NATIONAL INSTITUTE OF TECHNOLOGY WARANGAL

COURSE STRUCTURE AND SYLLABUS

FOR

M.Tech

MATERIALS AND SYSTEMS ENGINEERING DESIGN

Effective from 2016-17

DEPARTMENT OF MECHANICAL ENGINEERING

NATIONAL INSTITUTE OF TECHNOLOGY

WARANGAL – 506 004 (T.S), INDIA

NATIONAL INSTITUTE OF TECHNOLOGY WARANGAL

VISION

Towards a Global Knowledge Hub, striving continuously in pursuit of excellence in Education, Research, Entrepreneurship and Technological services to the society

MISSION

- Imparting total quality education to develop innovative, entrepreneurial and ethical future professionals fit for globally competitive environment.

- Allowing stake holders to share our reservoir of experience in education and knowledge for mutual enrichment in the field of technical education.

- Fostering product oriented research for establishing a self-sustaining and wealth creating centre to serve the societal needs.

DEPARTMENT OF MECHANICAL ENGINEERING

VISION

To be a global knowledge hub in mechanical engineering education, research, entrepreneurship and industry outreach services.

MISSION

- Impart quality education and training to nurture globally competitive mechanical engineers.

- Provide vital state-of-the-art research facilities to create, interpret, apply and disseminate knowledge.

- Develop linkages with world class educational institutions and R&D organizations for excellence in teaching, research and consultancy services.

GRADUATE ATTRIBUTES

The Graduate Attributes are the knowledge skills and attitudes, which the students have at the time of graduation. These attributes are generic and are common to all engineering programs.

These Graduate Attributes are identified by National Board of Accreditation.

1. **Scholarship of Knowledge**: Acquire in-depth knowledge of various manufacturing processes on a wider and global perspective, with an ability to discriminate, evaluate, analyze and synthesize existing and new knowledge, and integration of the same for enhancement of knowledge.
2. **Critical Thinking**: Analyze complex engineering problems critically, apply independent judgment for synthesizing information to make intellectual and/or creative advances for conducting research in a wider theoretical, practical and policy context.
3. **Problem Solving**: Think laterally and originally, conceptualize and solve manufacturing engineering problems, evaluate a wide range of potential solutions for those problems and arrive at feasible, optimal solutions after considering public health and safety, societal and environmental factors in the core areas of expertise.
4. **Research Skill**: Extract information pertinent to unfamiliar problems through literature survey and experiments, apply appropriate research methodologies, techniques and tools, design, conduct experiments, analyze and interpret data, demonstrate higher order skill and view things in a broader perspective, contribute individually/in group(s) to the development of scientific/technological knowledge in one or more domains of engineering.
5. **Usage of modern tools**: Create, select, learn and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modeling, to complex engineering activities with an understanding of the limitations.
6. **Collaborative and Multidisciplinary work**: Possess knowledge and understanding of group dynamics, recognize opportunities and contribute positively to collaborative-multidisciplinary scientific research, demonstrate a capacity for self-management and teamwork, decisionmaking based on open-mindedness, objectivity and rational analysis in order to achieve common goals and further the learning of themselves as well as others.
7. **Project Management and Finance**: Demonstrate knowledge and understanding of engineering and management principles and apply the same to one’s own work, as a

member and leader in a team, manage projects efficiently in respective disciplines and multidisciplinary environments after consideration of economic and financial factors.

8. **Communication**: Communicate with the engineering community, and with society at large, regarding complex engineering activities confidently and effectively, such as, being able to comprehend and write effective reports and design documentation by adhering to appropriate standards, make effective presentations, and give and receive clear instructions.
9. **Life-long Learning**: Recognize the need for, and have the preparation and ability to engage in life-long learning independently, with a high level of enthusiasm and commitment to improve knowledge and competence continuously.
10. **Ethical Practices and Social Responsibility**: Acquire professional and intellectual integrity, professional code of conduct, ethics of research and scholarship, consideration of the impact of research outcomes on professional practices and an understanding of responsibility to contribute to the community for sustainable development of society.
11. **Independent and Reflective Learning**: Observe and examine critically the outcomes of one’s actions and make corrective measures subsequently, and learn from mistakes without depending on external feedback.

CURRICULAR COMPONENTS FOR ALL M. TECH. PROGRAMS IN MECHANICAL ENGINEERING

Category	Sem – I	Sem – II	Sem – III	Sem – IV	Total No. of credits to be earned
Core courses	16	08	--	--	**24**
Electives	06	12	--	--	**18**
Lab Courses	04	04	--	--	**08**
Comprehensive Viva-Voce	--	--	02	--	**02**
Seminar	01	01	--	--	**02**
Dissertation	--	--	06	12	**18**
Total	**27**	**25**	**08**	**12**	**72**

DEPARTMENT OF MECHANICAL ENGINEERING

M.TECH. IN MATERIALS AND SYSTEMS ENGINEERING DESIGN

PROGRAM EDUCATIONAL OBJECTIVES:

Program Educational Objectives (PEOs) are broad statements that describe the career and professional accomplishments that the program is preparing graduates to achieve. They must be consistent with the mission of the Institution and Department. Department faculty members must continuously work with stakeholders (local employers, industry and RD advisors, and the alumni) to review the PEOs and update them periodically. The number of PEOs should be manageable and small in number, say 4±1, and should be achievable by the program.

PEO1	Analyze, design and evaluate materials and systems integration using the knowledge of mathematics, materialsengineering, control system and IT tools.
PEO2	Solve engineering problems using domain knowledge of materials and systems engineering.
PEO3	Apply management principles to execute projects of interdisciplinary nature adhering to professional ethics.
PEO4	Engage in lifelong learning to adapt to the changing needs for professional advancement.

MAPPING OF MISSION STATEMENTS WITH PROGRAM EDUCATIONAL OBJECTIVES:

Mission	PEO1	PEO2	PEO3	PEO4
Imparting quality education to the students and enhancing their skills to make them global competitive mechanical engineers.	3	3	2	2
Maintaining vital, state-of-the-art research facilities to provide its students and faculty with opportunities to create, interpret, apply and disseminate knowledge.	3	3	2	2
To develop linkages with world class R&D organizations and educational institutions in India and abroad for excellence in teaching research and consultancy practices.	3	3	2	2

1: Slightly 2: Moderately 3: Substantially

MAPPING OF PROGRAM EDUCATIONAL OBJECTIVES WITH GRADUATE ATTRIBUTES:

PEO	GA1	GA2	GA3	GA4	GA5	GA6	GA7	GA8	GA9	GA10	GA11
PEO1	3	3	2	3	3	1	2	1	1	-	-
PEO2	3	2	2	2	-	-	-	-	-	-	-
PEO3	2	3	3	3	2	-	-	-	-	-	-
PEO4	2	3	2	3	2	1	-	-	-	-	-
PEO5	1	1	1	1	1	1	2	-	-	-	-
PEO6	1	1	1	2	1	3	3	3	-	1	-
PEO7	1	1	1	1		2	2	-	-	3	1
PEO8	1	1	2	2	1	1	-	-	3	-	2
PEO9	1	1	3	3	1	1	1	-	-	1	2

PROGRAM OUTCOMES:

Program Outcomes, as per NBA, are narrower statements that describe what the students are expected to know and be able to do upon the graduation. These relate to the knowledge, skills and behavior the students acquire through the program. The Program Outcomes (PO) are specific to the program and should be consistent with the Graduate Attributes and facilitate the attainment of PEOs.

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

PO1	Apply knowledge of advanced materials, mechanical behavior, and characterization techniques for the analysis of problems in systems integration.
PO2	Evaluate materials and processing techniques to produce quality components.
PO3	Design, simulate and conduct experiments to generate adequate information for understanding the process or product behavior andobtain optimal solutions.
PO4	Develop and validate models for materials and systems integration using modern engineering and IT tools to solve complex real life problems.
PO5	Design and develop control systems for systems integration and productionprocesses.
PO6	Conceptualize and analyze new problems leading to research and development.
PO7	Communicate effectively with diverse groups while leading and executing interdisciplinary projects.
PO8	Design and develop methodologies for materials and systems integration adhering to professional, ethical, legal, security and social issues.
PO9	Engage in life-long learning as a means of enhancing knowledge and skills for professional advancements.

MAPPING OF PROGRAM OUTCOMES WITH PROGRAM EDUCATIONAL OBJECTIVES:

PEO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
1	3	3	3	3	2	3	1	2	1
2	3	3	3	3	3	1	1	1	1
3	2	2	1	1	2	3	3	3	3
4	1	1	1	1	1	3	3	3	3

SCHEME OF INSTRUCTION

M. TECH. (MATERIALS AND SYSTEMS ENGINEERING) COURSE STRUCTURE

I – Year, I – Semester

S. No.	Course Code	Course Title	L	T	P	Credits	Cat. Code
1	ME5601	Advanced Materials Processing	4	0	0	4	PCC
2	ME5602	Finite Element Applications in Materials Processing	4	0	0	4	PCC
3	ME5603	Mechatronics System Design	4	0	0	4	PCC
4	ME5604	Mechanical Behavior and Characterization of Materials	4	0	0	4	PCC
5		Elective – I	3	0	0	3	DEC
6		Elective – II	3	0	0	3	DEC
7	ME5641	Advanced Materials Processing and Testing Lab	0	0	3	2	PCC
8	ME5642	Process Simulation Lab	0	0	3	2	PCC
9	ME5643	Seminar – I	0	0	0	1	PCC
		Total	**22**	**0**	**6**	**27**	

I – Year, II – Semester

S. No.	Course Code	Course Title	L	T	P	Credits	Cat. Code
1	ME5651	Materials and Process Selection for Design	4	0	0	4	PCC
2	ME5652	Systems Engineering Design	4	0	0	4	PCC
3		Elective – III	3	0	0	3	DEC
4		Elective – IV	3	0	0	3	DEC
5		Elective – V	3	0	0	3	DEC
6		Elective – VI	3	0	0	3	DEC
7	ME5691	CAE Lab	0	0	3	2	PCC
8	ME5692	Systems Engineering Lab	0	0	3	2	PCC
9	ME5693	Seminar – 2	0	0	0	1	PCC
		Total	**20**	**0**	**6**	**25**	

II – Year, I – Semester

S. No.	CourseCode	Course Title	Credits	Cat.Code
1	ME5648	Comprehensive Viva-voce	2	PCC
2	ME5649	Dissertation Part-A	6	PCC
		Total	**8**	

II – Year, II – Semester

S. No.	Course Code	Course Title	Credits	Cat.Code
1	ME5699	Dissertation Part-B	12	PCC
		Total	**12**	

LIST OF ELECTIVES:

I Year, I Semester

S. No.	Course Code	Course Title	L-T-P	Credits
1	ME5131	Computational Fluid Dynamics	3-0-0	3
2	ME5613	Heat and Mass Transfer	3-0-0	3
3	ME5221	Micro and Nano Manufacturing	3-0-0	3
4	ME5231	Metrology & Computer Aided Inspection	3-0-0	3
5	ME5321	Enterprise Resource Planning	3-0-0	3
6	ME5331	Manufacturing Management	3-0-0	3
7	ME5336	Soft Computing Techniques	3-0-0	3
8	ME5421	Analysis & Synthesis of Mechanisms	3-0-0	3
9	ME5422	Mathematical Methods in Engineering	3-0-0	3
10	ME5611	Thermodynamics of Materials and Processes	3-0-0	3
11	ME5621	Advanced Metal Forming	3-0-0	3
12	ME5731	Additive Manufacturing	3-0-0	3
13	ME5612	Electrical Machines for Systems Design	3-0-0	3
14	ME5721	Integrated Product Design and Development	3-0-0	3

I Year, II Semester

S. No.	Course Code	Course Title	L-T-P	Credits
1	ME5171	Design of Heat Transfer Equipment	3-0-0	3
2	ME5172	New Venture Creation	3-0-0	3
3	ME5186	Energy Systems and Management	3-0-0	3
4	ME5187	Solar Energy Systems	3-0-0	3
5	ME5188	Energy Conservation & Waste Recovery	3-0-0	3
6	ME5471	Tribological System Design	3-0-0	3
8	ME5474	Composite Materials	3-0-0	3
9	ME5377	Reliability Engineering	3-0-0	3
10	ME5771	Re Engineering	3-0-0	3
11	ME5479	Optimization Methods for Engineering Design	3-0-0	3
12	ME5281	Precision Manufacturing	3-0-0	3
13	ME5483	CAD	3-0-0	3
14	ME5272	Product Design for Manufacturing and Assembly	3-0-0	3
15	ME5273	Tool Design	3-0-0	3
16	ME5274	Fluid Power Systems	3-0-0	3
17	ME5371	Supply Chain Management	3-0-0	3
18	ME5386	Design and Analysis of Experiments	3-0-0	3
19	ME5387	Project Management	3-0-0	3
20	ME5662	Controllers for System Design	3-0-0	3
21	ME5663	Applied Power Electronics for Systems Design	3-0-0	3
22	ME5671	Nano materials processing and Properties	3-0-0	3
23	ME5674	Thermal Coatings	3-0-0	3
24	ME5686	Non Destructive Testing	3-0-0	3
25	ME5170	Powder Metallurgy	3-0-0	3

ME5601	ADVANCED MATERIALS PROCESSING	PCC	4 – 0 – 0	4 Credits

PRE-REQUISITES: None

COURSE OUTCOMES: At the end of the course, the student will be able to:

CO1	Select suitable welding processes for joining different materials
CO2	Analyze metal removal mechanism in subtractive processes
CO3	Analyze and select appropriate transformation process to develop composites
CO4	Select a hybrid processor coating technology to improve the quality of products

CO-PO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	2	3	3	-	-	2	2	-	2
CO2	3	3	3	-	-	2	2	-	2
CO3	3	3	3	-	-	2	2	-	2
CO4	3	3	3	-	-	2	2	-	2

Additive Processes : Introduction welding power sources, TIG, MIG, plasma welding processes , applications and advantages, Friction welding: process variables and applications and advantages, Friction stir processing, process variables and applications and advantages, Electron beam welding , Laser beam welding: process variables and applications and advantages.

Subtractive processes: Hard turning and high speed milling - Laser Machining: Introduction to laser machining, application and advantages, Laser drilling, effect of processes parameters on machinability characteristics of materials. Laser cutting, Quality aspects in laser machining, Applications of laser micromachining, Electrical Discharge Machining.

Transformation processes: Advanced casting: Introduction, Principle of Stir casting, steps in stir casting process, Factors affecting stir casting process: stirring speed stirring time and temperature, preheat temperature of the mold, particle distribution, wettability between reinforcement and liquid metal and porosity - Advantages and application, composite preparation, analysis of composite, Squeeze casting process, advantages Slip casting: principle, applications, advantages and limitations.

Hybrid Processes: Process variables and applications and advantages Hybrid welding processes, hybrid welding process (TIG and Plasma welding, etc.), Hybrid machining processes – ECDM, EDG, ECM
Surface Coating: Coating Materials, Coating on different materials, Coating methods and its applications, Limitations.

Reading:

R.S.Mishra, Friction stir welding and processing, ASM International, 2007.
Nadkarni S.V., Modern Arc Welding Technology, Oxford IBH Publishers, 1996.
Surender Kumar, Technology of Metal Forming Processes, Prentice- Hall, Inc., 2008.
Y. Waseda, A. Muramatsu, Yoshio Waseda, Morphology Control of Materials and Nanoparticles: Advanced Materials Processing and Characterization, Springer, 2004

ME5602	FINITE ELEMENT APPLICATIONS IN MATERIALS PROCESSING	PCC	4 – 0 – 0	4 Credit

PRE-REQUISITES: None

COURSE OUTCOMES: At the end of the course, the student will be able to:

CO1	Apply finite element method to solve problems in solid mechanics
CO2	Formulate FE characteristic equations for two dimensional elements and analyze plain stress, plain strain, axi-symmetric and plate bending problems.
CO3	Solve heat transfer and fluid mechanics problems using the principles of FEM.
CO4	Analyze deformation processes using finite element principles.

CO-PO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	3	-	3	3	-	2	2	-	2
CO2	3	-	3	3	-	2	2	-	2
CO3	3	-	3	3	-	2	2	-	2
CO4	3	3	3	3	-	2	2	-	2

Introduction to FEA, Stresses and equilibrium, Strain displacement relations, Potential energy and equilibrium, FEA in 1 D problems: Element division, Numbering scheme, coordinates and shape functions - Galerkin Approach, Assembly of the global stiffness matrix and load vector, 1 D Problems, Temperature effects.

FEA in 2 D problems, Interpolation in two dimensions, natural coordinates, Isoparametric representation, Concept of Jacobian. Finite element formulation for plane stress plane strain and axi-symmetric problems; Triangular and Quadrilateral elements, higher order elements, subparametric, Isoparametric and superparametric elements. Formulation of plate bending elements using linear and higher order bending theories, Shell elements. Exercises on structural, flow and heat transfer problems.

FEA in Heat Transfer and Fluid Mechanics problems: Finite element solution for one dimensional heat conduction with convective boundaries. Formulation of element characteristics and simple numerical problems. Formulation for 2-D and 3-D heat conduction problems with convective boundaries. Finite element applications in potential flows; Formulation based on Potential function and stream function. Problems.

FEA in Metal forming – Plasticity and Viscoelasticity – Stress, strain and strain rate – Yield Criteria – Equilibrium and Virtual Work Rate Principle – Plastic potential and flow rule – Strain Hardening – Effective stress and strain – Few Case studies.

READING:

1. S S Rao, *The Finite Element Method in Engineering*, 4th Edition, Elsevier 2007.
2. Reddy, J.N., *Finite Element Method in Engineering*, Tata McGraw Hill, 2007.
3. Henry S Valberg , Applied Metal Forming: Including FEM Analysis, Cambridge Press. 2010

4. Shiro Kobayashi, Metal Forming and the Finite Element Method, Oxford University Press,

ME5603	MECHATRONICS SYSTEM DESIGN	L-T-P-C	4-0-0-4	4 Credits

PRE-REQUISITES: Basic Electrical & Electronics, Mathematics and Design of machine elements

COURSE OUTCOMES: At the end of the course the student will be able to:

CO1	Understand the fundamentals of mechatronic systems in a synergistic framework
CO2	Design and develop intelligent engineered products and processes to solve challenging technological problems.
CO3	Design and simulate mechatronic systems using microcontrollers and programmable logic controllers
CO4	Develop innovative approaches to solve real life problems

CO-PO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	-	-	2	2	2	-	2	-	2
CO2	3	3	2	3	3	-	2	-	2
CO3	-	-	3	3	3	-	2	-	2
CO4	3	-	2	3	3	-	2	3	2

Introduction: Overview of the course, Examination and Evaluation patterns, History of Mechatronics, Scope and Significance of Mechatronics systems, elements of mechatronic systems, needs and benefits of mechatronics in manufacturing

Sensors: classification of sensors basic working principles, Displacement Sensor - Linear and rotary potentiometers, LVDT and RVDT, incremental and absolute encoders. Strain gauges. Force/Torque – Load cells. Temperature – Thermocouple, Bimetallic Strips, Thermistor, RTD Accelerometers, Velocity sensors – Tachometers, Proximity and Range sensors – Eddy current sensor, ultrasonic sensor, laser interferometer transducer, Hall Effect sensor, and inductive proximity switch. Light sensors – Photodiodes, phototransistors, Flow sensors – Ultrasonic sensor, laser Doppler anemometer tactile sensors – PVDF tactile sensor, micro-switch and reed switch Piezoelectric sensors, vision sensor

Actuators: Electrical Actuators : Solenoids, relays, diodes, thyristors, triacs, BJT, FET, DC motor, Servo motor, BLDC Motor, AC Motor, stepper motors. Hydraulic & Pneumatic devices – Power supplies, valves, cylinder sequencing. Design of Hydraulic & Pneumatic circuits. Piezoelectric actuators, Shape memory alloys.

Basic System Models & Analysis: Modelling of one and two degrees of freedom Mechanical, Electrical, Fluid and thermal systems, Block diagram representations for these systems. Dynamic Responses of System: Transfer function, Modelling Dynamic systems, first order systems, second order systems.

Digital Electronics: Number systems, BCD codes and arithmetic, Gray codes, selfcomplimenting codes, Error detection and correction principles. Boolean functions using

Karnaugh map, Design of combinational circuits, Design of arithmetic circuits. Design of Code converters, Encoders and decoders.

Signal Conditioning: Operational amplifiers, inverting amplifier, differential amplifier, Protection, comparator, filters, Multiplexer, Pulse width Modulation Counters, decoders. Data acquisition – Quantizing theory, Analog to digital conversion, digital to analog conversion.

Controllers: Classification of control systems, Feedback, closed loop and open loop systems, Continuous and discrete processes, control modes, Two step Proportional, Derivative, Integral, PID controllers.

PLC Programming: PLC Principles of operation PLC sizes PLC hardware components I/O section Analog I/O section Analog I/O modules, digital I/O modules CPU Processor memory module Programming. Ladder Programming, ladder diagrams, timers, internal relays and counters, data handling, analogue input and output. Application on real time industrial automation systems.

Case studies of Mechatronics systems: Pick and place robot, Bar code, Engine Management system, Washing machine etc.

READING:

1. Devdas Shetty and Rochand A. Kolk, *Mechatronics System Design*, PWS Publishing Company, 2000.
2. Michel B. Histand and David G. Alcaiatore*, Introduction to Mechatronics and Measuring Systems,* Int. Edition, Mc. Graw Hill, 2001.
3. W. Bolton, *Mechatronics*, Pearson Education, New Delhi, 2002.

ME5604	MECHANICAL BEHAVIOR AND CHARACTERIZATION OF MATERIALS	PCC	4 – 0 – 0	4 Credits

PRE-REQUISITES: None

COURSE OUTCOMES: At the end of the course, the student will be able to:

CO1	Understand the mechanical behavior of ductile and brittle materials
CO2	Analyze creep, fatigue and fracture mechanisms for various materials
CO3	Develop fracture mechanism maps and analyze the reasons for failure of materials
CO4	Select a characterization technique to evaluate the behavior of materials

CO-PO MAPPING:

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

Introduction: A brief review of elastic and plastic deformation, dislocations and their properties. Dislocations in FCC, BCC and HCP metals, interactions with point defects and other dislocations. Tensile behavior, evaluation of strength and ductility parameters, Effect of strain rate and temperature on tensile behavior, and Protevin Le-Chatelier effect.

Creep: Types and mechanisms of creep deformation, Creep under combined stresses, deformation mechanism maps, Super plasticity, environmental effects, remaining life assessment.

Fatigue: High and low cycle fatigue, process of fatigue fracture, effect of mean stress, Cyclic stress/strain response of materials, establishment of cyclic stress/ strain curve, transition fatigue life, Coffin-Manson relationship, Evaluation of parameters, characterizing resistance against high cycle and Low cycle fatigue, Creep fatigue interaction, environmental effects, thermochemical fatigue.

Fracture Mechanics: Brief review of the basic concepts of linear elastic and elastic-plastic fracture mechanics, stress intensity parameter, J- integral and crack tip opening displacement as fracture criteria, standard procedures for experimental determination of these parameters.

Failure analysis: Analyzing Fractures, Micro mechanisms of brittle and ductile fracture, fracture mechanism maps, fractography, Visual Examination & Management of Applied Failure Analysis, Manage Failure Analysis.

Materials characterization techniques: Optical microscopy techniques, Quantitative metallography, Scanning electron microscopy: Image formation methods in SEM. Applications. Mechanical testing: Tensile, compression, hardness and impact testing. Optical, electrical and electronic strain measuring devices. Measurement of residual stress. Servo hydraulic test machines.

READING:

1. George E. Dieter, *Mechanical Metallurgy*, McGraw Hill, 2nd Edition, 2005.
2. Hellan K, *Introduction to Fracture Mechanics*, McGraw Hill, 2002
3. J.E.Dorn, *Mechanical Behavior of Materials at Elevated Temperatures*, McGraw Hill, 2000.
4. M.F Ashby and David R H Jones : *Engineering Materials I : Introduction to Properties, Applications and Design*,2010

ME5131	COMPUTATIONAL FLUID DYNAMICS	DEC	3 – 0 – 0	3 Credits

PRE-REQUISITES: None

Course Outcomes:

1.	Understand the stepwise procedure to completely solve a fluid dynamics problem using computational methods.
2.	Derive the governing equations and understand the behavior of the equations.
3.	Analyze the consistency, stability and convergence of various discretization schemes for parabolic, elliptic and hyperbolic partial differential equations.
4.	Analyze variations of SIMPLE schemes for incompressible flows and variations of Flux Splitting algorithms for compressible flows.
5.	Analyze various methods of grid generation techniques and application of finite difference and finite volume methods to various thermal problems.

CO-PO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1			3	3		2	2	-	2
CO2			3	3		2	2	-	2
CO3			3	3		2	2	-	2
CO4			3	3		2	2	-	2
CO5			3	3		2	2	-	2

Syllabus:

Governing equations of fluid motion and boundary conditions, turbulence modeling, finite volume method for diffusion problems, convection-diffusion problems, pressure-velocity coupling, SIMPLE and SIMPLER algorithms, unsteady flows, errors and uncertainty in CFD modeling, unstructured grid generation.

1. **INTRODUCTION**: Revision of pre-requisite courses
2. **GOVERNING EQUATIONS OF FLUID DYNAMICS**: The continuity equation, The momentum equation, The energy equation, Navier-Stokes equations for viscous flow, Euler equations for inviscid flow, Physical boundary conditions, Forms of the governing equations suited for CFD, Conservation form of the equations, shock fitting and shock capturing, Time marching and space marching.
3. **TURBULENCE AND ITS MODELLING**: Characteristics of turbulence, Effect of turbulent fluctuations on mean flow, Turbulent flow calculations, Turbulence modeling, Large eddy simulation, Direct Numerical Simulation.
4. **FINITE VOLUME METHOD FOR DIFFUSION PROBLEMS**: Finite volume method for 1-D steady state diffusion, 2-D and 3-D steady state diffusion, Example problems.

5. **FINITE VOLUME METHOD FOR CONVECTION-DIFFUSION PROBLEMS**: Steady 1-D convection-diffusion, Conservativeness, Boundedness and Tran sportiveness, Central, Upwind, Hybrid and Power law schemes, QUICK and TVD schemes.
6. **PRESSURE - VELOCITY COUPLING IN STEADY FLOWS**: Staggered grid, SIMPLE algorithm, Assembly of a complete method, SIMPLER, SIMPLEC and PISO algorithms, Worked examples of the above algorithms.
7. **FINITE VOLUME METHOD FOR UNSTEADY FLOWS**: 1-D unsteady heat conduction, Explicit, Crank-Nicolson and fully implicit schemes, Transient problems with QUICK, SIMPLE schemes.
8. **IMPLEMENTATION OF BOUNDARY CONDITIONS**: Inlet, Outlet, and Wall boundary conditions, Pressure boundary condition, Cyclic or Symmetric boundary condition.
9. **ERRORS AND UNCERTAINTY** IN CFD MODELING: Errors and uncertainty in CFD, Numerical errors, Input uncertainty, Physical model uncertainty, Verification and validation, Guide lines for best practices in CFD, Reporting and documentation of CFD results.
10. **UNSTRUCTURED GRID GENERATION**: Introduction, Domain nodalization, Domain triangulation, Advancing front methods, The Delaunay method, The respective algorithms with examples.
11. **CFD MODELING OF COMBUSTION**: Enthalpy of formation, Stoichiometry, Equivalence ratio, Adiabatic flame temperature, Equilibrium and dissociation, Governing equations of combusting flows, Modeling of a laminar diffusion flame, SCRC model for turbulent combustion.
12. **CFD FOR RADIATION HEAT TRANSFER**: Governing equations for radiation heat transfer, Popular radiation calculation techniques using CFD, The Monte Carlo method, The discrete transfer method, Raytracing, The discrete ordinates method.

References:

1. Versteeg, H. K. and Malalasekera, W., An Introduction to Computational Fluid Dynamics: The Finite Volume Method, 2nd Edition, Pearson, 2010.
2. Tannehill, J. C., Anderson, D. A. and Pletcher, R. H., Computational Fluid Mechanics and Heat Transfer, McGraw Hill, 2002.
3. Blazek, J., Computational Fluid Dynamics: Principles and Applications, 2nd Edition, Elsevier Science & Technology, 2006.
4. Chung, T. J., Computational Fluid Dynamics, Cambridge University Press, 2003.

ME 5132	Heat and Mass Transfer	Credit 3

Prerequisites: Nil

Course Outcomes: At the end of the course, the student shall be able to:

CO1 Understand both the physics and the mathematical treatment of the advanced topics pertaining to the modes of heat transfer.

CO2 Apply principles of heat transfer to develop mathematical models for uniform and non-uniform fins.

CO3 Employ mathematical functions and heat conduction charts in tackling two-dimensional and three-dimensional heat conduction problems.

CO4 Analyze free and forced convection problems involving complex geometries with proper boundary conditions.

CO5 Apply the concepts of radiation heat transfer for enclosure analysis.

CO6 Understand physical and mathematical aspects of mass transfer.

CO-PO MAPPING:

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

Detailed Syllabus:

Introduction to Heat Transfer – Different Modes, Governing Laws, Quasi-Linearization of the Stefan-Boltzmann Law, Applications to Heat Transfer, Simple Problems for recapitulation of the above.

General Heat Conduction Equation: General Heat Conduction Equation in (i) Cartesian, (ii) Polar and (iii) Spherical Co-ordinate Systems – Derivation of all the equations from first principles, Solution to heat conduction equation – Initial and Boundary Conditions, Different kinds of boundary conditions with examples.

Steady-state one-dimensional heat conduction problems in Cartesian System: Steady-state one-dimensional heat conduction problems (i) with and without heat generation and (ii) with and without varying thermal conductivity - in Cartesian system with various possible boundary conditions, Numerical Problems.

Steady-state radial heat conduction problems in Polar System: Steady-state radial heat conduction problems (i) with and without heat generation and (ii) with and without varying thermal conductivity - in Cylindrical system with various possible boundary conditions, Numerical Problems.

Steady-state radial heat conduction problems in Spherical System: Steady-state radial heat conduction problems (i) with and without heat generation and (ii) with and without varying thermal conductivity - in Spherical system with various possible boundary conditions, Numerical Problems.

Extended Surfaces or Fins: Extended Surfaces or Fins of various geometries – Uniform Fins, like Straight Rectangular and Circular Fins, Non-Uniform Fins, like Annular Fins and

Triangular Fins, Corrected fin-length concept of Harper and Brown, Fin Efficiency and Fin Effectiveness, Numerical Problems covering all the topics.

Steady-state two-dimensional heat conduction problems: Steady-state two-dimensional heat conduction problems in Cartesian and Cylindrical co-ordinates, Use of Bessel's functions, Numerical Problems.

Transient [Unsteady-state] heat conduction: Transient heat conduction, Different cases - Negligible internal thermal resistance, Negligible surface resistance, Comparable internal and surface resistances, Lumped body, Infinite plate of finite thickness and Semi-infinite Solid, Numerical problems, Heisler and Grober charts for Transient Conduction – Solution to (i) One-dimensional, (ii) Two-dimensional and (iii) Three-dimensional problems using the charts, Numerical problems.

Forced Convection: Forced Convection Flow over a flat plate, Boundary Layer Theory, Velocity and Thermal Boundary Layers, Prandtl number, Governing Equations – Continuity, Navier-Stokes and Energy equations, Boundary layer assumptions, Integral and Analytical solutions to above equations, Turbulent flow, Various empirical solutions, Numerical Problems concerning the above topics, Forced convection flow over cylinders and spheres, Internal forced convection flows – Constant wall temperature and Constant wall heat flux boundaries, laminar and turbulent flow solutions, Numerical Problems.

Free convection: Laminar and Turbulent flows, analytical and empirical solutions, Numerical Problems.

Thermal Radiation: Prevost's theory, Theories of propagation of thermal radiation, Fundamental principles - White, Opaque, Transparent, Black and Gray bodies, Spectral and Total emissive powers, Wien's, Rayleigh-Jeans and Planck's laws, Spectral energy distribution of a black body, Stefan-Boltzmann law for the total emissive power of a black body, Emissivity – types of emissivity, Numerical Problems, View factor, View factor algebra, Summation rule, Reciprocity Theorem, Hottel's crossed-string method, Electrical resistance concept to tackle two-body enclosures, Numerical problems.

Mass Transfer: Definition, Examples, Fick's law of diffusion, Fick's law as referred to ideal gases, Steady-state Isothermal Equi-molal counter diffusion of ideal gases, Mass diffusivity, Gilliland's equation, Isothermal evaporation of water and its subsequent diffusion into dry air, Mass transfer coefficient, Numerical problems.

Reading:

1. SadikKakac and YamanYener: Heat Conduction, Hemisphere, 2nd Edition, 2001.
2. Kays, W. M. and Crawford, M. E., Convective Heat and Mass Transfer, Tata McGraw Hill, 4th Edition, 2012.
3. Siegel, R. and Howell, J. R., Thermal Radiation Heat Transfer, Taylor and Francis, 4th Edition, 2002.

ME5221	MICRO AND NANO MANUFACTURING	DEC	3 – 0 – 0	3 Credits

PRE-REQUISITES: None

COURSE OUTCOMES: At the end of the course, the student shall be able to:

CO1	Understand different techniques for the synthesis and characterization of nano-materials
CO2	Design and analyze methods and tools for micro and nano-manufacturing.
CO3	Select micro and nano-manufacturing methods and identify key variables to improve quality of MEMS.
CO4	Choose appropriate industrially viable process, equipment and tools for a specific product.

CO-PO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1					2	2	2	-	2
CO2					2	2	2	-	2
CO3						2	2	-	2
CO4	2				2	2	2	-	2

DETAILED SYLLABUS:

Introduction: Importance of Nano-technology, Emergence of Nanotechnology, Bottom-up and Top-down approaches, challenges in Nanotechnology, Scaling Laws/Sizing effects.

Nano-materials Synthesis and Processing: Methods for creating Nanostructures; Processes for producing ultrafine powders- Mechanical grinding; Wet Chemical Synthesis of nano-materials- sol-gel process, Liquid solid reactions; Gas Phase synthesis of nano-materials-Furnace, Flame assisted ultrasonic spray pyrolysis; Gas Condensation Processing (GPC), Chemical Vapour Condensation(CVC)- Cold Plasma Methods, Laser ablation, Vapour – liquid –solid growth, particle precipitation aided CVD, summary of Gas Condensation Processing(GPC).

Structural Characterization: X-ray diffraction, Small angle X-ray Scattering, Optical Microscope and their description, Scanning Electron Microscopy (SEM), Scanning Probe Microscopy (SPM), TEM and EDAX analysis, Scanning Tunneling Microscopy (STM), Atomic force Microscopy (AFM).

Micro fabrication Techniques: Lithography, Thin Film Deposition and Doping, Etching and Substrate Removal, Substrate Bonding, MEMS Fabrication Techniques, Bulk Micromachining, Surface Micromachining, High- Aspect-Ratio Micromachining

Nanofabrication Techniques: E-Beam and Nano-Imprint Fabrication, Epitaxy and Strain Engineering, Scanned Probe Techniques, Self-Assembly and Template Manufacturing.

MEMS devices and applications: Pressure sensor, Inertial sensor, Optical MEMS and RF-MEMS, Micro-actuators for dual-stage servo systems.

READING :

1. Marc Madou,Fundamentals of Microfabrication: The Science of Miniaturization, Second Edition CRC Press, 2002.
2. Mark James Jackson, Microfabrication and Nanomanufacturing, CRC Press, 2005.
3. Gabor L. Hornyak, H.F Tibbals, Joydeep Dutta & John J Moore, Introduction to Nanoscience and Nanotechnology, CRC Press, 2009.
4. Ray F. Egerton , Physical Principles of Electron Microscopy: An Introduction to TEM, SEM, and AEM , Springer, 2005.
5. Robert F Speyer, Thermal Analysis of Materials, Marcel Dekker Inc , New York, 1994.
6. B.D. Cullity - Elements of X-Ray Diffraction, 3rd edition, Prentice Hall , 2002.
7. Tai-Ran Hsu, “MEMS and Microsystems: Design and Manufacture,” McGraw- Hill, 2008.

ME5231	METROLOGY AND COMPUTER AIDEDINSPECTION	3–0–0	3 Credits

PRE-REQUISITES: None

COURSE OUTCOMES: At the end of the course, the student shall be able to:

CO1	Explain the significance of calibration, traceability and uncertainty.
CO2	Identify measurement errors and suggest suitable techniques to minimize them.
CO3	Analyze the methods and devices for dimensional metrology.
CO4	Design limit gauges.
CO5	Assess surface roughness and form errors by computer aided inspection techniques.

CO-PO MAPPING:

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

INTRODUCTION: Accuracy, precision, limits fits and tolerances, types of assemblies, linear and angular measurements, design of limit gauges for different applications.

SURFACE ROUGHNESS MEASUREMENT: Definitions – Types of Surface Texture: Surface Roughness Measurement Methods- Comparison, Contact and Non-Contact type roughness measuring devices, 3D Surface Roughness Measurement, Nano Level Surface Roughness Measurement – Instruments.

MEASUREMENT OF FORM ERRORS: Straightness, flatness, alignment errors-surface texture-various measuring instruments-run out and concentricity, Computational techniques in measurement of form errors.

INTERFEROMETRY: Introduction, Principles of light interference – Interferometers – Measurement and Calibration – Laser Interferometry.

COMPUTER AIDED LASER METROLOGY: Tool Makers Microscope, Coordinate Measuring Machines – Applications, Laser Micrometer, Laser Scanning gauge. Computer Aided Inspection techniques - In-process inspection, Machine Vision system-Applications, LASER micrometer,Optical - LASER interferometers-applications.

IMAGE PROCESSING FOR METROLOGY: Overview, Computer imaging systems, Image Analysis, Preprocessing, Human vision system, Image model, Image enhancement, grey scale models, histogram models, Image Transforms – Examples.

Reading:

1. M. Mahajan, A text-book of Metrology, DhanpatRai& Co, 2009.
2. K. J. Hume, Engineering Metrology, 1970, Mc Donald & Co (Publishers), London
3. J.F.W. Galyer and C.R.Shotbolt, Metrology for Engineers, ELBS Edition, 5/e, 1993.
4. Thomas. G. G, Engineering Metrology, Butterworth PUB.1974.
5. R. K. Jain, Engineering Metrology, Khanna Publishers, 19/e, 2005.

ME5321	ENTERPRISE RESOURCE PLANNING	3-0-0	3 Credits

PRE-REQUISITES: NIL

COURSE OUTCOMES: At the end of the course, the student shall be able to:

CO1	Understand the concepts of ERP and managing risks.
CO2	Choose the technologies needed for ERP implementation.
CO3	Develop the implementation process.
CO4	Analyze the role of Consultants, Vendors and Employees.
CO5	Evaluate the role of PLM, SCM and CRM in ERP.

CO-PO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	3					2	2	-	2
CO2	3					2	2	-	2
CO3	3					2	2	-	2
CO4	3					2	2	-	2
CO5	3					2	2	-	2

DETAILED SYLLABUS:

Introduction to ERP: Enterprise – an overview, brief history of ERP, common ERP myths, Role of CIO, Basic concepts of ERP, Risk factors of ERP implementation, Operation and Maintenance issues, Managing risk on ERP projects.

ERP and Related Technologies: BPR, Data Warehousing, Data Mining, OLAP, PLM, SCM, CRM, GIS, Intranets, Extranets, Middleware, Computer Security, Functional Modules of ERP Software, Integration of ERP, SCM and CRM applications.

ERP Implementation: Why ERP, ERP Implementation Life Cycle, ERP Package Selection, ERP Transition Strategies, ERP Implementation Process, ERP Project Teams.

ERP Operation and Maintenance: Role of Consultants, Vendors and Employees, Successes and Failure factors of ERP implementation, Maximizing the ERP system, ERP and e-Business, Future Directions and Trends.

READING:

1. Alexis Leon, Enterprise Resource Planning, Tata McGraw Hill, Second Edition, 2008.
2. Jagan Nathan Vaman, ERP in Practice, Tata McGraw Hill, 2007.
3. Carol A Ptak, ERP: Tools, Techniques, and Applications for Integrating the Supply Chain, 2nd Edition, CRC Press, 2003.

ME5331	MANUFACTURING MANAGEMENT	DCC	3 – 0 – 0	3 Credits

PRE-REQUISITES: None

COURSE OUTCOMES: At the end of the course, the student shall be able to:

CO1	Design of production planning and control systems encompassing competitive priorities and strategies.
CO2	Evaluate and interpret Demand Forecast for production planning.
CO3	Design an optimal facility layout and select appropriate product design approach.
CO4	Apply ROP, MRP and JIT systems for inventory control in production systems.

CO-PO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	3					2	2	-	2
CO2	3					2	2	-	2
CO3	3					2	2	-	2
CO4	3					2	2	-	2

Competitive priorities and manufacturing strategy: Introduction, Historical perspective of manufacturing management, Competitive priorities and operational strategy, Functional area strategy and Capability, Case Study.

Demand Forecasting: Introduction, Quantitative Methods introduction, Time series and moving averages method, Exponential Smoothing method, Regression Analysis Method, Qualitative Methods.

Facility Design: Introduction and History, Product design and process selection, Capacity planning, Plant location and Plant layout.

Inventory control: From EOQ to ROP, Independent Demand Inventory control & Economic Order Quantity (EOQ), Dynamic lot sizing, Statistical inventory control models.

The MRP crusade: History, Need, Evolution, Dependent Demand & Material Requirement Planning (MRP), Structure of MRP system, MRP Calculations.

The JIT revolution: Just-in-Time System: origin & goals, Characteristics of JIT Systems, Continuous Improvement, The Kanban System, Strategic Implications of JIT System.

Production Planning and Control: Shop floor control, Production scheduling, Aggregate planning, Aggregate and workforce planning.

READING:

1. Krajewski U and Ritzman LP, Operations Management: Strategy and Analysis, Pearson Education Pvt Ltd., Singapore, 2002.
2. Gaither N and Frazier G, Operations Management, Thomson Asia Pvt. Ltd., Singapore, 2002.
3. Chase RB, Aquilano NJ and Jacobs RF, Operations Management for Competitive Advantage, McGraw-Hill Book Company, NY, 2001

ME 5336	SOFT COMPUTING TECHNIQUES	3-0-0	3

PRE REQUISITES: None

COURSE OUTCOMES: At the end of the course, the student shall be able to:

CO1	Classify and differentiate problem solving methods and tools.
CO2	Apply A*, AO*, Branch and Bound search techniques for problem solving.
CO3	Formulate an optimization problem to solve using evolutionary computing methods.
CO4	Design and implement GA, PSO and ACO algorithms for optimization problems in Mechanical Engineering.
CO5	Apply soft computing techniques for design, control and optimization of Manufacturing systems.

CO-PO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	3	-	3	3	-	2	2	-	2
CO2	3	2	2	3	2	2	2	-	2
CO3	2	3	2	3	2	2	2	-	2
CO4	3	3	3	3	3	2	2	-	2
CO5	3	3	3	3	3	2	2	-	2

DETAILED SYLLABUS:

Problem Solving Methods and Tools: Problem Space, Problem solving, State space, Algorithm's performance and complexity, Search Algorithms, Depth first search method, Breadth first search methods their comparison, A*, AO*, Branch and Bound search techniques, p type, Np complete and Np Hard problems.

Evolutionary Computing Methods: Principles of Evolutionary Processes and genetics, A history of Evolutionary computation and introduction to evolutionary algorithms, Genetic algorithms, Evolutionary strategy, Evolutionary programming, Genetic programming.

Genetic Algorithm and Genetic Programming: Basic concepts, working principle, procedures of GA, flow chart of GA, Genetic representations, (encoding) Initialization and selection, Genetic operators, Mutation, Generational Cycle, applications.

Swarm Optimization: Introduction to Swarm intelligence, Ant colony optimization (ACO), Particle swarm optimization (PSO), Artificial Bee colony algorithm (ABC), Other variants of swarm intelligence algorithms.

Advances in Soft Computing Tools: Fuzzy Logic, Theory and applications, Fuzzy Neural networks, Pattern Recognition, Differential Evolution, Data Mining Concepts, Applications of above algorithms in manufacturing engineering problems.

Artificial Neural Networks: Neuron, Nerve structure and synapse, Artificial Neuron and its model, activation functions, Neural network architecture: single layer and multilayer feed forward networks, recurrent networks. Back propagation algorithm, factors affecting back propagation training, applications.

Application of Soft Computing to Mechanical Engineering/Production Engineering Problems: Application to Inventory control, Scheduling problems, Production, Distribution, Routing, Transportation, Assignment problems.

READING:

1. Tettamanzi Andrea, Tomassini and Marco, *Soft Computing Integrating Evolutionary, Neural and Fuzzy Systems*, Springer, 2001.
2. Elaine Rich, *Artificial Intelligence*, McGraw Hill, 2/e, 1990.
3. Kalyanmoy Deb, *Multi-objective Optimization using Evolutionary Algorithms*, John Wiley and Sons, 2001.

ME 5421	ANALYSIS AND SYNTHESIS OF MECHANISMS	Elective	3-0-0	3

PRE-REQUISITES:

Course Outcomes: At the end of the course, the student shall be able to:

CO1	Understand basic mechanisms and machines and formulate the design problem.
CO2	Develop analytical equations for relative position, velocity and acceleration of all moving links.
CO3	Analyze Simple and Complex mechanisms.
CO4	Apply the knowledge of Kinematic theories to practical problems of mechanism design and synthesis.
CO5	Design higher pair kinematic linkages for a given application.

CO-PO Mapping:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	3	2	2	2	2	2	2	-	2
CO2	2	3		3		2	2	-	2
CO3	3	2	2	2	2	2	2	-	2
CO4	2	2	2	2	2	2	2	-	2
CO5	2	2	2	2	2	2	2	-	2

INTRODUCTION: Mechanisms and machines, Planer and Spatial Mechanisms, Mobility, type of motion, links, joints and kinematic chains, of mechanisms, four bar chain, isomers, Linkage transformation, Inversion, four link planar mechanisms, Groshof condition, spring as a link, complaint mechanisms, Practical considerations – pin joints versus sliders.

POSITION ANALYSIS: Position and systems, co-orindinate transformation, rotation, translation and combined motion, Algebraic position analysis, position any point on a linkage, transmission angles, toggle positions.

KINEMATICS OF RIGID BODIES: Plane Motion of a rigid body, graphical velocity and acceleration analysis, Instantaneous centres of velocity, Centrodes, velocity of rub, Analytical solutions for velocity Analysis – velocity of any point on a linkage, Acceleration of any point on a linkage, coriolis acceleration. Analytical solutions for velocity and acceleration analysis - loop closure equations, Case studies – four-bar pin joined linkage, four link slider-crank.

ANALYTICAL LINKAGE SYNTHESIS: Types of kinematic synthesis – Motion and Path generation, Number synthesis, Dimensional synthesis, Two position synthesis for rocker output, Precision Points, Comparison of analytical and graphical two position synthesis, three position synthesis.

GRAPHICAL LINKAGE SYNTHESIS: Two position synthesis for rocker output, Three position synthesis, Position synthesis for more than three positions(four and six bar quick return), Coupler curves, Exact and approximate straight line mechanisms.

CAM: Terminology, types of follower, follower motions, cams, SVAJ diagrams, law of cam design, Single and Double dwell cam design using SHM, cycloidal displacement, combined functions. Critical path motion, practical design considerations.

GEARS AND GEAR TRAINS: Law of gearing, involute tooth form, pressure angle, backlash, contact ratio, Interference and method to avoid interference, Gear Train and its analysis

Reading:

1. Kinematics and Dynamics of machnery, R L. Norton, Pearson , 2009
2. Kinematics Analysis and Synthesis of Mechanisms - A K Mallik, Amitabha Ghosh and Guntur, D. CRC Press, 2011
3. Mechanical Engineering Design - Shigley et al., Tat McGraw Hill, 2011.

ME5422	MATHEMATICAL METHODS IN ENGINEERING	PCC	3 - 0 - 0	3 Credits

PRE-REQUISITES: None

COURSE OUTCOMES: At the end of the course the student will be able to:

CO1	Extend the methods of Applied Linear Algebra to engineering design problems.
CO2	Solve problems involving Nonlinear Optimization in engineering.
CO3	Simulate engineering systems using Numerical Methods.
CO4	Model physical systems using Differential Equations.

CO-PO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	3	3	2			2	2	2	2
CO2	3	3	2			2	2	2	2
CO3	3	3	2			2	2	2	2
CO4	3	3	2			2	2	2	2

Solution of Systems of Linear Equations: Introduction, Basic Ideas of Applied Linear Algebra, Systems of Linear Equations, Square, Non-Singular Systems, Ill-Conditioned and Ill-Posed Systems.

The Algebraic Eigenvalue Problem: The Algebraic Eigenvalue Problem, Canonical Forms, Symmetric Matrices, Methods of Plane Rotations, Householder Method, Tridiagonal Matrices, QR Decomposition, General Matrices.
Selected Topics in Linear Algebra and Calculus: Singular Value Decomposition, Vector Space: Concepts, Multivariate Calculus, Vector Calculus in Geometry, Vector Calculus in Physics.
An Introductory Outline of Optimization Techniques: Solution of Equations, Introduction to Optimization, Multivariate Optimization, Constrained Optimization: Optimality Criteria, Constrained Optimization: Further Issues.
Selected Topics in Numerical Analysis: Interpolation, Regression, Numerical Integration, Numerical Solution of ODE's as IVP Boundary Value Problems, Question of Stability in IVP Solution, Stiff Differential Equations, Existence and Uniqueness Theory.

Ordinary Differential Equations: Theory of First Order ODE's, Linear Second Order ODE's, Methods of Linear ODE's, ODE Systems, Stability of Dynamic Systems.
Application of ODE's in Approximation Theory: Series Solutions and Special Functions, Sturm-Liouville Theory, Approximation Theory and Fourier Series, Fourier Integral to Fourier Transform, Minimax Approximation.
Overviews: PDE's, Complex Analysis and Variational Calculus: Separation of Variables in PDE's, Hyperbolic Equations, Parabolic and Elliptic Equations, Membrane Equation, Analytic Functions , Integration of Complex Functions, Singularities and Residues, Calculus of Variations.

READING:

1. B. Dasgupta , Applied Mathematical Methods, Pearson Education, 2006.
2. E. Kreyszig , Advanced Engineering Mathematics, Wiley, 2010.
3. M. T. Heath, Scientific Computing, McGraw-Hill Education, 2001.
4. Steven Chapra, Applied Numerical Methods with Matlab, McGraw-Hill Education, 2011.

ME5611	THERMODYNAMICS OF MATERIALS & PROCESSES	DEC	3– 0 – 0	3 Credits

PRE-REQUISITES: None

COURSE OUTCOMES: At the end of the course the student will be able to:

CO1	Understand Laws of Thermodynamics using inference from real life examples.
CO2	Derive relations between absolute temperature and properties of gases using relationships of ideal gases,
CO3	Analyzeengineering systems of automotive engines, refrigeration and cooling using thermodynamic principles.
CO4	Derive important relationships in chemical thermodynamics using combustion,enthalpy and free energy concepts
CO5	Apply phase equilibrium of one component and two component systems and phase diagrams to important natural and engineered phenomena

CO-PO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	3			2		2	2	2	2
CO2	3			2		2	2	2	2
CO3	3	3	3	3		2	2	2	2
CO4	3					2	2	2	2
CO5	3		3			2	2	2	2

Introduction to basic thermodynamics. (Systems, boundary) Developing thermodynamic relationships using three basic functions, Entropy (S), Volume (V), number of moles (N) using Legendre transformations.

Non cyclic and cyclic processes – Isothermal, Adiabatic, Isochoric, Isobaric, polytropic. (Numerical) Cyclic processes – Carnot cycle, Otto cycle, Diesel cycle, dual cycle, Rankine cycle, Brayton cycle.

Laws of thermodynamics, zeroth, first, second, third, entropy concept. Concepts of micro and macro-states, Approach to design of the temperature measurement device. C_p, C_v derivations, derivations for α, β. One component systems, clausius - clayperon equation.
Planck-Boltzmann equation,

Solution theory, Quasi-chemical approach to solutions, activities in multi-component systems, Solubility of one component in another phase, Thomson - Freundlich equation, solubility of a metastable phase, retrograde solubility, Free energy vs. composition diagrams, phase diagrams, Rate kinetics, diffusion of metals in fluids.

READING:

1. D. R. Gaskell, *Introduction to Thermodynamics of Materials*, Taylor and Francis, 2006.
2. Richardson, F.D., *Physical Chemistry of Melts in Metallurgy,* Vol. 1 and 2, Academic Press, 1974.

3. Smith, Van Ness and Abbot :*Introduction to Chemical Engineering Thermodynamics:*
Tata Mcgraw Hill 2003

ME5612	ELECTRICAL MACHINES FOR SYSTEM DESIGN	L-T-P-C	3 -0 - 0 - 3	3 Credits

PRE-REQUISITES: Basics of Electricity and Magnetism

COURSE OUTCOMES: At the end of the course the student will be able to:

CO1	Design electrical machines using the fundamentals of electricity, magnetism and circuits
CO2	Select appropriate materials for components of electricalmachines
CO3	Apply appropriate processes to manufacture electrical machine components
CO4	Evaluate performance of Electrical Machines

CO-PO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	3	-	-	-	-	-	2		2
CO2	3	3	3	-	-	-	2		2
CO3	3	3	3	-	-	-	2		2
CO4	3	3	3	-	-	-	2		2

Fundamentals of Electricity, Magnetism and Circuits:
B-H curve of Magnetic material, Faradays laws of electro- magnetic induction, Voltage induced in a conductor, Lorentz force on a conductor, Hysteresis loss, Eddy current loss, Copper Losses, Torque and Power of a Motor, Moment of Inertia, Transmission of heat generated in Motor

Introduction to Electrical Machines:
Motor design characteristics, Classification of Electric Motors, Motor design and operation parameters, Sizing equations, Motor design process, IP code

Rotor Design:
Rotor in Induction Motor, Permanent Magnet Motor, Rotor manufacturing processes, Interference fit;

Shaft Design:
Shaft materials, Shaft loads, Shaft manufacturing methods

Stator Design: Stator lamination, Magnet wire, Stator insulation, Manufacturing processes, Encapsulation and impregnation

Motor Frame Design:
Types of Motor Housing; End bell manufacture

Motor Bearing,
Bearing classification, Bearing materials, Bearing selection

Motor Power losses:
Copper losses, Eddy current and Hysteresis losses, Friction losses, Windage losses

Motor cooling:
Forced air cooling techniques Liquid cooling techniques, Phase cooling techniques

Motor vibration and acoustic noise
Vibration measurement, Vibration control; Noise measurement and noise abatement techniques

Motor Testing
Testing equipment and Measuring Instruments, off-line Motor testing, Online Motor Testing

READING:

1. Wei Tong: Mechanical Design of Electric Motors, CRC Press
2. Theodore Wildi: Electrical Machines, Drives and Power Systems, Pearson Education, Asia
3. AK Sawhney: A course in Electrical Machine Design, Dhanpat Rai & Co

ME5621	ADVANCED METAL FORMING	L-T-P-C	3 -0 - 0 - 3	3 CREDITS

PRE-REQUISITES: None

COURSE OUTCOMES: At the end of the course the student will be able to:

CO1	Solve for strain rates, temperatures and metallurgical states in forming problems
CO2	Develop process maps for metal forming processes using plasticity principles.
CO3	Estimate formability limits for sheets and bulk metals.
CO4	Evaluate workability of different ductile materials
CO5	Apply FE principles to simulate metal forming processes

CO-PO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	3	3	3	2		2	2	2	2
CO2	3	3	3	2		2	2	2	2
CO3	3	3	3	2		2	2	2	2
CO4	3	3	3	2		2	2	2	2
CO5	3	3	3	2		2	2	2	2

Introduction Metal forming as a manufacturing process and its relation with other processes – Classification based on type of stresses - Examples.

Theoretical analysis (theory of plasticity), Stress-strain relationship, Strain hardening, Material incompressibility, Work of plastic deformation, Work hardening, Yield criteria, Flow rule, Yield criterion and flow rule for Anisotropic material, Initiation and extent of plastic flow- Problems.

Overview of various metal forming operations: Mechanics of Various Plastic Flow Problems Introduction to; (i). Theory of slip lines, Upper bound theorem, Lower bound theorem.
Forging processes: Metal flow in forging, Analysis of plane strain compression, Analysis of compression of circular disc with slab method.
Extrusion Processes: Calculation of extrusion load using slab method, slip line method and upper bound method. Defects in extrusion. Direct & indirect extrusion.
Wire Drawing Processes: Introduction,wire drawing load calculation using slab method.
RollingProcesses: Analysis of longitudinal strip or sheet rolling process (calculation of roll separating force, torque & power, angle of bite, maximum reduction in rolling), rolling defects.
Sheet forming: Mechanics – Flow Rules – Anisotropy - Formability of sheet, Formability tests, forming limit diagrams, Case studies.
Pressing and Sintering: Workability Studies – Densification - Problems & Case Studies

Incremental Forming: Statics and Kinematics of Incremental Stresses and Strains - The Kinematics of Two-Dimensional Strain, The Kinematics of Three-Dimensional Strain, Incremental Stresses in Two Dimensions, Incremental Stresses in Three Dimensions, Equilibrium Equations for the Stress Field in Two Dimensions, Equilibrium Equations for the Stress Field in Three Dimensions,

Modeling and Simulation in Metal Forming: Plasticity and Viscoelasticity – Constitutive relations **-** The Plane Strain Compression Test, FEM Model and Input Data to the Model - Deformations in the Compression Gap - Effective Strain and Strain-Rate Distributions in Deformed Zones - Damage Parameter and Edge Cracking.

READING:

1. Surender Kumar, *Technology of Metal Forming Processes*, Prentice - Hall, Inc., 2008.
2. Henry S. Valberg, *Applied Metal Forming - Including FEM Analysis*, Cambridge University Press, 2010.
3. Metal Forming: Mechanics and Metallurgy by William F. Hosford and Robert M. Caddell, Prentice-Hall (USA) – 2012
4. Slater.RA.C.Engineering Plasticity-Theory & Applications to Metal Forming, John Wiley and Sons, 1987.
5. ShiroKobayashi,Altan.T, Metal Forming and Finite Element Method, Oxford University Press, 1989
6. Maurice A. Biot, Mechanics of Incremental Deformations, John Wiley & Sons,2008

E5731	ADDITIVE MANUFACTURING	DEC	3-0-0	3 Credits

PRE-REQUISITES: None

COURSE OUTCOMES: At the end of the course, the student shall be able to:

CO1	Understand the working principle and process parameters of AM processes
CO2	Apply the suitable process for fabricating a given product
CO3	Use the suitable post process based on product application
CO4	Explore the applications of AM processes in various fields
CO5	Design and develop a product for AM Process

CO-PO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	2	2	2	2	3	2	2	2	2
CO2	2	2	2	2	2	2	2	2	2
CO3	2	2	3	2	2	2	2	2	2
CO4	3	3	3	3	3	2	2	2	2
CO5	3	2	3	3	3	2	2	2	2

Introduction to Additive Manufacturing (AM): Need for Additive Manufacturing, Generic AM process, Distinction between AM and CNC, Classification of AM Processes, Steps in AM process, Advantages of AM, Major Applications.

Vat Photopolymerization AM Processes: Stereolithography (SL), Materials, SL resin curing process, Micro-stereolithography, Process Benefits and Drawbacks, Applications of Photopolymerization Processes.

Material Jetting AM Processes: Evolution of Printing as an Additive Manufacturing Process, Materials, Process Benefits and Drawbacks, Applications of Material Jetting Processes.

Binder Jetting AM Processes: Materials, Process Benefits and Drawbacks, Research achievements in printing deposition, Technical challenges in printing, Applications of Binder Jetting Processes.

Extrusion-Based AM Processes: Fused Deposition Modelling (FDM), Principles, Materials, Plotting and path control, Bio-Extrusion, Process Benefits and Drawbacks, Applications of Extrusion-Based Processes.

Sheet Lamination AM Processes: Materials, Laminated Object Manufacturing (LOM), Ultrasonic Consolidation (UC), Gluing, Thermal bonding, LOM and UC applications.

Powder Bed Fusion AM Processes: Selective laser Sintering (SLS), Materials, Powder fusion mechanism, SLS Metal and ceramic part creation, Electron Beam melting (EBM), Process Benefits and Drawbacks, Applications of Powder Bed Fusion Processes.

Directed Energy Deposition AM Processes: Process Description, Laser Engineered Net Shaping (LENS), Direct Metal Deposition (DMD), Electron Beam Based Metal Deposition, Benefits and drawbacks, Applications of Directed Energy Deposition Processes.
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

Errors in AM Processes: Pre-processing, processing, in–situ processing, post-processing errors, Part building errors in SLA, SLS, etc.

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, defense, automobile, Bio-medical and general engineering industries.

READING:

1. Ian Gibson, David W Rosen, Brent Stucker., “Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing”, 2nd Edition, Springer, 2015.
2. Chua Chee Kai, Leong Kah Fai, “3D Printing and Additive Manufacturing: Principles & Applications”, 4th Edition, World Scientific, 2015.
3. Ali K. Kamrani, EmandAbouel Nasr, “Rapid Prototyping: Theory & Practice”, Springer, 2006.
4. D.T. Pham, S.S. Dimov, Rapid Manufacturing: The Technologies and Applications of Rapid Prototyping and Rapid Tooling, Springer 2001.
5. RafiqNoorani, Rapid Prototyping: Principles and Applications in Manufacturing, John Wiley & Sons, 2006

ME5721	INTEGRATED PRODUCT DESIGN AND DEVELOPMENT	DEC	3 – 0 – 0	3 Credits

PRE-REQUISITES: None

COURSE OUTCOMES: At the end of the course, the student shall be able to:

CO1	Understand the reverse engineering and redesign methodology, and modern design theories.
CO2	Identify the significance of analytical and numerical techniques in product development engineering.
CO3	Develop physical models by applying the concepts of product design theory and robust design.
CO4	Apply embodiment principles in product development process.
CO5	Develop products by considering the social, environmental and ethical concerns.

CO-PO MAPPING:

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

Introduction: Modern Product Development and Design Theories: Understanding theopportunity, Develop a concept, Implement a concept, Reverse engineering and redesign methodology.

Product Design Process: Need Identification, Kano diagram, Establishing Engineering Characteristics, Quality Function Deployment (QFD), Product Design Specification (PDS), Information Gathering for EDP.

Concept Generation: Creative methods for design, Functional decomposition and synthesis, Morphological methods, Theory of Inventive Problem solving, Axiomatic Design (AD).

Concept evaluation and decision making: Decision Theory, Evaluation methods, Pugh's concept, weighted decision Matrix.

Embodiment Design: Product Architecture, Configuration and Parametric design Concepts, Ergonomics and Design for Environment,and detailed design.

Ethical Issues and Team Management: Ethical issues considered duringEngineering design process, Product liability, Tort law, functioning, discharge, Team Dynamics and problem solving tools in design, Case studies.

READING:

1. George E Dieter, “Engineering Design” 3rd Ed., , McGraw Hill, 2001.
2. Kevin N. Otto, Kristin L. Wood, “Product Design”, Pearson Education, 2004.
3. Gahl, W Beitz J Feldhusun, K. G. Grote, “Engineering Design”, 3rd Edition, Springer 2007.
4. W. Ernest Eder, S. Hosendl., “Design Engineering”, CRC Press, 2008.
5. Ali K. Kamrani and EmadAbouel Nasr, “Engineering Design and Rapid Prototyping”, Springer, 2010.

ME5641	**Advanced Materials Processing and Testing Lab**	**0-0-3-2**

COURSE OUTCOMES: At the end of the course, the student will be able to:

CO1	Perform macro and microstructural characterization of cast products
CO2	Evaluate the effect of thermomechanical processing on the mechanical, metallurgical and electrical properties of materials.
CO3	Synthesize metallic and ceramic powders
CO4	Characterize the materials synthesized and processed through coatings, additive manufacturing and powder metallurgical techniques.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	3	3	3	-	-	-	2	2	3
CO2	3	3	3	-	-	-	2	2	3
CO3	3	3	3	-	-	3	2	2	3
CO4	3	3	3	-	-	2	2	2	3

The lab course will cover the following advanced materials processing methods together with testing and characterization of the material products by a host of characterization techniques. The labs will be done by the students in NFTDC over a dedicated 2 week period.

1. Advanced Casting Techniques: Continuous Casting

Experiments:

1.1 Direct casting of rod and strip in a vertical concast system; Understanding of solidification profile in concast systems;

1.2 Design analysis of Concast Apparatus;

1.3 Macro and microstructural characterization by optical metallography, hardness and tensile properties of as cast materials

2. Thermo - Mechanical Processing:

Experiments:

2.1 Hot Rolling of Cu and Al alloys;

2.2 Solution Treatment and Age Hardening

2.3 Micro structural characterization, Hardness and Tensile properties

2.4 Electrical conductivity and hardness vs TMP (as cast, hot forged, ST, aged conditions)

3. Coatings and Surface Engineering:

3.1 Plasma Coating: (Cu or Al2O3on MS)

3.2 Diffusion Coating (boronizing)

3.3 Electrochemical coating

3.4 Magnetron Sputtering

3.4 Microstructural Characterization, Hardness, Peel test, SEM

3.5 Design Analysis of HE HV plasma systems

4. Nano-Materials Synthesis and Additive Manufacturing:

4.1 Nano materials synthesis using chemical combustion and or sol gel methods

4.2 Preparation of nano-inks

4.3 Ink Jet printing on glass or metal substrates

4.4 Design analysis of IJP Apparatus

4.5 Particle size analysis, XRD, SEM

5. Advanced Ceramic Processing:

5.1 Ceramic slurry preparation
5.2 Tape casting
5.3 Sintering: conventional and microwave
5.4 Cold iso static pressing
5.5 Particle size, density and porosity

6. Powder Metallurgical Processing:

6.1 Alloy powders preparation and pressing
6.2 Vacuum sintering
6.3 Microstructure & property measurements

ME5642	Process Simulation Lab	0-0-3-2

COURSE OUTCOMES: At the end of the course, the student shall be able to:

CO1	Apply built-in functions in simulation packages to solve numerical problems.
CO2	Developcodesforsolvingproblemsinvolvingdifferenttypesofmathematicalmodelsan equations (ODE, PDE, Linear and nonlinearequations).
CO3	Solve and analyze flow and heat transfer problems.
CO4	Develop process maps for different metal forming processes for achieving defects free products using simulation packages.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	2	-	-	3	-	-	2	2	3
CO2	2	-	-	3	-	2	2	2	3
CO3	2	-	2	3	-	3	2	2	3
CO4	3	3	3	3	-	3	2	2	3

Syllabus

FEM in Heat Transfer and Fluid Mechanics problems: Finite element solution for one dimensional heat conduction with convective boundaries. Formulation for 2-D and 3-D heat conduction problems with convective boundaries. Finite element applications in potential flows; Formulation based on Potential function and stream function.

Friction in Metal Forming - Reduction and Proportions of the Plastic Zone - Deformations from the Velocity Field-Technological Tests and Physical Simulation - Flow Stress Data - Formability and Workability - Friction and Friction Models -Experimental Metal Flow Analysis – FEA of Technological Tests -Forging - FEA of Forging.

The lab will include experiments from the following domain.

Ex No 1. Introduction to MATLAB and practice
Ex No 2.Practice session on handling basic arithmetic etc
Ex No 3.Writing codes with control loops, functions and scripts
Ex No 4.Developing codes for visualization and plotting
Ex No 5.Solving problems involving linear and nonlinear equations
Ex No 6.Solving problems involving ordinary and partial differential equations Ex No7.Solving fluid flow and heat transfer problems
Ex No8.Solving problems on various deformation processes using simulation packages

ME5643	SEMINAR – I	PCC	0– 0 – 0	1 Credits

SEMINAR OUTCOMES: At the end of the seminar, the student shall be able to:

CO1	Identify and compare technical and practical issues related to materials and systems engineering design
CO2	Outline annotated bibliography of research demonstrating scholarly skills.
CO3	Prepare a well-organized report employing elements of critical thinking and technical writing.
CO4	Demonstrate the ability to describe, interpret and analyze technical issues and develop competence in presenting.

CO-PO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	3						3	2	3
CO2	3						3	2	3
CO3	3						3	2	3
CO4	3						3	2	3

II Semester

DETAILED SYLLABUS

ME5651	Materials and Process Selection for Design	PCC	4 – 0 – 0	4 Credits

Pre-requisites: -NIL-
Course Outcomes: At the end of the course the student will be able to:

CO1	Select materials as per the design requirements of a given product.
CO2	Analyze the selection strategy and attribute limits for selecting appropriate processes
CO3	Develop the shape factors for structural sections
CO4	Design and develop hybrid materials to create product personality

Mapping of course outcomes with program outcomes

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	3	3	-	2	-	-	2	-	2
CO2	3	3	2	2	-	3	2	-	2
CO3	3	3	-	2	-	3	2	-	2
CO4	3	3	2	2	-	3	2	-	2

Introduction: The families of Engineering materials, The Design process, types of design, Design tools and materials data.
Materials Selection-The basics and case studies: Introduction and synopsis, the selection strategy, attribute limits and material indices, the selection procedure, computer-aided selection, the structural index, summary and conclusions, case studies
Selection of material and shape, case studies: Introduction and synopsis, shape factors, Microscopic or micro-structural shape factors, limits to shape efficiency, exploring and comparing structural sections, material indices that include shape, co-selecting material and shape, summary and conclusions, case studies
Selecting candidate processes: A strategic view, selecting candidate processes, process information maps, Prima selection strategies, Prima categories: Casting, forming, machining processes.
Designing Hybrid materials and case studies: Introduction and synopsis, filling holes in material property space, hybrids of type 1, 2, 3, 4, Summary and conclusions, case studies
Information and knowledge sources for design: Introduction and synopsis, Information for materials and processes, screening information, supporting information, ways of checking and estimating data, Summary and conclusions
Materials and industrial design: Introduction and synopsis, the requirements pyramid, product character, using materials and processes to create product personality - Summary and conclusions.

Reading:

1. M.F. Ashby: Engineering Materials, 4th Edition, Elsevier, 2005.
2. M.F. Ashby: Materials Selection in Mechanical Design, Butterworth Heinemann, 2005.
3. ASM Publication, Vol.20: Materials Selection and Design, ASM, 1997.
4. Pat L. Mangonon: The Principles of Materials Selection and Design, Prentice Hall International, Inc.1999.
5. K.G.Swift and J.D.Booker,Process selection from Design to manufacture,BH Publication.

ME5652	SYSTEMS ENGINEERING DESIGN	L-T-P-C	4 -0-0-4	4 Credits

PRE-REQUISITES: None

COURSE OUTCOMES: At the end of the course, the student will be able to:

CO1	Understand the various types of electrical power sources and their characteristics
CO2	Analyze the interaction of mechanical, electrical and magnetic elements in the generation of electricity
CO3	Understand the role and benefits of electro-magnetic mechanical systems
CO4	Perform modeling, simulation and stability analysis of electro-mechanical systems

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	3	-	-	-	3	3	2	-	2
CO2	2	-	2	2	3	3	2	-	2
CO3	-	-	-	-	3	3	2	-	2
CO4	2	-	2	3	3	3	2	-	2

System of Measurements:
SI units and Derived units;Speed, Torque, Energy, Power, Temperature, Pressure, Flow, Vibration

DC Power Systems:
Batteries, Fuel Cells, Solar Photo-Voltaic Sources

Electrical Systems components:
Resistors, Capacitors, Inductors, Ohms law, KVL, KCL, Voltage and Current division, Series circuits, Parallel circuits, Network Theorems, Single phase AC Sources, Three Phase AC Sources, Star connection, Delta connection, Power measurement in Single Phase and Three Phase Circuits

Magnetic Systems components:
Magnetic materials, Relative permeability, B-H relationship,Magnetic circuits, Hysteresis and Eddy current losses

Electromagnetic Systems:
Faradays laws of Electromagnetic induction, statically induced EMF, Transformers, Auto Transformer, Potential Transformer, Current Transformer,

Electro Magnetic Mechanical Systems
Lorentz Force, Electric Motors,Induction Motors, Constructional features,Rotating magnetic field, Synchronous Motors, Stepper Motors, Dynamically generated EMF, DC generators, AC Generators Machine Losses, Efficiency, Rating and cooling

Power Systems:
Thermal Power Plants, Hydro-electric Power plants, Diesel-Electric Generators, Wind-Electric Generators

Electrical Heating Systems:
Resistance Heating, Induction Heating, Dielectric Heating

Control Systems:
Open loop and Closed loop control Systems, Control System Components, Laplace Transforms, Mathematical Models of Physical Systems, Transfer function, Pole-Zero plot of Transfer functions, Time Response of First order and Second Order Systems, Stability analysis, Root locus, Frequency domain analysis

READING:

1. HUGHES: Electrical and Electronic Technology, Pearson Education
2. *THEODORE WIDI: Electrical Machines, Drivesand Power Systems, Pearson Education*
3. *IJ NAGRATH, M.GOPAL :Control Systems Engineering:*

ME5691	CAE LABORATORY	PCC	3 – 0 – 0	2

PRE-REQUISITES: None

COURSE OUTCOMES: At the end of the course, the student shall be able to:

CO1	Draw complex geometries of machine components in sketch mode.
CO2	Develop analytical and synthetic curves used in engineering practiceby writing software code.
CO3	Generate freeform shapes in part mode to visualize components
CO4	Create complex engineering assemblies using appropriate assembly constraints
CO5	Design and analyze engineering components using CAD data exchange formats.

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	-	-	2	3	-	-	3	2	3
CO2	-	-	2	3	-	-	3	2	3
CO3	-	-	2	3	-	-	3	2	3
CO4	-	-	2	3	-	-	3	2	3
CO5	-	-	3	3	-	-	3	2	3

LIST OF EXPERIMENTS:

Introduction Sessions

1. Introduction and Installation of CAD/CAM/CAE Softwares
2. Introduction to Solid Modelling & Pro/E Package
3. Working with sketch mode of Pro/E
4. Introduction to MATLAB Programming

Module I

1. Working with creating features (Extrude & Revolve)
2. Working with Datum Planes
3. Working with the tools like Hole, Round, Chamfer and Rib
4. Working with the tools like Pattern, Copy, Rotate, Move and Mirror
5. Working with advanced modeling tools (Sweep, Blend & Swept Blend)
6. Assembly modelling in Pro/E
7. Generating, editing and modifying drawings in Pro/E

Module II

1.Exercises on Analytic Curves (Lines, Circles, Ellipses, Parabolas, Hyperbolas, Conics) using MATLAB Programming

2. Exercises on Synthetic Curves (Cubic Spines, Bezier Cures, B-Spine Curves) using MATLAB Programming

ME5692	Systems Engineering Lab	0	0	3	2	PCC

Pre-requisites: None

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

CO1	Understand different measurement systems
CO2	Perform PLC programming and hardware integration
CO3	Understand software based DAQ system
CO4	Applypneumatic, hydraulic and electrical actuators on real life systems

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	-	-	3	3	2	-	3	2	3
CO2	-	-	3	3	3	3	3	2	3
CO3	-	-	3	3	3	-	3	2	3
CO4	-	-	3	3	3	3	3	2	3

LIST OF EXPERIMENTS:

1. Control of Process parameters using PLC (water level, process temp,pressure)
2. Implementation of DAQ system .for process parameters (temp. Pressure, flow) using LabVIEW
3. Tuning of PID controller
4. Control of Pneumatic /Hydraulic Actuators using PLC
5. Characterization of Induction motor
6. Characterization of BLDC motor
7. Characterization of Stepper motor
8. Calibration of sensors and its indicators(pressure,temperature)

Reading:

1. Devdas Shetty and Rochand A. Kolk, Mechatronics System Design, PWS Publishing Company, 2000.
2. Michel B. Histand and David G. Alcaiatore, Introduction to Mechatronics and Measuring Systems, Int. Edition, Mc. Graw Hill, 2001.
3. W. Bolton, Mechatronics, Pearson Education, New Delhi, 2002.
4. LabviewHandbook

ME5293	SEMINAR –II	PCC	0-0-2	1 Credits

COURSE OUTCOMES: At the end of the course, the student shall be able to:

CO1	Identify and compare technical and practical issues related to the area of materials and systems engineering.
CO2	Outline annotated bibliography of research demonstrating scholarly skills.
CO3	Prepare a well-organized report employing elements of technical writing and critical thinking
CO4	Demonstrate the ability to describe, interpret and analyze technical issues and develop competence in presenting.

CO-PO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	2						3	3	3
CO2	2						3	3	3
CO3	2						3	3	3
CO4	2						3	3	3

ME5171	DESIGN OF HEAT TRANSFER EQUIPMENT	3 Credits

Pre-Requisites: Nil

Course Outcomes:

CO1	Understand the physics and the mathematical treatment of typical heat exchangers.
CO2	Apply LMTD and Effectiveness methods in the design of heat exchangers and analyze the importance of LMTD approach over AMTD approach.
CO3	Analyze the performance of double-pipe counter flow (hair-pin) heat exchangers.
CO4	Design and analyze the shell and tube heat exchanger.
CO5	Understand the fundamental, physical and mathematical aspects of boiling and condensation.
CO6	Classify cooling towers and explain their technical features.

CO-PO Mapping:

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	3	2	-	2	3	2	2	2	2
CO2	3	2	-	2	2	2	2	2	2
CO3	3	2	-	2	2	2	2	2	2
CO4	3		-	2		2	2	2	2
CO5	3	2	-		2	2	2	2	2
CO6	3		-		2	2	2	2	2

DETAILED SYLLABUS:

Introduction to Heat Exchangers: Definition, Applications, Various methods of classification of heat exchangers with examples

General Back-bone Equation for heat exchangers: Derivation from steady-state steady-flow considerations.

Mathematical treatment of Heat Exchangers: Concept of Overall Heat Transfer Coefficient, Derivation of the concerned equations, Fouling, Fouling Factor, Factors contributing to fouling of a heat exchanger, Ill-Effects of fouling, Numerical Problems

Mathematical treatment of Heat Exchangers: Concept of Overall Heat Transfer Coefficient, Derivation of the concerned equations, Fouling, Fouling Factor, Factors contributing to fouling of a heat exchanger, Ill-Effects of fouling, Numerical Problems
Concept of Logarithmic Mean Temperature Difference: Expression for the same for single-pass parallel-flow and single-pass counter flow heat exchangers – Derivation from first principles, Special Cases, LMTD for a single-pass cross-flow heat exchanger – Nusselt's approach, Chart solutions of Bowman et al. pertaining to LMTD analysis for various kinds of

heat exchangers, Numerical Problems on all the above items, Arithmetic Mean Temperature Difference [AMTD], Relation between AMTD and LMTD, Logical Contrast between AMTD and LMTD, LMTD of a single-pass heat exchanger with linearly varying overall heat transfer coefficient [U] along the length of the heat exchanger.

Concept of Effectiveness: Effectiveness-Number of Transfer Units Approach, Derivations of expressions for effectiveness of single-pass parallel-flow and counter-flow heat exchangers, Physical significance of NTU, Heat capacity ratio, Different special cases of the above approach, Chart solutions of Kays and London pertaining to Effectiveness-NTU approach, Numerical Problems on the above.

Hair-Pin Heat Exchangers: Introduction to Counter-flow Double-pipe or Hair-Pin heat exchangers, Industrial versions of the same, Film coefficients in tubes and annuli, Pressure drop, Augmentation of performance of hair-pin heat exchangers, Series and Series-Parallel arrangements of hair-pin heat exchangers, Comprehensive Design Algorithm for hair-pin heat exchangers, Numerical Problems.

Shell and Tube Heat Exchangers: Single-Pass, One shell-Two tube [1S-2T] and other heat exchangers, Industrial versions of the same, Classification and Nomenclature, Baffle arrangement, Types of Baffles, Tube arrangement, Types of tube pitch lay-outs, Shell and Tube side film coefficients, Pressure drop calculations, Numerical Problems.

Principles of Boilers and Condensers: Boiling, Fundamentals and Types of boiling – Pool boiling curve, Various empirical relations pertaining to boiling, Numerical problems on the above, Condensation – Classification and Contrast, Types of condensers, Nusselt's theory on laminar film-wise condensation, Empirical Refinements, Several empirical formulae, Numerical problems on condensation and condensers.

Cooling Towers: Cooling towers – basic principle of evaporative cooling, Psychrometry, fundamentals, Psychrometric chart, Psychrometric Processes, Classification of cooling towers, Numerical problems on cooling towers.

READING:

1. Kays, W. M. and London, A. L., Compact Heat Exchangers, 2nd Edition, McGraw – Hill, New York.
2. Donald Q. Kern: Process Heat Transfer, McGraw – Hill, New York.
3. Incropera, F. P. and De Witt, D. P., Fundamentals of Heat and Mass Transfer, 4th Edition, John Wiley and Sons, New York.

ME5172	NEW VENTURE CREATION	3 - 0 - 0 (3 Cr)

Pre - Requisites:

Course Outcomes: At the end of the course, the student shall be able to:

CO1	Understand entrepreneurship and entrepreneurial process and its significance in economic development.
CO2	Develop an idea of the support structure and promotional agencies assisting ethical entrepreneurship.
CO3	Identify entrepreneurial opportunities, support and resource requirements to launch a new venture within legal and formal frame work.
CO4	Develop a framework for technical, economic and financial feasibility.
CO5	Evaluate an opportunity and prepare a written business plan to communicate business ideas effectively.
CO6	Understand the stages of establishment, growth, barriers, and causes of sickness in industry to initiate appropriate strategies for operation, stabilization and growth.

CO-PO Mapping:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	2		2			2	2	2	2
CO2	2		2			2	2	2	2
CO3	2		2			2	2	2	2
CO4	2		2			2	2	2	2
CO5	2		2			2	2	2	2
CO6	2		2			2	2	2	2

Entrepreneur and Entrepreneurship: Introduction; Entrepreneur and Entrepreneurship; Role of entrepreneurship in economic development; Entrepreneurial competencies and motivation; Institutional Interface for Small Scale Industry/Enterprises.
Planning a New Enterprise: Opportunity Scanning and Identification; Creativity and product development process; The technology challenge - Innovation in a knowledge based economy, Sources of Innovation Impulses – Internal and External; Drucker's 7 Sources of Innovation Impulses, General Innovation Tools, Role of Innovation during venture growth; Market survey and assessment; choice of technology and selection of site.
Establishing a New Enterprises: Forms of business organization/ownership; Financing new enterprises -Sources of capital for early-stage technology companies; Techno Economic Feasibility Assessment; Engineering Business Plan for grants, loans and venture capital.
Operational Issues in SSE: Develop a strategy for protecting intellectual property of the business with patent, trade secret, trademark and copyright law; Financial management issues; Operational/project management issues in SSE; Marketing management issues in SSE; Relevant business and industrial Laws.

Performance appraisal and growth strategies: Strategies to anticipate and avoid the pitfalls associated with launching and leading a technology venture; Management performance assessment and control; Causes of Sickness in SSI, Strategies for Stabilization and Growth.

Readings:

1. Byers, Dorf, and Nelson. 'Technology Ventures: From Ideas to Enterprise'. McGraw Hill. ISBN-13: 978-0073380186., 2010.
2. Bruce R Barringer and R Duane Ireland, 'Entrepreneurship: Successfully Launching New Ventures', 3rd ed., Pearson Edu., 2013.
3. D.F. Kuratko and T.V. Rao, 'Entrepreneurship: A South-Asian Perspective', Cengage Learning, 2013
4. Dr. S.S. Khanka, 'Entrepreneurial Development' (4th ed.), S Chand & Company Ltd., 2012.
5. Dr. Vasant Desai, 'Management of Small Scale Enterprises', Himalaya Publishing House, 2004.

ME5186	ENERGY SYSTEMS AND MANAGEMENT	3 - 0 - 0 (3 Cr)

Prerequisites:

Course Outcomes: At the end of the course, the student shall be able to:

CO1	Understand the fundamentals of energy management
CO2	Select methods of energy production for improved utilization.
CO3	Apply the principles of thermal engineering and energy management to improve the performance of thermal systems.
CO4	Analyze the methods of energy conservation and energy efficiency for buildings, air conditioning, heat recovery and thermal energy storage systems.
CO5	Evaluate energy projects on the basis of economic and financial criteria.

CO-PO Mapping:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	2		2			2	2	2	2
CO2	2		2			2	2	2	2
CO3	2		2			2	2	2	2
CO4	2		2			2	2	2	2
CO5	2		2			2	2	2	2

Introduction: Review of the concepts of Thermodynamics, Fluid Mechanics and Heat Transfer, Properties of Heat transfer media – Pure substances, Thermal fluids, Air-water vapour mixtures; Heat transfer equipment- Heat exchangers, Steam plant

Energy storage Methods and systems: Thermal, Electrical and Mechanical energy storage methods and systems, Energy saving

Energy conversion systems: Thermo-mechanical energy conversion systems – IC Engines, Gas Turbines and Steam turbines

Heat recovery systems: Incinerators, regenerators and boilers

Energy Conservation: Methods of energy conservation and energy efficiency for buildings, air conditioning, heat recovery and thermal energy storage systems

Energy Management: Principles of Energy Management, Energy demand estimation, Organising and Managing Energy Management Programs, Energy pricing

Energy Audit: Purpose, Methodology with respect to process Industries, Characteristic method employed in Certain Energy Intensive Industries

Economic Analysis: Scope, Characterization of an Investment Project

Case studies

Readings:

1. Turner, W. C., Doty, S. and Truner, W. C., Energy Management Hand book, 7th edition, Fairmont Press, 2009.
2. De, B. K., Energy Management audit & Conservation, 2nd Edition, Vrinda Publication, 2010.
3. Murphy, W. R., Energy Management, Elsevier, 2007.
4. Smith, C. B., Energy Management Principles, Pergamon Press, 2007.

ME5674	Thermal Coatings	3-0-0	3

PRE-REQUISITES: None

COURSE OUTCOMES: At the end of the course the student will be able to:

CO1	Identify appropriate powder production methods for a given application
CO2	Evaluate optimum process parameters for different thermal spray techniques
CO3	Develop thermal coatings withknowledge of physical and chemical mechanisms.
CO4	Evaluate the coated surfaces for physical, chemical and mechanical properties.

CO-PO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	3	3	-	-	-	-	2	-	2
CO2	3	3	-	-	-	-	2	-	2
CO3	3	3	-	-	-	3	2	-	2
CO4	3	3	-	-	-	3	2	-	2

Materials Used for Spraying- Methods of Powders Production - Atomization - Sintering or Fusion - Spray Drying (Agglomeration) - Cladding - Mechanical Alloying (Mechanofusion) - Self-propagating High-temperature Synthesis (SHS) - Other Methods - Methods of Powders Characterization - Grain Size - Chemical and Phase Composition - Internal and External Morphology - High-temperature Behaviour - Apparent Density and Flowability- Feeding, Transport and Injection of Powders - Powder Feeders - Transport of Powders - Injection of Powders

Thermal Spraying Techniques- Introduction - Flame Spraying - Principles - Process Parameters - Coating Properties - Atmospheric Plasma Spraying (APS) - Principles - Process Parameters - Coating Properties - Arc Spraying (AS) - Principles - Process Parameters - Coating Properties - Detonation-Gun Spraying (D-GUN) - Principles - Process Parameters - Coating Properties - High-Velocity Oxy-Fuel (HVOF) Spraying - Principles - Process Parameters - Coating Properties - Vacuum Plasma Spraying (VPS) - Principles - Process Parameters - Coating Properties - Controlled-Atmosphere Plasma Spraying (CAPS) - Principles -Process Parameters - Coating Properties - Cold-Gas Spraying Method (CGSM) - Principles - Process Parameters - Coating Properties - New Developments in Thermal Spray Techniques

Pre-Spray Treatment - Introduction-Surface Cleaning - Substrate Shaping - Surface Activation - Masking

Post-Spray Treatment- Heat Treatment - Electromagnetic Treatment - Furnace Treatment - Hot Isostatic Pressing (HIP) - Combustion Flame Re-melting - Impregnation - Inorganic Sealants - Organic Sealants - Finishing - Grinding - Polishing and Lapping

Physics and Chemistry of Thermal Spraying- Jets and Flames - Properties of Jets and Flames - Momentum Transfer between Jets or Flames and Sprayed Particles - Theoretical Description - Experimental Determination of Sprayed Particles' Velocities - Examples of Experimental Determination of Particles Velocities - Heat Transfer between Jets or Flames and Sprayed Particles - Theoretical Description - Methods of Particles' Temperature Measurements - Chemical Modification at Flight of Sprayed Particles - Coating Build-Up - Impact of Particles - Particle Deformation - Particle Temperature at Impact - Nucleation, Solidification and Crystal Growth - Mechanisms of Adhesion - Coating Growth - Mechanism of Coating Growth

Methods of Coatings Characterization - Methods of Microstructure Characterization - Methods of Chemical Analysis - Crystallographic Analyses - Microstructure Analyses - Other Applied Methods - Mechanical Properties of Coatings - Adhesion Determination - Hardness and Microhardness- Elastic Moduli, Strength and Ductility - Properties Related to Mechanics of Coating Fracture - Friction and Wear - Residual Stresses

Reading.

1. Lech Pawlowski, TheScience and EngineeringofThermal Spray Coatings, Wiley, 2008.
2. Huibin Xu, HongboGuo, Thermal Barrier Coatings, Wood Head Publishing, 2011.

ME5471	TRIBOLOGICAL SYSTEMS DESIGN	DEC	3 – 0 – 0	3 Credits

Pre-Requisites: Nil

Course Outcomes: At the end of the course, the student shall be able to:

CO1	Analyze properties of lubricant and select proper lubricant for a given application.
CO2	Determine tribological performance parameters of sliding contact in different lubrication regimes.
CO3	Design and select appropriate bearings for a given application
CO4	Predict the type of wear and volume of wear in metallic and polymer surfaces.

CO-PO Mapping:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	2	2	-			-	2		2
CO2	2	2	2	-		2	2		2
CO3	3		-	-		2	2		2
CO4	3		-	2		2	2		2

Detailed Syllabus:

Introduction: Overview of the course, history and basic concept of friction, wear and lubrication.

Lubricants: Types of lubricants, Objectives of lubricant, Physical properties of lubricants, Selection of lubricant.

Lubrication modes and Theories of hydrodynamic lubrication: Modes of lubrication - hydrodynamic, hydrostatic, Elasto-hydrodynamic, mixed and boundary lubrication, Reynolds' equation, Applications of hydrodynamic lubrication theory - Journal bearing and Inclined thrust pad bearing, Hydrodynamic lubrication of roughened surfaces, Theories of Externally pressurized lubrication, Squeeze-film lubrication, Elasto-hydrodynamic lubrication and air lubricated bearing.

Lubrication regimes and bearings design: Rheological lubrication regime, Functional lubrication regime, Bearing types and its selection. Bearings design.

Friction and Wear: Origin of sliding friction, Contact between two bodies in relative motion, Types of wear and their mechanisms - Adhesive wear, Abrasive wear, Wear due to surface fatigue and wear due to chemical reactions, wear of metallic materials, Tribology of polymers.

Reading:

1. Stachowaik, G.W., Batchelor, A.W., *Engineering Tribology*, 3rd Ed., Elsevier, 2010.
2. Majumdar B.C, *Introduction to bearings*, S. Chand & Co., Wheeler publishing, 1999.
3. Andras Z. Szeri, *Fluid film lubrication theory and design*, Cambridge University press, 1998.

ME5474	COMPOSITE MATERIALS	DEC	3– 0 – 0	3 Credits

PRE-REQUISITES: None

COURSE OUTCOMES: At the end of the course the student will be able to:

CO1	Understand composite material and their reinforcements
CO2	Select constituent materials to develop appropriate composites
CO3	Analyze interfaces of composites for predicting their mechanical properties.
CO4	Develop metal matrix, ceramic matrix and polymer matrix composites with calculated values of constituents
CO5	Analyze the performance of composites

CO-PO MAPPING:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	3	3				3	2		2
CO2	3	3	2			3	2		2
CO3	3	3				3	2		2
CO4	3	3				2	2		2
CO5	3	3	2			3	2		2

Introduction:

Overview of the course, history and basic concept of composites, Types and constituents, reinforcement and matrices, interface and mechanism of strengthening.

Fundamental concepts:

Definition and Classification of Composites, particulate and dispersion hardened composites, continuous and discontinuous fibre reinforced composites MMC, PMC, CMC.

Metal Matrix Composites Processing: Liquid state processes, solid state processes and in situ processes.

Interface: Role, reactions, bonding mechanisms and bond strength.

Properties and applications: Strength, stiffness, creep, fatigue and fracture; thermal, damping and tribological properties.

Polymer Matrix Composites Processing: Hand layup and spray technique, filament winding, pultrusion, resin transfer molding, bag and injection molding, sheet molding compound.

Matrix resins-thermoplastics and thermosetting matrix resins.

Reinforcing fibers- Natural fibers (cellulose, jute, coir etc.), carbon fiber, glass fiber, Kevlar fiber, etc.Particulate fillers-importance of particle shape and size.

Coupling agents-surface treatment of fillers and fibers, significance of interface in composites. short and continuous fibre reinforced composites, critical fibre length, and anisotropic behavior.

Ceramic Matrix Composites Processing: Cold pressing & sintering, hot pressing reaction bonding processes, infiltration, in-situ chemical reaction, Sol-Gel and polymer pyrolysis, self-propagating high temperature synthesis. Carbon- carbon composites, Interfaces.

Rule of mixtures. Stress, strain transformations.

Nanocomposites: introduction to Nanocomposites, advantages disadvantages

Test methods: Quality assessment, physical and mechanical property characterization.

READING:

1. Chawla, K. K. (2012). *Composite materials: science and engineering*. Springer Science & Business Media.
2. Hull, D., & Clyne, T. W. (1996). *An introduction to composite materials*. Cambridge university press.
3. Steven L. Donaldson, ASM Handbook Composites Volume 21, 2001.
4. Krishan K. Chawla, Composite Materials, Science and Engineering, Springer, 2001.
5. Suresh G. Advani, E. Murat Sozer, Process Modelling in Composites Manufacturing, 2nd Ed. CRC Press, 2009
6. Mai, Y. W., & Yu, Z. Z. (2006). *Polymer nanocomposites*. Woodhead publishing.

ME5377	RELIABILITY ENGINEERING	DEC	3 – 0 – 0	3 Credits

PRE-REQUISITES: None

COURSE OUTCOMES: At the end of the course, the student shall be able to:

CO1	Understand the concepts of Reliability, Availability and Maintainability.
CO2	Develop hazard-rate models to know the behavior of components.
CO3	Build system reliability models for different configurations.
CO4	Assess reliability of components & systems using field & test data.
CO5	Implement strategies for improving reliability of repairable and non-repairable systems

CO-PO MAPPING:

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1			3	3		2	2		2
CO2			3	3		2	2		2
CO3			3	3		2	2		2
CO4			3	3		2	2		2
CO5			3	3		2	2		2

DETAILED SYLLABUS:

Introduction: Probabilistic reliability, failures and failure modes, repairable and non-repairable items, pattern of failures with time, reliability economics

Component Reliability Models: Basics of probability & statistics, hazard rate & failure rate, constant hazard rate model, increasing hazard rate models, decreasing hazard rate model, time-dependent & stress-dependent hazard models, bath-tub curve

System Reliability Models: Systems with components in series, systems with parallel components, combined series-parallel systems, k-out-of-m systems, standby models, load-sharing models, stress-strength models, reliability block diagram

Life Testing & Reliability Assessment: Censored and uncensored field data, burn-in testing, acceptance testing, accelerated testing, identifying failure distributions & estimation of parameters, reliability assessment of components and systems

Reliability Analysis & Allocation: Reliability specification and allocation, failure modes and effects and criticality analysis (FMECA), fault tree analysis, cut sets & tie sets approaches

Maintainability Analysis: Repair time distribution, MTBF, MTTR, availability, maintainability, preventive maintenance.

READING:

1. Ebeling CE, *An Introduction to Reliability and Maintainability Engineering*, TMH, New Delhi, 2004.
2. O’Connor P and Kleymer A, *Practical Reliability Engineering*, Wiley, 2012.

ME5771	RE- ENGINEERING	DEC	3 – 0 – 0	3 Credits

PRE-REQUISITES: None

COURSE OUTCOMES: At the end of the course, the student shall be able to:

CO1	Identify the steps involved in re-engineering of a given component.
CO2	Design and fabricate an existing component with suitable modifications as per customer's requirements.
CO3	Select and configure a suitable re-engineering system for inspection and manufacturing.
CO4	Apply the re-engineering techniques in aerospace, automobile and medical sectors.

CO-PO MAPPING:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	3		2	2		2	2	2	2
CO2	2	2	3	2	2	2	2	2	2
CO3	3	2	2	3		2	2	2	2
CO4	3	2	3	2	2	2	2	2	2

Introduction to reverse engineering, Re-Engineering–The Generic Process

Geometric Modelling using Point Cloud Data: Point Cloud acquisition, Surface Modelling from a point clouds, Meshed or Faceted Models, Planar Contour Models, Points to Contour Models, Surface Models, Segmentation and Surface Fitting for Prismatic objects and Free Form Shapes.

Methodologies and Techniques for Re-Engineering: The Potential for Automation with 3-D Laser Scanners, What Is Not Re-Engineering, What is Computer-aided (Forward) Engineering, What Is Computer-aided Reverse Engineering, Computer Vision and Re-Engineering

Re-Engineering–Hardware and Software: Contact Methods Noncontact Methods, Destructive Method.

Selecting a Re-Engineering System: The Selection Process, Some Additional Complexities, Point Capture Devices, Triangulation Approaches, "Time-of-flight" or Ranging Systems, Structured-light and Stereoscopic Imaging Systems, issues with Light-based Approaches, Tracking Systems, Internal Measurement Systems, X-ray Tomography, Destructive Systems, Some Comments on Accuracy, Positioning the Probe, Post processing the Captured Data, Handling Data Points, Curve and Surface Creation, Inspection Applications, Manufacturing Approaches.

Integration Between Re-Engineering and Additive Manufacturing: Modeling Cloud Data in Re-Engineering, Data Processing for Rapid Prototyping, Integration of RE and RP for Layer-based Model Generation, Adaptive Slicing Approach for Cloud Data Modeling, Planar Polygon Curve Construction for a Layer, Determination of Adaptive Layer Thickness.

Re-Engineering in Automotive, Aerospace, Medical sectors: Legal Aspects of Re-Engineering: Copyright Law, Re-Engineering, Recent Case Law, Barriers to Adopting Re-Engineering. A discussion on a few benchmark case studies.

READING:

1. K. Otto and K. Wood, *Product Design: Techniques in Reverse Engineering and New Product Development*, Prentice Hall, 2001.
2. Reverse Engineering: An Industrial Perspective by Raja and Fernandes, Springer-Verlag 2008.
3. AnupamSaxena, Birendra Sahay, “Computer Aided Engineering Design”, Springer, 2005.
4. Ali K. Kamrani and EmadAbouel Nasr, “Engineering Design and Rapid Prototyping”, Springer, 2010.

ME 5479	Optimization Methods for Engineering Design	ELECTIVE	3-0-0	3

Prerequisites: Nil

Course Outcomes: At the end of the course, the student shall be able to:

CO1	Formulate a design task as an optimization problem
CO2	Solve unconstrained optimization problems
CO3	Formulate constrained optimization problems and solve using corresponding methods
CO4	Solve discontinuous optimization problems using special methods
CO5	Solve nonlinear optimization problems with evolutionary methods

CO-PO Matrix:

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1			3	3		2	2		2
CO2			3	3		2	2		2
CO3			3	3		2	2		2
CO4			3	3		2	2		2
CO5			3	3		2	2		2

Detailed Syllabus:

Introduction to Optimization in Design: Problem formulation, Optimization problems in Mechanical Engineering, Classification of methods for optimization

Single-variable Optimization: Optimal criteria, Derivative-free methods (bracketing, region elimination), Derivative based methods, root-finding methods.

Multiple-variable Optimization: Optimal criteria, Direct search methods (Box's, Simplex, Hooke-Jeeves, Conjugate methods), Gradient-based methods (Steepest Descent, Newton's, Marquardt's, DFP method). Formulation and Case studies.

Constrained Optimization: KKT conditions, Penalty method, Sensitivity analysis, Direct search methods for constrained optimization, quadratic programming, GRG method, Formulation and Case studies.

Specialized algorithms: Integer programming (Penalty function and branch-and-bound method), Geometric programming.

Evolutionary Optimization algorithm: Genetic algorithms, simulated annealing, Anti-colony optimization, Particle swarm optimization.

Multi-objective Optimization: Terminology and concepts, the concepts of Pareto optimality and Pareto optimal set, formulation of multi-objective optimization problem, NSGA.

Case studies and Computer Implementation: Representative case studies for important methods and development of computer code for the same to solve problems.

READINGS:

1. Jasbir Arora, Introduction to Optimum Design, Academic Press, 2004

2. KALYANMOY DEB, OPTIMIZATION FOR ENGINEERING DESIGN: Algorithms and Examples, PHI, 2004.

3. Kalyanmoy Deb, Multi-Objective Optimization using Evolutionary Algorithms, Wiley, 2001.

ME5281	PRECISION MANUFACTURING	DEC	3 – 0 – 0	3 Credits

PRE-REQUISITES: Nil

COURSE OUTCOMES: At the end of the course, the student shall be able to:

CO1	Understand the concept of accuracy and precision
CO2	Apply fits and tolerances for parts and assemblies as per ISO standards.
CO3	Evaluate the machine tool and part accuracies.
CO4	Estimate the surface quality of machined components

CO-PO MAPPING:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1		2				2	2	2	2
CO2		2	2			2	2	2	2
CO3	2	2				2	2	2	2
CO4	2	2				2	2	2	2
CO5	2	2	2			2	2	2	2

DETAILED SYLLABUS:

Accuracy and Precision: Introduction - Accuracy and precision – Need – application of precision machining- alignment testing of machine tools, accuracy of numerical control system, specification of accuracy of parts and assemblies.
Tolerance and fits: Tolerance and fits, hole and shaft basis system, types of fits- Types of assemblies-probability of clearance and interference fits in transitional fits.
Concept of part and machine tool accuracy: Specification of accuracy of parts and assemblies, accuracy of machine tools, alignment testing of machine tools.
Errors during machining: Errors due to compliance of machine-fixture-tool-work piece (MFTW) System, theory of location, location errors, errors due to geometric inaccuracy of machine tool, errors due to tool wear, errors due to thermal effects, errors due to clamping. Statistical methods of accuracy analysis.
Surface roughness: Definition and measurement, surface roughness indicators (CLA, RMS, etc,.) and their comparison, influence of machining conditions, methods of obtaining high quality surfaces, Lapping, Honing, Super finishing and Burnishing processes.

READING:

1. R.L.Murty, ”Precision Engineering in Manufacturing”, New Age International Publishers, 1996.
2. V.Kovan, "Fundamentals of Process Engineering", Foreign Languages Publishing House, Moscow, 1975
3. Eary and Johnson, "Process Engineering for Manufacture"
4. J.L.Gadjala, "Dimensional control in Precision Manufacturing", McGraw Hill Publishers.

ME5483	COMPUTER AIDED DESIGN	DEC	3 – 0 – 0	3 Credits

PRE-REQUISITES: Nil

COURSE OUTCOMES: At the end of the course, the student shall be able to:

CO 1	Apply geometric transformations and projection methods in CAD.
CO 2	Develop geometric models to represent curves.
CO 3	Develop surface models for engineering design.
CO 4	Model engineering components using solid modelling techniques for design.

CO – PO mapping

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9
CO 1				3			2		2
CO 2				3			2		2
CO 3				3			2		2
CO 4				3		2	2		2

DETAILED SYLLABUS:

Introduction: Introduction to CAE, CAD. Role of CAD in Mechanical Engineering, Design process, software tools for CAD, geometric modelling.

Transformations in Geometric Modeling: Introduction,Translation, Scaling, Reflection, Rotation in 2D and 3D. Homogeneous representation of transformation, Concatenation of transformations. Computer-Aided assembly of rigid bodies, applications of transformations in design and analysis of mechanisms, etc. Implementation of the transformations using computer codes.

Projections: Projective geometry, transformation matrices for Perspective, Axonometric projections, Orthographic and Oblique projections. Implementation of the projection formulations using computer codes.

Introduction to Geometric Modeling for Design: Introduction to CAGD, CAD input devices, CAD output devices, CAD Software, Display Visualization Aids, and Requirements of Modelling.

Curves in Geometric Modeling for Design: Differential geometry of curves**,** Analytic Curves, PC curve, Ferguson's Cubic Curve, Composite Ferguson, Curve Trimming and Blending. Bezier segments Bernstein polynomials, Composite Bezier. B-spline basis functions, Properties of basic functions, NURBS. Conversion of one form of curve to other. Implementation of the all the curve models using computer codes in an interactive manner.

Surfaces in Geometric Modeling for Design: Surfaces entities (planar, surface of revolution, lofted etc). Free-form surface models (Hermite, Bezier, B-spline surface). Boundary interpolating surfaces (Coon's). Implementation of the all the surface models using computer codes.

Solids in Geometric Modeling for Design: Solid entities, Boolean operations, Topological aspects, Invariants. Write-frame modeling, B-rep of Solid Modelling, CSG approach of solid modelling. Popular modeling methods in CAD softwares. Data Exchange Formats and CAD Applications**:**

Reading:

1. Michael E. Mortenson, Geometric Modeling, Tata McGraw Hill, 2013.
2. A. Saxena and B. Sahay, Computer-Aided Engineering Design, Anamaya Publishers, New Delhi, 2005.
3. Rogers, David F., An introduction to NURBS: with historical perspective, Morgan Kaufmann Publishers, USA, 2001.
4. David F. Rogers, J. A. Adams, Mathematical Elements for Computer Graphics, TMH, 2008.

ME527	PRODUCT DESIGN FOR MANUFACTURING AND ASSEMBLY	DEC	3 – 0 – 0	3 Credits

PRE-REQUISITES: None

COURSE OUTCOMES: At the end of the course, the student shall be able to:

CO1	Understand the quality aspects of design for manufacture and assembly.
CO2	Apply Boothroyd method of DFM for product design and assembly.
CO3	Apply the concept of DFM for casting, welding, forming and assembly.
CO4	Identify the design factors and processes as per customer specifications.
CO5	Apply the DFM method for a given product.

CO-PO MAPPING:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1		2				2	2	2	2
CO2	2	2	2	2		2	2	2	2
CO3	2	2		2		2	2	2	2
CO4	2	2	2			2	2	2	2
CO5	2	2				2	2	2	2

DETAILED SYLLABUS:

Introduction to DFM, DFMA: How Does DFMA Work?, Reasons for Not Implementing DFMA, What Are the Advantages of Applying DFMA During Product Design?, Typical DFMA Case Studies, Overall Impact of DFMA on Industry.

Design for Manual Assembly: General Design Guidelines for Manual Assembly, Development of the Systematic DFA Methodology, Assembly Efficiency, Effect of Part Symmetry, Thickness, Weight on Handling Time, Effects of Combinations of Factors, Application of the DFA Methodology.

High speed Automatic Assembly & Robot Assembly: Design of Parts for High-Speed Feeding and Orienting, Additional Feeding Difficulties, High-Speed Automatic Insertion, General Rules for Product Design for Automation, Design of Parts for Feeding and Orienting, Product Design for Robot Assembly.

Design for Machining and Injection Molding: Machining Using Single-Point & Multi point cutting tools, Choice of Work Material, Shape of Work Material, Machining Basic Component

Shapes, Cost Estimating for Machined Components, Injection Molding Materials, The Molding Cycle, Injection Molding Systems, Molding Machine Size, Molding Cycle Time, Estimation of the Optimum Number of Cavities, Design Guidelines.
Design for Sheet Metal working & Die Casting: Dedicated Dies and Press-working, Press Selection, Turret Press working, Press Brake Operations, Design Rules, The Die Casting Cycle, Auxiliary Equipment for Automation, Determination of the Optimum Number of Cavities, Determination of Appropriate Machine Size, Die Casting Cycle Time Estimation, Die Cost Estimation, Design Principles.

Design for Assembly Automation: Fundamentals of automated assembly systems, System configurations, parts delivery system at workstations, various escapement and placement devices used in automated assembly systems, Quantitative analysis of Assembly systems, Multi station assembly systems, single station assembly lines.

READING:

1. Geoffrey Boothroyd, Assembly Automation and Product Design, Marcel Dekker Inc., NY, 3rd Edition, 2010.
2. Geoffrey Boothroyd, Hand Book of Product Design, Marcel Dekker Inc., NY, 1992.

ME5273	TOOL DESIGN	DEC	3 – 0 – 0	3 Credits

PRE-REQUISITES: None
COURSE OUTCOMES: At the end of the course, the student shall be able to:

CO1.	Analyze the geometrical and dimensional details of a production drawing
CO2.	Design locating and clamping systems for a given component
CO3.	Design jigs and fixtures for conventional and NC machining
CO4.	Select and design dies for press working operations
CO5.	Design single point and multipoint cutting tools

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1		3				2	2	2	2
CO2		3				2	2	2	2
CO3		3				2	2	2	2
CO4		3				2	2	2	2
CO5		3				2	2	2	2

DETAILED SYLLABUS:
Basic principles of tool design: Tool design – An overview, Introduction to Jigs and fixtures.

Work holding devices: Basic principle of six point location, Locating methods and devices, Principle of clamping and Types of clamps.

Design of jigs: Type of Drill bushes, Classification of drill jigs, Design of drill jigs.
Design of fixtures: Design of milling fixtures, Design of turning fixtures

Press tool design: Introduction to Die cutting operations, Introduction to press and classifications, Die set assembly with components, Introduction to Centre of pressure, Examples of center of pressure, Design of piercing die, Design of blanking die, Progressive, Compound and Combination dies.

Design of cutting tools: Introduction to cutting tools, Design of single point tool, Design of drill bit, Design of milling cutter

NC machines work holding devices: Tool design for NC machines- An introduction, Fixture design for NC Machine, Tool holding methods for NC Machine, ATC and APC for NC Machines, Tool presetting for NC Machine.
Reading:
1. Donaldson.C, G.H.Lecain and V.C.Goold "Tool Design", TMH, New Delhi, 2010
2. Wilson.F.W. "Fundamentals of Tool Design", ASME, PHI, New Delhi, 2010.

ME5274	FLUID POWER SYSTEMS	DEC	3 – 0 – 0	3 Credits

PRE-REQUISITES: None

COURSE OUTCOMES: At the end of the course, the student shall be able to:

CO1	Understand common hydraulic components, their use, symbols, and mathematical models
CO2	Design, analyze and implement control systems for physical systems.
CO3	Design and analyze FPS circuits with servo systems, fluidic and tracer control.
CO4	Analyze the operational problems in FPS and suggest remedies.

CO-PO MAPPING:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	2								1
CO2	3	2	2	2					1
CO3	3	2	2	2					1
CO4	3	2	1						1

DETAILED SYLLABUS:

Basic components: Introduction, Basic symbols, Merits, Demerits and applications, Pumps, actuators, Valves.

Hydraulic Circuits: Regenerative sequence, Semiautomatic, automatic Speed controls.

Power amplifiers and tracer control systems: Introduction and type of copying systems, Single coordinate parallel tracer control systems, tracer control systems with input pressure, tracer control systems with four edge tracer valve, Static and dynamic copying system, Types of tracer valve.

Design of Hydraulic circuits: Design of hydraulic circuits for various machine tools.
Servo system: Introduction and types, Hydro mechanical servo valve system, Electro hydraulic servo valve system, Introduction and evolution.

Fluidics: Introduction and evolution, Type of gates and their features, Applications of Fluidics.
Simulation: FPS implementation and analysis.

READING:

1. Esposito, Fluid power with applications, Pearson, 2011
2. M.Galalrabie,Rabie M “Fluid Power Engg.” Professional Publishing, 2009
3. John J Pippenger and W.Hicks, “Industrial hydraulics” Tata McGraw Hill, 1980.

ME5371	SUPPLY CHAIN MANAGEMENT	DEC	3-0-0	3 Credits

PRE-REQUISITES: Nil

COURSE OUTCOMES: At the end of the course, the student shall be able to:

CO1	Understand the decision phases and apply competitive and supply chain strategies.
CO2	Understand drivers of supply chain performance.
CO3	Analyze factors influencing network design.
CO4	Analyze the role of forecasting in a supply chain
CO5	Evaluate the influence of aggregate planning, inventory, IT and coordination in a supply chain performance.

CO-PO MAPPING:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1				-	2	2	2	2	2
CO2		3	2	-	2	2	2	2	2
CO3		2		-	-	2	2	2	2
CO4			2			2	2	2	2
CO5					2	2	2	2	2

DETAILED SYLLABUS:

Strategic Framework: Introduction to Supply Chain Management, Decision phases in a supply chain, Process views of a supply chain: push/pull and cycle views, Achieving Strategic fit, Expanding strategic scope.
Supply Chain Drivers and Metrics: Drivers of supply chain performance, Framework for structuring Drivers, Obstacles to achieving strategic fit.
Designing Supply Chain Network: Factors influencing Distribution Network Design, Design options for a Distribution network, E-Business and Distribution network, Framework for Network Design Decisions, Models for Facility Location and Capacity Allocation.
Forecasting in SC: Role of forecasting in a supply chain, Components of a forecast and forecasting methods, Risk management in forecasting.
Aggregate Planning and Inventories in SC: Aggregate planning problem in SC, Aggregate Planning Strategies, Planning Supply and Demand in a SC, Managing uncertainty in a SC: Safety Inventory.
Coordination in SC: Modes of Transportation and their performance characteristics, Supply Chain IT framework, Coordination in a SC and Bullwhip Effect.

READING:

1. Sunil Chopra and Peter Meindl, 'Supply Chain Management - Strategy, Planning and Operation', 6th Edition, Pearson Education Asia, 2016.
2. David Simchi-Levi, PhilpKamintry and Edith Simchy Levy, 'Designing and Managing the Supply Chain - Concepts Strategies and Case Studies', 3nd Edition, Tata-McGraw Hill, 2016.
3. John J Coyle, et.al., 'Managing Supply Chains A Logistics Approach', 9th Edition, Cengage Learning, 2013.
4. Jeremy F Shapiro, 'Modeling the Supply Chain', 2nd Edition, Cengage Learning, 2007.

ME5386	DESIGN AND ANALYSIS OF EXPERIMENTS	DEC	3-0-0	3 Credits

PREREQUISITES: None

COURSE OUTCOMES: At the end of the course, the student shall be able to:

CO1	Formulate objective(s) and identify key factors in designing experiments for agiven problem.
CO2	Develop appropriate experimental design to conduct experiments for a given problem.
CO3	Analyze experimental data to derive valid conclusions.
CO4	Optimize process conditions by developing empirical models using experimental data.
CO5	Design robust products and processes using parameter design approach.

CO-PO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	-	3	3	3	-	2	2	-	2
CO2	-	3	3	3	-	2	2	-	2
CO3	-	3	3	3	-	2	2	-	2
CO4	-	3	3	3	-	2	2	-	2
CO5	-	3	3	3	-	2	2	-	2

DETAILED SYLLABUS:

Fundamentals of Experimentation: Role of experimentation in rapid scientific progress, Historical perspective of experimental approaches, Steps in experimentation, Principles of experimentation;

Simple Comparative Experiments: Basic concepts of probability and statistics, Comparison of two means and two variances, Comparison of multiple (more than two) means & ANOVA;

Experimental Designs: Factorial designs, fractional factorial designs, orthogonal arrays, standard orthogonal arrays & interaction tables, modifying the orthogonal arrays, selection of suitable orthogonal array design, analysis of experimental data;

Response Surface Methodology: Concept, linear model, steepest ascent, second order model, regression;

Taguchi's Parameter Design: Concept of robustness, noise factors, objective function & S/N ratios, inner-array and outer-array design, data analysis.

READING:

1. Montgomery DC, Design and Analysis of Experiments, 7th Edition, John Wiley & Sons, NY, 2008.
2. Ross PJ, Taguchi Techniques for Quality Engineering, McGraw-Hill Book Company, NY, 2008.

ME5387	PROJECT MANAGEMENT *	DEC	3-0-0	3 Credits

PRE-REQUISITES: None

COURSE OUTCOMES: At the end of the course the student will be able to:

CO1	Understand the importance of projects and its phases.
CO2	Analyze projects from marketing, operational and financial perspectives.
CO3	Evaluate projects based on discount and non-discount methods.
CO4	Develop network diagrams for planning and execution of a given project.
CO5	Apply crashing procedures for time and cost optimization.

CO-PO MAPPING:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	3	-	2		-	2	2	2	2
CO2			2	2	-	2	2	2	2
CO3					-	2	2	2	2
CO4					-	2	2	2	2
CO5					-	2	2	2	2

DETAILED SYLLABUS:

Introduction: Introduction to Project Management, History of Project Management, Project Life Cycle.
Project Analysis: Facets of Project Analysis, Strategy and Resource Allocation, Market and Demand Analysis, Technical Analysis, Economic and Ecological Analysis.
Financial Analysis: Financial Estimates and Projections, Investment Criteria, Financing of Projects.
Network Methods in PM: Origin of Network Techniques, AON and AOA differentiation, CPM network, PERT network, other network models.
Optimization in PM: Time and Cost trade-off in CPM, Crashing procedure, Scheduling when resources are limited.
Project Risk Management: Scope Management, Work Breakdown Structure, Earned Value Management, Project Risk Management.

READING:

1. Prasanna Chandra, Project: *A Planning Analysis,* Tata McGraw Hill Book Company, New Delhi, 4th Edition, 2009.

2. Cleland, Gray and Laudon, *Project Management*, Tata McGraw Hill Book Company, New Delhi, 3rd Edition, 2007.

3. Clifford F. Gray, Gautam V. Desai, Erik W. Larson Project Management ,Tata McGraw-Hill Education, 2010

ME5662	CONTROLLERS FOR SYSTEM DESIGN	L-T-P-C	3 -0 - 0 - 3	3 Credits

PRE-REQUISITES: Basics of Electricity and Magnetism

COURSE OUTCOMES: At the end of the course the student will be able to:

CO1	Select electro-mechanical components used in the control of machines
CO2	Synthesize methods used for control of motors at the start and normal run
CO3	Develop strategies for safety and protection of motors during abnormal operating conditions
CO4	Design control circuits foroperation and maintenance of industrial machines

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1					3	2	2		2
CO2					3	2	2		2
CO3			3		3	2	2		2
CO4			3		3	2	2		2

DETAILED SYLLABUS:

Introduction to control of Machines:
Manual control, Magnetic control, Development of two-wire and three-wire Control, Remote control operation of Motor, Interlocking of Drives

Control Circuit Components:
Fuses, Switches, Switch Fuse units, MCCB, MCB, Push Button, Selector Switch, Limit Switches, Contactors, Relays, Time Delay Relays, Float Switch, solenoid valve , Symbols for various components, Control diagrams

Controllers for Motors:
Starters for DC Motor, Single Phase Motor, 3 Phase Squirrel cage Motors; Controllers for Adjustable speed Drives

Protection of Motors:
Overload, Short circuit, Phase failure and phase reversal, under voltage, Pressure Switches, Temperature switches

Industrial Machines control circuits:
Planer Machine, Overhead Crane, Battery Trolley, Air Compressor

READING:

1. SK Bhattacharya and Brijinder Singh: Control of Machines, New Age International (P) Limited, Publishers
2. Kanneth B. Renford: Electrical Control of Machines, Delmar Publishers Inc
3. Eswar: Handbook of Electrical Motor Control, Tata McGraw Hill Publishing Company Ltd, New Delhi

ME5663	APPLIED POWER ELECTRONICS FOR SYSTEMS DESIGN	L-T-P-C	3 -0 - 0 - 3	3 Credi

PRE-REQUISITES: Basics of Electricity and Magnetism

COURSE OUTCOMES: At the end of the course the student will be able to:

CO1	Understand the operation of power conversion systems like rectifier, converter and inverter
CO2	Understand the operation of discrete power electronic devices in a hybrid electric vehicle
CO3	Select and carry out the sizing of appropriate electric motor for traction application
CO4	Estimate and design the energy source required for traction application

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1				3	3		2		2
CO2				3	3		2		2
CO3			3	3	3	2	2		2
CO4			3	3	3	2	2		2

DETAILED SYLLABUS:

Power Electronic Converters:
Rectifier; Converters: Buck, Boost, Buck-Boost, Fly Back; Inverter

Motors for Traction Application:
Induction Motor, Permanent Magnet Motor, Switched Reluctance Motor, Design and sizing of Traction Motors

Hybrid Electric Vehicles:
Architecture of HEVs: Series, Parallel, Series-Parallel configurations; Hybridization: Micro, Mini,PHEV,REEV,EV; Vehicle Dynamics

Power Electronics in HEVs:
Introduction, Principle of Power Electronics, Power Electronic switches: Diode, Power BJT, Power MOSFET, IGBT, SCR, Gate Drive Circuits, and Protection of Devices

Power Electronic Drives for Electrical Machines
Introduction, Induction Motor Drives, Permanent Magnet Motor Drives, Switched Reluctance Motor Drives

Sensors for Power Electronic drive application on Traction Motors:
Temperature measurement, Hall Effect principle, Voltage and Current measurement using Hall Effect; Speed, Position, Torque sensors

Energy sources:
Batteries, Ultra-capacitors, Fuel Cells, Solar Energy

Power Electronics for Battery Management

Types of Batteries, Battery Terminology, Battery Management, Battery charging circuits, Battery charging during Regenerative Braking

READING:

1. Chris Mi, M.AbulMasrur and David WenzhongGao:Hybrid Electric Vehicles(Principles and Applications with practical perspectives): a John Wiley @Sons Ltd Publication

2. Iqbal Hussain: Electric and Hybrid Vehicles Design Fundamentals, CRC Press, Taylor and Francis Group

3. Ali Emadi: Handbook of Automotive Power Electronics and Motor Drives, CRC Press, Taylor and Francis Group

ME5686	NON-DESTRUCTIVE TESTING	DEC	3– 0 – 0	3 Credits

PRE-REQUISITES: None

COURSE OUTCOMES: At the end of the course the student will be able to:

CO1	Understand the principles of NDT methods
CO2	Identify appropriate nondestructive testing methods for failure identification
CO3	Utilize radiography to identify underlying failure sites
CO4	Analyze flaws using advanced eddy current methods
CO5	Utilize acoustic emission to identify leaks

DETAILED SYLLABUS:

Introduction to NDT, Liquid penetrant test: Physical Principles, Procedure for penetrant testing, penetrant testing materials, Penetrant testing methods, sensitivity, Applications and limitations, typical examples.

Ultrasonic testing: Basic properties of sound beam, Ultrasonic transducers, Inspection methods, Techniques for normal beam inspection, Techniques for angle beam inspection, Flaw characterization techniques, Applications of ultrasonic testing, Advantages and limitations.

Thermography: Basic principles, Detectors and equipment, techniques, applications.

Radiography: Basic principle, Electromagnetic radiation sources, radiographic imaging, Inspection techniques, applications, limitations, typical examples.

Eddy current test: Principles, instrumentation for ECT, techniques, sensitivity, advanced eddy Current test methods, applications, limitations.

Acoustic emission: Principle of AET, Technique, instrumentation, sensitivity, applications, Acoustic emission technique for leak detection.

Magnetic particle inspection: Principle of MPT, Procedure used for testing a component, sensitivity, limitations.

READING:

1. Peter J. Shull ,*Nondestructive Evaluation: Theory, Techniques and Applications*, Marcel Dekkar, 2002.
2. P. Mclntire (Ed.), *Non Destructive Testing Hand Book,* Vol. 4, American Society for Non Destructive Society, 2010
3. ASM Metals Hand Book, *Non Destructive Testing and Quality Control,* Vol. 17, ASM, 1989.

MM5170	POWDER METALLURGY	DEC	3 – 0 – 0	3 Credits

PRE-REQUISITES: None

COURSE OUTCOMES: At the end of the course, the student shall be able to:

CO1	Distinguish and compare powder preparation techniques
CO2	Identify the characterization techniques for powder formulation
CO3	Differentiate between conventional powder compaction and modern compaction techniques
CO4	Analyze the sintering mechanism of powder compacts
CO5	Develop mechanical components through powder metallurgical techniques

CO-PO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	2					2		2	2
CO2	2	2	2	2		2		2	2
CO3		2				2		2	2
CO4						2		2	2
CO5	2	3		2		2		2	2

DETAILED SYLLABUS:

General Concepts: Introduction and History of Powder Metallurgy (PM), Present and Future Trends of PM

Powder Production Techniques: Different Mechanical and Chemical methods, Atomisation of Powder, other emerging processes, Performance Evaluation of different Processes, Design & Selection of Process.

Characterization Techniques: Particle Size & Shape Distribution, Electron Microscopy of Powder, Interparticle Friction, Compressionability, Powder Structure, Chemical Characterization

Microstructure Control in Powder: Importance of Microstructure Study, Microstructures of Powder by Different techniques

Powder Shaping: Particle Packing Modifications, Lubricants & Binders, Powder Compaction & Process Variables, Pressure & Density Distribution during Compaction, Isostatic Pressing, Injection Molding, Powder Extrusion, Slip Casting, Tape Casting, Analysis of Defects of Powder Compact, Laser Engineering Net Shaping (LENS), 3D Printers for Ceramics

Sintering: Theory of Sintering, Sintering of Single & Mixed Phase Powder, Liquid Phase Sintering, Sintering Variables, Modern Sintering Techniques, Physical & Mechanical Properties Evaluation, Structure-Property Correlation Study, Modern Sintering techniques, Defects Analysis of Sintered Components

Application of Powder Metallurgy: Filters, Tungsten Filaments, Self-Lubricating Bearings, Porous Materials, Biomaterials etc. A few case studies.

READING:

1. Powder Metallurgy Technology, Cambridge International Science Publishing, 2002.
2. J. S. Hirschhorn: Introduction to Powder Metallurgy, American Powder Metallurgy Institute, Princeton, NJ, 1976.
3. P. C. Angelo and R. Subramanian: Powder Metallurgy- Science, Technology and Applications, PHI, New Delhi, 2008.
4. ASM Hand Book, vol. 7: Powder Metallurgy, ASM International.