NATIONAL INSTITUTE OF TECHNOLOGY WARANGAL

M.TECH – Materials and Systems Engineering Design

SCHEME OF INSTRUCTION AND SYLLABI

for M. Tech. Materials and Systems Engineering Design

(Effective from 2021-22)

DEPARTMENT OF MECHANICAL ENGINEERING

Vision and Mission of the Institute

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.

Department of Mechanical Engineering:

Brief about the Department:

The Department of Mechanical Engineering was established in the year 1959. The department presently offers one Under Graduate Programme, i.e., B. Tech in Mechanical Engineering with an intake of 170 students, seven M. Tech programs - Thermal Engineering, Machine Design, Automobile Engineering, Material System and Engineering Design, Manufacturing Engineering, Computer Integrated Manufacturing and Additive Manufacturing, one PG Diploma in Additive Manufacturing and Ph. D programs. At present, the Department has 48 faculty members with research expertise in different specializations of Mechanical Engineering. The Department has good research facilities for both experimental as well as simulation-based research. The department has liaison with reputed industries and R&D organizations such as NFTDC, DMRL, DRDL, ARCI, BHEL, CPRI, CMTI, etc. All the faculty of the department are actively engaged in R&D and Consultancy. Presently, the department is handling about 25 funded projects worth Rs. 3.00 crores. The department has recently acquired Metal 3D Printer at a cost of Rs. 1.4 Crores under TEQIP – III grants. The institute is establishing SIEMENS Centre of Excellence in Digital Manufacturing and Industry 4.o in which the department is playing a key role. The department produces a large number of publications, and offers solutions to the industry regularly and is also active with regular outreach activities like workshops, conferences and executive programs for industry personnel. The department has been recognized as QIP Centre for M. Tech and Ph. D programmes.

List of Programmes offered by the Department:

Program	Title of the Programme
B. Tech.	Mechanical Engineering
M. Tech.	Thermal Engineering
	Automobile Engineering
	Manufacturing Engineering
	Machine Design
	Computer Integrated Manufacturing
	Materials and Systems Engineering Design
	Additive Manufacturing
PG Diploma	Additive Manufacturing
Ph.D.	Mechanical Engineering

Note: Refer to the following weblink for Rules and Regulations of M.Tech. program:
https://www.nitw.ac.in/main/MTechProgram/rulesandregulations/

DEPARTMENT OF MECHANICAL ENGINEERING
M.TECH. IN MATERIALS AND SYSTEMS ENGINEERING DESIGN

PROGRAMME 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 are consistent with the mission of the Institution and Department. Department faculty members continuously worked with stakeholders (local employers, industry and R&D advisors and the alumni) to review and update them periodically.

PEO1	Analyse, design and evaluate materials and systems integration using the knowledge of mathematics, materials engineering, 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 PROGRAMME EDUCATIONAL OBJECTIVES:

Mission Statement	PEO1	PEO2	PEO3	PEO4
Impart quality education and training to nurture globally competitive mechanical engineers.	3	3	2	2
Provide vital state of the art research facilities to create, interpret, apply and disseminate knowledge.	3	2	3	3
Develop linkages with world-class educational institutions and R&D organizations for excellence in teaching, research and consultancy services.	3	2	3	2

1: Slightly **2: Moderately** **3: Substantially**

Programme Outcomes (POs)

Programme Outcomes are narrower statements that describe what the students are expected to know and be able to do upon the graduation. They relate the knowledge, skills and behaviour of the students acquire through the programme. The Programme Outcomes (PO) are specific to the programme and facilitate the attainment of PEOs.

PO1	Carryout independent research/investigation and development work to solve practical problems
PO2	Write and present a substantial technical report/document
PO3	Demonstrate a degree of mastery in materials and systems engineering design at a level higher than the Bachelor's programme
PO4	Apply knowledge of advanced materials, mechanical behaviour, and control techniques for the design and analysis of manufacturing processes and systems integration issues.
PO5	Develop and validate models for materials and systems integration using modern engineering and IT tools to solve complex real life problems.
PO6	Engage in lifelong learning adhering to professional, ethical, legal, safety, environmental and societal aspects for career excellence.

MAPPING OF PROGRAMME OUTCOMES WITH PROGRAMME EDUCATIONAL OBJECTIVES:

0	PO1	PO2	PO3	PO4	PO5	PO6
PEO 1	3	3	3	3	2	3
PEO 2	3	3	3	3	3	2
PEO 3	2	2	2	2	2	3
PEO 4	2	2	2	2	2	3

Credits in Each Semester

Category	I Year, Sem – I	I Year, Sem – II	II Year, Sem – I	II Year, Sem – II	Total No. of credits to be earned
Core courses	12	06	--	--	**18**
Electives	06	12	--	--	**18**
Lab Courses	04	04	--	--	**08**
Comprehensive Viva-Voce	--	--	02	--	**02**
Seminar	01	01	--	--	**02**
Dissertation	--	--	12	20	**32**
Total	**23**	**23**	**14**	**20**	**80**

SCHEME OF INSTRUCTION

M. Tech. (MATERIALS AND SYSTEMS ENGINEERING DESIGN) Course Structure

I – Year: I – Semester

S. No.	Course Code	Course Title	L	T	P	Credits	Cat. Code
1	ME5601	Advanced Materials Processing	3	0	0	3	PCC
2	ME5602	Finite Element Applications in Materials Processing	3	0	0	3	PCC
3	ME5603	Mechatronics System Design	3	0	0	3	PCC
4	ME5604	Mechanical Behaviour and Characterization of Materials	3	0	0	3	PCC
5		Elective – I	3	0	0	3	PEC
6		Elective – II	3	0	0	3	PEC
7	ME5605	Advanced Materials Processing and Testing Laboratory	0	1	2	2	PCC
8	ME5606	Process Simulation Laboratory	0	1	2	2	PCC
9	ME5648	Seminar – I	0	0	2	1	SEM
		Total	**18**	**2**	**7**	**23**	

PCC – Programmme Core Course; DEC: Department Elective Course

I – Year: II – Semester

S. No.	Course Code	Course Title	L	T	P	Credits	Cat. Code
1	ME5651	Materials and Process Selection for Design	3	0	0	3	PCC
2	ME5652	Systems Engineering Design	3	0	0	3	PCC
3		Elective – III	3	0	0	3	PEC
4		Elective – IV	3	0	0	3	PEC
5		Elective – V	3	0	0	3	PEC
6		Elective – VI	3	0	0	3	PEC
7	ME5653	CAE Laboratory	0	1	2	2	PCC
8	ME5654	Systems Engineering Laboratory	0	1	2	2	PCC
9	ME5698	Seminar – II	0	0	2	1	SEM
		Total	**18**	**2**	**7**	**23**	

II – Year: I – Semester

S. No	Course Code	Course Title	Credits	Cat. Code
1	ME6647	Comprehensive Viva-voce	2	CVV
2	ME6649	Dissertation Part-A	12	DW
		Total	**14**	

II – Year: II – Semester

S. No	Course Code	Course Title	Credits	Cat. Code
1	ME6699	Dissertation Part-B	20	DW
		Total	**20**	

List of Elective Courses (M. Tech – MSED)

I – Year: I – Semester

S. No	Course Code	Course Title	L-T-P	Credits	Cat. Code
Program Specific Elective Courses					
1	ME5611	Surface Engineering	3-0-0	3	PEC
2	ME5612	Electrical Machines for Systems Design	3-0-0	3	PEC
3	ME5613	Mechanics of Metal Forming	3-0-0	3	PEC
Elective Courses from M. Tech Manufacturing Engineering					
1	ME5211	Micro and Nano Manufacturing	3-0-0	3	PEC
2	ME5212	Metrology and Computer Aided Inspection	3-0-0	3	PEC
Elective Courses from M. Tech Computer Integrated Manufacturing					
1	ME5311	Enterprise Resource Planning	3-0-0	3	PEC
2	ME5312	Manufacturing Management	3-0-0	3	PEC
3	ME5313	Soft Computing Techniques	3-0-0	3	PEC
Elective Courses from M. Tech Additive Manufacturing					
1	ME5711	Integrated Product Design and Development	3-0-0	3	PEC
2	ME5712	3D Printing	3-0-0	3	PEC
Elective Courses from M. Tech Thermal Engineering					
1	ME5102	Computational Methods in Thermal Engineering	3-0-0	3	PEC
2	ME5113	Renewable Sources of Energy	3-0-0	3	PEC
3	ME5114	Energy Systems and Management	3-0-0	3	PEC
Elective Courses from M. Tech Machine Design					
1	ME5413	Analysis and Synthesis of Mechanisms	3-0-0	3	PEC
2	ME5415	Mathematical Methods in Engineering	3-0-0	3	PEC

List of Elective Courses (M. Tech – MSED)

I – Year: II – Semester

S. No	Course Code	Course Title	L-T-P	Credits	Cat. Code
Program Specific Elective Courses					
1	ME5661	Controllers for System Design	3-0-0	3	PEC
2	ME5662	Applied Power Electronics for Systems Design	3-0-0	3	PEC
3	ME5663	Thermodynamics of Materials and Processes	3-0-0	3	PEC
4	ME5664	Non-Destructive Testing and Evaluation	3-0-0	3	PEC
Elective Courses from M. Tech Manufacturing Engineering					
1	ME5262	Product Design for Manufacturing and Assembly	3-0-0	3	PEC
2	ME5263	Tool Design	3-0-0	3	PEC

3	ME5264	Geometric Dimensioning and Tolerancing	3-0-0	3	PEC
4	ME5266	Precision Manufacturing	3-0-0	3	PEC
Elective Courses from M. Tech Computer Integrated Manufacturing					
1	ME5361	Supply Chain Management	3-0-0	3	PEC
2	ME5363	Intelligent Manufacturing Systems	3-0-0	3	PEC
3	ME5365	Sustainable Manufacturing	3-0-0	3	PEC
4	ME5367	Reliability Engineering	3-0-0	3	PEC
5	ME5368	Industry 4.o and IIoT	3-0-0	3	PEC
6	ME5369	Design and Analysis of Experiments	3-0-0	3	PEC
7	ME5370	Project Management	3-0-0	3	PEC
8	ME5371	AI and ML for Mechanical Systems	3-0-0	3	PEC
Elective Courses from M. Tech Additive Manufacturing					
1	ME5762	Powders for Additive Manufacturing	3-0-0	3	PEC
2	ME5763	Re-Engineering	3-0-0	3	PEC
Elective Courses from M. Tech Thermal Engineering					
1	ME5166	Design of Heat Transfer Equipment	3-0-0	3	PEC
2	ME5170	Essentials of Entrepreneurship	3-0-0	3	PEC
3	ME5172	Solar Energy Systems	3-0-0	3	PEC
4	ME5173	Energy Conservation and Waste Heat Recovery	3-0-0	3	PEC
Elective Courses from M. Tech Machine Design					
1	ME5466	Tribology in Design	3-0-0	3	PEC
2	ME5467	Advanced Composite Technologies	3-0-0	3	PEC
3	ME5469	Optimization Methods for Engineering Design	3-0-0	3	PEC

DETAILED CORE COURSE SYLLABUS

I YEAR – I SEMESTER

ME5601	ADVANCED MATERIALS PROCESSING	3-0-0: 3

Pre-Requisites: NIL

Course Outcomes:

At the end of the course, the student will be able to

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

Course Articulation Matrix:

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

Syllabus:

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.

Super Alloys: Properties, microstructure, melting and casting practice of super alloys Microstructure of Ni-base & Co-base heat-resistant casting alloys. Temperature and Time dependent Transformation - Relationship of properties to microstructure in super alloys.

Learning Resources:

Text Books:

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

Reference Books:

1. Superalloys: Source Book, ASM International.

Online resources:

1. https://onlinecourses.nptel.ac.in/noc19_mm13/preview

2. https://nptel.ac.in/courses/112/107/112107077/

ME 5602	FINITE ELEMENT APPLICATIONS IN MATERIALS PROCESSING	3-0-0: 3

Pre-Requisites: NIL

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 analyse plain stress, plain strain, axi-symmetric and plate bending problems.
CO3	Solve heat transfer and fluid mechanics problems using the principles of FEM.
CO4	Analyse deformation processes using finite element principles.

Course Articulation Matrix:

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

Syllabus:

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.

Non Linear FEA – Introduction to Non Linear Finite Element Analysis – Nonlinearities – Solution Methods – Newton Raphson – Modified Newton Raphson – Secant Method – Incremental Force Method - Problems

FEA of Elasto Plastic Problems –One and Multidimensional Elastoplasticity – Yield Criteria – Hardening Models – Mathematical Formulations - Problems

FEA in Heat Transfer problems: Finite element solution for one dimensional heat conduction with convective boundaries. Formulation of element characteristics and simple numerical problems. Formulation for 2-D problems with convective boundaries, Problems.

Modelling of microstructure evolution - Nucleation and growth kinetics -Classical cellular automaton models - Simulation of solidification grain structures by classical cellular automaton models - Simulation of dendritic growth by modified cellular automaton models.

Learning Resources:

Text Books:

1. Applied Metal Forming: Including FEM Analysis, Henry S Valberg, Cambridge Press, 2010
2. Introduction to Non Linear Finite Element Analysis, Nam Ho Kim, Springer, 2015.
3. Process Modelling of Metal Forming and Thermomechanical Treatment, C. R. Boer· N. Rebelo H. Rydstad . G. Schroder, Springer-Verlag, 1986.

Reference Books:

1. The Finite Element Method in Engineering, S S Rao, 4th Edition, Elsevier 2007.
2. Finite Element Method in Engineering, Reddy, J.N., Tata McGraw Hill, 2007.

ME 5603	MECHATRONICS SYSTEM DESIGN	3-0-0: 3

Pre-Requisites: NIL

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

Course Articulation Matrix:

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

Syllabus:

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.

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, self-complimenting 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.

Learning Resources:

Text Books:

1. Mechatronics System Design, Devdas Shetty and Rochand A. Kolk, PWS Publishing Company, 2000.

Reference Books:

1. Introduction to Mechatronics and Measuring Systems, Michel B. Histand and David G. Alcaiatore, Int. Edition, Mc. Graw Hill, 2001.

2. Mechatronics, W. Bolton, Pearson Education, New Delhi, 2002.

ME 5604	MECHANICAL BEHAVIOR AND CHARACTERIZATION OF MATERIALS	3-0-0: 3

Pre-Requisites: NIL

Course Outcomes:

At the end of the course, the student will be able to

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

Course Articulation Matrix:

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

Syllabus:

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 behaviour, evaluation of strength and ductility parameters, Effect of strain rate and temperature on tensile behaviour, 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: Analysing 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.

Learning Resources:

Text Books:

1. Mechanical Metallurgy, George E. Dieter, McGraw Hill, 2nd Edition, 2005.
2. Introduction to Fracture Mechanics, Hellan K, McGraw Hill, 2002.
3. Mechanical Behaviour of Materials at Elevated Temperatures, J.E.Dorn, McGraw Hill, 2000.
4. Deformation and Fracture Mechanics of Engineering Materials, Richard W. Hertzberg, Richard P. Vinci, Jason L. Hertzberg, 5th Edition, Wiley, 2012.

Reference Books:

1. Engineering Materials I : Introduction to Properties, Applications and Design, M.F Ashby and David R H Jones :,2010.
2. Mechanical behaviour of Materials, Marc Andre Meyers and Krishna Kumar Chawla, 2009.

DETAILED ELECTIVE COURSE SYLLABUS

I YEAR – I SEMESTER

ME5102	COMPUTATIONAL METHODS IN THERMAL ENGINEERING	3-0-0: 3

Prerequisites: NIL

Course Outcomes:

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

CO1	Derive the governing equations and understand the behaviour of the equations.
CO2	Derive algebraic equations using finite volume methods for various fluid flow and heat transfer problems.
CO3	Solve systems of linear and non-linear equations using state of the art iterative algorithms.
CO4	Analyse the error and uncertainty in numerical models used for various algorithms.
CO5	Model the radiation heat transfer and turbulent flow problems using advanced techniques.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	3	3		1
CO2	2	2	3	3		1
CO3	2	2	3	3		1
CO4	2	2	3	3		1
CO5	2	2	3	3		1

Syllabus:

Introduction: Revision of Fluid Mechanics and Heat transfer fundamentals.

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.

Finite volume method for diffusion problems: Derivation of equations for 1-D, 2-D and 3-D steady state diffusion, Solution of 1-D, 2-D and 3-D steady state heat conduction of slab.

Finite volume method for convection-diffusion problems: Conservativeness, Boundedness and Transportiveness, Central, Upwind, Hybrid and Power law schemes, QUICK and TVD schemes.

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.

Solution of discretized equations: Direct and Indirect or iterative methods, TDMA algorithm, Point-iterative methods (Jacobi method, Gauss-Seidel Method, Relaxation method), Multigrid methods

Finite volume method for 1-D unsteady flows: 1D unsteady heat conduction (Explicit, Crank-Nicolson and fully implicit schemes), Transient problems with QUICK, SIMPLE schemes, Implementation of boundary conditions: Inlet, Outlet, and Wall boundary conditions, Pressure boundary condition, Cyclic or Symmetric boundary condition.

Errors and uncertainty in CFD modelling: Numerical errors, Input uncertainty, Physical model uncertainty, Verification and validation, Guidelines for best practices in CFD, Reporting and documentation of CFD results.

CFD modelling of turbulent flows: Characteristics of turbulence, Effect of turbulent fluctuations on mean flow, Turbulent flow calculations, Turbulence modelling, Large Eddy Simulation, Direct Numerical Simulation.

Grid Generation: Unstructured grid generation, Domain nodalization, Domain triangulation, Advancing front methods, The Delaunay method, The respective algorithms with examples.

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.

Learning Resources:

Text Books:

1. An introduction to computational fluid dynamics: the finite volume method, H.K. Versteeg, W. Malalasekera, Longman Group, England, 2007, 2nd Edition.
2. Computational Fluid Dynamics the Basics with Applications, Anderson. J.D(Jr), McGraw Hill Education, 2017.

Reference Books:

1. Computational Fluid Dynamics, Hoffman, K.A., and Chiang, S.T., Vol. I, II and III, Engineering Education System, 2000, 4th edition.
2. Computational Fluid Dynamics, Chung, T.J., Cambridge University Press, 2014, 2nd Edition.
3. Computational Fluid Mechanics and Heat Transfer, Anderson, D.A., Tannehill, J.C., and Pletcher, R.H., CRC Press, 2013, 3rd Edition.

Online Resources:

1. Computational Fluid Dynamics using Finite Volume Method by Dr.KameswararaoAnupindi (IIT Madras), NPTEL Course (Link: https://nptel.ac.in/courses/112/106/112106294/)
2. Foundations of Computational Fluid Dynamics by Prof. S. Vengadesan (IIT Madras), NPTEL Course (Link: https://nptel.ac.in/courses/112/106/112106186/)

Computational Fluid Dynamics by Prof. Suman Chakraborty (IIT Kharagpur), NPTEL Course (Link: https://nptel.ac.in/courses/112/105/112105045/)

ME5113	RENEWABLE SOURCES OF ENERGY	3-0-0: 3

Prerequisites: NIL

Course Outcomes:

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

CO1	Identify the renewable energy sources, their utilization and storage
CO2	Understand the basic concepts of the solar radiation and analyse the solar thermal systems for their utilization
CO3	Understand the principle of working of solar cells and their modern manufacturing techniques
CO4	Analyse wind energy, biomass and Fuel cell systems and their applications
CO5	Design of solar thermal and energy storage systems for specific applications
CO6	Evaluate the energy conversion from ocean thermal energy, geothermal energy, biomass and magneto hydrodynamic power generation

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	1	2	3	3
CO2	3	2	2	3	3	2
CO3	2	2	3	3	3	2
CO4	2	2	2	1	3	2
CO5	3	3	3	2	3	2
CO6	2	2	2	1	3	2

Syllabus:

Introduction: Overview of the course, Examination and Evaluation patterns. Classification of energy resources, Environmental Aspects of Energy – Global warming & Climate change – Role of Renewables, Energy-Environment-Economy, energy scenario in the world and India, Thermodynamics of Energy Sources – A brief review.

Energy storage: Necessity for energy storage. Classification of methods of energy storage. Thermal energy storage; sensible heat storage, latent heat storage., Mechanical energy storage: Pumped hydel storage, Compressed air storage and Flywheel storage, Reversible chemical reaction storage. Electromagnetic energy storage. Hydrogen energy storage. Chemical battery storage.

Basic sun-earth relationships: Definitions. Celestial sphere, altitude-azimuth, declination-hour angle and declination-right ascension coordinate systems for finding the position of the sun, celestial triangle and coordinates of the sun. Greenwich Mean Time, Indian Standard Time, Local Solar Time, sunrise and sunset times & day length.

Solar radiation: Nature of solar radiation, solar radiation spectrum, solar constant, extra-terrestrial radiation on a horizontal surface, attenuation of solar radiation, beam, diffuse and global radiation. Measurement of global, diffuse and beam radiation. Prediction of solar radiation; Angstrom model, Page model, Hottel's model, Liu and Jordan model etc. Insolation on an inclined surface, angle of incidence.

Solar thermal systems: Principle of working of solar water heating systems, solar cookers, solar desalination systems, solar ponds, solar chimney power plant, central power tower power plants etc. Classification of solar concentrators, Basic definitions such as concentration ratio, angle of acceptance etc., Tracking of the sun; description of different tracking modes of solar collectors and the determination of angle of incidence of insolation in different tracking modes, Concept of Green building and associated design parameters.

Photovoltaic energy conversion: Introduction. Single crystal silicon solar cell, i-v characteristics, effect of insolation and temperature on the performance of silicon cells. Different types of solar cells. Modern technological methods of producing these cells. Indian and world photovoltaic energy scenario. Solar Cell, Module, and Array Construction, Maximizing the Solar PV Output and Load Matching.

Wind energy: Origin of winds, nature of winds, wind data measurement, Variation of Wind Speed with Height, Basics of fluid mechanics, Estimation of Wind Energy at a Site: Betz's law, Wind Turbine Aerodynamics, wind turbine types and their construction, wind-diesel hybrid system, environmental aspects, Wind Energy Storage, wind energy programme in India and the world.

Fuel cells: Introduction, applications, classification, different types of fuel cells such as phosphoric acid fuel cell, alkaline fuel cell, PEM fuel cell, MC fuel cell. Thermodynamic analysis of fuel cells, Development and performance fuel cells.

Biomass: Introduction, photosynthesis, biofuels, biomass resources, biomass conversion technologies, urban waste to energy conversion, biomass to ethanol conversion, biomass energy scenario in India, biogas production, constant pressure and constant volume biogas plants, operational parameters of the biogas plant, design of bio-digester, Energy Farming

Other forms of Energy: Ocean Energy: Ocean thermal energy; open cycle & closed cycle OTEC plants, environmental impacts, challenges, present status of OTEC systems. Ocean tidal energy; single basin and double basin plants, their relative merits. Ocean wave energy; basics of ocean waves, different wave energy conversion devices, relative merits;

Geothermal energy: Origin, applications, types of geothermal resources, relative merits;

Magneto hydrodynamic Power Generation: applications; Origin and their types; Working principles.

Learning Resources:

Text Books:

1. Non-conventional Energy Resources, B.H.Khan, Tata McGraw Hill, New Delhi, 2017, 3rd edition
2. Energy Technology: Non-Conventional, Renewable and Conventional, S.Rao and B.B.Parulekar, Khanna Publishers, 2010, 1st Edition.

Reference Books:

1. Solar Energy-Principles of Thermal Collection and Storage, S.P.Sukhatme and J.K.Nayak, TMH, 2010, 3rd edition (6 reprint).
2. Solar Energy Thermal Processes, J.A.Duffie and W.A.Beckman, John Wiley, 2013, 4th edition.

Online Resources:

1. Non-conventional Energy Resources by Prof. PrathapHaridoss (IIT Madras), NPTEL Course (Link: https://nptel.ac.in/courses/121/106/121106014/)

ME5114	ENERGY SYSTEMS AND MANAGEMENT	3-0-0: 3

Prerequisites: NIL

Course Outcomes:

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

CO1	Understand the fundamentals of energy management
CO2	Apply the principles of thermal engineering and energy management to improve the performance of thermal systems.
CO3	Analyse the methods of energy conservation and energy efficiency for buildings, air conditioning, heat recovery and thermal energy storage systems.
CO4	Design viable energy projects.

Course Articulation Matrix:

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

Syllabus:

Introduction: Review of the concepts of Thermodynamics, Fluid Mechanics and Heat Transfer, Need for energy storage, Grid balancing: Supply and demand concept for energy management. Heat transfer equipment- Heat exchangers, Steam plant

Energy storage Methods and systems: Thermal, Electrical and Mechanical energy storage methods and systems, Energy saving in IC engines and Gas turbines.

Direct Energy Conversion methods: Magneto-hydrodynamic (MHO) power generation, Thermionic power generation, Thermoelectric power generation, Fuel cells, Hydrogen energy system

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 and Case studies.

Learning Resources:

Text Books:

1. Energy Management audit & Conservation, De, B. K., Vrinda Publication, 2010, 2nd Edition.
2. Energy Management, Murphy, W. R., Elsevier, 2007, 1st Edition.

Reference Books:

1. Energy Management Hand book, Doty, S. and Truner, W. C., Fairmont Press, 2009, 7th edition.

Online Resources:

1. International Energy Agency Website, (Link: https://www.iea.org/)
2. Indian Renewable Energy Development Agency Limited Website, (Link: https://www.ireda.in)
3. Ministry of Power, GoI, Website, (Link: https://powermin.gov.in/)

ME 5211	MICRO AND NANO MANUFACTURING	3-0-0: 3

Pre-requisites: NIL

Course Outcomes:

At the end of the course, the student will be able to

CO1	Understand different techniques for the synthesis and characterization of nano-materials
CO2	Design and analyse 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.

Course Articulation Matrix:

	PO1		**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	1			2	1		1
CO2	2			3	2		
CO3	2			3	2	2	1
CO4	3			2	2	2	1

Syllabus:

Introduction: Importance of Nano-technology, Emergence of Nanotechnology, Bottom-up and Top-down approaches, challenges in Nanotechnology, Scaling Laws in Mechanics, fluids, thermodynamics, Electromagnetism, tribology and Examples. Trimmer force scaling vector.

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.

Learning Resources:

Text Books:

1. MEMS and Microsystems: Design and Manufacture,Tai-Ran Hsu, McGraw- Hill, 2008
2. Fundamentals of Microfabrication: The Science of Miniaturization, Marc Madou, CRC Press, 2002, Second Edition.
3. Microfabrication and Nanomanufacturing,Mark James Jackson, CRC Press, 2005.

Reference Books:

1. Introduction to Nanoscience and Nanotechnology, Gabor L. Hornyak, H.F Tibbals, Joydeep Dutta & John J Moore, CRC Press, 2009.
2. Physical Principles of Electron Microscopy: An Introduction to TEM, SEM, and AEM, Ray F. Egerton, Springer, 2005.
3. Thermal Analysis of Materials, Robert F Speyer, Marcel Dekker Inc , New York, 1994.
4. Elements of X-Ray Diffraction, B.D. Cullity,,Prentice Hall , 2002, 3rd edition.

Online Resources:

1. www.nptel.com

ME 5212	METROLOGY AND COMPUTER AIDED INSPECTION	3-0-0: 3

Pre-requisites: NIL

Course Outcomes:

At the end of the course, the student will be able to

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

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2		2	1		2
CO2	2		2	2	2	
CO3	2		2	3	1	
CO4	3		2	2		
CO5	2		3	2	2	

Syllabus:

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.

Learning Resources:

Text Books:

1. A text-book of Metrology, M. Mahajan, DhanpatRai& Co, 2009.
2. Engineering Metrology, R. K. Jain, Khanna Publishers, 19/e, 2005.

Reference Books:

1. Engineering Metrology, K. J. Hume, Mc Donald & Co (Publishers), London, 1970.
2. Metrology for Engineers, J.F.W. Galyer and C.R.Shotbolt, ELBS Edition, 5/e, 1993.
3. Engineering Metrology, Thomas. G. G, Butterworth PUB.1974.

Online Resources:

1. https://nptel.ac.in/

ME 5311	ENTERPRISE RESOURCE PLANNING	3-0-0: 3

Pre-requisites: NIL

Course Outcomes:

At the end of the course, the student will 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	Analyse the role of Consultants, Vendors and Employees.
CO5	Evaluate the role of PLM, SCM and CRM in ERP.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	1	2	2	2	1
CO2	2	1	2	2	3	2
CO3	2	2	2	2	2	1
CO4	2	1	2		1	1
CO5	2	1	2	2	2	1

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.

Learning Resources:

Text Books:

1. Enterprise Resource Planning, Alexis Leon, Tata McGraw Hill, Second Edition, 2008.

2. ERP in Practice, Jagan Nathan Vaman, Tata McGraw Hill, 2007.

3. ERP: Tools, Techniques, and Applications for Integrating the Supply Chain, Carol A Ptak, CRC Press, 2003, 2nd Edition.

ME 5312	MANUFACTURING MANAGEMENT	3-0-0: 3

Pre-requisites: NIL

Course Outcomes:

At the end of the course, the student will 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 by considering SCM issues.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	2	1	3	2
CO2	2		1	2	1	
CO3	3	2	2	2	2	1
CO4	2	1	2	3	3	1

Syllabus:

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.

Supply Chain Management: 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.

Learning Resources:

Text Books:

1. Operations Management: Strategy and Analysis, Krajewski U and Ritzman LP, Pearson Education Pvt Ltd., Singapore, 2002.
2. Operations Management, Gaither N and Frazier G, Pearson, 12th Edition, 2001.

Reference Books:

1. Operations Management for Competitive Advantage, Chase RB, Aquilano NJ and Jacobs RF, McGraw-Hill Book Company, NY, 2001.

ME 5313	SOFT COMPUTING TECHNIQUES	3-0-0:3

Pre-requisites: NIL

Course Outcomes:

At the end of the course, the student will 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.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1			1			
CO2	2		2	3	1	
CO3	3		2	1	2	
CO4	3		3	3	2	
CO5	3	2	2	3	2	1

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.

Deep 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.

Learning Resources:

Text Books:

1. Soft Computing Integrating Evolutionary, Neural and Fuzzy Systems, Tettamanzi Andrea, Tomassini and Marco, Springer, 2001.
2. Artificial Intelligence, Elaine Rich, McGraw Hill, 2/e, 1990.
3. Multi-objective Optimization using Evolutionary Algorithms, Kalyanmoy Deb, John Wiley and Sons, 2001.
4. Optimization for Engineering Design: Algorithms and Examples, Kalyanmoy Deb, PHI, Ltd, 2012.

References:

1. https://in.mathworks.com/content/dam/mathworks/ebook/gated/machine-learning-ebook-all-chapters.pdf.

Online Resources:

1. https://www.iitk.ac.in/kangal/index.shtml

ME 5413	ANALYSIS AND SYNTHESIS OF MECHANISMS	3-0-0: 3

Pre-requisites: NIL

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	Analyse 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.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	2	3	2	1
CO2	3	3	3	3	3	3
CO3	2	3	3	3	3	3
CO4	3	3	3	2	2	2
CO5	3	3	3	3	2	2

Syllabus:

Introduction: Review of kinematic chains, equivalent chains and their inversions.

Positionanalysis: Position and systems, co-ordinate transformation, rotation, translation and combined motion, algebraic position analysis, loop closure equations, position of any point on a linkage, transmission angles and toggle positions, position-based synthesis of planar mechanisms.

Kinematics of rigid bodies: Plane motion of a rigid body, graphical velocity and acceleration analysis, instantaneous centers 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, coriollis acceleration, analytical solutions for velocity and acceleration analysis, 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.

Learning Resources:

1. Kinematics Analysis and Synthesis of Mechanisms, A K Mallik, Amitabha Ghosh and Guntur,D CRC Press, 2011
2. Planar Multibody Dynamics, Parviz E Nikravesh, CRCPress,2016
3. Design of Machinery An Introduction to the Synthesis and Analysis of Mechanisms and Machines, RobertLNorton,2nd Edition, McGraw Hillreprint 2011
4. Advanced Mechanism Design: Analysis and Synthesis, Sandorand Erdman, vol II, PHI, New Delhi, 2010
5. Theory of Machines and Mechanisms, Shigley, Pennock and Uicker, 4th Edition, Oxford University Press,2011

ME 5415	MATHEMATICAL METHODS IN ENGINEERING	3-0-0: 3

Pre-requisites: 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	Identify constrained and unconstrained optimization problems and solve using corresponding methods
CO3	Solve nonlinear optimization problems with evolutionary methods
CO4	Apply data driven methods to solve engineering problems

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	3	3	1	2
CO2	2	2	3	3	2	2
CO3	3		3	3	3	2
CO4	3		3	3	3	2

Syllabus:

Mathematical Modeling: Modeling of systems related to mechanical engineering, assumptions, appropriate methods and fundamental of a computer implementation

Numerical Linear Equations: Introduction, Basic Ideas of Applied Linear Algebra, Systems of Linear Equations, Square, Non-Singular Systems, the Algebraic Eigen value Problem, Matrix Decompositions, Computer implementation of the methods for applications in engineering analysis.

Outline of Optimization Techniques: Introduction to Optimization, Multivariate Optimization, Constrained Optimization, Optimality Criteria, Computer implementation of the methods for applications in design optimization, manufacturing and thermal process optimization.

Topics in Numerical Analysis: Interpolation, Regression, Numerical Integration, Numerical Solution of ODE'sas IVP Boundary Value Problems. Application of numerical methods for research in mechanical engineering.

Overviews: PDE's and Variational Calculus: Separation of Variables in PDE's, Hyperbolic Equations, Parabolic and Elliptic Equations, Membrane Equation, and Calculus of Variations. Applications in mechanical engineering research.

Learning Resources:

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

ME5611	SURFACE ENGINEERING	3-0-0: 3

Pre-Requisites: NIL

Course Outcomes:

At the end of the course, the student will be able to

CO1	Understand the micro mechanisms involved in failure at different service conditions.
CO2	Identify the materials for surface engineering and characteristics.
CO3	Understand the fundamentals of basic surface modification techniques.
CO4	Select thick and thin layer coating technology to enhance the surface properties.
CO5	Evaluate the metallurgical, mechanical and tribological properties of engineered surfaces.

Course Articulation Matrix:

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

Syllabus:

Introduction: Concept and Importance, classification of surface modification techniques, advantages and their limitations.

Surface Degradation: Causes, types and consequences of surface degradation, Forms of wear – adhesive, abrasive, surface fatigue, corrosive, fretting and erosive wear, Classical governing laws related to wear, techniques to evaluate the wear damage.

Materials for Surface Engineering: Materials characteristics, their importance in surface engineering, wear resistant materials, selection of materials for engineering the surfaces for specific applications, New coating concepts including multi-layer structures, functionally gradient materials (FGMs), intermetallic barrier coatings and thermal barrier coating, Presurface treatment.

Conventional surface engineering practice: Surface engineering by material removal: like etching, grinding, polishing, etc. Surface engineering by material addition: like hot dipping, Electro-plating, carburizing, Cyaniding, etc.

Coating based Surface Modification Techniques: Principles and application of weld surfacing: SMAW, SAW, GMAW, Thermal spraying – flame spraying, electric arc spraying, plasma spraying, detonation gun spraying and high velocity oxy fuel spraying, Cold-Gas Spraying Method (CGSM), Principles, Process Parameters, Coating Properties.

Irradiation based and beam based techniques: Laser cladding, alloying, glazing, laser and induction hardening, heat treatment of steel and remelting by laser / TIG. Microwave glazing.

Thin Film coating techniques: Ion implantation, chemical vapour deposition (CVD) and physical vapour deposition (PVD), carburizing, nitriding, plasma nitriding, cyaniding.

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

Characterization of coatings and surfaces: Measurement of coatings thickness, porosity &adhesion of surface coatings, Measurement of residual stress & stability, Surface microscopy, topography and Spectroscopic analysis of modified surfaces.

Learning Resources:

Text Books:

1. "Surface engineering: Enhancing the life of tribological components" Dheerendra Kumar Dwivedi. Springer, New Delhi, 2018.
2. Surface Engineering D.Srinivasa Rao, Daya Publishing House, 2017.

Reference Books:

1. Surface Engineering for Corrosion and Wear Resistance by J.R. Davis, ASM International, 2001.

2. ASM Hand book – Surface Engineering, ASM International, vol. 5, 9th edition, 1994.

3. Surface Engineering for Wear Resistances by K.G. Budinski. Prentice Hall Publisher, 1988.

Online Resources:

1. https://nptel.ac.in/courses/113/105/113105086/
2. https://nptel.ac.in/courses/112/107/112107248/

ME 5612	ELECTRICAL MACHINES FOR SYSTEM DESIGN	3-0-0: 3

Pre-Requisites: NIL

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 electrical machines
CO3	Apply appropriate processes to manufacture electrical machine components
CO4	Evaluate performance of Electrical Machines

Course Articulation Matrix:

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

Syllabus:

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

Learning Resources:

Text Books:

1. Mechanical Design of Electric Motors, Wei Tong: CRC Press, 2017.

Reference Books:

1. Electrical Machines, Drives and Power Systems, Theodore Wildi: Pearson Education, Asia, 2018.
2. A course in Electrical Machine Design, AK Sawhney: Dhanpat Rai& Co., 2016.

ME 5613	MECHANICS OF METAL FORMING	3-0-0: 3

Pre-Requisites: NIL

Course Outcomes:

At the end of the course, the student will be able to

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

Course Articulation Matrix:

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

Syllabus:

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

Description of Material properties: Tensile test, effect of properties on forming. Sheet deformation processes: Uni-axial tension, general sheet forming processes, Yield criteria, Flow rule, Yield criterion and flow rule for Anisotropic material, work of plastic deformation, isotropic and anisotropic yield functions, Bauschinger effect modelling, effective stress and strain. Sheet deformation in plane stress: strain distributions, strain diagram, deformation modes, effective stress-strain laws, principal tensions.

Rolling Processes: Analysis of longitudinal strip or sheet rolling process (calculation of roll separating force, torque & power, angle of bite, maximum reduction in rolling), rolling defects.

Forging processes: Metal flow in forging, Analysis of plane strain compression, Analysis of compression of circular disc.

Extrusion Processes: Calculation of extrusion load, advances in extrusion, Defects in extrusion. Direct & indirect extrusion.

Wire Drawing Processes: Introduction, wire drawing load calculation.

Sheet forming: Mechanics: Flow Rules – Anisotropy - Formability of sheet, Formability tests, forming limit diagrams, strain path diagrams, Case studies.

Pressing and Sintering: Workability Studies – Densification

Recent advances: Hydroforming, tailor welded blanks, friction stir welding of sheets, incremental sheet forming.

Modelling and Simulation in Metal Forming: The Plane Strain Compression Test, FEM Model and Input Data to the Model - process simulation for deep drawing, Effective Strain and Strain-Rate, Distributions in Deformed Zones.

Case studies: Case studies on the manufacturing aspects of products using the lessons learnt.

Learning Resources:

Text Books:

1. Sheet metal forming processes Constitutive modelling and numerical simulation, D. Banabic, Springer-Verlag Berlin Heidelberg, 2010
2. Mechanics of sheet metal forming, Butterworth-Heinemann, Z. Marciniak, J. L. Duncan, S. J. Hu, Elsevier, 2002
3. Fundamentals of metal forming, R. H. Wagoner, J. L. Chenot, John Wiley and Sons, 1997
4. Metal forming Mechanics and Metallurgy, W. F. Hosford, R. M. Caddell, Printice Hall, 2007

Reference Books:

1. Modelling Techniques for Metal Forming Processes, G.K. Lal, P.M. Dixit and N.Venkat Reddy, Alpha Science, 2011
2. Theory of Plasticity, J. Chakrabarty, McGraw Hill, 1998.
3. Basic engineering plasticity, D. W. A. Rees, Elsevier, 2000
4. Theory of Engineering Plasticity, R. Narayanasamy, R Ponalagusamy, Ahuja Book Company, 2000.
5. Applied Metal Forming - Including FEM Analysis, Henry S. Valberg, Cambridge University Press, 2010.

ME 5711	INTEGRATED PRODUCT DESIGN AND DEVELOPMENT	3-0-0: 3

Pre-requisites: NIL

Course Outcomes:

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

CO1	Apply product design strategies for the development of innovative products
CO2	Develop new product models by applying the concepts of product design theory and robust design.
CO3	Apply embodiment principles in product development process.
CO4	Develop products by considering the social, environmental and ethical concerns.

Course Articulation Matrix:

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

Detailed Syllabus:

Introduction: Product Development and Design Theories-History, Road map to Engineering Design Process-stages, Technology insertion, Organization for design and product development, Business strategies, Working in teams, Assignment of course project.

Problem definition: Need Identification, Kano diagram, Establishing Engineering Characteristics, Quality Function Deployment (QFD)-, Product Design Specification (PDS), information sources.

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

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

Ethical Issues and Team Management: Ethical issues considered during Engineering design process, Contracts-Breach and discharge, product liability, Precautions by designer to avoid product liability.

Learning Resources:

Text Books:

1. Engineering Design, George E Dieter, Publisher, McGraw Hill, 2012, 4th edition

Reference Books:

1. Kevin N. Otto, Kristin L. Wood, "Product Design", Pearson Education, 2004.
2. W. Ernest Eder, S. Hosendl., "Design Engineering", CRC Press, 2008.

Online Resources:

1. https://nptel.ac.in/courses/107/103/107103082/

ME5712	3D PRINTING	3-0-0: 3

Pre-Requisites: NIL

Course Outcomes:

At the end of the course, the student will be able to

CO1	Understand the working principles and process parameters of 3D printing processes
CO2	Explore different 3D printing processes and suggest suitable methods for building a particular component
CO3	Perform suitable post processing operation based on product repair requirement
CO4	Design and develop a working model using 3D printing Processes

Course Articulation Matrix:

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

Detailed Syllabus:

Introduction to Additive Manufacturing: Introduction to AM, AM evolution, Distinction Between AM & CNC machining, Steps in AM, Classification of AM processes, Advantages of AM and Types of materials for AM.

Vat Photopolymerization AM Processes: Stereolithography (SL), Materials, Process Modelling, SL resin curing process, SL scan patterns, Micro-stereolithography, Mask Projection Processes, Two-Photon vat photopolymerization, Process Benefits and Drawbacks, Applications of Vat Photopolymerization, case studies.

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, Process Modelling, Plotting and path control, Bio-Extrusion, Contour Crafting, Process Benefits and Drawbacks, Applications of Extrusion-Based Processes, case studies.

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

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

Directed Energy Deposition AM Processes: Process Description, Material Delivery, Laser

Engineered Net Shaping (LENS), Direct Metal Deposition (DMD), Electron Beam Based Metal Deposition, Processing-structure-properties, relationships, Benefits and drawbacks, Applications of Directed Energy Deposition Processes. Friction stir additive manufacturing**:** process, parameters, advantages, limitations and applications, Additive friction stir deposition process: principle, parameters, applications, functionally graded additive manufacturing components, Case studies.

Wire Arc Additive Manufacturing: Process, parameters, applications, advantages and disadvantages, case studies.

Materials science for AM - Multifunctional and graded materials in AM, Role of solidification rate, Evolution of non-equilibrium structure, microstructural studies, Structure property relationship, case studies.

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, case studies.

Guidelines for Process Selection: Introduction, Selection Methods for a Part, Challenges of Selection, Example System for Preliminary Selection, Process Planning and Control.

Learning Resources:

Text Books:

1. Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing, Ian Gibson, David W Rosen, Brent Stucker, Springer, 2015, 2nd Edition.
2. 3D Printing and Additive Manufacturing: Principles & Applications, Chua Chee Kai, Leong Kah Fai, World Scientific, 2015, 4th Edition.

References Books:

1. Rapid Prototyping: Laser-based and Other Technologies, Patri K. Venuvinod and Weiyin Ma, Springer, 2004.
2. Rapid Manufacturing: The Technologies and Applications of Rapid Prototyping and Rapid Tooling, D.T. Pham, S.S. Dimov, Springer 2001.
3. Rapid Prototyping: Principles and Applications in Manufacturing, RafiqNoorani, John Wiley & Sons, 2006.
4. Additive Manufacturing, Second Edition, Amit Bandyopadhyay Susmita Bose, CRC Press Taylor & Francis Group, 2020.
5. Additive Manufacturing: Principles, Technologies and Applications, C.P Paul, A.N Junoop, McGrawHill, 2021.

Online resources:

1. https://www.nist.gov/additive-manufacturing
2. https://www.metal-am.com/
3. http://additivemanufacturing.com/basics/
4. https://www.3dprintingindustry.com/
5. https://www.thingiverse.com/
6. https://reprap.org/wiki/RepRap

DETAILED LABORATORY COURSE SYLLABUS

I YEAR – I SEMESTER

ME 5605	ADVANCED MATERIALS PROCESSING AND TESTING LABORATORY	0-1-2: 2

Pre-Requisites: NIL

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.

Course Articulation Matrix:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	3	3	3		3
CO2	3	3	3	3	2	3
CO3	3	3	3	3		3
CO4	3	3	3	3	2	3

Syllabus:

List of Experiments:

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 concastapparatus;
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 Al_2O_3on MS)

3.2 Diffusion Coating (boronizing)

3.3 Electrochemical coating

3.4 Magnetron Sputtering

3.5 Microstructural Characterization, Hardness, Peel test, SEM

3.6 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

7. Processing of Steels:

7.1 Thermo mechanical processing of steels

ME 5606	PROCESS SIMULATION LABORATORY	0-1-2: 2

Pre-Requisites: NIL

Course Outcomes:

At the end of the course, the student will be able to

CO1	Apply built-in functions in simulation packages to solve numerical problems.
CO2	Develop codes for solving problems involving different types of mathematical models and equations (ODE, PDE, Linear and nonlinear equations).
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.

Course Articulation Matrix:

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

Syllabus:

The lab will include experiments from the following domain.

Ex No 1. Introduction to simulation software package 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 No 7 Solving 1 D and 2D linear FEA problems
Ex No 8 Solving Non-Linear problems using N-R, modified N-R, Secant, Displacement and Force control methods
Ex No 9. Solving problems on various deformation processes using simulation packages

Learning Resources:

Text Book:

1. MATLAB Programming for Engineers, Stephen J. Chapman, 6th Edition, Cengage, 2019.

ME 5648	SEMINAR – I	0-0-2: 1

Pre-requisites: NIL

Seminar Outcomes:

At the end of the course, the student will be able to

CO1	Identify and compare technical and practical issues related to area of course specialization.
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 analyse technical issues and develop competence in presenting.

Course Articulation Matrix:

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

Evaluation Scheme:

Task	**Description**	**Weightage**
I	Clarity on the topic	10
II	Literature survey	30
III	Content	30
IV	Presentation	20
V	Response to Questions	10
TOTAL		**100**

Task-CO mapping:

Task/CO	CO1	CO2	CO3	CO4
I	X			
II		X		
III			X	
IV				X
V				X

DETAILED CORE COURSE SYLLABUS

I YEAR – II SEMESTER

ME 5651	MATERIALS AND PROCESS SELECTIONFOR DESIGN	3-0-0: 3

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	Analyse 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

Course Articulation Matrix:

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

Syllabus:

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.

Learning Resources:

Text Books:

1. Engineering Materials, M.F. Ashby: 4th Edition, Elsevier, 2005.
2. Materials Selection in Mechanical Design, M.F. Ashby: Butterworth Heinemann, 2005.
3. Materials Selection and Design, ASM Publication, Vol.20: ASM, 1997.
4. The Principles of Materials Selection and Design, Prentice Hall International, Pat L. Mangonon: Inc.1999.

Reference Books:

1. Process selection from Design to Manufacture, K.G.Swift and J.D.Booker, BH Publication, 1997.

ME 5652	SYSTEMS ENGINEERING DESIGN	3-0-0: 3

Pre-Requisites: Nil

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	Analyse 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 modelling, simulation and stability analysis of electro-mechanical systems

Course Articulation Matrix:

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

Syllabus:

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

Learning Resources:

Text Books:

1. Electrical and Electronic Technology, HUGHES: Pearson Education

Reference Books:

1. Electrical Machines, Drives and Power Systems, THEODORE WIDI: Pearson Education, 2013.

2. Control Systems Engineering, IJ NAGRATH, M.GOPAL, New Age International Publishers, 2017.

DETAILED ELECTIVE COURSE SYLLABUS

I YEAR – II SEMESTER

ME5166	DESIGN OF HEAT TRANSFER EQUIPMENT	3-0-0: 3

Pre-Requisites: NIL

Course Outcomes:

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

CO1	Understand the physics and the mathematical treatment of typical heat exchangers.
CO2	Apply LMTD and Effectiveness - NTU methods in the design of heat exchangers
CO3	Design the shell and tube heat exchanger.
CO4	Apply the principles of boiling and condensation in the design of boilers and condensers
CO5	Design cooling towers from the principles of psychrometry

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	1	2		
CO2	3	2	2	2	2	3
CO3	3	2	2	3	2	2
CO4	3	2	3	3	2	3
CO5	3	2	2	3		2

Syllabus:

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

Governing 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.

Concept of Logarithmic Mean Temperature Difference: Expression 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, 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, 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.

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, Industrial standards, 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.

Plate heat exchangers: Introduction, Mechanical Features - Plate pack and the frame, Plate types, Advantages and performance limits, Passes and flow arrangements, Heat transfer and 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.

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

Learning Resources:

Text Books:

1. Compact Heat Exchangers, Kays, W. M. and London, A. L., McGraw – Hill, New York, 2nd Edition, 1998.
2. Fundamentals of Heat Exchanger Design, Shah, R. K. and Sekulic, D. P., John Wiley and Sons, New Jersey, 2003.

Reference Books:

1. Fundamentals of Heat and Mass Transfer, Incropera, F. P. and Dewitt, D. P., 7th Edition, John Wiley and Sons, New York, 2013.

Online Resources:

1. Heat Exchangers: Fundamentals And Design Analysis by Prof. Indranil Ghosh, IIT Kharagpur, NPTEL Course (Link: https://nptel.ac.in/courses/112/105/112105248/)

ME5170	ESSENTIALS OF ENTREPRENEURSHIP	3-0-0: 3

Pre-Requisites: NIL

Course Outcomes:

At the end of the course, the student will 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 framework
CO4	Develop a framework for technical, economic and financial feasibility to prepare a written business plan
CO5	Understand the stages of establishment, growth, barriers, and causes of sickness in industry to initiate appropriate strategies for operation, stabilization and growth

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	2	1			2
CO2	2	3	3			3
CO3	1	2	1		2	2
CO4	2	3	3		2	3
CO5	3	2	1		2	3

Syllabus:

Entrepreneur and Entrepreneurship: Introduction; Entrepreneur and Entrepreneurship; Role of entrepreneurship in economic development; Entrepreneurial competencies and motivation; EDP models, Institutional Interface for Small Scale Industry/Enterprises.

Business Idea generation: Opportunity Scanning and Identification; Creativity and product development process; The technology challenge – Innovation in a knowledge-based economy, sources of innovation pulses – 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.

Planning a Start-up Enterprise: Forms of business organization/ ownership; Financing new enterprises – sources of capital for early-stage technology companies; Techno Economic Feasibility Assessment; Preparation of Business Plan for grants, loans and venture capital.

Operational Issues for new enterprises: 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 pitfalls associated with launching and leading a technology venture; Management performance assessment and control; Causes of Sickness in SSI, Strategies for Stabilization and Growth.

Learning Resources:

Text Books:

1. Technology Ventures: From Ideas to Enterprise, Byers, Dorf, and Nelson, McGraw Hill. ISBN-13: 978-0073380186., 2010
2. Entrepreneurship: Successfully Launching New Ventures, Bruce R Barringer and R Duane Ireland, Pearson Edu., 2013 3rd ed.
3. Entrepreneurial Development, S.S. Khanka, S Chand & Company Ltd., 2012, 4th ed.
4. Entrepreneurship: A South-Asian Perspective, D.F. Kuratko and T.V. Rao, Cengage Learning, 2013.

Reference Books:

1. A Handbook for New Entrepreneurs, Entrepreneurship Development Institute of India, Ahmedabad, 1988.
2. The practice of entrepreneurship, G.G. Meredith, R.E. Nelson & P.A. Neck, ILO, 1982
3. Management of Small-Scale Enterprises, Dr. Vasant Desai, Himalaya Publishing House, 2004.

ME5172	SOLAR ENERGY SYSTEMS	3-0-0: 3

Pre-Requisites: NIL

Course Outcomes:

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

CO1	Understand the fundamentals of solar energy and its conversion techniques
CO2	Estimate solar energy through radiation principles
CO3	Design thermal and electrical energy storage systems
CO4	Design solar thermal and photovoltaic systems
CO5	Understand solar passive architecture

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	1	2	3	2
CO2	2	2	1	2	3	1
CO3	3	2	3	3	3	2
CO4	3	2	3	3	3	2
CO5	2	2	2	2	2	2

Syllabus:

INTRODUCTION: Overview of the course; Examination and Evaluation patterns; Basic concepts of energy; Introduction to Renewable Energy Technologies; Energy and Environment: Global warming, acid rains, Depletion of ozone layer; Global and Indian Scenario of renewable energy sources.

ENERGY STORAGE: Thermal – sensible and latent heat storage materials, electrical – lead acid and lithium ion batteries, design and analysis of thermal and electrical energy storage systems.

SOLAR RADIATION AND COLLECTORS: Solar angles - day length, angle of incidence on tilted surface – Sun path diagrams - shadow determination – extra terrestrial characteristics - measurement and estimation on horizontal and tilted surfaces – flat plate collector thermal analysis - heat capacity effect - testing methods-evacuated tubular collectors - concentrator collectors – classification - design and performance parameters - tracking systems – compound parabolic concentrators - parabolic trough concentrators - concentrators with point focus - Heliostats – performance of the collectors.

APPLICATIONS OF SOLAR THERMAL TECHNOLOGY: Principle of working, types - design and operation of - solar heating and cooling systems - solar water heaters – thermal storage systems – solar still – solar cooker – domestic, community – solar pond – solar drying.

SOLAR PV FUNDAMENTALS: Semiconductor – properties - energy levels - basic equations of semiconductor devices physics. Solar cells - p-n junction: homo and hetro junctions – metal semiconductor interface - dark and illumination characteristics - figure of merits of solar cell - efficiency limits - variation of efficiency. with band-gap and temperature - efficiency measurements - high efficiency cells - preparation of metallurgical, electronic and solar grade Silicon - production of single crystal Silicon: Czokralski (CZ) and Float Zone (FZ) method - Design of a complete silicon – GaAs- InP solar cell - high efficiency III-V, II- VI multi junction solar cell; a-Si-H based solar cells quantum well solar cell - thermophotovoltaics.

SOLAR PHOTOVOLTAIC SYSTEM DESIGN AND APPLICATIONS: Solar cell array system analysis and performance prediction- Shadow analysis: reliability - solar cell array design concepts - PV system design - design process and optimization - detailed array design - storage autonomy - voltage regulation - maximum tracking - use of computers in array design - quick sizing method – array protection and trouble shooting - centralized and decentralized SPV systems – stand alone - hybrid and grid connected system - System installation - operation and maintenances - field experience - PV market analysis and economics of SPV systems.

SOLAR PASSIVE ARCHITECTURE: Thermal comfort - heat transmission in buildings-bioclimatic classification – passive heating concepts: direct heat gain - indirect heat gain - isolated gain and sunspaces - passive cooling concepts: evaporative cooling - radiative cooling - application of wind, water and earth for cooling; shading - paints and cavity walls for cooling – roof radiation traps - earth air-tunnel. – energy efficient landscape design – thermal comfort – concept of solar temperature and its significance - calculation of instantaneous heat gain through building envelope.

Learning Resources:

Text Books:

1. Solar Energy, Sukhatme S P and Nayak J K, Tata McGraw Hill, 2017, 4th Edition.
2. Solar Engineering of Thermal Processes, Duffie, J. A. and Beckman, W. A., John Wiley, 2013, 4th Edition.
3. Solar Energy: Fundamentals & Applications, Garg H P., Prakash J., Tata McGraw Hill, 2017, 1st revised edition.
4. Fundamentals of Solar Cells: PV Solar Energy Conversion, Alan L Fahrenbruch and Richard H Bube, Academic Press, 1983.

Reference Books:

1. Handbook of Solar Energy - Theory, Analysis and Applications, Tiwari G.N.., Arvind Tiwari and Shyam, Springer, 2016.
2. Principles of Solar Engineering, Goswami, D.Y., Kreider, J. F. and Francis., 2000.

Online Resources

1. Solar Engineering Technology by Prof. V.V. Satyamurty (IIT Kharagpur), NPTEL Course (Link: https://nptel.ac.in/courses/112/105/112105051/)
2. Solar Photovoltaics: Fundamentals, Technology and Applications by Prof. SoumitraSatapathi (IIT Roorkee), NPTEL Course (Link: https://nptel.ac.in/courses/115/107/115107116/)

ME5173	ENERGY CONSERVATION & WASTE HEAT RECOVERY	3-0-0: 3

Pre-Requisites: NIL

Course Outcomes:

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

CO1	Identify and assess the energy conservation opportunities in different thermal systems
CO2	Outline the methods of energy storage and identify the appropriate methods of energy storage for specific applications
CO3	Understand the energy conversion techniques
CO4	Evaluate the performance of heat recovery system for industrial applications

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	1	3	1	3	3
CO2	1	1	3	1	3	3
CO3	1	1	3	1	3	3
CO4	2	1	3	3	3	3

Syllabus:

INTRODUCTION: Overview of the course; Examination and Evaluation patterns; Basic concepts of energy; Energy and Environment: Global warming, acid rains.

ENERGY STORAGE: Need for energy storage, thermal, electrical, magnetic and chemical energy storage systems.

FUEL COMBUSTION AND GASIFICATION: Fuel Composition and Heating Value; Combustion stoichiometry and calculation; Gaseous product combustion; Coal gasification; Gasification process and gasifiers.

ENERGY CONSERVATION: Introduction; Principles of thermodynamics: Rankine and Brayton cycles; enhancement of efficiency by reheat, regenerative, intercooling; topping, bottoming and combined cycles; concept of tri generation; Boilers :Types, Performance evaluation of boilers, Boiler Water Treatment and blow down, Introduction to FBC Boilers, Mechanism and Operational Features of FBC, Retrofitting FBC system to conventional boilers.

WASTE HEAT RECOVERY: Classification, Advantages and applications, Selection criteria for waste heat recovery technologies, waste heat recovery devices: recuperators, regenerators, economizers, plate heat exchangers, thermic fluid heaters, Waste heat boilers-design aspects; fluidized bed heat exchangers, heat pipe exchangers, heat pumps; Saving potential.

Learning Resources:

Text Books:

1. Energy Storage, J Jensen, Elsevier, 2013

Reference Books:

1. Lee SS EDS, Seagate Subrata, Waste Heat Utilization and Management, Hemisphere, Washington, 1983.
2. Advance Energy Systems, Nikolai V. Khartchenko, Taylor and Francis Publishing, 2013, 2nd Edition.
3. Powerplant Technology, M.M.El-Wakil, Tata McGraw Hill, 20103, Indian Edition

Online Resources:

1. Bureau of Energy Standards Official Website, Link: https://www.beeindia.gov.in

ME 5262	PRODUCT DESIGN FOR MANUFACTURING AND ASSEMBLY	3-0-0: 3

Pre-requisites: NIL

Course Outcomes:

At the end of the course, the student will 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.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	1	1		1
CO2	2	1		2		
CO3	2	3		2		1
CO4	2	1	1	1		2
CO5	2	3	1	2	2	1

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, and 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 *as*sembly systems, Quantitative analysis of Assembly systems, Multi station assembly systems, single station assembly lines.

Learning Resources:

Text Books:

1. Assembly Automation and Product Design, Geoffrey Boothroyd, Marcel Dekker Inc., NY, 3rd Edition,2010.

Reference books:

1. Hand Book of Product Design, Geoffrey Boothroyd, Marcel Dekker Inc., NY, 1992.

Online resources:

1. https://nptel.ac.in/noc/courses/noc21/SEM1/noc21-me66/
2. https://www.rapiddirect.com/blog/design-for-assembly/

ME 5263	TOOL DESIGN	3-0-0: 3

Pre-requisites: NIL

Course Outcomes:

At the end of the course, the student will be able

CO1	Analyse 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

Course Articulation Matrix:

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

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.

Learning Resources:

Text Books:

1. Tool Design, Donaldson.C, G.H.Lecain and V.C.Goold TMH, New Delhi, 2010

2. Fundamentals of Tool Design, Wilson.F.W, ASME, PHI, New Delhi, 2010.

Reference books:

1. Machine design data book, Lingaiah, Karnati, McGraw-Hill Education, 2003.

Online resources:

1. https://www.toolsdesign.com/

ME 5264	GEOMETRIC DIMENSIONING AND TOLERANCING	3-0-0: 3

Pre-requisites: NIL

Course Outcomes:

At the end of the course, the student will be able to

CO1	Interpret GDT symbols on a print.
CO2	Identify minimum and maximum material conditions
CO3	Measure and verify position tolerances with applied material conditions
CO4	Apply basic rectangular datum reference frames

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3		
CO2	3		3	3		
CO3	3		3	3		
CO4	3	3	3	3		

Syllabus:

Introduction: Scope, Definitions, Fundamental Rules, Units of Measure, Types of Dimensioning, Application of Dimensions, Dimensioning Features, Location of Features

Principles of Tolerancing: Direct Tolerancing Methods, Tolerance Expression, Interpretation of Limits, Single Limits, Tolerance Accumulation, Limits of Size, Applicability of Modifiers on Geometric Tolerance Values and Datum Feature References, Screw Methods, Gears and Splines, Boundary Conditions, Angular Surfaces, Conical Tapers, Flat Tapers, Radius, Tangent Plane, Statistical Tolerancing.

Symbology: Use of Notes to Supplement Symbols, Symbol Construction, Feature Control Frame Symbols, Feature Control Placement, Definition of Tolerance Zone, Tabulated Tolerances

Datum Reference Frames: Degrees of Freedom, Degrees of Freedom Constrained by Primary Datum Features, Regardless of Material Boundary, Constraining Degrees of Freedom of a Part, Datum Feature Simulator, Theoretical and Physical Application of Datum Feature Simulators, Datum Reference Frame, Datum Features and Controls, Specifying Datum Features in an Order of Precedence, Establishing Datums, Multiple Datum Features, Mathematically Defined Surface, Multiple Datum reference Frames, Functional Datum Features, Rotational Constraint about a Datum Axis or Point, Application of MMB, LMB and RMB to Irregular Features of Size, Datum Feature Selection Practical Applications, Simultaneous Requirements, Restrained Condition, Datum Reference Frame Identification, Customized Datum Reference Frame Construction, Application of a Customized Datum Reference Frame, Datum Targets

Form Tolerances: Form Control, Specifying Form Tolerances, Application of Free-State Symbol

Orientation Tolerances: Orientation Control, Orientation Symbols, Specifying Orientation Tolerances, Tangent Plane, Alternative Practice

Location Tolerances: Positional Tolerancing, Positional Tolerancing Fundamentals – I and II, Pattern Location, Coaxial Feature Controls, Tolerancing for Symmetrical Relationships

Profile Tolerances: Profile, Tolerance Zone Boundaries, Profile Applications, Material Condition and Boundary Condition Modifiers as Composite Profile, Multiple Single-Segment Profile Tolerancing, Combined Controls

Runout Tolerances: Runout, Runout Tolerance, types of Runout Tolerances, Applications, Specification.

Learning Resources:

Text Books:

1. Geometric Dimensioning and Tolerancing by P.S. Gill, (Publ.) S. K. Kataria& Sons, 2009
2. Geometric Dimensioning and Tolerancing: Applications and Techniques for Use in Design: Manufacturing, and Inspection, by James D. Meadows, CRC Press, 1995

Reference Books:

1. Simplified GD & T: Based on ASME-Y 14.5-2009 by Ashok Kumar 2nd Edition, Azuko*Publishing* 2009

Online resources:

1. https://www.gd-t.com/resources
2. http://www.etinews.com/free_gdt_resources.html
3. https://formlabs.com/blog/gdt-geometric-dimensioning-and-tolerancing/

ME5266	PRECISION MANUFACTURING	3-0-0: 3

Pre-Requisites: NIL

Course Outcomes:

At the end of the course, the student will 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

Course Articulation Matrix:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3		3	3	2	
CO2	3		3	3	2	
CO3	3		3	3	2	
CO4	2		2	2	2	

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.

Learning resources:

Text Books:

1. Precision Engineering in Manufacturing, R.L.Murty, New Age International Publishers, 1996.
2. Fundamentals of Process Engineering, V.Kovan, Foreign Languages Publishing House, Moscow, 1975

Reference books:

1. Process Engineering for Manufacture, Eary and Johnson,Prentice Hall, 1962.
2. Dimensional control in Precision Manufacturing, J.L.Gadjala, McGraw Hill Publishers, 2012.

Online resources:

1. https://www.nptel.ac.in/
2. https://precisionmfg.com/
3. https://cmti.res.in/precision-manufacturing-and-process-engineering/

ME 5361	SUPPLY CHAIN MANAGEMENT	3-0-0: 3

Pre-requisites: NIL

Course Outcomes:

At the end of the course, the student will be able to

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

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2		2		2	1
CO2	2	1	2		2	1
CO3	3	1	2	2	2	1
CO4	2		2	2	2	1
CO5	2	1	2	3	2	1

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.

Learning Resources:

Text Books:

1. Supply Chain Management - Strategy, Planning and Operation, Sunil Chopra and Peter Meindl, Pearson Education Asia, 2010, 4th Edition.

2. Designing and Managing the Supply Chain - Concepts Strategies and Case Studies, David Simchi-Levi, Philp Kamintry and Edith Simchy Levy, Tata-McGraw Hill, 2000, 2nd Edition.

Reference books:

1. Managing Supply Chains A Logistics Approach', John J Coyle, Cengage Learning, 2013, 9th Edition.
2. Modelling the Supply Chain', Jeremy F Shapiro, Cengage Learning, 2007, 2nd Edition.

Online Resources:

1. https://scm.mit.edu/

ME 5363	INTELLIGENT MANUFACTURING SYSTEMS	3-0-0: 3

Pre-requisites: NIL

Course Outcomes:

At the end of the course, the student will be able to

CO1	Develop reachability graphs for various manufacturing system problems using petri net models
CO2	Develop knowledge representation to establish models for processing
CO3	Apply clustering techniques to identify the variations in information sharing
CO4	Apply machine learning techniques for various real-life applications in manufacturing systems
CO5	Evaluate block chain technology in the context of manufacturing systems design

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	1	2	2		1
CO2			2	2	2	1
CO3	1		2	2		1
CO4	3	1	2	3		1
CO5	2	2	2	3		

Syllabus:

Petri Nets: Key concepts and definitions, principles of net theory, Place/Transition Systems and Elementary Net (EN) Systems. Token game, reachability, state graph, behavioural properties like deadlock and boundedness, behavioural equivalence and normal forms. Elementary Net Systems: Causality, conflict, concurrency, and confusion. Examples of Petri net models. Examples in manufacturing Systems

Components of Knowledge Based Systems: Basic Components of Knowledge Based Systems, Knowledge Representation, Comparison of Knowledge Representation Schemes, Interference Engine, Knowledge Acquisition, Clustering. Examples in manufacturing Systems Cloud Manufacturing and Networking with TCP/IP: Introduction to cloud computing: cloud models, cloud service examples, cloud-based services & applications. Introducing TCP/IP, IP Addressing and Related Topics, Data Link and Network Layer TCP/IP Protocols, Internet Control Message Protocol (ICMP), Transport Layer TCP/IP Protocols, Basic TCP/IP Services.

Machine Learning: Machine Learning – Concept, Artificial Neural Networks, Biological and Artificial Neuron, Deep Nets, Applications in manufacturing; Use of probability and fuzzy logic for machine thinking, Examples in manufacturing Systems.

Agent and Multi-agent systems: Agents, agent definitions and classification, multi-agent systems, Models of agency, architectures and languages, Agent communication and interaction protocols. Examples in manufacturing Systems

Block Chain Technology: Basic Concepts, Trust- The need for trust, Forms of trust, The problem space for block chain. Cryptography - Information security as a form of trust, Public and Private keys, Digital signatures, Hashing. Examples in manufacturing Systems

Learning Resources:

Text Books:

1. Automation, Production Systems and CIM", Groover M.P. Prentice-Hall, New Delhi, 2009.
2. A Comprehensive guide to AI and Expert Systems", Robert Levine, McGraw Hill Inc, 1986.
3. Automation, Production Systems and Computer Integrated Manufacturing", Mikell P. Groover, PHI, 2008, 8th edition.

References:

1. Guide to TCP/IP, Ed Tittel, Laura Chappell, Third Edition. Course Technology Incorporated, 2007,
2. Automated Planning- Theory and Practice, Malik Ghallab Malik, Morgan Kaufmann, 2004.
3. Machine Learning, Mitchell T, Mc-Graw Hill, 2012.

Online Resources:

1. https://www.anylogic.com/use-of-simulation/agent-based-modeling/
2. http://pipe2.sourceforge.net/
3. https://in.mathworks.com/content/dam/mathworks/ebook/gated/machine-learning-ebook-all- chapters.pdf
4. Intelligent Manufacturing Systems, Andrew Kusiak/Prentice Hall.

ME 5365	SUSTAINABLE MANUFACTURING	3-0-0: 3

Pre-requisites: NIL

Course Outcomes:

At the end of the course, the student will be able to

CO1	Understand the concept of sustainable manufacturing relates to current technologies and manufacturing decisions
CO2	Perform carbon footprint analysis and Life Cycle Assessment (LCA) specific to manufacturing systems and processes.
CO3	Develop Green Manufacturing process, Lean manufacturing and Green supply chain techniques
CO4	Evaluate the economics and environmental impact of sustainable manufacturing alternatives – Case studies.

Course Articulation Matrix:

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

Syllabus:

Introduction: Concept of sustainability, manufacturing, operations, processes, practices, Resources in manufacturing, five Ms, system approach to manufacturing, Basic experimental design, factor identification, quantification, comparison, Motivations and Barriers to Green Manufacturing, Environmental Impact of Manufacturing, Strategies for Green Manufacturing. Metrics for Green Manufacturing, Metrics Development Methodologies.

Management of waste & pollution: Types, sources and nature of wastes, waste processing, green processing & engineering operations, Energy recovery, and 3 R& 6 R principle. Types of pollution and management: Anti pollution approaches & guide lines.

Environment friendly materials: Materials for sustainability , eco-friendly and new age energy efficient and smart materials , alternative manufacturing practices , materials and selection of manufacturing processes , control on use of renewable materials , Bio-degradable materials recycling of materials.

Sustainable Manufacturing Tools: Principles of green manufacturing and its efficiency, Green manufacturing and sustainability, System model architecture and module, Design and planning, control or tools for green manufacturing (Qualitative Analysis), Consumption Analysis, Life Cycle Analysis, Efficiency, Sustainability tools). Standards for green manufacturing (ISO 14000 and OHSAS 18000), Waste stream mapping and application, Design for environment and for sustainability – Discuss the Product Life Cycle of manufactured goods.

Life Cycle Analysis: Remanufacture and disposal, Tools for LCA, Optimization for achieving sustainability in unit manufacturing, Green manufacturing Lean models, value analysis, carbon footprint, analysis for carbon footprint Green manufacturing: sustainability framework Green manufacturing techniques: factors effecting sustainability.

Green manufacturing techniques: Dry and near-dry machining, edible oil based cutting fluids Green manufacturing techniques: cryogenic machining for eco-efficiency Green manufacturing, Lean manufacturing, Lean techniques for green manufacturing Waste assessment and strategies for waste reduction in green manufacturing, Reconfigurable manufacturing systems.

Green Supply Chain: Carbon footprints in transportation Green Supply chain: techniques and implementation Green Supply chain, Logistics management Green Supply Chain as Product Life Cycle Management, Servitization.

Case Studies: Green packaging and supply chain, implementation of lean manufacturing at industries

Learning Resources:

Text Books:

1. Design of Experiments, Montgomery Douglas, John Wiley and Sons, Inc. 2017.
2. Green manufacturing: fundamentals and applications. Dornfeld, D.A. Springer Science & Business Media, 2012..
3. Materials and the environment: eco-informed material choice. Ashby, M. F. Elsevier, 2012.

References:

1. Sustainability in the process industry. Klemes, J., McGraw-Hill. 2011
2. Green Management, M. Karpagam, Geetha Jaikumar, Ane Books Pvt. Ltd. 2010
3. Design for Environment: A guide to sustainable Product Development Sustainable Development, M.K. Ghosh Roy, Ane Books Pvt.Ltd,2009.

ME 5367	RELIABILITY ENGINEERING	3-0-0: 3

Pre-requisites: NIL

Course Outcomes:

At the end of the course, the student will be able to

CO1	Understand the concepts of Reliability, Availability and Maintainability
CO2	Develop hazard-rate models to know the behaviour 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.

Course Articulation Matrix:

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

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.

Text Books:

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

ME 5368	INDUSTRY 4.0 and IIoT	3-0-0: 3

Pre-requisites: Nil

Course Outcomes:

At the end of the course, the student will be able to

CO1	Explore how Industry 4.0 will change the current manufacturing technologies and processes by digitizing the value chain
CO2	Understand the drivers and enablers of Industry 4.0
CO3	Learn about various IIoT-related protocols
CO4	Build simple IIoT Systems using Arduino and Raspberry Pi

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2		3	1	2	
CO2	2		2	2	1	
CO3	2		3	3		
CO4			3	3	1	2

Syllabus:

Introduction to Industry 4.0: Industry 4.0: Globalization and Emerging Issues, The Fourth Revolution, LEAN Production Systems, Mass Customization, Smart and Connected Business Perspective, Smart Factories, Industry 4.0: Cyber Physical Systems and Next Generation Sensors, Collaborative Platform and Product Lifecycle Management, Augmented Reality and Virtual Reality, Artificial Intelligence, Big Data and Advanced Analysis

Introduction to IIoT: Architectural Overview, Design principles and needed capabilities, IoT Applications, Sensing, Actuation, Basics of Networking, M2M and IoT Technology Fundamentals- Devices and gateways, Data management, Business processes in IoT, Everything as a Service (XaaS), Role of Cloud in IoT, Security aspects in IoT.

Elements of IIoT: Hardware Components- Computing (Arduino, Raspberry Pi), Communication, Sensing, Actuation, I/O interfaces. Software Components- Programming API's (using Python/Node.js/Arduino) for Communication Protocols-MQTT, ZigBee, Bluetooth, CoAP, UDP, TCP.

IIoT Application Development: Solution framework for IoT applications- Implementation of Device integration, Data acquisition and integration, Device data storage- Unstructured data storage on cloud/local server, Authentication, authorization of devices. Case Studies: IoT case studies and mini projects based on Industrial automation, Transportation, Agriculture, Healthcare, Home Automation.

Learning Resources:

Text Books:

1. Introduction to Industrial Internet of Things and Industry 4.0, SudipMisra, Chandana Roy, Anandarup Mukherjee, CRC Press, 2020.
2. A Hands on Approach", Vijay Madisetti, ArshdeepBahga, Ïnternet of Things, University Press, 2009.
3. Introduction to Internet of Things: A practical Approach", Dr. SRN Reddy, RachitThukral and Manasi Mishra, ETI Labs,2010
4. The Internet of Things: Enabling Technologies, Platforms, and Use Cases", Pethuru Raj and Anupama C. Raman, CRC Press, 2012
5. Designing the Internet of Things", Adrian McEwen, Wiley, 2015

Reference Books:

1. Internet of Things: Architecture and Design, Raj Kamal, McGraw Hill., 2005.
2. Getting Started with the Internet of Things, CunoPfister, O Reilly Media, 2007.

Online Resources:

1. https://onlinecourses.nptel.ac.in/noc21_cs17/preview

ME 5369	DESIGN AND ANALYSIS OF EXPERIMENTS	3-0-0: 3

Pre-requisites: NIL

Course Outcomes:

At the end of the course, the student will be able to

CO1	Formulate objective(s) and identify key factors in designing experiments for a given problem.
CO2	Develop appropriate experimental design to conduct experiments for a given problem.
CO3	Analyse 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.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	1	2	2		1
CO2	3		2	3		1
CO3	3	1	2	3		1
CO4	3		2	3		1
CO5	2		2	3		1

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

Learning Resources:

Text Books:

1.Design and Analysis of Experiments, Montgomery DC, 7th Edition, John Wiley & Sons, NY, 2008

2.Taguchi Techniques for Quality Engineering, Ross PJ, McGraw-Hill Book Company, NY, 2008.

ME 5370	PROJECT MANAGEMENT	3-0-0: 3

Pre-requisites: NIL

Course Outcomes:

At the end of the course, the student will be able to

CO1	Understand the importance of projects and its phases.
CO2	Analyse 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.

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3		2	2		2
CO2	3	1	2	2		2
CO3	2	1	2			2
CO4	2	1	2	2	2	2
CO5	2	1	2	2		2

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.

Text Books:

1. Project: A Planning Analysis, Prasanna Chandra, Tata McGraw Hill Book Company, New Delhi, 4th Edition,2009.
2. Project Management, Cleland, Gray and Laudon, Tata McGraw Hill Book Company, New Delhi, 3rd Edition, 2007.
3. Larson Project Management , Clifford F. Gray, Gautam V. Desai, Erik W., Tata McGraw-Hill Education, 2010

ME 5371	ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING FOR MECHANICAL SYTEMS	3-0-0: 3

Pre-Requisites: NIL

Course Outcomes:

At the end of the course, the student will be able to

CO1	Understand the core concepts of Mechanical Systems in the context of Industry 4.0
CO2	Apply AI, ML and Deep Learning concepts on Various Mechanical Systems
CO3	Apply the statistical and optimization techniques on Mechanical Systems
CO4	Evaluate the Mechanical System performance using simulation and experimental analysis

Course Articulation Matrix:

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

Detailed Syllabus:

Introduction to Mechanical Systems evolution in the context of Industry 4.0, Key issues: Adaptability, Intelligence, Autonomy, Safety, Sustainability, Interoperability, Flexibility of Mechanical Systems.

Introduction of Statistics; Descriptive statistics: Central tendency measures, Dispersion measures, data distributions, centre limit theorem, sampling, sampling methods; Inferential Statistics: Hypothesis testing, confidence level, degree of freedom, P-value, Chi-square test, ANOVA, Correlation V's Regression, Uses of Correlation and regression.

Artificial Intelligence: Brief review of AI history, Problem formulation: Graph structure, Graph implementation, state space representation, search graph and search tree, Search Algorithms: random search, Depth-first, breadth-first search and uniform-cost search. Heuristic: Best first search, A* and AO* algorithm, generalization of search problems. Ontology; Fuzzy; Meta-heuristics.

Machine Learning: Overview of supervised and unsupervised learning; Supervised Learning: Linear Regression, Non-linear Regression Model evaluation methods, Logistic Regression, Neural Networks; Unsupervised Learning: K-means clustering, C-means Clustering. Convolutional Neural Networks (CNN), Pooling, Padding Operations, Interpretability in CNNs, Limitations in CNN. Cases with respect to different mechanical systems.

Introduction to Raspberry Pi; Installation of Raspbian OS on Raspberry Pi; Controlling LED using Raspberry Pi; Integrating IR Sensor with Raspberry Pi;

Controlling LED with IR Sensor; Integrating Temperature and amp; Humidity Sensor with Raspberry Pi read Current Environment Values, Collecting the sensor data using Raspberry Pi; Matlab toolboxes - Simulink, Mechanical Systems implementation: From features to software components, Mapping software components to ECUs.

Learning Resources:

Text Books:

1. Rajkumar, Dionisio De Niz ,and Mark Klein, *Cyber-Physical Systems*, Wesley Professional.
2. Rajeev Alur, *Principles of Cyber-Physical Systems*, MIT Press, 2015.
3. Robert Levine et al., "*A Comprehensive guide to AI and Expert Systems*", McGraw Hill Inc, 1986.

References:

1. E. A. Lee and S. A. Seshia, "Introduction to Embedded Systems: A Cyber-Physical Systems Approach", 2011.
2. C. Cassandras, S. Lafortune, "Introduction to Discrete Event Systems", Springer 2007.
3. Constance Heitmeyer and Dino Mandrioli, "Formal methods for real-time computing", Wiley publisher, 1996.
4. Montgomery Douglas, 2017. Design of Experiments, John Wiley and Sons, Inc.

ME 5466	TRIBOLOGY IN DESIGN	3-0-0: 3

Pre-requisites: NIL

Course Outcomes:

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

CO1	Analyse properties of lubricant and select proper lubricant for a given application.
CO2	Identify 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.

Course Articulation Matrix:

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

Syllabus:

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

Introduction to Concept of tribodesign: Specific principles of tribodesign; Tribological problems in machine design: Plain sliding bearings, Rolling contact bearings, Piston, piston rings and cylinder liners, Cam and cam followers, Friction drives, Involute gears, Hypoid gears, Worm gears, Seals.

Friction and Wear: Origins of sliding friction: Contact between bodies in relative motion, Friction due to adhesion, Friction due to ploughing, Friction due to deformation, Energy dissipation during friction, Friction under complex motion conditions, Types of wear and their mechanisms: Adhesive wear, Abrasive wear, Wear due to surface fatigue, Wear due to chemical reactions, Sliding contact between surface asperities, Wear in lubricated contacts, Wear and friction of metallic, polymeric and ceramic composite materials

Lubrication modes and Theories of hydrodynamic lubrication: Lubricants-Types of lubricants, Objectives of lubricant, Physical properties of lubricants, Selection of lubricant. 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.

Tribo Design of Machine Elements: Lower Kinematic pairs – Sliding bearings, mechanical face seal, clutches and brakes; Higher Kinematic pairs – Ball bearing, Roller bearing, Gear contacts. Case studies.

Learning Resources:

Text Books:

1. Engineering Tribology, Stachowaik,G.W.,Batchelor,A.W.,3rdEd.,Elsevier,2010.
2. Tribology in Machine Design, TA Stolarski, Butterworth-Heinemann, 2000.
3. Engineering Tribology, Williams JA, OxfordUniv. Press,2001.
4. Introductiontobearings,MajumdarB.C,S.Chand&Co.,Wheelerpublishing,1999.

References:

1. Fluid film lubrication theory and design, Andras Z. Szeri, Cambridge Universitypress,1998.
2. Basic lubrication theory, Cameron A, EllisHorwood Ltd.,2002.
3. Tribology Hand Book,NealeMJ,CBSPublications,2012.
4. Mechanical Vibrations, Venkatachalam R.,PHI Publications,2018

ME 5467	ADVANCED COMPOSITE TECHNOLOGIES	3-0-0: 3

Pre-requisites: NIL

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	Analyse interfaces of composites for predicting their mechanical properties.
CO4	Develop metal matrix, ceramic matrix and polymer matrix composites with calculated values of constituents
CO5	Analyse the performance of composites

Course Articulation Matrix:

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

Syllabus:

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 insitu 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 behaviour.

Ceramic Matrix Composites Processing: Cold pressing & sintering, hot pressing reaction bonding processes, infiltration, in-situ chemical reaction, Sol-Gel and polymer pyrolysis, selfpropagating 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.

Learning Resources:

Text Books:

1. Composite Materials Science and Engineering, Chawla, Springer
2. An introduction to composite materials, Hull, Cambridge
3. ASM Handbook Composites, Steven L. Donaldson, Volume 21,2001.

References:

5. Composite Materials, Science and Engineering, Krishan K. Chawla,Springer,2001.
6. Process Modelling in Composites Manufacturing, Suresh G. Advani, E. Murat Sozer, 2ndEd. CRC Press, 2009

ME 5469	OPTIMIZATION METHODS FOR ENGINEERING DESIGN	3-0-0: 3

Pre-requisites: 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	Identify constrained and unconstrained optimization problems and solve using corresponding methods
CO3	Solve discontinuous optimization problems using special methods
CO4	Solve nonlinear optimization problems with evolutionary methods

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	3	3	1	2
CO2	2	2	3	3	2	2
CO3	3		3	3	3	2
CO4	3		3	3	3	2

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 Casestudies.

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

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.

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

Learning Resources:

Text Books:

1. Introduction to Optimum Design, Jasbir Arora, Academic Press, 2004
2. Optimization For Engineering Design: Algorithms and Examples, Kalyanmoy Deb, PHI, 2004.

References:

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

ME 5661	CONTROLLERS FOR SYSTEM DESIGN	3-0-0: 3

Pre-Requisites: NIL

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 for operation and maintenance of industrial machines

Course Articulation Matrix:

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

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

Learning Resources:

Text Books:

1. Control of Machines, SK Bhattacharya and Brijinder Singh: New Age International (P) Limited, Publishers, 2013.

Reference Books:

1. Electrical Control of Machines, Kanneth B. Renford: Delmar Publishers Inc, 2015.
2. Handbook of Electrical Motor Control, Eswar: Tata McGraw Hill Publishing Company Ltd, New Delhi, 2013.

ME 5662	APPLIED POWER ELECTRONICS FOR SYSTEM DESIGN	3-0-0: 3

Pre-Requisites: NIL

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

Course Articulation Matrix:

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

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

Learning Resources:

Text Books:

1. Hybrid Electric Vehicles (Principles and Applications with practical perspectives), Chris Mi, M. AbulMasrur and David WenzhongGao: A John Wiley @Sons Ltd Publication, 2015.

Reference Books:

1. Electric and Hybrid Vehicles Design Fundamentals, Iqbal Hussain: CRC Press, Taylor and Francis Group, 2015
2. Handbook of Automotive Power Electronics and Motor Drives, Ali Emadi: CRC Press, Taylor and Francis Group, 2017.

ME 5663	THERMODYNAMICS OF MATERIALS AND PROCESS	3-0-0: 3

Pre-Requisites: NIL

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	Analyse engineering 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

Course Articulation Matrix:

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

Syllabus:

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. Cp, Cv 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.

Learning Resources:

Text Books:

1. Introduction to Thermodynamics of Materials, D. R. Gaskell, Taylor and Francis, 2006.

Reference Books:

1. Physical Chemistry of Melts in Metallurgy, Vol. 1 and 2, Richardson, F.D., Academic Press, 1974.
2. Introduction to Chemical Engineering Thermodynamics: Smith, Van Ness and Abbot : Tata Mcgraw Hill 2003.

ME 5664	NON-DESTRUCTIVE TESTING AND EVALAUTION	3-0-0: 3

Pre-Requisites: NIL

Course Outcomes:

At the end of the course, the student will be able to

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

Course Articulation Matrix:

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

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.

NDT of Composites: Codes and Conventions - Difficulties - Few Case Studies.

Learning Resources:

Text Books:

1. Non Destructive Evaluation: Theory, Techniques and Applications, Peter J. Shull , Marcel Dekkar, 2002.
2. Non Destructive Testing Hand Book, Vol. 4, P. McIntire (Ed.), American Society for Non Destructive Society, 2010

Reference Books:

1. Non Destructive Testing and Quality Control, ASM Metals Hand Book, Vol. 17, ASM, 1989.

ME5762	POWDERS FOR ADDITIVE MANUFACTURING	3-0-0: 3

Pre-Requisites: NIL

Course Outcomes:

At the end of the course, the student will be able to

CO1	Propose manufacturing techniques to produce powders for additive manufacturing applications
CO2	Characterize powders developed from different manufacturing processes
CO3	Identify appropriate compaction techniques to densify powder preforms
CO4	Analyse the sintering mechanism of powder compacts
CO5	Propose methods to develop mechanical components through additive manufacturing techniques

Course Articulation Matrix:

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

Detailed Syllabus

General Concepts: Introduction and History of Powder Metallurgy and powders for additive manufacturing.

Powder Production Techniques: Different Mechanical and Chemical methods, Atomisation of Powder, other emerging processes, Performance Evaluation of different Processes, processing of metal powders, production and qualification of polymer powders.

Characterization Techniques: Particle Size & Shape Distribution, Electron Microscopy of Powder, Interparticle Friction, Compression ability, 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.

Metal powders in additive manufacturing: powders for direct energy deposition, powder for powder bed fusion process, requirements for powders used in additive manufacturing, handling of metal powders.

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 parts, Additive manufactured parts and A few case studies.

Learning Resources:

Text Books:

1. Powder Metallurgy Technology, G. S Upadhyaya, Cambridge International Science Publishing, 2002. 2nd Edition.
2. Powder Metallurgy Science, Technology and Materials, Anish Upadhyaya, Gopal Shankar Upadhyaya, Taylor & Francis Group, 2018.
3. Powder Metallurgy- Science, Technology and Applications, P. C. Angelo and R. Subramanian, PHI, New Delhi, 2008.

Reference Books:

1. Introduction to Powder Metallurgy, J. S. Hirschhorn, American Powder Metallurgy Institute, Princeton, NJ, 1976.
2. ASM Hand Book, vol. 7: Powder Metallurgy, ASM International
3. Advances in Powder Metallurgy: Properties, Processing and Applications, Isaac Chang, Yuyuan Zhao, Woodhead Publishing Series in Metals and Surface Engineering, Elsevier, 2013.
4. Powder Metallurgy, S. A. Tsukerman, Pergamon publishing, 1965, 1st Edition.

Online Resources:

1. https://www.epma.com/
2. https://www.pmai.in/
3. https://www.hoganas.com/en/powder-technologies/additive-manufacturing-metal-powders/
4. https://www.metalpowder.sandvik/en/products/applications/additive-manufacturing/
5. https://nptel.ac.in/courses/113/106/113106098/

ME 5763	RE- ENGINEERING	3-0-0: 3

Pre-requisites: NIL

Course Outcomes:

At the end of the course, the student will be able to

CO1	Identify the steps involved in re-engineering of a given component.
CO2	Design 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.

Course Articulation Matrix:

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

Detailed Syllabus:

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: Modelling 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 Modelling, 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.

Learning Resources:

Text Books:

1. Product Design: Techniques in Reverse Engineering and New Product Development, K. Otto and K. Wood, Prentice Hall, 2001.
2. Reverse Engineering: An Industrial Perspective, Raja and Fernandes, Springer-Verlag 2008.

Reference Books:

1. Computer Aided Engineering Design, Anupam Saxena, Birendra Sahay, Springer, 2005.
2. Engineering Design and Rapid Prototyping, Ali K. Kamrani and Emad Abouel Nasr, Springer, 2010.
3. Advanced CAD Modeling Explicit, Parametric, Free-Form CAD and Re-engineering, Nikola Vukašinović and, JožeDuhovnik, Springer, 2019.

Online Resources:

1. https://www.polyga.com/reverse-engineering-101-scan-to-cad/
2. https://www.bft international.com/en/artikel/bft_Reverse_engineering_techniques_From_3D_scanning_to_the_CAD_file_in_the_3357131.html
3. https://physicaldigital.com/what-is-reverse-engineering/
4. https://all3dp.com/2/reverse-engineering-software-reverse-engineering-tools/

DETAILED LABORATORY COURSE SYLLABUS

I YEAR – II SEMESTER

ME 5653	CAE LABORATORY	0-1-2: 2

Pre-Requisites: NIL

Course Outcomes:

At the end of the course, the student will be able to

CO1	Draw complex geometries of parts in sketch mode.
CO2	Develop MATLAB codes for analytical and synthetic curves.
CO3	Create complex engineering assemblies using appropriate assembly constraints.
CO4	Practice on CAD data exchange formats used in design and analysis of Engineering components.
CO5	Analyse 2D/3D components using a FEA software.

Course Articulation Matrix:

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

Syllabus

LIST OF EXPERIMENTS:

1. Introduction to Solid Modelling Packages

2. Working with sketch mode of Solid modelling Package

3. Working with creating features (Extrude & Revolve)

4. Develop Code for various analytical curves

5. Develop Code for various synthetic curves

6. Working with various editing tools in Solid Modelling

7. Working with advanced modelling tools (Sweep, Blend & Swept Blend)

8. Assembly modelling using appropriate assembly constrains

9. Working with CAD Data Exchange formats: IGES, ACIS, DXF STL, AMF, STEP

10. Analysis of simple 2D/3D component using a FEA software

Learning Resources:

Text Books:

1. Applied Numerical Methods with MATLAB for Engineers & Scientists, Steven Chapra, McGraw-Hill, 2018, 4th Edition.
2. Sham Tickoo, AutoCAD 2017 for Engineers & Designers, Dreamtech Press, 23rd Edition,2016.

3. Autodesk Fusion 360 Black Book, Verma G., CAD CAM CAE Works, 2021, 2nd Edition.

Reference Books:

1. Principles of CAD/CAM/CAE, Kunwoo Lee, Pearson, 1999.
2. Engineering Computation with MATLAB, David Smith, Pearson, 2013, 3rd Edition.

Online Resources:

1. Self-Paced Tutorials https://help.autodesk.com/view/fusion360/ENU/courses/
2. Product Documentation: https://help.autodesk.com/view/fusion360/ENU/?guid=GUID-1C665B4D-7BF7-4FDF-98B0-AA7EE12B5AC2
3. https://sites.ualberta.ca/~wmoussa/AnsysTutorial/
4. https://www.ansys.com/en-in/academic/learning-resources
5. http://engineering.nyu.edu/mechatronics/vkapila/matlabtutor.html

ME 5654	SYSTEMS ENGINEERING LABORATORY	0-1-2: 2

Pre-Requisites: NIL

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	Apply pneumatic, hydraulic and electrical actuators on real life systems

Course Articulation Matrix:

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

Syllabus:

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)

Learning Resources:

Text Books:

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

ME 5698	SEMINAR – II	0-0-2: 1

Pre-requisites: NIL

Seminar Outcomes:

At the end of the course, the student will be able to

CO1	Identify and compare technical and practical issues related to area of course specialization.
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 analyse technical issues and develop competence in presenting.

Course Articulation Matrix:

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

Evaluation Scheme:

Task	Description	Weightage
I	Clarity on the topic	10
II	Literature survey	30
III	Content	30
IV	Presentation	20
V	Response to Questions	10
TOTAL		**100**

Task-CO mapping:

Task/CO	CO1	CO2	CO3	CO4
I	X			
II		X		
III			X	
IV				X
V				X

DETAILED SYLLABUS

II YEAR – I SEMESTER

ME 6647	COMPREHENSIVE VIVA – VOCE	2 Credits

COMPREHENSIVE VIVA – VOCE OUTCOMES: At the end of the comprehensive viva-voce, the student shall be able to:

CO1	Comprehend the knowledge gained in the course work
CO2	Identify principles of working of additive manufacturing systems and controls
CO3	Demonstrate the ability in problem solving and to communicate effectively.

CO-PO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3		3	2		3
CO2	3		3	3	2	3
CO3	3		3	3	3	3

ME 6649	DISSERTATION PART – A	12 Credits

DISSERTATION OUTCOMES: At the end of the part – A of dissertation, the student shall be able to:

CO1	Identify a topic in advanced areas of additive manufacturing
CO2	Review literature to identify gaps and define objectives and scope of the work
CO3	Employ the ideas from literature and develop research methodology
CO4	Develop a model, experimental set-up and/or computational techniques necessary to meet the objectives.

M.Tech Dissertation Rubric Analysis:

Task	Description
I	Selection of Topic
II	Literature Survey
III	Defining the Objectives and Solution Methodology
IV	Performance of the Task
V	Dissertation Preparation
VI	Review (Presentation & Understanding)
VII	Viva-Voce
VIII	Publications /Possibility of publication

	ME 6649			
Task (% Weightage)	**CO1**	**CO2**	**CO3**	**CO4**
I (10)	X			
II (20)	X	X		
III (30)			X	
IV (40)				X

CO-PO MAPPING:

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	3	1		3
CO2	3	2	3	1		3
CO3	3	3	3	3	3	3
CO4	3	3	3	3	3	3

DETAILED SYLLABUS

II YEAR – II SEMESTER

ME 6699	DISSERTATION PART – B	20 Credits

DISSERTATION OUTCOMES: At the end of the part – B of dissertation, the student shall be able to:

CO1	Identify the materials and methods for carrying out experiments/develop a code
CO2	Execute the research methodology with a concern for society, environment and ethics
CO3	Analyse, discuss and justify the results/trends and draw valid conclusions
CO4	Prepare the report as per recommended format and present the work orally adhering to stipulated time
CO5	Explore the possibility to publish/present a paper in peer reviewed journals/conference without plagiarism

Task – CO Mapping:

	ME 6699				
Task (% Weightage)	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
IV (40)	X	X			
V (20)				X	
VI (10)			X		
VII (20)				X	
VIII (10)					X

CO-PO MAPPING:

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

NOTE: Refer to the following link for the guidelines to prepare dissertation report:
https://www.nitw.ac.in/main/PGForms/NITW/