and Rapid Tooling", Springer, 2001.
3. Andreas Gebhardt, "Understanding Additive Manufacturing", Hanser Publishers, 2011.

Manufacturing Processes Laboratory-II

ME 607	Manufacturing Processes Laboratory–II	PCC	0-0-2	1 Credits

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Evaluate the work material effect on chip morphology.
CO2	Estimate the cutting forces in orthogonal cutting.
CO3	Measure tool flank wear in cylindrical turning.
CO4	Analyze the effect of process parameter on cutting force in milling.
CO5	Perform PCM and measure undercut achieved
CO6	Determine the MRR and TWR in electro-discharge machine.
CO7	Demonstrate the wire EDM process.
CO8	Perform MIG welding of steel and measure weld dimensions.

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1	3	1	1			1	2		1
CO2	3	2	1	3	1	1			1	2		1
CO3	3	2		3	1	1			1	2		1
CO4	3	2		3	1	1			1	2		1
CO5	3	1		2	1	2			1	2		2
CO6	3	1	1	2	1	2			1	2		2
CO7	1	1	1	2	1	2			1	1		2
CO8	1	1	1	2	1	2			1	2		2

List of Practicals/Experiments/Assignments

1. Measurement of cutting forces in turning operation.
2. Measurement of cutting forces in milling operation.
3. Measurement of cutting forces in drilling operation.
4. Study the effect of cutting parameters on surface finish.
5. Study the effect of cutting parameters on flank wear.
6. Measurement of cutting tool temperature by using work tool thermocouple technique.
7. To develop a manual part program of a given component on CNC Lathe using G and M codes.
8. To develop a manual part program of a given component on CNC Lathe using stock removal cycle.
9. To develop a manual part program of a given component on CNC Lathe using canned cycle.
10. To develop a manual part program of a given component on CNC Milling machine using G and M code.
11. To develop a manual part program of a given component on CNC Milling machine using pocket milling cycle.
12. To develop a manual part program of a given component on CNC Milling machine using canned cycle.
13. To examine the effect of parameters on MRR and TWR in electro discharge machining.
14. To evaluate machining accuracy in EDM.

Industrial visits to study manufacturing practices.

Machine Design Practice-II

ME 608	Machine Design Practice-II	PCC	0-0-2	1 Credit

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Apply design process to an open ended problems
CO2	Determine suitable material and size for structural component of machine/system
CO3	Apply iterative technique in design including making estimate of unknown values for first computation and checking or revisiting and re-computing
CO4	Choose logically and defend selection of design factors
CO5	Design of components for given part/system i.e shaft, keys, coupling, links, screws, springs etc.
CO6	Work effectively as a part of design group/team
CO7	Have good communication skill, orally, graphically as well as in writing

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1	2	2			2	1				
CO2	1	3	2	1			1	1				1
CO3	3	2	2	1			1	1				1
CO4	2	2	2	2			1	1				1
CO5	3	3	2	1			2	1				1
CO6						1	1	1	2	2		2
CO7								1	1	2	2	3

List of Practicals/Experiments/Assignments

1. The term work shall consist of 2 design projects based on syllabus of Machine Design-III. Each design project shall consist of 2 full imperial size sheets-one involving assembly drawings with a part list and overall dimensions and other sheet involving drawings of individual components. Manufacturing tolerances, surface finish symbols and geometric tolerances should be specified, wherever necessary, so as to make it a working drawing.
   A design report giving all necessary calculations for the design of components and assembly should be submitted in a separate file. Sheets for one of the projects will be drawn using AutoCAD and computer printouts using plotter of the same will be attached along with the design report.
2. At least two assignments based on topics of syllabus of Machine Design-II.

Thermal Engineering Lab-II

ME 609	Thermal Engineering Lab-II	PCC	0-0-2	1 Credit

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Conduct test on hydraulic turbines like Pelton wheel, Francis turbine, IC Engines, Refrigeration and air conditioning test units, solar system etc. to study their performance.
CO2	Draw performance curves of these machines/systems.
CO3	Analyse the results obtained from the tests.
CO4	Draw conclusions based on the results of the experiments

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1		2		2	1							
CO2	1	1			1							
CO3		1			1							
CO4				2								

List of Practicals/Experiments/Assignments

A. Fluid Machines (Any **Two** experiments from the list)

1. Trial to study hydraulic jump
2. Trial on Pelton Turbine for performance testing.
3. Trial on Francis Turbine for performance testing.
4. Trial on Kaplan Turbine for performance testing.
5. Trial on Centrifugal Pump with constant and variable speed.
6. Trial on Gear Pump/Reciprocating Pump for performance testing.
7. Visit to Hydel Power Plant

B. IC Engines (Any **Three** experiments from the list)

1. Trial on Diesel engine- variable load test and energy balance.
2. Trial on Petrol engine- variable speed test and energy balance.
3. Trial on Petrol Engine- Morse Test.
4. Measurements of exhaust emissions of Petrol engine & Diesel engine.
5. Visit to Large Vehicle Service Center/Industry related Automobiles/Components.

C. Refrigeration (Any Two from the list**) and Air-conditioning (Any Two** from the list**)**

1. Trial on vapour compression Refrigeration system
2. Trial on Ice Plant
3. Trial on Window Air Conditioner
4. Trial on Water to Water Heat Pump
5. Trial on Air to Water Heat Pump
6. Trial on Vortex Tube Refrigeration system
7. Trial on Electrolux Vapour Absorption Refrigeration system
8. Study and practice of sensible heating and cooling Air- conditioning process
9. Study and practice of cooling and dehumidification Air- conditioning process
10. Study and practice of heating and humidification Air- conditioning process
11. Study and practice of adiabatic air mixing Air- conditioning process
12. Study and practice of reheating Air- conditioning process
13. Study and practice of direct Evaporative cooling Air- conditioning system

14. Study and practice of indirect – direct Evaporative cooling Air- conditioning system
15. Field visit to Central Air-conditioning plant/Ice plant/Refrigeration plant

D. Renewable Energy (Any One from the list)

1. Performance Test on Solar Water Heater
2. Performance Test on Solar Air Heater
3. Performance Test on Solar Photovoltaic Cells
4. Performance Test on Solar Still
5. Performance Test on Solar Cooker (Box type/ Dish type)
6. Power Plant Visit

Technical Project on Community Services

ME 610	Technical Project for Community Services	PCC	0-0-3	2 Credit

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Visit nearby places to understand the problems of the community
CO2	Select one of the problems for the study, state the exact title of the project and define scope of the problem
CO3	Explain the motivation, objectives and scope of the project
CO4	Evaluate possible solutions of the problem
CO5	Design, produce, test and analyze the performance of product/system/process
CO6	Modify, improve the product/system/process

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1						2	1	1		2		1
CO2		2								2	1	
CO3						1				2	1	
CO4		1	2				1	2				
CO5	1	1	2	3	1	1	1	2	1	1	1	
CO6			2	1	1		1	1				

Rationale

The role of technical institutes in giving technical and advisory services to the surrounding community need not be emphasized. It is desirable that each faculty member and student be involved in rendering services to community and economy. Moreover, as per Section (4) of the Act of this University, technical services to community, particularly the backward areas, is one of the basic objects of the University. In view of this, “Technical Project related to Community Services” has been included in the curriculum. This will ensure the participation of each student as well as faculty in this activity.

The weekly contact hours and the evaluation scheme for this project are as stated above. The nature of project work should be as given below in the course contents.

List of Practicals/Experiments/Assignments

The projects may be of varying nature such as a technical study/survey, design/development of a technology solution for an identified need, infusion/transfer of technology, etc. All this will be within the ambit of technology and expertise available within the University.

The student may form small groups, typically of 2 to 3 students, and carry out the project under the supervision of a faculty member.

Summer Vacation Training

ME 611	Summer Vacation Training	PCC	---	---

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	To make the students aware of industrial culture and organizational setup
CO2	To create awareness about technical report writing among the student.

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1		1	1			2		1			3	3
CO2		1	1			2		1			3	2

Students will have to undergo 6 weeks training programme in the Industry during the summer vacation after VIth semester examination. It is expected that students should understand the organizational structure, various sections and their functions, products/services, testing facilities, safety and environmental protection measures etc.

Also, students should take up a small case study and propose the possible solution(s).

They will have to submit a detailed report about the training programme to the faculty coordinator soon after joining in final year B. Tech. Programme. They will have to give a power point presentation in front of the group of examiners.

Semester VII

Mechatronics

ME 701	Mechatronics	PCC	3-0-0	3 Credits

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Define sensor, transducer and understand the applications of different sensors and transducers
CO2	Explain the signal conditioning and data representation techniques
CO3	Design pneumatic and hydraulic circuits for a given application
CO4	Write a PLC program using Ladder logic for a given application
CO5	Understand applications of microprocessor and micro controller
CO6	Analyse PI, PD and PID controllers for a given application

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1	1	3	2				2	1		1
CO2	3	2			3	3	2				1	3
CO3	1	1		3	3	2	1		3		1	3
CO4	3	3	1	1	3		1	1	1			
CO5	3			1	3	2	3					2
CO6		3	3		3	3	1	1	3			2

Course Contents:

Unit 1: Introduction

Introduction to Mechatronic systems, elements, advantages; practical examples of Mechatronic systems.

Sensors and Transducers: Various types of sensors and transducers used in Mechatronic system such as pressure sensors, temperature sensors, velocity sensors, Acceleration sensors, proximity sensors, position sensors, force sensors, Optical encoders, Capacitive level sensor, tactile sensors, Selection of sensors.

Unit 2: Signal Conditioning and Data Representation

Types of electronic signals, Need for signal processing, Operational amplifiers: Types, classification and applications, Opto-isolators, Protection devices, Analogue to Digital and Digital to Analog Converters, Interfacing devices, Electro-magnetic Relays.

Data representation systems, Displays, Seven segment displays, LCD displays, Printers, Data loggers, Data Acquisition Cards/Systems

Unit 3: Drives

Electrical Drives: Types of Electrical Motors, AC and DC motors, DC servomotors, Stepper motors, linear motors, etc.

Pneumatics and Hydraulics: Components of Pneumatic systems, actuators, direction control valves, pneumatic air preparation, FRL unit, methods of actuation of valves, Sequencing of Pneumatic cylinders using Cascade and shift register methods. Electro-pneumatic valves, Electro- pneumatic circuits using single and double solenoid methods.
Hydraulic cylinders, design of cylinder, Design of Piston and piston rod, Valves, poppet valve, house pipes and design of tubing, Meter-in and Meter-out circuits.

Unit 4: Microprocessor and Microcontroller

8085 microprocessor: architecture, various types of registers and their functions in 8085µP, Instruction sets, interfacing, applications. 8081 microcontroller: architecture, Instruction sets, various pins and their functions interfacing, applications.

Programmable Logic Controller: Introduction, Architecture, Types of inputs/outputs, Specifications, guidelines for Selection of PLCs, Programming: Ladder logic and FBD

Unit 5: Control Systems

Open and closed loop system; block diagram manipulation/reduction, Transfer function, modeling of Mechanical Systems using Spring, Dashpot and Mass equivalence.

Unit 6: Stability of Systems

On/Off controller, Proportional Control, Integral control, Derivative Control; PI, PD and PID Controllers, Introduction to control using state variable system models, Bode Plots and stability criteria.

Texts:

1. HMT Limited, "Mechatronics", Tata McGraw Hill Publications, 1998.
2. W. Bolton, "Mechatronics; Electronic Control System in Mechanical Engineering", Pearson Education Asia, 1999.
3. Raven, "Automatic Control Engineering", Tata McGraw Hill Publications, New York, 1986.

References:

1. R. K. Rajput, "A textbook of Mechatronics", S. Chand and Co., 2007.
2. Michael B. Histand, David G. Alciatore, "Introduction to Mechatronics and Measurement Systems", Tata McGraw Hill International Editions, 2000.
3. D. A. Bradley, D. Dawson, N. C. Buru, A. J. Loader, "Mechatronics", Chapman and Hall, 1993.

Industrial Engineering and Management

ME 702	Industrial Engineering and Management	PCC	4-0-0	4 Credit

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Impart fundamental knowledge and skill sets required in the Industrial Management and Engineering profession, which include the ability to apply basic knowledge of mathematics, probability and statistics, and the domain knowledge of Industrial Management and Engineering
CO2	Produce ability to adopt a system approach to design, develop, implement and innovate integrated systems that include people, materials, information, equipment and energy.
CO3	Understand the interactions between engineering, businesses, technological and environmental spheres in the modern society.
CO4	Understand their role as engineers and their impact to society at the national and global context.

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1											2	1
CO2									2	2	2	
CO3								2				
CO4								2				2

Course Contents:

Unit 1: Introduction

Managing and managers, management- science, theory and practice, functions of management, evolution of management theory, contributions of Taylor, Fayol and others.

Planning: The nature and purpose of planning, objectives, strategies, policies and planning premises, decision making.

Organizing: The nature and purpose of organizing, departmentation, Line/ staff authority and decentralization, effective organizing and organizational culture.

Unit 2: Human Resource Management

Staffing: Human resource management and selection, orientation, apprentice training and Apprentice Act (1961), performance appraisal and career strategy, job evolution and merit rating, incentive schemes.

Leading: Managing and human factor, motivation, leadership, morale, team building, and communication.

Controlling: The system and process of controlling control techniques, overall and preventive control.

Unit 3: Production/Operations Management
Operations management in corporate profitability and competitiveness, types and characteristics of manufacturing systems, types and characteristics of services systems.
Operations planning and Control: Forecasting for operations, materials requirement planning, operations scheduling.

Unit 4: Design of Operational Systems
Product/process design and technological choice, capacity planning, plant location, facilities layout, assembly line balancing, and perspectives on operations systems of the future.

Unit 5: Introduction to Industrial Engineering
Scope and functions, history, contributions of Taylor, Gibreth, Gantt and others.
Work Study and Method Study: Charting techniques, workplace design, motion economy principles.
Work Measurement: Stopwatch time study, micromotion study, predetermined time system (PTS), work sampling.

Unit 6: Ergonomics
Basic principles of ergonomics
Concurrent Engineering: Producibility, manufacturability, productivity improvement.
Total Quality Management: Just in time (JIT), total quality control, quality circles, six sigma.

Texts:

1. H. Koontz, H. Weirich, "Essentials of Management", Tata McGraw Hill book Co., Singapore, International Edition, 5th edition, 1990.
2. E. S. Buffa, R. K. Sarin, "Modern Production/Operations Management", John Wiley and Sons, New York, International Edition, 8th edition, 1987.
3. P. E. Hicks, "Industrial Engineering and Management: A New Perspective", Tata McGraw Hill Book Co., Singapore, International Edition, 2nd edition, 1994.

References:

1. J. L. Riggs, "Production Systems: Planning, Analysis and Control", John Wiley & Sons, New York, International Edition, 4th edition, 1987.
2. H. T. Amrine, J. A. Ritchey, C. L. Moodie, J. F. Kmec, "Manufacturing Organization and Management", Pearson Education, 6th edition, 2004.
3. International Labour Organization (ILO), "Introduction to Work Study", International Labour Office, Geneva, 3rd edition, 1987.
4. www.nptel.com.

Computer Aided Design and Manufacturing (CAD/CAM)

ME 703	CAD/CAM	PCC	4-0-0	4 Credit

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	List and describe the various input and output devices for a CAD work station
CO2	Carry out/calculate the 2-D and 3-D transformation positions (Solve problems on 2-D and 3-D transformations)
CO3	Describe various CAD modeling techniques with their relative advantages and limitations
CO4	Describe various CAD modeling techniques with their relative advantages and limitations
CO5	Develop NC part program for the given component, and robotic tasks
CO6	Describe the basic Finite Element procedure
CO7	Explain various components of a typical FMS system, Robotics, and CIM
CO8	Classify parts in part families for GT
CO9	Describe and differentiate the CAPP systems

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3											1
CO2	3	2	1		2							1
CO3	1		1									1
CO4	3											1
CO5	1	3	3		1							1
CO6	3	1	1		1							1
CO7	3											1
CO8	3	1	2	3	1							1
CO9	2	1										1

Course Contents:

Unit 1: Computer Aided Design (CAD)

Hardware required for CAD: Interactive input output devices, Graphics software: general requirements and ground rules, 2-D curves like Line, Circle, etc. and their algorithms, 2-D and 3-D transformations such as Translation, Scaling, Rotation and Mirror

Unit 2: Bezier and B-splines Curves

Equations and Applications, window and view port clipping algorithms, 3-D geometries, CSG, B-rep, wire frame, surface and solid modeling and their relative advantages, limitations and applications.

Unit 3: Computer Aided Manufacturing (CAM)

Numerical Control, Elements of a NC system, Steps in NC based manufacturing, Point to

point, straight line and contouring control, Manual and Computer Assisted Part Programming, NC and APT programming, Adaptive control, Distributed Numerical Control.

Unit 4: Finite Element Methods

Introduction, Types of elements, Degrees of freedom, Field variable, Shape function, Boundary conditions, Meshing, Nodal displacements, Plain stress and plain strain problems, 1-D, 2-D and 3-D problems, Static, dynamic and thermal analysis, Preprocessors – solvers – postprocessor.

Unit 5: Flexible Manufacturing System

Introduction, Components of FMS, Group Technology, Part classification and families, Composite part, Types of FMS layouts, Advantages of FMS

Robotics: Robot configurations, Drives for robots, Sensors used in robotics, Programming technique, Programming languages, Applications, Latest development in robotics

Unit 6: Computer Aided Process Planning

Introduction, Retrieval and Generative CAPP systems, generation of Machining Data.

Computer Integrated Manufacturing: Introduction, Types of data, Types of interfaces, Computer network structures, Computerized production management systems, Inventory management, MRP, Operation scheduling, Process monitoring, Computer aided quality control, Testing/Inspection methods.

Texts:

1. Ibrahim Zeid, "CAD/CAM Theory and Practice", Tata McGraw Hill Publication,
2. M. P. Grover, Zeemer, "CAD/CAM/CIM", Prentice Hall, India.

Power Plant Technology

ME 704	Power Plant Technology	PCC	3-0-0	3 Credit

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Recognize the current power generation scenario across the globe and compare the different sources used by different nations for power generation. Discuss the most important energy source in India for power generation along with its current status. and the types of power plants
CO2	Describe the fuel handling and ash handling in thermal power plants.
CO3	Explain the working of steam turbine power plant, gas turbine power plant, thermal power plant, diesel power plant, hydroelectric power plant, nuclear power plant and non-conventional power generation plants like wind power plants, tidal power plants, solar photovoltaic power plants and fuel cells, solar thermal power plants. Write functions of their important components.
CO4	Describe different high pressure boilers used in power plants and write their advantages.
CO5	Study Rankine cycle with reheat, regeneration and reheat – regeneration, etc. and analyze their performance.

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1				1	1					
CO2	1	1										
CO3	1											
CO4	1	1										
CO5	1	2										

Course Contents:

Unit 1: Sources of Energy for Power Plant

Fossil fuels, petroleum products, Hydel, Nuclear, Wind, Tidal and Geo-thermal energy etc. **Cycle for Steam and Gas Turbine Power Plant:** Rankine cycle, Reheat cycle, Regenerative cycle, Reheat-regenerative cycle, Binary cycle, topping cycle, Cogeneration, Regeneration, and Intercooling.

Unit 2: High Pressure Boilers

Introduction, Advantages of high pressure boilers, Lamont boiler, Benson boiler, Loeffler boiler, Schmidt-Hartmann boiler, Velox boiler, super critical boiler, Design consideration for modern boilers, Introduction to IBR.

Unit 3: Thermal Power Plant

Introduction, general layout of modern thermal power plant, working, site selection and material requirements.

Fuel and Ash Handling: Introduction, out-plant and in-plant handling of coal, coal storage, coal crushing and pulverized coal systems, coal burning methods, overfeed underfeed stokers, pulverized fuels and their advantages, pulverized fuel burners, ash handling systems, different types of dust collectors, ash and dust disposal.

Unit 4: Diesel Power Plant

Introduction, field of use, plant layout, comparison of diesel power plant with other power plants, recent developments.

Gas Turbine Power Plant (GTPP): Introduction, classification and comparison with other types, types GTPP, advantages and disadvantages over other power plants, gas handling, present and future trends.

Unit 5: Hydro-Electric Power Plant

Introduction, general layout of hydro-electric power plant, Site selection, Classification, Run-off river plants with and without pondage, store reservoir plants, pump-storage plants, Advantages of hydro-electric power plant, Safety measures.

Nuclear Power Plant: Introduction, nuclear reactions, nuclear fuels, site selection, components of reactors, types of reactors, material requirement, effect of nuclear radiation, disposal of nuclear waste, safety requirement of nuclear power plant.

Unit 6: Economy Analysis of Power plants

Introduction, load calculation, load curve, diversity factor, load factor, plant use factor,

meeting fluctuating load by various power plants, cost of electrical energy, performance and operating characteristics of power plants, load division among generators.
Non-conventional Power Generation: Solar Energy Collector Types, Low, medium and high temperature power plants, OTEC, wind power plants, tidal & geothermal power plants, solar photovoltaic power plants. Fuel cells.

Texts:
1. P. K. Nag, "Power Plant Engineering", Tata McGraw Publishing Hill Co.
2. El Wakil, "Power Plant Technology", Tata McGraw Hill Publishing Co.

References:
1. S. C. Arora, S. Domkundwar, " A Course in Power Plant Engineering", Dhanpat Rai and Sons, New Delhi.
2. Frederick T. Morse, "Power Plant Engineering", Affiliated East-West Press Pvt. Ltd. New Delhi.

Elective VI
Finite Element Analysis

ME 705A	Finite Element Analysis	PCE	3-0-0	3 Credit

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Understand the basic principle of Finite element methods and its applications
CO2	Use matrix algebra and mathematical techniques in FEA
CO3	Identify mathematical model for solution of common engineering problem
CO4	Solve structural , thermal problems using FEA
CO5	Derive the element stiffness matrix using different methods by applying basic mechanics laws
CO6	Understand formulation for two and three dimensional problems

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1	1		1				1		1	1
CO2	2	3	2	1	2	1		1			2	1
CO3	3	2	2	1	1				1		2	1
CO4	3	3	2	1	2		1		1		2	1
CO5	3	1	1		1		1				2	1
CO6	1	1	1						1		1	1

Course Contents:

Unit 1: Introduction
Finite element analysis and its need, Advantages and limitations of finite element analysis (FEA), FEA procedure.

Unit 2: Elements of Elasticity
Stress at a point, Stress equation of equilibrium, 2-D state of stress, Strains and displacements, Stress-strain relationship for 2-D state of stress, Plane stress and plane strain approach.

Unit 3: Relevant Matrix Algebra
Addition, subtraction and multiplication of matrices, Differentiation and integration of matrices, Inverse of a matrix, Eigen values and eigen vectors, Positive definite matrix, Gauss elimination.

Unit 4: One-Dimensional Problems
Introduction, FE modeling, Bar element, Shape functions, Potential energy approach, Global stiffness matrix, Boundary conditions and their treatments, Examples.

Unit 5: Trusses and Frames
Introduction, Plane trusses, Element stiffness matrix, Stress calculations, Plane frames, examples.

Unit 6: Two-dimensional Problems
Introduction and scope of 2-D FEA, FE modeling of 2-D problem, Constant strain triangle, other finite elements (no mathematical treatment included), Boundary conditions.

Texts:

1. T. R. Chandrupatla, A. D. Belegundu, "Introduction to Finite Elements in Engineering", Prentice Hall of India Pvt. Ltd., 3rd edition, New Delhi, 2004.
2. P. Seshu, "A Textbook of Finite Element Analysis", Prentice Hall of India Pvt. Ltd., New Delhi, 2003.
3. R. D. Cook, D. S. Malkus, M. E. Plesha, R. J. Witt, "Concepts and Applications of Finite Element Analysis", John Wiley & Sons, Inc.

References:

1. K. J. Bathe, "Finite Element Procedures", Prentice Hall of India Pvt. Ltd., 2006.

Elective VI

Mechanical Vibrations

ME 705B	Mechanical Vibrations	PCE	3-0-0	3 Credit

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Understand the cause and effect of vibration in mechanical system
CO2	Formulate governing equation of motion for physical system
CO3	Understand role of damping, stiffness and inertia in mechanical system
CO4	Analyze rotating system and calculate critical speeds
CO5	Estimate the parameters of vibration isolation system
CO6	Estimate natural frequencies and mode shapes of continuous system

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	1	1	2	1	1					2
CO2	3	3	2	1	1							2
CO3	3	2	2	1	1							2
CO4	3	3	2	2	2							2
CO5	3	3	2	2	2		3					2
CO6	3	3	3	2								2

Course Contents:

Unit 1: Single DOF- Free Vibrations

Basic concepts: Causes and effect of vibrations, practical applications, harmonic and periodic motions, vibration terminology, vibration model, Equation of motion -natural frequency, Energy method, Rayleigh method, principle of virtual work, damping model, viscously damped free vibration, Oscillatory, non-oscillatory and critically damped motions, logarithmic decrement. Coulomb's damping.

Unit 2: Single DOF- Forced Vibrations

Analysis of linear and torsional system subjected to harmonic force excitation, force transmissibility, Magnification factor, motion transmissibility, vibration isolation, typical isolator and mounts, critical speed of single rotor, undamped and damped.

Unit 3: Two DOF Systems

Introduction, formulation of equation of motion, equilibrium method, lagrangian method, free vibration response, Eigen values and eigen vector, Normal mode and mode superposition, Coordinate coupling, decoupling equation of motion.

Unit 4: Torsional Vibration

Simple system with one or two rotor masses, Multi DOF system: transfer matrix method, geared system, and branched system.

Unit 5: Multi Degree of Freedom System

Formulation of equation of motion, free vibration response, natural mode and mode shapes, orthogonality of model vectors, normalization of model vectors, decoupling of modes, model analysis, mode superposition technique. Free vibration response through model analysis. DF

Unit 6: Continuous Systems

Vibration of strings, longitudinal and transverse vibration of rods, transverse vibrations of beams, equation of motions and boundary conditions, transverse vibration of beams, natural frequencies and mode shapes.

Texts:

1. L. Meirovich, “Elements of Vibration Analysis”, Tata McGraw Hill.

References:

1. S. S. Rao, “Mechanical Vibrations”, Pearson education.
2. W. T. Thompson, “Theory of Vibration”, CBS Publisher.

Elective VI

Surface Engineering

ME 705C	Surface Engineering	PCE	3-0-0	3 Credit

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Learn the importance and need of surface engineering
CO2	Describe various surface cleaning and modification techniques
CO3	Understand the concepts of surface integrity
CO4	Compare various surface coating technologies
CO5	Select appropriate method of coating for a given application
CO6	Apply measurement techniques and carry out characterization of coated surfaces.

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2		1							1		1
CO2	2				2							
CO3	2	2	1	2						1		
CO4	2				1	1		1		1		
CO5	2	2	1		1		1	1	1	1	1	
CO6	2	2	1	2	2			1	1	1		

Course Contents:

Unit 1: Introduction
Definition, Significance, Role of surface Engineering in creating high performance product, Functional characteristics of a surface, Nature of surfaces: Deformed layer, Beilby layer, chemically reacted layer, Physisorbed layer, Chemisorbed layer; Classification of Surface Engineering Techniques.

Unit 2: Surface Preparation Techniques
Factors affecting selection of cleaning process, Significance of surface preparation, Classification of cleaning processes, Chemical cleaning processes; Mechanical Processes; Substrate considerations, Surface contaminants or soils, Tests for cleanliness.

Unit 3: Surface Integrity
Definition, Importance, Surface alterations, Factors in Surface Integrity: Visual, Dimensional, Residual stress, Tribological, Metallurgical; Measuring Surface Integrity effects: Minimum and Standard data set, Macroscopic and microscopic examination.

Unit 4: Surface Modification Techniques
Classification, Thermal treatments: Laser and electron beam hardening, Mechanical treatments: Short peening: Peening action, surface coverage and peening intensity, Types and

sizes of media, Control of process variables, equipment;
Ion Implantation: Basic Principle, Advantages and disadvantages, equipment.

Unit 5: Surface Coating Techniques
Thermal Spraying: Types and applications; Chemical Vapour Deposition: Principles, Reactions, Types and applications; Physical Vapour Deposition: Basic principle, Evaporation, Sputtering, Ion Plating, Applications; Electroplating: Principle of working and applications; Types of Coatings: Hard, Soft, Single layer, Multi-layer.

Unit 6: Characterization of Coatings
Physical characteristics and their measurements: Coating thickness, Surface Morphology and Microstructure. Mechanical properties and their Measurements: Hardness, Adhesion, Friction and Wear.

References:

1. ASM Handbook, "Volume 5: Surface Engineering", ASM International.
2. K. G. Budinski, "Surface Engineering for Wear Resistance", Prentice Hall.
3. T. Burakowski, T. Wierschon, "Surface Engineering of Metals: Principles, Equipment, Technologies", CRC Press.
4. B. Bhushan, B. K. Gupta, "Handbook of Tribology: Materials, Coatings, and Surface Treatments", Tata McGraw Hill Publications.
5. ASM Handbook, "Volume 16: Machining", ASM International.

Elective VI

Human Resource Management

ME 705D	Human Resource and Management	PCE	3-0-0	3 Credit

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Describe trends in the labor force composition and how they impact human resource management practice.
CO2	Discuss how to strategically plan for the human resources needed to meet organizational goals and objectives.
CO3	Define the process of job analysis and discuss its importance as a foundation for human resource management practice
CO4	Explain how legislation impacts human resource management practice.
CO5	Compare and contrast methods used for selection and placement of human resources.
CO6	Describe the steps required to develop and evaluate an employee training program
CO7	Summarize the activities involved in evaluating and managing employee performance.
CO8	Identify and explain the issues involved in establishing compensation systems.

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1					2						1	
CO2											3	
CO3										2		
CO4								2		2		
CO5									2	3		
CO6										1		3
CO7										2	2	
CO8											2	

Course Contents:

Unit 1: Introduction to Human Resource Management

Concept of management, concept of human resource management, personnel to human resource management, human resource management model, important environmental influences like government regulations, policies, labor laws and other legislation. **Acquisition of human resources:** Human resource planning, Demand for man power, Weaknesses of manpower planning, job analysis, job specification, recruitment sources, recruitment advertising, the selection process, selection devices, equal opportunities: Indian and foreign practices, socializing the new employee

Unit 2: Development of Human Resources

Employee Training and Management Development: Training, Training and Learning, Identification of training needs, training methods, Manager Development, Methods for developing managers, evaluating training effectiveness

Career Development: Concept of career, value of effective career development, external versus internal dimensions to a career, career stages, linking career dimensions with stages

Unit 3: Motivation of Human Resources

Definition of motivation, Nature and Characteristics of Motivation, Theories of motivation: Maslow's Need Hierarchy Theory, Drucker Theory, Likert Theory, Herzberg Two Factor Theory, McClelland Theory, McGregor Theory X and Y, etc., Psychological approach.

Job Design and Work Scheduling: Design, Scheduling and Expectancy Theory, Job characteristics model, job enrichment, job rotation, work modules, flex-time, new trends in work scheduling.

Unit 4: Performance Appraisal

Performance appraisal and expectancy theory; appraisal process, appraisal methods, factors that can destroy appraisal.

Rewarding the Productive Employee: Rewards and expectancy theory, types of rewards, qualities of effective rewards, criterions for rewards.

Unit 5: Maintenance of Human Resources

Compensation Administration: Concept of Compensation Administration, Job evaluation, Pay structures, Incentives compensation plans.

Benefits and Services Benefits: Something for everybody, Services, Trends in benefits and services.
Discipline: Concept of Discipline, types of discipline problems, general guidelines, disciplinary action, employment-at-will doctrine, disciplining special employee groups
Safety and Health: safety programs, health programs, stress, turn out.

Unit 6: Labor Relations
Unions, Major labor legislation, goals of group representation.
Collective Bargaining: Objectives, scope, participants of collective bargaining, process of collective bargaining, trends in collective bargaining
Research and the future: What is research? Types of research, why research in human resource management, Secondary sources: where to look it up, Primary sources: relevant research methods, current trends and implications for human resource management.

Texts:

1. David A. DeCenzo, Stephen P. Robbins, "Personnel/Human Resources Management", Prentice Hall of India Pvt. Ltd, 3rd edition, 2002.
2. Trevor Bolton, "An Introduction to Human Resource Management", Infinity Books, 2001.

References:

1. Ellen E. Kossek, "Human Resource Management– Transforming the Workplace", Infinity Books, 2001.
2. G. S. Batra, R. C. Dangwal, " Human Resource Management New Strategies", Deep and Deep Publications Pvt. Ltd., 2001.
3. D. M. Silvera, " HRD: The Indian Experience", New India Publications, 2nd edition, 1990.

Elective VI

Design of Heat Exchangers

ME 705E	Design of Heat Exchangers	PCE	3-0-0	3 Credit

Pre-Requisites: Heat Transfer

Course Outcomes: At the end of the course, students will be able to:

CO1	Understand the various design aspects of Heat Exchangers
CO2	Design and analysis of Shell and Tube Heat Exchanger used in process industries
CO3	Develop design procedure through programming and simulation
CO4	Understand the Mechanical design of Heat exchanger

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	1				1					
CO2	3	3	1				1					
CO3	3	3	1	1	3							
CO4	3	3	1	1								

Course Contents:

Unit 1: Introduction
Classification, overview of heat exchanger design methodology: design specification, thermo hydraulic design, and other considerations.

Unit 2: Basic Design Theory
LMTD Method, E-NTU method, P-NTU method, P method and P1-P2 method.

Unit 3: Heat Exchanger Design Procedures
Design of: double-pipe, shell and tube, tube-fin, plate-fin heat exchangers.

Unit 4: Selection of Heat Exchangers
Selection criteria, general selection guidelines of shell and tube heat exchangers, plate-fin heat exchangers.

Unit 5: Thermodynamic Modeling and Analysis
Modeling of heat exchanger based on I law, irreversibility.

Unit 6: Header Design
Flow mal-distribution, fouling and corrosion, advances in heat exchangers.

Texts:
1. R. K. Shah, Deusan P. Sekulic, "Fundamentals of heat exchanger design", John Willeyand Sons, 2003.
2. S. Kakac, "Heat Exchangers: Thermal Hydraulic Fundamentals and Design", Hemisphere, Tata McGraw Hill Publications.

References:
1. D. Q. Kern, A. D. Kraus, "Extended Surface Heat transfer", Tata McGraw Hill Publications.
2. W. M. Kays, A. C. London, "Compact Heat Exchangers", Tata McGraw Hill Publications.

Mechatronics Lab

ME 706	Mechatronics Lab	PCC	0-0-2	1 Credits

Pre-Requisites: Mechatronics

Course Outcomes: At the end of the course, students will be able to:

CO1	Understand the various types of sensors and their applications
CO2	Design a pneumatic circuit for a given application
CO3	Design a hydraulic circuit for a given application
CO4	Write a PLC program using Ladder logic
CO5	Experiment PID controller for controlling temperature
CO6	Demonstrate the capacitance sensor for measuring level

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2							3			1
CO2	1	1	3	3	3		3		3			1
CO3	1	1	3	3	3		3		3			1
CO4	2		3	1	3		1		3			1
CO5	1	1	3	3	3	3	2		3			1
CO6	1	1	3	3	2		2		3			1

List of Practicals/Experiments/Assignments

1. Study and demonstration of various types of sensors
2. Speed control of various types of Electrical Motors
3. Minimum two circuits on Pneumatics to be developed on Pneumatic trainer kit
4. Minimum two circuits on Electro-Pneumatics to be developed on Electro-Pneumatic trainer kit
5. Minimum two circuits on Hydraulics and Electro-hydraulics to be developed on Hydraulic trainer kit
6. Programming of Microprocessor and Microcontroller
7. Programming on PLC
8. Demonstration of Process control such as temperature, level, flow, etc. control using PID controller

CAD/CAM Lab

ME 707	CAD/CAM Lab	PCC	0-0-2	1 Credit

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Construct CAD part models, assembly model and drafting of machine elements using CAD software.
CO2	Evaluate stresses in components subjected to simple structural loading using FE software
CO3	Write NC programs for turning and milling
CO4	Describe case study of industrial robots

Mapping of course outcomes with program outcomes

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

List of Practicals/Experiments/Assignments

1. Part modeling of machine elements using any one of the CAD software out of ProE, CATIA, Unigraphics or Autodesk Inventor Professional.
2. Assembly modeling of assembly or subassembly of engineering products using any one of the CAD software out of ProE, CATIA, Unigraphics or Autodesk Inventor Professional.
3. Drafting of Parts and Assembly of engineering assembly using any one of the CAD software out of ProE, CATIA, Unigraphics, or Autodesk Inventor Professional.
4. Minimum 4 structural analysis problems to be solved using a CAE software like Ansys, Hyperworks, etc.
5. Minimum 2 Jobs (Programs) on CNC Turning operations
6. Minimum 2 Jobs (programs) on CNC Milling operation
7. Case Study of an Industrial Robot

Seminar

ME 708	Seminar	PCC	0-0-3	2 Credit

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	State the exact title of the seminar
CO2	Explain the motivation for selecting the seminar topic and its scope
CO3	Search pertinent literature and information on the topic
CO4	Critically review the literature and information collected
CO5	Demonstrate effective written and verbal communication

Mapping of course outcomes with program outcomes

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

Course Contents:

Before the end of Semester VII, each student will have to deliver a seminar on a subject mutually decided by candidate and his/her guide. The student should select the topic for his/her seminar which is latest and relevant. The student, as a part of the term work, should submit the write-up of the seminar topic in duplicate, typed on A4 size sheets in a prescribed format and bound at the end of semester.
The performance of the student will be evaluated on the basis of the contents, the presentation and discussion during the delivery of seminar before the evaluation committee appointed by the Department.

Project Stage-I

ME 709	Project Stage-I	PCC	0-0-4	2 Credits

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	State the exact title of the project and problem definition
CO2	Explain the motivation, objectives and scope of the project
CO3	Review the literature related to the selected topic of the project
CO4	Design the mechanism, components of the system and prepare detailed drawings.
CO5	Evaluate the cost considering different materials/manufacturing processes

Mapping of course outcomes with program outcomes

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

Course Contents:
The students in a group of not more than FOUR will work under the guidance of the faculty member on the project work undertaken by them. The completion of work, the submission of the report and assessment should be done at the end of VII Sem.
The project work should consist of any of the following or appropriate combination:

1. A comprehensive and up-to-date survey of literature related to study of a phenomenon or product.
2. Design of any equipment and / or its fabrication and testing.
3. Critical Analysis of any design or process for optimizing the same.
4. Experimental verification of principles used in applications related to various specializations related to Mechanical Engineering.
5. Software development for particular applications.
6. A combination of the above.

It is expected that the students should complete at least 40% of the total project work in VII Semester. The objective is to prepare the students to examine any design or process or phenomenon from all angles, to encourage the process of independent thinking and working and to expose them to industry.

The students may preferably select the project works from their opted elective subjects. The students should submit the report in a prescribed format, before the end of VII semester. The report shall be comprehensive and presented typed on A_4 size sheets and bound. Number of copies to be submitted is number of students plus two. The assessment would be carried out by the panel of examiners for both, term work and oral examinations.

Semester VIII

Elective VII

Biomechanics

ME 801A	Biomechanics	PCE	3-0-0	3 Credit

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Explain various forces and mechanisms and define Newton's law of motion, work and energy, moment of inertia
CO2	Describe forces and stresses in different human joints
CO3	Discuss bio fluid mechanics in cardiovascular and respiratory system in human body
CO4	Differentiate between hard tissues and soft tissues
CO5	Understand concepts of implants and Identify different techniques used in biomechanics implants

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	1			1	1	1	1		1	1
CO2	2	2	2			1	2		1		1	1
CO3	2	2	2			1	1	1	1			1
CO4	1	1	1				1	1	1			1
CO5	1	1	2				1	1			1	1

Course Contents:

Unit 1: Introduction
Review of principle of mechanics, vector mechanics-resultant forces of coplanar and non-coplanar and concurrent and non-concurrent forces, parallel forces in planes, equilibrium of coplanar forces, Newton's law of motion, work and energy, moment of inertia.

Unit 2: Biomechanics of Joints
Skeletal joints, forces and stresses in human joints, type of joints, biomechanical analysis of elbow, shoulder, spinal column, hip knee and ankle.

Unit 3: Bio-fluid Mechanics
Introduction, viscosity and capillary viscometer, Rheological properties of blood, laminar flow, cardiovascular and respiratory system.

Unit 4: Hard Tissues
Bone structure and composition, Mechanical properties of bones, cortical and cancellous bones, visco-elastic properties, Maxwell and Vigot model – Anisotropy

Unit 5: Soft Tissues
Structure and functions of soft tissue: cartilage, tendon, ligament and muscle, Material properties of cartilage, tendon and ligament and muscle

Unit 6: Biomechanics of Implant
Specification for prosthetic joints, biocompatibility, requirement of biomaterial, characterization of different type of biomaterials, fixation of implants.

Texts/References:

1. Y. C. Fung, "Biomechanics: Mechanical properties of living tissues", springer-verlag, 2nd edition, 1993.
2. D. J. Schneck, J. D. Bronzino, "Biomechanics: Principle and Applications", CRC Press, 2nd edition, 2000.

Elective VII
Failure Analysis and Design

ME 801B	Failure Analysis and Design	PCE	3-0-0	3 Credit

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	State and compare different theories of failures
CO2	Define the fractures in materials and compare the different theories of fractures
CO3	Discuss the different modes of fractures, crack propagation and R curves, S-N curves
CO4	Define and identify fatigue failures
CO5	Describe creep failure, brittle fracture and ductile fracture
CO6	Identify Design Application of the Knowledge of Failure

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1	2	2	1		2					1
CO2	1	1	1				1				1	1
CO3	1	2	1	1	1		1				1	1
CO4	1	2	1	1			1		1			1
CO5	1	2	2	1			1		1			1
CO6	1	3	2	1	1	1	1		1		1	1

Course Contents:

Unit 1: Theories of Failure
Maximum shear stress theory, Maximum normal stress theory, Maximum distortion energy theory, Maximum strain theory, Applicability of theories of failure.

Unit 2: Fracture
Type of fracture, Theoretical cohesive strength of metals, Griffith theory of brittle fracture, fracture single crystals, Metallographic aspects of fracture, Dislocation theories of brittle fracture, Ductile fracture, Notch effects, Fracture under combined stresses.

Unit 3: Fracture Mechanics
Strain energy release rate, Stress intensity factor, Fracture toughness, Plane strain toughness testing, Crack-opening displacement, J-Integral to solve energy of crack formation, R-curves, Toughness of material.
Fatigue Failure: Stress cycle, S-N curve, Description of fatigue fractured parts, Phases of fatigue fracture, Fatigue crack propagation, Effects of metallurgical variables, Temperature, Stress concentration, Size and surface factors, Fatigue under combined stresses.

Unit 4: Creep Failure
Creep curve, Structural changes and mechanisms during creep, Activation energy for steady-state creep, Fracture at elevated temperature.
Brittle Fracture: Transition temperature curves, Fracture analysis diagrams, various types of embitterment, Fracture under very rapid loading.

Unit 5: Ductile Fracture
Condition for necking, Dislocation and void formation activities, Types of fractured parts.
Assessment of Types of Fractures by Observation: Comparison between different fractured parts undergoing various type of fracture.

Unit 6: Design Application of the Knowledge of Failure
Design considering fatigue-Geber's parabola, Soderberg equation, Lubricating optimally to combat bearing failures. Selection of materials to prevent seizure, galling, etc. Wear reduction techniques, Fracture toughness consideration in design.

Texts/References:

1. F. Madoyag, "Metal Fatigue Design and Theory"
2. L. Sors, "Fatigue Design of Machine Components", Pergamon Press
3. S. T. Rolfe and J. M. Barson, "Fracture and Fatigue Control Structures", Prentice Hall.
4. David Broek, "Elementary Engineering Fracture Mechanics", Noordnoff
5. G. E. Dieter, "Mechanical Metallurgy", Tata McGraw Hill Book Co., New Delhi.

Elective VII

Automobile Engineering

ME 801C	Automobile Engineering	PCE	3-0-0	3 Credit

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Identify the different parts of the automobile.
CO2	Explain the working of various parts like engine, transmission, clutch, brakes etc.,
CO3	Demonstrate various types of drive systems.
CO4	Apply vehicle troubleshooting and maintenance procedures.
CO5	Analyze the environmental implications of automobile emissions. And suggest suitable regulatory modifications.
CO6	Evaluate future developments in the automobile technology.

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1										
CO2	1	2		2		1						
CO3	1	1		1	1							
CO4	2			3	1							
CO5		2			1	1	2					
CO6	1		2			2						

Course Contents:

Unit 1: Introduction
Vehicle specifications, Classifications, Chassis layout, Frame, Main components of automobile and articulated vehicles; Engine-cylinder arrangements, Power requirements, Tractive efforts and vehicle performance curves.

Unit 2: Steering and Suspension Systems
Steering system; Principle of steering, Centre point steering, Steering linkages, Steering geometry and wheel alignment, power steering.
Suspension system: its need and types, Independent suspension, coil and leaf springs, Suspension systems for multi-axle vehicles, troubleshooting and remedies.

Unit 3: Transmission System
Clutch: its need and types, Gearboxes: Types of gear transmission, Shift mechanisms, Over running clutch, Fluid coupling and torque converters, Transmission universal joint, Propeller shaft, Front and rear axles types, Stub axles, Differential and its types, Four wheel drive.

Unit 4: Brakes, Wheels and Tyres
Brake: its need and types: Mechanical, hydraulic and pneumatic brakes, Disc and drum type: their relative merits, Brake adjustments and defects, Power brakes, Wheels and Tyres: their types; Tyre construction and specification; Tyre wear and causes; Wheel balancing.

Unit 5: Electrical Systems
Construction, operation and maintenance of lead acid batteries, Battery charging system, Principle and operation of cutout and regulators, Starter motor, Bendix drive, Solenoid drive, Magneto-coil and solid stage ignition systems, Ignition timing.

Unit 6: Vehicle Testing and Maintenance
Need of vehicle testing, Vehicle tests standards, Different vehicle tests, Maintenance: trouble shooting and service procedure, over hauling, Engine tune up, Tools and equipment for repair and overhauling, Pollution due to vehicle emissions, Emission control system and regulations.

Texts:
1. Kripal Singh, "Automobile Engineering", Vol. I and II, Standard Publishers.
2. G. B. S. Narang, "Automobile Engineering", Dhanpat Rai and Sons.

References:
1. Joseph Heitner, "Automotive Mechanics", East-West Press.
2. W. H. Crouse, "Automobile Mechanics", Tata McGraw Hill Publishing Co.

Elective VII

Engineering Tribology

ME 801D	Engineering Tribology	PCE	3-0-0	3 Credit

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Understand the basic concepts and importance of tribology.
CO2	Evaluate the nature of engineering surfaces, their topography and surface characterization techniques
CO3	Analyze the basic theories of friction and frictional behavior of various materials
CO4	Select a suitable lubricant for a specific application
CO5	Compare different wear mechanisms
CO6	Suggest suitable material combination for tribological design.

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2											
CO2	2	1	2	2		1						
CO3	2	3	1	2	1	1	1					
CO4	2	2	2		1	1	2		1		1	
CO5	1	1	1	1	1							
CO6	2	2	2		2	2	2		1	1	1	

Course Contents:

Unit 1: Introduction
Definition of tribology, friction, wear and lubrication; importance of the tribological studies.
Surface Topography: Methods of assessment, measurement of surface roughness-different statistical parameters (R_a, R_z, R_{max}, etc.), contact between surfaces, deformation between single and multiple asperity contact, contact theories involved

Unit 2: Friction
Coulomb and Amontons laws of friction, its applicability and limitations, comparison between static, rolling and kinetic friction, friction theories, mechanical interlocking, molecular attraction, electrostatic forces and welding, shearing and ploughing, models for asperity deformation.

Unit 3: Lubrication
Types of lubrication, viscosity, characteristics of fluids as lubricant, hydrodynamic lubrication, Reynold's equation, elasto-hydrodynamic lubrication: partial and mixed, boundary lubrication, various additives, solid lubrication.

Unit 4: Wear
Sliding wear: Abrasion, adhesion and galling, testing methods pin-on-disc, block-on-ring, etc., theory of sliding wear, un-lubricated wear of metals, lubricated wear of metals, fretting wear of metals, wear of ceramics and polymers.
Wearing by plastic deformation and brittle fracture. Wear by hard particles: Two-body abrasive wear, three-body abrasive wear, erosion, effects of hardness shape and size of particles.

Unit 5: Wear and Design
Introduction, estimation of wear rates, the systems approach, reducing wear by changing the operating variables, effect of lubrication on sliding wear, selection of materials and surface engineering. principles and applications of tribodesign.

Unit 6: Materials for Bearings
Introduction, Rolling bearings, Fluid film lubricated bearings, marginally lubricated and dry bearings, gas bearings.

Texts:

1. I. M. Hutchings, "Tribology, Friction and Wear Engineering Materials", Edward Arnold, London.
2. R. C. Gunther, "Lubrication", Baily Brothers and Swinfen Limited.
3. F. T. Barwell, "Bearing Systems, Principles and Practice", Oxford University Press.

References:

1. B. C. Majumdar, "Introduction to Tribology of Bearings", A. H. Wheeler & Co. Private Limited, Allahabad.
2. D. F. Dudley, "Theory and Practice of Lubrication for Engineers", John Willey and Sons.
3. J. Halling, "Principles of Tribology", McMillan Press Limited.

4. Cameron Alas Tair, “Basic Lubrication Theory”, Wiley Eastern Limited.
5. M. J. Neale, “Tribology Hand book”, Butterworth’s.
6. D. D. Fuller, “Lubrication”.

Elective VII

Heating Ventilation Air Conditioning and Refrigeration (HVAC and R)

ME 801E	HVAC and R	PCE	3-0-0	3 Credit

Pre-Requisites: Refrigeration and Air conditioning

Course Outcomes: At the end of the course, students will be able to:

CO1	Understand the various methods of Refrigeration
CO2	Explain thermal analysis of vapour compression system
CO3	Understand the environmental aspect of refrigerants and alternate refrigerants
CO4	Comfort aspect of air-conditioning
CO5	Understand the ventilation and basic of duct design

Mapping of course outcomes with program outcomes

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

Course Contents:

Unit 1: Review of Refrigeration and Air-Conditioning
Vapour Compression System: Ewings construction, Effect of evaporator and condenser temperature on cycle performance, effects of suction superheating, Liquid sub-cooling, liquid-vapour heat exchanger, estimation of compressor displacement, C.O.P. and power requirement, waste heat recovery opportunities

Unit 2: Compound Vapour Compression System
Multi-evaporator, multi-compressor systems and cascade system, Vapour Absorption System: Aqua-ammonia system, lithium bromide-water system, electrolux refrigerator, comparison with vapour compression cycle (descriptive treatment only), P-T-ξ chart, thermodynamic analysis and capacity control

Unit 3: Refrigerants for Vapour Compression System
Desirable properties, selection, Zeotrops and Azeotropes, necessity for replacement of CFC refrigerants, natural refrigerants

Unit 4: Air Conditioning Process Calculations
Sensible and latent heat loads SHF, GSHF, RSHF, outside conditions, indoor conditions,

estimation of coil capacity required, bypass factor, evaporative cooling, Ventilation, Classification, Need, fresh air requirement in various applications.

Unit 5: Thermal Comfort
Thermal comfort: Heat transfer from human body by sensible and latent heat transfer. Metabolic heat generation, steady state model for heat transfer, effect of clothing and definition of effective temperatures, comfort conditions, human comforts, comfort chart

Unit 6: Distribution of Air
Principle of air distribution, duct design methods, friction chart, duct materials, methods of noise control. Basics of Air-conditioning controls

Texts:

1. C. P. Arora, "Refrigeration and Air Conditioning", Tata McGraw Hill Publications, New Delhi, 2nd edition, 2000.
2. W.F. Stoeker, J. P. Jones, "Principles of Refrigeration and Air Conditioning", Tata McGraw Hill Publications, New York, 2nd edition, 1982.

References:

1. ASHRAE Handbook - Fundamentals and Equipment, 1993.
2. ASHRAE Handbook – Applications, 1961.
3. ISHRAE Handbook
4. Prof. Ram Gopal, NPTEL Lectures, IIT Kharagpur.
5. Carrier Hadbook
6. R. C. Jordan, G. B. Priester, "Refrigeration and Air Conditioning", Prentice Hall of India Ltd., New Delhi, 1969.
7. J. L. Threlkeld, "Thermal Environmental Engineering", Prentice Hall, New York, 1970.

Elective VIII
Robotics

ME 802A	Robotics	PCE	3-0-0	3 Credit

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	List the various components of a typical Robot, grippers, sensors, drive system and describe their functions
CO2	Calculate the word to joint and joint to word coordinates using forward and reverse transformations
CO3	Calculate the gripper forces, drive sizes, etc.
CO4	Develop simple robot program for tasks such as pick and place, arc welding, etc. using some robotic language such as VAL-II, AL, AML, RAIL, RPL, VAL
CO5	Evaluate the application of robots in applications such as Material Handling, process operations and Assembly and inspection
CO6	Discuss the implementation issues and social aspects of robotics

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												
CO5												
CO6												

Course Contents:

Unit 1: Introduction
Various basic components of a Robotic system, various configurations, work envelopes, Manipulators, sensors, controllers, etc.

Unit 2: Mechanical System in Robotics
Motion conversion, Kinematic chains, position analysis, forward and backward transformations, natural and joint space coordinates.

Unit 3: Drives for Robot
Electrical drives**,** Stepper motor, DC motors, AC motors, hydraulic and pneumatic drives, hybrid drives, drive selection for robotics joints.

Unit 4: Sensors in Robotics
Position sensor, velocity sensor, proximity sensors, touch sensors, force sensors, etc.

Unit 5: Robot Programming
Path planning, Lead through (manual and powered) programming, teach pendant mode, programming languages, AL, AML, RAIL, RPL, VAL pment in robotics
Artificial Intelligence for Robots: Knowledge Representation, Problem representation and problem solving, search techniques in problem solving

Unit 6: Robot Applications
Application of robot in: Material handling, assembly and inspection, process operations, etc.

Texts:
1. M. P. Grover, “Industrial Robotics: Technology, Programming and Applications”, Tata McGraw Hill Publication.

References:
1. Saeed B. Niku, “Introduction to Robotics, Analysis, Systems, Applications”, Pearson Education.
2. Richard D. Klafter, “Robotic Engineering: An Integrated Approach”, Prentice Hall of India.

Elective VIII

Tool Condition Monitoring

ME 802B	Tool Condition Monitoring	PCE	3-0-0	3 Credit

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Understand the need for Tool Condition Monitoring (TCM)
CO2	Describe the different sensors used in TCM
CO3	Apply the TCM Technique to machines like Lathe, Drilling, Milling
CO4	Apply the TCM to EDM, ECM
CO5	Demonstrate the TCM using force , vibration and sound sensors

Mapping of course outcomes with program outcomes

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

Course Contents:

Unit 1: Introduction
Need and role of monitoring system and different methods of tool condition monitoring.

Unit 2: Sensors
Role of sensors in manufacturing, Types of sensors, Principles of sensors for manufacturing.

Unit 3: Condition Monitoring
Condition monitoring of manufacturing systems using: force, vibration, sound and neural networks.

Unit 4: Acoustic Emission
Tool condition monitoring using acoustic emission: principle of working, types of AE sensors and applications to metal cutting processes.

Unit 5: Applications of Sensors
Applications of sensors in casting and forming, Process monitoring and use of sensors in forging, Monitoring of non-conventional manufacturing processes such as EDM, ECM.

Unit 6: Tool Condition Monitoring for CNC Machines
Tool condition monitoring for CNC machines like lathe, milling machines, drilling machines using sensors for workpiece and tooling.

Texts:

1. H. K. Tonshoff, I. Inasaki, "Sensors Applications", Vol. I, Sensors in Manufacturing, Wiley-VCH, New York, 2001.
2. D. M. Considiene, G. D. Considine, "Standard Handbook of Industrial Automation", Chapman and Hall, 1975.

References:

1. S. D. Murphy, "In-process Measurement and Control", Marcel Dekker, 1983.
2. S. Soloman, "Sensors and Control systems in Manufacturing", Tata McGraw Hill International Editions, USA, 1987.

Elective VIII

Experimental Stress Analysis

ME 802C	Experimental Stress Analysis	PCE	3-0-0	3 Credits

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Explain the measurement of strain under static and dynamic loads
CO2	Describe the mechanical, optical pneumatic and electrical strain gauges for strain measurement
CO3	Analysis of measuring circuits and stains of different strain gauge rosettes.
CO4	Explain optical methods of stress analysis
CO5	Understand basic principles of photoelasticity and use it as an analysis tool.
CO6	Selecting coating techniques, coating materials.

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1		1										
CO2		2	2		2							2
CO3				3								2
CO4			1									
CO5					2							2
CO6					2							2

Course Contents:

Unit 1: Introduction

Need of stress analysis; experimental methods, Merits and demerits of experimental methods.

Unit 2: Basics of Elasticity
Stress at a point, stress equations of equilibrium, 2-D state of stress, Strains and displacements, Stress strain relationship for 2-D state of stress, Plane stress and plane strain approach.

Unit 3: Measurement of Strain
Strain gauges: Mechanical, optical, electrical, acoustical and semiconductor; Grid method of strain analysis.

Unit 4: Electrical Strain Gauges
Gauge construction, Strain gauge adhesives and mounting techniques, Gauge sensitivity and gauge factor, Strain gauge linearity, hysteresis and zero shift, Temperature compensation. Environmental effects: moisture, humidity and hydrostatic pressure, high and cryogenic temperatures, The Wheatstone bridge, Calibration of strain gauge circuit, Strain analysis method: 3-element rectangular rosette, torque gauge.

Unit 5: Basics of Optics
Nature of light, Wave theory of light, Optical instruments, Plane and circular polariscopes.

Unit 6: Theory of Photoelasticity
Stress optics law, Effects of a stressed model in a plane polariscope, Effects of principal stress directions, Effects of principal stress difference, Effects of a stressed model in circular polariscope in dark and light field arrangements, 2-D Photoelasticity, Isochromatic and isoclinic fringe patterns, Materials for 2-D Photoelasticity, Introduction to moiré fringe technique and coating methods.

Texts:
1. J. W. Dally, W. F. Riley, "Experimental Stress Analysis", Tata McGraw Hill Publications, 3rd edition.

References:
1. C. Perry, H. R. Lissner, "The Strain Gage Primer", Tata McGraw Hill, 2000.
2. Abdul Mubeen, "Experimental Stress Analysis", Dhanpat Rai and Sons, 2001.
3. P. S. Theocaris, "Moire Fringes in Strain Analysis", Pergammon Press, 2002.

Elective VIII

Energy Conservation and Management

ME 802D	Energy Conservation and Management	PCE	3-0-0	3 Credits

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Understand energy problem and need of energy management
CO2	Carry out energy audit of simple units
CO3	Study various financial appraisal methods
CO4	Analyse cogeneration and waste heat recovery systems
CO5	Do simple calculations regarding thermal insulation and electrical energy conservation

Mapping of course outcomes with program outcomes

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

Course Contents:

Unit 1: Introduction
General energy problem, Energy use patterns and scope of conservation. Energy Management Principles: Need, Organizing, Initiating and managing an energy management program.

Unit 2: Energy Auditing
Elements and concepts, Types of energy audits, Instruments used in energy auditing.
Economic Analysis: Cash flows, Time value of money, Formulae relating present and future cash flows - single amount, uniform series.

Unit 3: Financial Appraisal Methods
Payback period, Net present value, Benefit-cost ratio, Internal-rate of return, Life cycle costs/benefits. Thermodynamics of energy conservation, Energy conservation in Boilers and furnaces, Energy conservation in Steam and condensate system.

Unit 4: Cogeneration
Concept, Types of cogeneration systems, performance evaluation of a cogeneration system. Waste Heat Recovery: Potential, benefits, waste heat recovery equipment's.
Space Heating, Ventilation Air Conditioning (HVAC) and water heating of building, Transfer of heat, Space heating methods, Ventilation and air conditioning, Heat pumps, Insulation, Cooling load, Electric water heating systems, Electric energy conservation methods.

Unit 5: Insulation and Heating
Industrial Insulation: Insulation materials, Insulation selection, Economical thickness of insulation.
Industrial Heating: Heating by indirect resistance, direct resistance heating (salt bath furnace), and Heat treatment by induction heating in the electric arc furnace industry.

Unit 6: Energy Conservation in Electric Utility and Industry
Energy costs and two part tariff, Energy conservation in utility by improving load factor, Load curve analysis, Energy efficient motors, Energy conservation in illumination systems, Importance of Power factor in energy conservation, Power factor improvement methods, Energy conservation in industries

Texts:

1. Callaghan, "Energy Conservation".
2. D. L. Reeg, "Industrial Energy Conservation", Pergamon Press.

References:

1. T. L. Boyen, “Thermal Energy Recovery”, Wiley Eastern.
2. L. J. Nagrath, “System Modeling and Analysis”, Tata McGraw Hill Publications.
3. S. P. Sukhatme, “Solar Energy”, Tata McGraw Hill Publications.

Elective VIII

Modeling of Thermal System and Optimization

ME 802E	Modeling of Thermal Systems and Optimization	PCE	3-0-0	3 Credit

Pre-Requisites: Thermal Engineering

Course Outcomes: At the end of the course, students will be able to:

CO1	Understand the formulation and modelling
CO2	Explain thermal system analysis and optimization
CO3	Learn and implement packaged software to simulate thermal system simulation
CO4	Understand and use the optimization of thermal systems

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3				1		1				
CO2	3	3				1						
CO3	3				3	1	3	3	3			
CO4		1	3			2						

Course Contents:

Unit 1: Introduction

Preliminaries, Workable, Optimal and Nearly optimal designs, life cycle design, thermal system design aspects, concept creation and assessment, computer-Aided thermal system design.

Unit 2: Thermodynamics, Modeling and Design Analysis

Basic concepts and definition, control volume concepts, property relations, reacting mixtures and combustion, thermodynamic model-cogeneration system, modeling and design of piping system.

Unit 3: Exergy Analysis

Exergy, physical exergy, exergy balance, chemical exergy, applications, guidelines for evaluating and improving thermodynamic effectiveness.

Applications with Heat and Fluid Flow: Thermal insulation, fins, electronic packages.

Unit 4: Applications with Thermodynamics and Heat and Fluid flow

Heat exchangers, the trade-off between thermal and fluid flow irreversibilities, air preheater preliminary design, additional applications.

Economic Analysis: Estimation of total capacity investment, principles of economic evaluation, calculation of revenue requirements, livelized costs and cost of the main product, profitability evaluation and comparison of alternative investments.

Unit 5: Thermo-economic Analysis and Evaluation
Fundamentals of thermo-economics, thermo-economic variables for component evaluation, thermo-economic evaluation, additional costing considerations.

Unit 6: Thermo-economic Optimization
Introduction, cost-optimal exergetic efficiency for an isolated system component, optimization of heat exchanger networks, analytical and numerical optimization techniques, design optimization for the cogeneration-case study, thermo-economic optimization of complex systems.

Texts:

1. Yogesh Jaluria, "Design and Optimization of Thermal Systems", Tata McGraw Hill Companies, Inc.
2. W. F. Stoecker, "Design of Thermal Systems", Tata McGraw Hill, 3rd edition, 1989.

References:

1. B. K. Hodge, "Analysis and Design of Thermal Systems", Prentice Hall Inc., 1990.
2. I. J. Nagrath, M. Gopal: "Systems Modelling and Analysis", Tata McGraw Hill.
3. D. J. Wide, "Globally Optimal Design", Wiley Interscience, 1978.

Elective VIII

Utilization of Solar Energy

ME 802F	Utilization of Solar Energy	PCE	3-0-0	3 Credit

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Describe measurement of direct, diffuse and global solar radiations falling on horizontal and inclined surfaces.
CO2	Analyze the performance of flat plate collector, air heater and concentrating type collector.
CO3	Understand test procedures and apply these while testing different types of collectors.
CO4	Study and compare various types of thermal energy storage systems.
CO5	Analyze payback period and annual solar savings due to replacement of conventional systems.
CO6	Design solar water heating system for a few domestic and commercial applications.

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1											
CO2	1	2				1						
CO3	2			1	1		2					
CO4	1	1										
CO5		2			1							
CO6			2	3		1	1					

Course Contents:

Unit 1: Solar Radiation
Introduction, spectral distribution, solar time, diffuse radiation, Radiation on inclined surfaces, measurement of diffuse, global and direct solar radiation.

Unit 2: Liquid Flat Plate Collectors
Introduction, performance analysis, overall loss coefficient and heat transfer correlations, collect or efficiency factor, collect or heat removal factor, testing procedures.

Unit 3: Solar Air Heaters
Introduction, types of air heater, testing procedure.

Unit 4: Concentrating Collectors
Types of concentrating collectors, performance analysis

Unit 5: Thermal Energy Storage
Introduction, sensible heat storage, latent heat storage and thermo chemical storage
Solar Pond: Solar pond concepts, description, performance analysis, operational problems.

Unit 6: Economic Analysis
Definitions, annular solar savings, payback period.

Texts:

1. J. A. Duffie, W. A. Beckman, “Solar Energy Thermal Processes”, John Wiley, 1974.
2. K. Kreith, J. F. Kreider, “Principles of Solar Engineering”, Tata McGraw Hill Publications, 1978.

References:

1. H. P. Garg, J. Prakash, “Solar Energy: Fundamentals and Applications”, Tata McGraw Hill Publications, 1997.
2. S. P. Sukhatme, “Solar Energy Principles of Thermal Collection and Storage”, Tata McGraw Hill Publications, 1996.

Elective IX
Plant Maintenance

ME 803A	Plant Maintenance	PCE	3-0-0	3 Credits

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Recognize troubles in mechanical elements.
CO2	Assemble, dismantle and align mechanisms in sequential order.
CO3	Carry out plant maintenance using on-line, shut down, corrosion, productive and preventive maintenance.
CO4	Analyze economics of power plants and list factors affecting the power plants
CO5	Explain the linkages between these different aspects and how they impact on overall maintenance effectiveness;

Mapping of course outcomes with program outcomes

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

Course Contents:

Unit 1: Introduction
Introduction to concept of maintenance, Type of maintenance; Preventive, Productive, corrective, online, shut down and their significance.

Unit 2: Preventive Maintenance
Preventive maintenance and its importance, Repair cycle, systematic recording, preventive maintenance, Programming and types of schedules, Manpower and machine planning, Lubrication methods and practice, Color code schedule.

Unit 3: Online Maintenance
On-line maintenance, attending to joints, Valves, Pumps and other equipment's leakages, Making shaft arrangement, stand by unit, repairing damage to insulation, etc. without stopping the plant, attending faulty equipment, Fault finding and trouble shoots.

Unit 4: Shutdown Maintenance
Shutdown maintenance, Economic aspects of timing, duration of Timing and duration of shut down maintenance, Execution by using PERT and CPM.

Unit 5: Maintenance of Mechanical Equipment
Maintenance of major equipment like boiler, furnaces, kilns, shells and tube heat exchangers, pump and compressor, Towers, Cooling vessels, Valves piping .

Unit 6: Plant Condition Monitoring
Plant condition monitoring systems, instrumentation, Data collection and analysis, life expectancy and maintenance scheduling. The economics of maintenance management.

Text:
1. Lindley R. Hinggin, L. C. Morrow, "Maintenance Engineering Hand book", Tata McGraw Hill Book Company.

References:
1. Duncan C. Richardson, PE, "Plant Equipment and Maintenance Engineering Handbook", McGraw Hill Education, New York, Chicago, 2014.

Elective IX

Design of Air Conditioning Systems

ME 803B	Design of Air Conditioning System	PCE	3-0-0	3 Credit

Pre-Requisites: Basic Air conditioning

Course Outcomes: At the end of the course, students will be able to:

CO1	Understand the cooling load calculation
CO2	Explain concept of ventilation and its implementation
CO3	Learn duct design applied to real life situation
CO4	Learn and differentiate the various modern air conditioning systems/units

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2		2	1	1	1			1	
CO2	3	3				1	2					
CO3	3	3	3	2	2	1	1	1			2	
CO4		1	1	1		1	1	1				

Course Contents:

Unit 1: Introduction
Moist Air properties, Psychrometry of various air condition processes, SHF, dehumidified air quantity, HVAC Equipment

Unit 2: Human Comfort
Human comfort, environment comfort indices, clothing resistance, metabolisms, indoor air quality, ventilation air, inside design conditions, outside design conditions.

Unit 3: Heat Flow
Heat Flow in Buildings, Building Heat Transfer, Cooling Load Calculation, Ventilation load, Effective sensible heat factor and selection of air conditioning apparatus.

Unit 4: Air Diffusion
Room air diffusion, filtration, duct design, pressure drop, air distribution design, outlets

Unit 5: Air Conditioning Equipment
Fans, pumps and blowers, performance & selection

Unit 6: Air Conditioning Systems
Air conditioning systems; constant volume, VAV, terminal reheat systems, single zone and multi zone systems, dual duct system, fan coil unit, noise control.

Texts:

1. W. F. Stoecker, J. P. Jones, "Principles of Refrigeration and Air Conditioning", Tata McGraw Hill Publications.
2. C. P. Arora, "Refrigeration and Air Conditioning", Tata McGraw Hill Publications.
3. Manohar Prasad, "Refrigeration and Air Conditioning", New Age International, 3rd edition, 2011.
4. R. C. Arora, "Refrigeration and Air Conditioning", PHI Learning Pvt. Ltd., 2010.

References:

1. "Handbook of Air Conditioning System Design", Carrier Air Conditioning Co., 1965.
2. W. P. Jones, "Air Conditioning Engineering", Edward Arnold Publishers Ltd., London, 1984.
3. James L. Threlkeld, "Thermal Environmental Engineering", Prentice Hall, New York, 1970.

Elective IX

Process Equipment Design

ME 803C	Process Equipment Design	PCE	3-0-0	3 Credit

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Understand the factors influencing design of pressure vessel
CO2	Calculate thickness and thickness variation for cylindrical storage tank
CO3	Estimation of thickness for thin and thick wall pressure vessels
CO4	Design of flange and gasket selection for cylindrical pressure vessels
CO5	Selection of various blade and baffle arrangement for agitators
CO6	Design of support for horizontal and vertical vessel

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1		1			1	1	1				1
CO2	2	2	1			1	1	1				1
CO3	2	2	2			1	1	1				1
CO4	2	2	2			1	1	1				1
CO5	2	2	1			1	1	1				1
CO6	2	2	2			1	1	1				1

Course Contents:

Unit 1: Design Considerations for Pressure Vessel

Selection of type of vessel, Methods of fabrication, Effect of fabrication methods, Various criteria in vessel design, Economic considerations, Types of process equipment, Constructional requirement and applications. Fabrication and testing, Inspection and non-destructive testing of equipment.

Unit 2: Storage Vessel

Design methods of atmospheric storage vessel: storage of fluids, storage of non-volatile liquids, storage of volatile liquids, storage of gases, Optimum tank proportion, Bottom design, Shell design, Wind girder for open top tank, Rub curb angle, Self supported roof, Design of rectangular tank,

Unit 3: Pressure Vessel

Unfired process vessel with internal and external pressure, Operating condition, Selection of material, Design condition, Stresses, Design criteria, Design of shell subjected to internal and external pressure, Cylindrical vessel under combined loading,

Design of heads and closures: flat head and formed heads for vessel. Design consideration for rectors and chemical process vessels. Flange facings, Gaskets, Design of flanged joint, Flange thickness, and Blind flanges.

Unit 4: High Pressure Vessel

Design of thick walled high-pressure vessel, Constructional features, Materials for high-pressure vessels, Multilayer vessel with shrink fit construction, Thermal expansion for shrink fitting, stress in multi shell or shrink fit construction, autofrettage, Pre-stressing. Tall vessels and their design, Stress in shell, Determinations of longitudinal stresses, Longitudinal bending stresses due to eccentric loads, Determination of resultant longitudinal stresses.

Unit 5: Agitated Vessel

Type of agitators, Baffling, Power requirement for agitation, Design based on torque and bending moment, Design based on critical speed, Blade design, Hub and key design, Stuffing box and gland design, Turbine agitator design,

Unit 6: Support for Pressure Vessel

Bracket or lug support: Thickness of the base plate, Thickness of web (gusset) plate, Column support for bracket base plate for column or leg support. Skirt Support: Skirt design, Skirt bearing plate, and Anchor bolt design, Design of bolting chair. Saddle Support: Longitudinal bending moment, Stresses in shell at saddle.

Texts:

1. V. V. Mahajani, S. B. Umarji, "Process Equipment Design", Macmillan Publisher India Ltd.
2. L. E. Brownell, E. H. Young, "Process equipment design", John Wiley and Sons.
3. C. Bhattacharya, "Introduction to process Equipment Design".

Reference Book:

1. Dennis Moss, "Pressure Vessel Design Manual", Elsevier.
2. John F. Harvey, "Theory and Design of Pressure Vessels", CBS Publication.

Elective IX

Analysis and Synthesis of Mechanisms

ME 803D	Analysis and Synthesis of Mechanisms	PCE	3-0-0	3 Credit

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Differentiate planar and spatial mechanism
CO2	Perform kinematic and dynamic analysis of planer mechanism with rigid bodies
CO3	Estimate element mass and stiffness matrices and write equations of motion fo elastic linkage model
CO4	Synthesize, graphically, function generation and rigid body guidance with two, three and four accuracy points using pole method, centre point and circle point curves
CO5	Able to derive Euler-Savy equation and Freudenstein's equation
CO6	Synthesize, analytically, four-bar and slider-crank mechanism for prescribed angula velocities and accelerations using complex numbers

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1	1						1	1		1
CO2	3	3	2	1	3	1						
CO3	3	3	1	1						1	1	1
CO4	3	3	2	1	3	1	1					1
CO5	3	3	2	1								1
CO6	3	3	2	1	3	1	1					1

Course Contents:

Unit 1: Basic Concepts

Definitions and assumptions, planar and spatial mechanisms, kinematic pairs, degree of freedom.

Unit 2: Kinematic Analysis of Complex Mechanisms

Velocity-acceleration analysis of complex mechanisms by the normal acceleration and auxiliary point method.

Unit 3: Dynamic Analysis of Planar Mechanisms
Inertial forces in linkages, kineto-static anlaysis of mechanisms by matrix method, analysis of elastic mechanisms, beam element, displacement fields for beam element, element mass and stiffness matrices, system of matrices, elastic linkage model, equations of motion.

Unit 4: Curvature Theory
Fixed and moving centroides, inflection circle, Euler-Savy equation, Bobillier constructions, cubic of stationary curvature, Ball's point, applications of dwell mechanisms.

Unit 5: Graphical Synthesis of Planar Mechanisms
Type, number and dimensional synthesis, function generation, path generation and rigid body guidance problems, accuracy (precision) points, Chebychev spacing, types of errors, Graphical synthesis for function generation and rigid body guidance with two, three and four accuracy points using pole method, centre point and circle point curves, Bermester points, synthesis for five accuracy points, branch and order defects, synthesis for path generation.

Unit 6: Analytical Synthesis of Planar Mechanisms
Analytical synthesis of four-bar and slider-crank mechanism, Freudenstein's equation, synthesis for four accuracy points, compatibility condition, synthesis of four-bar for prescribed angular velocities and accelerations using complex numbers. Complex number method for synthesis.

Texts:

1. A. Ghosh, A. K. Mallik, "Theory of Machines and Mechanisms", Affiliated East-West Press.
2. R. S. Hartenberg, J. Denavit, "Kinematic Synthesis of Linkages", Tata McGraw Hill Inc.

References:

1. A. G. Erdman, G. N. Sandor, "Mechanism Design-Analysis and Synthesis", Vol. 1 and 2, Prentice Hall of India Ltd.
2. J. E. Shigley, J. J. Uicker, "Theory of Machines and Mechanisms", Tata McGraw Hill Inc.
3. R. L. Norton, "Design of Machinery: An Introduction to Synthesis and Analysis of Mechanisms and Machines", Tata McGraw Hill Inc.
4. A. S. Hall, Kinematics of Linkage Design, Prentice Hall of India Ltd.

Elective IX

Alternative Fuels for IC Engines

ME 803E	Alternative Fuels for IC Engines	PCE	3-0-0	3 Credit

Pre-Requisites: IC Engines

Course Outcomes: At the end of the course, students will be able to:

CO1	State and define properties of petroleum fuels such as Specific gravity, Density, Molecular weight, Vapour pressure, Viscosity, Flash point, Fire point, Performance Number, Cetane Number, Octane number etc.,
CO2	Study the production method of various alternative fuels, their performance characteristics.
CO3	Understand need, advantages and environmental effects of traditional and alternative fuels.
CO4	Recognize current engine trends and future prospects (or) modification to use dual fuels and alternative fuels requirements.
CO5	Choose and Apply various pollution control methods on their emission characteristics.

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1										
CO2		1	1									
CO3					1		2					
CO4					1	1						
CO5	2				1		1					

Course Contents:

Unit 1: Fuels
Introduction, Structure of petroleum, Refining process, Products of refining process, Fuels for spark ignition, Knock rating of SI engine fuels, Octane number requirement, Diesel fuels and Numericals.

Unit 2: Properties of Petroleum Products
Specific gravity, Density, Molecular weight, Vapour pressure, Viscosity, Flash point, Fire point, Cloud point, Pour point, Freezing point, Smoke point & Char value, Aniline point, Octane Number, Performance Number, Cetane Number, Emulcification, Oxidation Stability, Acid Value/Number, Distillation Range, and Sulphur content.

Unit 3: Alternative Fuels for IC Engines
Need for alternative fuels such as Ethanol, Methanol, LPG, CNG, Hydrogen, Biogas and Producer gas and their methods of manufacturing**.**

Unit 4: Single Fuel Engines
Properties of alternative fuels, Use of alternative fuels in SI engines, Engine modifications required, Performance and emission characteristics of alternative fuels in SI mode of operation v/s gasoline operation.

Unit 5: Dual Fuel Engine
Need and advantages, The working principle, Combustion in dual fuel engines, Factors affecting combustion in dual fuel engine, Use of alcohols, LPG, CNG, Hydrogen, Biogas and Producer gas in CI engines in dual fuel mode. Engine modifications required. Performance

and emission characteristics of alternative fuels (mentioned above) in Dual Fuel mode of operation v/s Diesel operation.

Unit 6: Biodiesels

What are biodiesels Need of biodiesels, Biodiesel production methods, Properties of biodiesels V/s petro-diesel, Performance and emission characteristics of biodiesels v/s Petro-diesel operation?

Availability: Suitability and Future prospects of these gaseous fuels in Indian context. Environmental pollution with conventional and alternate fuels, Pollution control methods and packages.

Texts:

1. Osamu Hirao, Richard Pefley, "Present and Future Automotive Fuels", Wiley Inter-science Publication, NY, 1988.
2. V. Ganesan, "Internal Combustion Engines", Tata McGraw Hill Publishing.

References:

1. R. P. Sharma, M. L. Mathur, "A Course in Internal Combustion Engines", D. Rai and Sons.
2. O. P. Gupta, "Elements of Fuels, Furnaces & Refractory's", Khanna Publishers, 2000.
3. John B. Heywood, "Internal Combustion Engines Fundamentals", Tata McGraw Hill International Edition.

Elective X

Design of Piping System

ME 804A	Design of Piping System	PCE	3-0-0	3 Credit

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Understand the piping connections, fittings, piping codes, standards and piping representation.
CO2	Describe different piping layouts and understand the design of different piping system
CO3	Analyze and identify the suitable pipe installations
CO4	Calculate different stresses and reactions in given piping layout
CO5	Explain different process auxiliaries in piping systems
CO6	Design of piping in various systems such as refrigeration, steam power plant, underground piping system etc.

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1	1			1	1	1				1
CO2	1	2	1			1	1	1				1
CO3	1	2	1			1	1	1				1
CO4	2	3	2			1	1	1				1
CO5	1	2	2			1	1	1				1
CO6	2	3	2			1	1	1				1

Course Contents:

Unit 1: Process Piping
Scope of Piping; Code and Standards; Mechanical Design Fundamentals; Mechanical design of piping system; Wall thickness; Piping size selection; Steel and cast iron pipe; Steel and wrought iron pipe; Light wall pipe; Tubing; Pipe connection and fittings; Rail fittings; Piping elements and specialties; Pipe representation; Welded and flanged fittings; Valves.

Unit 2: Piping System Layout and Design
Piping layout; Equipment Layout; Process Piping Layout; Utility Piping Layout; Pipe flow sheets; Tube fastening and attachment; Non- ferrous tube fittings; Ducts and elbows; Pipe and tube design data; Design of steam piping; Design of oil piping; Design of cast iron pipe; Miscellaneous design and applications; Pipe line; Flexibility expansive forces in pipe lines; Expansion stresses and reaction pipe lines.

Unit 3: Pipe Installation
Selection of materials; Piping design; Basic principle; Piping sketches; Steam reducing and regulating valves; Selection of pipe size; Pipe hydraulics and sizing; Flow of water in pipes; Economical pipe selection; Selection of steam pipe size; Determination of steam pipe size; Development of plot plan; Flexibility analysis.

Unit 4: Process Auxiliaries
Piping; Explanation of code; Methods of fabrication; Nominal pipe
size; Non-metallic piping and tubing; Pipe sizing by internal diameter; Choosing the final pipe size; Process steam piping; Pressure relief system; Pressure relief devices; Design of pressure relief system; Layout by scale model method.

Unit 5: Mechanical Piping Design
Piping drawings; Piping stress design; Internal or external fluid pressure stresses; Design of overhead piping; Design of underground piping; Erection of piping and support; Insulation; Drainage piping design; Design of natural gas pipe line.

Unit 6: Design of Piping System for the Following Applications
a) Refrigeration piping system, b) Cryogenic piping systemic, c) Transmission piping system, d) Steam power plant piping system, e) Underground steam-piping system, f) Underground petroleum piping, g) Submerged piping for petroleum products, h) Piping system sprinklers, i) Non-metallic piping; Selection and joining techniques; Cross Country Pipe Technology.

Texts/References:

1. J. M. Coulson, R. K. Sinnott, J. F. Richerdson, "Chemical Engineering", Vol. VI, Maxwell McMillan International Edition.
2. Sabin Crocker, "Piping Handbook", Tata McGraw Hill Publication, 5th edition.

Elective X

Product Life Cycle Management

ME 804B	Product Life Cycle Management	PCE	3-0-0	3 Credit

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Understand the need and advantages of PLM
CO2	Describe the various PLM strategies
CO3	Describe the various steps in design and development of product
CO4	Understand the technology forecasting
CO5	Describe the importance of innovation in product design and development
CO6	Apply PLM to at least one product

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1												
CO2												
CO3												
CO4												
CO5												
CO6												

Course Contents:

Unit 1: Introduction and Strategies to PLM

Need for PLM, opportunities and benefits of PLM, different views of PLM, components of PLM, phases of PLM, PLM feasibility study, PLM visioning, Industrial strategies, strategy elements, its identification, selection and implementation, change management for PLM.

Unit 2: Product Data Management (PDM)

Human resources in product lifecycle, Information, Standards, Vendors of PLM Systems and Components, PDM systems and importance, reason for implementing a PDM system, financial Justification of PDM, barriers to PDM implementation

Unit 3: Product Design

Engineering design, organization and decomposition in product design, product design process, methodical evolution in product design, concurrent engineering, design for 'X' and design central development model. Strategies for recovery at end of life, recycling, human factors in product design. Modeling and simulation in product design.

Unit 4: New Product Development
Structuring new product development, building decision support system, Estimating market opportunities for new product, new product financial control, implementing new product development, market entry decision, launching and tracking new product program, Concept of redesign of product.

Unit 5: Technology Forecasting
Future mapping, invocating rates of technological change, methods of technology forecasting such as relevance trees, morphological methods and mission flow diagram, combining forecast of different technologies, uses in manufacture alternative.

Unit 6: PLM Software and Tools
Product data security. Product structure, workflow, Terminologies in workflow, The Link between Product Data and Product Workflow, PLM applications, PDM applications

Texts/References:

1. Grieves, Michael, "Product Lifecycle Management", Tata McGraw-Hill, 2006, ISBN 007145230330.
2. Antti Saaksvuori, Anselmi Immonen, "Product Life Cycle Management", Springer, 1st edition, 2003.
3. Stark, John, "Product Lifecycle Management: Paradigm for 21st Century Product Realization", Springer-Verlag, 2004.
4. Fabio Giudice, Guido La Rosa, "Product Design for the environment-A life cycle approach", Taylor & Francis, 2006.
5. Robert J. Thomas, "NPD: Managing and forecasting for strategic processes".

Elective X

Advanced IC Engines

ME 804C	Advanced IC Engines	PCE	3-0-0	3 Credit

Pre-Requisites: IC Engines

Course Outcomes: At the end of the course, students will be able to:

CO1	Define and Distinguish between Spark ignition and Compression ignition system. Describe Air- fuel supply systems in ic engines.
CO2	Identify and Demonstrate normal and abnormal combustion in combustion chambers of IC engines. According to which able to analyse and Design combustion chambers.
CO3	Recognize and discuss engine emissions formation, effects and various methods to reduce emissions and their measuring equipment's.
CO4	Understand combustion and emission characteristics of an alternative energy sources and suggest appropriate applications of alternative fuels such as bio diesels, natural gas, LPG, hydrogen, etc. and their Engine modifications for using these fuels.
CO5	Apply and interpret with the recent trends IC engine techniques such as HCCI, CRDI, GDI, etc. with latest measuring equipments.

Mapping of course outcomes with program outcomes

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

Course Contents:

Unit 1: Spark Ignition Engines
Mixture requirements, Fuel injection systems, Monopoint, Multipoint & Direct injection, Stages of combustion: Normal and Abnormal combustion, Knock: Factors affecting knock, Combustion chambers.

Unit 2: Compression Ignition Engines
Diesel Fuel Injection Systems, Stages of combustion, Knocking, Factors affecting knock, Direct and Indirect injection systems, Combustion chambers, Fuel Spray behaviour, Spray structure and spray penetration, Air motion, Introduction to Turbo charging.

Unit 3: Pollutant Formation and Control
Pollutant, Sources, Formation of Carbon Monoxide, Unburnt hydrocarbon, Oxides of Nitrogen, Smoke and Particulate matter, Methods of controlling Emissions, Catalytic converters, Selective Catalytic Reduction and Particulate Traps, Methods of measurement, Emission norms and Driving cycles.

Unit 4: Alternative Fuels
Alcohol, Hydrogen, Compressed Natural Gas, Liquefied Petroleum Gas and Bio Diesel: Properties, Suitability, Merits and Demerits, Engine Modifications.

Unit 5: Recent Trends/Developments
Air assisted Combustion, Homogeneous charge compression ignition engines, Variable Geometry turbochargers, Common Rail Direct Injection Systems, Hybrid Electric Vehicles – NOx Adsorbers, Onboard Diagnostics.

Unit 6: Multi-fuel Engines
Multi-fuel engines, HCCI, GDI, and Exhaust after processing devices.

Texts:

1. V. Ganesan, "Internal Combustion Engines", TMH, 2nd edition, 2002.
2. R. B. Mathur, R. P. Sharma, "Internal Combustion Engines", Dhanpat Rai & Sons 2007.
3. E. F. Obert, “Internal Combustion Engines”.

References:

1. Duffy Smith, "Auto Fuel Systems", The Good Heart Willcox Company, Inc., 1987.
2. Eric Chowenitz, "Automobile Electronics", SAE Publications, 1995.

Elective X

Machine Tool Design

ME 804D	Machine Tool Design	PCE	3-0-0	3 Credits

Pre-Requisites: Machine design and Manufacturing processes-II

Course Outcomes: At the end of the course, students will be able to:

CO1	Understand basic motion involved in a machine tool.
CO2	Design machine tool structures for conventional and CNC machines.
CO3	Design and analyze system for specified speeds and feeds.
CO4	Understand control strategies for machine tool operations.
CO5	Design of rotary and linear drive for machine tools.
CO6	Analyze machine tool structure for design accuracy.

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1	2	1	1	1				1	1	1
CO2	3	1	3	1	2	1	1		1	1	1	1
CO3	2	1	2	1	1	1			1	1	1	1
CO4	2	1	1	1	1	1	1			1	1	1
CO5	3	1	3	1	1	1	1		1	1	1	1
CO6	2	1	2	1	1	1	1		1	1	1	1

Course Contents:

Unit 1: Introduction
Kinematics of different types of machine tools, selection of cutting conditions and tools, calculations of cutting force on single point and multipoint tools, hole machining, calculation of power, accuracy requirements and standards.

Unit 2: Design of Rotary Drives
Design of spindle drives, AC motors with stepped drive, DC and AC variable speed drive motor characteristics and selection, principle of speed controllers, timing belts and other types of transmission belting, closed loop operation of mail drives, rotary indexing drives.

Unit 3: Design of Feed Drives
Feed drive using feed boxes, axes feed drive of CNC drives, DC and AC servomotors, characteristics controllers and their selection, Ball screws and friction guide ways, linear motion systems, design calculation of drives, closed loop operations of feed drive, linear indexing drives.

Unit 4: Control Elements
Single and multi-axis CNC controllers, hydraulic control, Pneumatic control limit switches, proximity switches, sequencing control using hardwired and PLC systems.
Design of machine tool structures: Static and dynamic stiffness, dynamic analysis of cutting process, stability, forced vibration, ergonomics and aesthetics in machine tool design.

Unit 5: Design of Spindle and Spindle Supports
Function of spindles, design requirements, standard spindle noses, design calculation of spindles, bearing selection and mounting.
Finite elements analysis of machine tool structures: Examples of static, dynamic and thermal analysis and optimization of typical machine tool structure like column and using a finite element analysis package.
Unit 6: Design of Special Purpose Machines
Modular design concepts, standard modules, example of design of typical SPM with CNC, transfer machines.

Texts:

1. N. K. Mehta, "Machine Tool Design", Tata McGraw Hill Book Co., 1991.
2. P.C. Sharma, "A Textbook of Machine Tools and Tool Design", S. Chand & Co. Ltd., 1 January 2005.
3. Sen and Bhattacharya, "Principles of Machine Tools", 1 Jan 2009.
4. Yoram Koren, "Computer control of manufacturing systems", Tata McGraw Hill Education, 2009.

References:

1. Aacherkan, "Machine Tool Design", Vol. I and Vol. III, Mir Publishers, Moscow,1970.
2. W. L. Cheney, "Details of Machine Tool Design (Classic Reprint)", Forgotten Books, 20 Sep 2016.
3. Central Machine Tool Institute, "Machine Tool Design Handbook", Tata McGraw Hill Education, 1st Edition, 16 June 2001.
4. Nicholas Lisitsyn, Alexis V Kudryashov, Oleg Trifonov, Alexander Gavryusin, N Acherkan, Nicholas Weinstein, "Machine Tool Design", Vol. I, University Press of the Pacific, 20 April 2000.

Elective X

Numerical Heat Transfer

ME 804E	Numerical Heat Transfer	PCE	3-0-0	3 Credit

Pre-Requisites: Heat Transfer

Course Outcomes: At the end of the course, students will be able to:

CO1	Learn the concept of Numerical Heat Transfer and its application
CO2	Explain boundary conditions and partial differential equations and formulation
CO3	Analysis the conduction problems using Numerical technique
CO4	Learn the converge methodology and techniques
CO5	Write programme based 1-D and 2-D conduction problem using NHT

Mapping of course outcomes with program outcomes

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

Course Contents:

Unit 1: Introduction
Basic approach in solving a problem by Numerical Methods, Finite difference method, Method of discretization, control volume approach, Numerical error, Grid independence test.

Unit 2: Partial Differential Equations
Classification of PDEs, Elliptic, Parabolic and Hyperbolic Equations, Initial and Boundary conditions, Initial and boundary value problems.

Unit 3: Numerical Methods for Conduction Heat Transfer (Part 1)
Application of heat conduction, steady and unsteady heat conduction, Dimensionality in conduction, Basic approach in Numerical Heat conduction, one dimensional steady state problem.

Unit 4: Numerical Methods for Conduction Heat Transfer (Part 2)
Two dimensional problems, Transient one dimensional problem, Eular, crank – Nicholson and pure implicit method, stability.

Unit 5: Numerical Methods for Incompressible Fluid Flow
Introduction, Governing equations, Navier Stokes Equations, Stream function velocity method, general algorithm inviscid flow.

Unit 6: Numerical Methods for Convection Heat Transfer
Introduction, Convection diffusion, Thermal boundary layer flow, transient free convection.

Texts:

1. P. S. Ghoshdastidar, “Computer Simulation of Flow and heat transfer”, Tata McGraw Hill Publications, New Delhi.
2. Suhas V. Patankar, “Numerical Heat Transfer and Fluid Flow”, Tata McGraw Hill Book Company.
3. Varsteeg, Malalasekera, “An introduction to Computational Fluid Dynamics The finite volume method”, Pearson Prentice hall.

References:

1. M. Necati Ozisik, “Finite Difference Methods in Heat transfer”, CRC Press.
2. D. A. Anderson, J. C. Tannehill, R. H. Pletcher, “Computational Fluid Dynamics and Heat transfer”, Hemisphere Publishing.

Elective XI

Tool Design

ME 805A	Tool Design	PCE	3-0-0	3 Credits

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Understand ASA and ORS systems of tool geometry.
CO2	Understand the geometry of single point and multi point cutting tool
CO3	Understand principles of locating and clamping systems, and Design jig and fixture for conventional and NC machining
CO4	Select and design progressive, compound or combination dies for press working operations
CO5	Select and design drawing, and bending dies.
CO6	Understand forging operations with single and multi-impression dies

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1		1			1							1
CO2		1										1
CO3	2	2	3		1							
CO4	1	2	1	1	3		1					2
CO5		2	1		3							2
CO6	1	2	1		1				1			1

Course Contents:

Unit 1: Design of Single Point Cutting Tools
Introduction, designation of cutting tools, ORS and ASA system, Importance of tool angles, design of chip breakers, machining forces and merchant's circle diagram. Taylor's tool life equation.

Unit 2: Design of Multipoint Cutting Tools
Drill: Nomenclature, design of drill, moment, thrust force and power required. Milling Cutters: Nomenclature, design of milling cutter, power required for milling. Broaches: Nomenclature, design of broach, broaching power, length of toothed portion.

Unit 3: Design of Jigs and Fixtures
Twelve degree of freedom, 3-2-1, 4-2-1 method of location, Redundancy, fool proofing, locating & clamping**:** locating devices, clamping devices, Quick acting devices, drill bushes,

Drilling jigs**:** need, design principles, types of drilling jigs. Milling fixtures**:** essential features of a milling fixtures, types, Indexing of Jigs and Fixtures.

Unit 4: Press Tool Design

Press working equipment, press selection, types of dies, clearance, angular clearance, stripper plate, cutting forces , method of reducing cutting forces , die block design, punch , punch design , methods of holding punch, centre of pressure, scrap strip layout. Blanking die design, piercing die design, design of progressive dies.

Unit 5: Bending and Drawing Dies

Bending Dies: v-bending, bending forces, bend allowance, spring back and its prevention, design principles.

Drawing Dies: introduction , difference between bending , and drawing , metal flow during drawing, design consideration: radius of draw die, punch radius, draw clearance, drawing speed, calculation of blank size, number of draws, drawing pressure, blank hold pressure.

Unit 6: Forging Die Design and Mould Design

Forging dies, single impression dies, multiple impression dies,

Forging design factors: draft, fillet and corner radius, parting line, shrinkage and die wear, mismatch, finish allowances, webs and ribs.

Die design for drop forging and press forging: preliminary forging operation, fullering, edging, bending, flattering, blocking, finishing, cutoff, die block dimensions.

Determination of stock size in closed and open die forging, Mould design: injection mould, mould base, design of simple two plate injection moulds, mould materials.

Texts:

1. P. C. Sharma, “A Text Book of Production Engineering”, S. Chand & company ltd., New Delhi, 2001.
2. P. H. Joshi, “Jigs & Fixtures”, Tata McGraw Hill Publishing Co. New Delhi, 2001.
3. M. H. A. Kempster, “Introduction of Jigs and Fixtures design”, The English Language Book Society and Hodder and Stoughton, London, 3rd edition, 1982.

References:

1. Geoffery Boothroyd, Winston Knight, “Fundamentals of Machining and Machine Tools”, Taylors and Francis, 3rd edition, 2006.
2. E. G. Hoffman, “Jigs and Fixtures”, 5th Cengage Learning, 2004.

Elective XI

Advanced Refrigeration

ME 805B	Advanced Refrigeration	PCE	3-0-0	3 Credit

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Analyse the compound vapour compression system
CO2	Design the refrigeration condenser and evaporator
CO3	Understand the global impact of refrigerants
CO4	Analyse the vapour absorption system
CO5	Learn the refrigeration piping design
CO6	Understand the refrigeration controls

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1		1			1	1	1				
CO2	2	3	2		2							
CO3			2			3	3	2				
CO4	3	3	1		1			1				
CO5	1	1		2	1							
CO6			1									

Course Contents:

Unit 1: Vapour Compression Refrigeration
Vapour compression refrigeration, actual cycle, second law efficiency, multistage compression with inter-cooling, Multi-evaporator systems, Cascade systems.

Unit 2: Characteristics of Compressors
Performance characteristics and capacity control of reciprocating and centrifugal compressors, screw compressor and scroll compressor.

Unit 3: Evaporator Design
Design, selection of evaporators, condensers, system balance, control systems, motor selection.

Unit 4: Refrigerants
History, Nomenclature, Refrigerants, alternative refrigerants, CFC/HCFC phase-out regulations, action with lubricating oil, retrofitting, refrigerant blends, effects on refrigeration components.Thermoelectric and nonconventional refrigeration systems, adiabatic de-magnetization

Unit 5: Vapor Absorption Refrigeration
Vapor absorption refrigeration, Li-Br and aqua ammonia system, calculation of mass flow rate and system performance, energy balance, controls, analysis of rectifier and analyzer, single effect and double effect systems, vapour transformer.

Unit 6: Refrigeration Controls
Refrigeration controls, Expansion devices: design and selection, refrigeration system piping design

Texts:

1. W. F. Stoecker, J. P. Jones, "Principles of Refrigeration and air-conditioning", Tata McGraw Hill Publications.
2. C. P. Arora, "Refrigeration and Air-conditioning", Tata McGraw Hill Publications.
3. Manohar Prasad, "Refrigeration and Air conditioning".
4. R. C. Arora, Refrigeration and Air-conditioning, Prentice Hall.

References:

1. W. B. Gosney, "Principles of Refrigeration", Cambridge University Press.
2. W. F. Stoecker, "H. B. of Industrial Refrigeration", McGraw Hill Companies, Inc.
3. R. J. Dossat, "Principles of Refrigeration", Pearson Education.
4. ASHRAE H. B. – Refrigeration
5. ASHARAE H. B. – Fundamental

Elective XI
Cryogenic Systems

ME 805C	Cryogenic Systems	PCE	3-0-0	3 Credit

Pre-Requisites: Refrigeration

Course Outcomes: At the end of the course, students will be able to:

CO1	Learn the concept of low temperature and its application
CO2	Explain liquefaction systems and cryogenic heat exchangers
CO3	Do the analysis the cryo-coolers
CO4	Design and analysis separation and distillation column
CO4	Define and understand the cryogenic insulation and storage vessel

Mapping of course outcomes with program outcomes

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

Course Contents:

Unit 1: Introduction

Introduction**,** Industrial applications, recent development, properties of cryogenic fluids-oxygen, nitrogen, air, hydrogen and helium. Behaviour of structural materials at Cryogenic temperature: Mechanical properties, thermal properties, thermoelectric properties.

Unit 2: Liquefaction of Cryogenic Gases

Ideal cycle, system performance parameters, Joule Thomson effect, adiabatic expansion,

liquefaction systems; Simple Linde-Hampson system, Precooled Linde-Hampson system, Cascade system, Claude system.

Unit 3: Liquefaction Systems for Neon, Hydrogen and Helium
Precooled Linde-Hampson system fpr neon and hydrogen, Claude system for hydrogen, Helium refrigerated hydrogen liquefaction system

Unit 4: Cryogenic Refrigeration Systems
Ideal refrigeration systems, Philips refrigerator, Vuilleumier refrigerator, Solvay refrigerator, Gifford-McMohan refrigerator, Pulse tube refrigerator, Magnetic cooling

Unit 5: Separation of Gases
Principles of rectification**,** Rectifiers column, separation column design; plate calculation, Types of rectification columns

Unit 6: Insulation
Vacuum insulation, fibrous materials, Solid foams, Gas filled power, comparison, critical thickness. Vacuum Technology: Importance, Pump down time, Flow regimes, Components of vacuum systems, Vacuum pumps.

Texts:

1. Barron F. Randall**, "**Cryogenic Systems", Oxford University Press, New York
2. Guy, K White, "Experimental Techniques in low Temperature Physics", Claredon Press, Oxford, 1987.
3. "Advanced Cryogenic Engineering", Proceedings of Cryogenic Engineering Conference, Vol 1-145, Plenum press, New York, 1968.

References:

1. Marshall Sitting, Stephen Kidd, "Cryogenic Research and Applications", D. Van Nostrand, Inc USA, 1963.

Elective XI

Material Handling Systems

ME 805D	Material Handling Systems	PCE	3-0-0	3 Credits

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Explain principles, objectives of material handling systems
CO2	Understand the design requirement of material handling systems like storing, hoisting, and conveying equipment's
CO3	Implement CIMS (Computer Integrated Manufacturing Systems) in material handling systems
CO4	Implement safety regulations in material handling systems

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1		2	1		2							2
CO2	1	3	1		3	2		1	1			2
CO3	1	1		1	2			1	1	1	2	2
CO4					2	1		1		1	1	2

Course Contents:

Unit 1: Introduction
Principles of material handling, Objective and benefits of better material handling, material handling and plant layout, concepts of unit load containerization and palletisation.

Unit 2: Material handling Equipment's and Systems for Various Materials
Storing equipment's like pallets, bins, racks, decking, order picking, positioning equipment's. Hoisting equipment's like jacks, pulleys, hand trolleys, hoists, power hoist, various types of cranes and elevators. Conveying equipment's like belt, chain, roller, wheel, trolley, tray conveyors, gravity and vibratory type conveyors, screw conveyors. Mobile equipment's like hand trucks, fork lift trucks, powered industrial trucks and tractors, powered stackers, reach trucks, order pickers.

Unit 3: Material Handling in CIMS
Need, Comparison with conventional systems, Equipment like industrial robots and automatically guided vehicles etc.

Unit 4: Material Flow
Operation sequence, material flow pattern, stages of material flow at receiving, in process and at shipping, flow planning criteria & design of flow pattern.

Unit 5: Selection of Material Handling Equipment
Factors affecting selection of material handling equipment, Material handling equation, Choices of Material Handling Equipment, General Procedure for Selection, Basic Analytical techniques, Selection of suitable types of material handling systems , Functions and Parameters, affecting service, packing and storage material, Selection of Material Handling Equipment in Green Sand Moulding Foundry, Sugar Manufacturing Industry.

Unit 6: Safety and Training
Need, Environmental and human factors in material handling, Safety Regulations

Texts:

1. Immer J. R., "Material Handling", Tata McGraw Hill Publication.
2. James Apple, "Material Handling System Design", John Wiley
3. Theodore H., Allegre Sr., "Material Handling Principles & Practice", CBS Publishers & Distributors

References:

1. James Apple, “Plant Layout and Material Handling”, John Wiley
2. O. P. Khanna, “Work Study”, Dhanpat Rai and Sons
3. Work Study – I. L. O.

Elective XI

Advanced Methods in Engineering Design

ME 805E	Advanced Methods in Engineering Design	PCE	3-0-0	3 Credits

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	Understand about engineering optimization and identify the optimization problems
CO2	Explain the theory of plates: its equations, boundary conditions and analyze the rectangular plate
CO3	Discuss the different modes of fractures, crack propagation and R curves
CO4	Define and identify fatigue failures
CO5	Describe design of composites and Hooks law for different materials
CO6	Explain design and reliability

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1	2	2	1		2					1
CO2	1	2	2	1			1				1	1
CO3	1	2	2	1	1	1					1	1
CO4	3	2	2	1		1		1		1	1	1
CO5	1	2	2	1	1	1					1	1
CO6	3	2	2	1		1		1		1	1	1

Course Contents:

Unit 1: Engineering Optimization

Engineering applications of optimization, statement of optimization problem, classification of optimization problem, Classical optimization-Introduction, single variable optimization, multivariable optimization with no constraint, equality constraint, inequality constraint, Linear programming problem, unconstrained optimisation problem

Unit 2: Theory of Plates

The elasticity approach, assumptions of classical plate theory, moment curvature relations, equilibrium equations, governing bi-harmonic equation, boundary conditions, solution of problem, strain energy of plate, analysis of rectangular plate using Navier’s and Levy’s methods.

Unit 3: Fracture Mechanics

Introduction to linear elastic fracture mechanics, modes of fracture, stress intensity factor,

crack initiation and crack opening phenomenon, stress distribution around the crack tip under various loading conditions, fracture toughness G_{Ic} , R-curves, critical strain energy release rate.

Unit 4: Fatigue Failure

Stress cycles, S-N curve, Goodman diagram, description of fatigue fractured parts, fatigue curve, fatigue crack propagation, low cycle fatigue, high cycle fatigue, mechanism of fatigue failure, effects of various variables on fatigue, fatigue under combined stresses.

Creep Failure: Creep curve, structural changes and mechanisms during creep, activation energy for steady-state creep, and fracture at elevated temperature.

Unit 5: Design of Composites

Basic concepts and terminology, classification, advantages and limitations, Hooke's law for anisotropic, monoclinic, orthotropic, specially orthotropic, transversely isotropic and isotropic materials, Hooke's law for 2-D unidirectional lamina

Unit 6: Design for Reliability

Reliability definition, failure, failure density, failure rate, hazard rate, mean time to failure, MTBF, maintainability, availability, pdf, cdf, safety and reliability, quality assurance and reliability, bath tub curve, stress strength interaction

Texts/References:

1. S. S. Rao, "Engineering Optimization-Theory & Practice", New Age Int. Publication
2. R. Ganguli, "Engineering Optimization-A Modern Approach", Universities Press
3. T. K. Vardan and K. Bhaskar, "Analysis of Plates-Theory and Problems", Narosa Publishing House.
4. S. P. Timoshenko and S. Woinowsky-Krieger, "Theory of Plates and Shells", Tata McGraw Hill Book Company
5. T. L. Anderson, "Fracture Mechanics-Fundamentals and Applications", CRC Press
6. D. Broek, "Elementary Engineering Fracture Mechanics", Noordnoff
7. G. E. Dieter, "Mechanical Metallurgy", Tata McGraw Hill Book Company
8. R. M. Jones, "Mechanics of Composites", Taylor and Francis Inc.
9. D. Hull and T. W. Clyne, "An Introduction to Composite Materials", Cambridge University Press
10. L. P. Kollar and G. S. Springer, "Mechanics of Composite Structure", Cambridge University Press.
11. J. N. Reddy, "Mechanics of Laminated Composite Plates and Shells-Theory and Analysis", CRC Press
12. L. S. Srinath, "Concepts of Reliability Engineering", Affiliated East-West Press (P) Ltd.
13. A. K. Govil, "Reliability Engineering", Tata McGraw Hill Publishing Co. Ltd.

Project Stage-II

ME 808	Project Stage-II	PCC	0-0-8	4 Credit

Pre-Requisites: None

Course Outcomes: At the end of the course, students will be able to:

CO1	State the aim and objectives for this stage of the project
CO2	Construct and conduct the tests on the system/product
CO3	Analyze the results of the tests.
CO4	Discuss the findings, draw conclusions, and modify the system/product, if necessary.

Mapping of course outcomes with program outcomes

Course Outcomes	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1										
CO2			2	2	2	1	1					
CO3		1			1	2		1		1		
CO4			2	1	2	1	2			3		1

Course Contents:

Since Project Stage II is in continuation to Project Stage I, the students are expected to complete the total project by the end of semester VIII. After completion of project work, they are expected to submit the consolidated report including the work done in stage I and stage II. The report shall be comprehensive and presented typed on A_4 size sheets and bound. The number of copies to be submitted is number of students plus two. The assessment would be carried out by the panel of examiners for both, term work and oral examinations.