NATIONAL INSTITUTE OF TECHNOLOGY

WARANGAL-506 004

Course structure and Syllabus

of

M.Tech.

MANUFACTURING ENGINEERING

DEPARTMENT OF MECHANICAL ENGINEERING

NATIONAL INSTITUTE OF TECHNOLOGY

WARANGAL – 506 004 (T.S), INDIA

(With effective from 2016-17)

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

M.TECH IN MANUFACTURING ENGINEERING

Graduate Attributes

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

1. **Scholarship of Knowledge**: Acquire in-depth knowledge of various manufacturing processes on a wider and global perspective, with an ability to discriminate, evaluate, analyze and synthesize existing and new knowledge, and integration of the same for enhancement of knowledge.

2. **Critical Thinking**: Analyze complex engineering problems critically, apply independent judgment for synthesizing information to make intellectual and/or creative advances for conducting research in a wider theoretical, practical and policy context.

3. **Problem Solving**: Think laterally and originally, conceptualize and solve manufacturing engineering problems, evaluate a wide range of potential solutions for those problems and arrive at feasible, optimal solutions after considering public health and safety, societal and environmental factors in the core areas of expertise.

4. **Research Skill**: Extract information pertinent to unfamiliar problems through literature survey and experiments, apply appropriate research methodologies, techniques and tools, design, conduct experiments, analyze and interpret data, demonstrate higher order skill and view things in a broader perspective, contribute individually/in group(s) to the development of scientific/technological knowledge in one or more domains of engineering.

5. **Usage of modern tools**: Create, select, learn and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modeling, to complex engineering activities with an understanding of the limitations.

6. **Collaborative and Multidisciplinary work**: Possess knowledge and understanding of group dynamics, recognize opportunities and contribute positively to collaborative-multidisciplinary scientific research, demonstrate a capacity for self-management and teamwork, decision-making based on open-mindedness, objectivity and rational analysis in order to achieve common goals and further the learning of themselves as well as others.

7. **Project Management and Finance**: Demonstrate knowledge and understanding of engineering and management principles and apply the same to one's own work, as a member and leader in a team, manage projects efficiently in respective disciplines and multidisciplinary environments after consideration of economic and financial factors.

8. **Communication**: Communicate with the engineering community, and with society at large, regarding complex engineering activities confidently and effectively, such as, being able to comprehend and write effective reports and design documentation by adhering to appropriate standards, make effective presentations, and give and receive clear instructions.

9. **Life-long Learning**: Recognize the need for, and have the preparation and ability to engage in life-long learning independently, with a high level of enthusiasm and commitment to improve knowledge and competence continuously.

10. **Ethical Practices and Social Responsibility**: Acquire professional and intellectual integrity, professional code of conduct, ethics of research and scholarship, consideration of the impact of research outcomes on professional practices and an understanding of responsibility to contribute to the community for sustainable development of society.

11. **Independent and Reflective Learning**: Observe and examine critically the outcomes of one's actions and make corrective measures subsequently and learn from mistakes without depending on external feedback.

PROGRAM EDUCATIONAL OBJECTIVES:

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

PEO1.	Analyze, design and evaluate manufacturing processes using the knowledge of mathematics, science, engineering and IT tools.
PEO2.	Solve real life manufacturing engineering problems using technological advancements for societal development.
PEO3.	Apply management principles to execute projects of inter-disciplinary nature adhering to professional ethics.
PEO4.	Engage in lifelong learning to adapt to the changing needs for professional advancement.

MAPPING OF MISSION STATEMENTS WITH PROGRAM EDUCATIONAL OBJECTIVES:

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

MAPPING OF PROGRAM EDUCATIONAL OBJECTIVES WITH GRADUATE ATTRIBUTES:

PEO/GA	GA1	GA2	GA3	GA4	GA5	GA6	GA7	GA8	GA9	GA10	GA11
PEO1	3	3	3	3	3	3	-	-	-	-	1
PEO2	3	3	3	3	2	3	2	3	-	3	2
PEO3	2	1	2	2	1	3	3	3	-	2	2
PEO4	1	1	3	2	1	3	2	-	3	3	3

PROGRAM OUTCOMES:

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

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

PO1	Apply engineering knowledge, techniques and modern tools to analyze problems in manufacturing engineering.
PO2	Identify manufacturing processes and measurement techniques to produce required components.
PO3	Design and conduct experiments to analyze process or product behavior to provide optimal solutions.
PO4	Develop and validate models to solve complex manufacturing systems using modern engineering and IT tools.
PO5	Develop management control systems for production planning, logistics and services.
PO6	Conceptualize and analyze new problems leading to research and development.
PO7	Communicate effectively with diverse groups while leading and executing interdisciplinary projects.
PO8	Apply professional, ethical, legal, security and social issues in the design of manufacturing systems.
PO9	Engage in life-long learning as a means of enhancing knowledge and skills for professional advancement.

MAPPING OF PROGRAM OUTCOMES WITH PROGRAM EDUCATIONAL OBJECTIVES:

PEO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
PEO1	3	3	2	3	1	1	1	2	1
PEO2	3	2	2	3	1	1	1	1	1
PEO3	2	1	1	1	3	1	1	1	1
PEO4	1	1	1	1	1	1	1	3	2

SCHEME OF INSTRUCTION
M.Tech. (Mechanical Engineering) Course Structure

I - Year I - Semester

S. No.	Course Code	Course Title	L	T	P	Credits	Cat. Code
1	ME5201	Metal Cutting – Theory and Practice	4	0	0	4	PCC
2	ME5202	Design and Analysis of Machine Tools	4	0	0	4	PCC
3	ME5203	CNC & AM Technologies	4	0	0	4	PCC
4	ME5204	Advanced CAD	4	0	0	4	PCC
5		Elective - 1	3	0	0	3	DEC
6		Elective - 2	3	0	0	3	DEC
7	ME5241	Manufacturing Engineering Laboratory	0	0	3	2	PCC
8	ME5242	CAE Laboratory	0	0	3	2	PCC
9	ME5243	Seminar – 1	0	0	2	1	PCC
		TOTAL	**22**	**0**	**8**	**27**	

I – Year, II - Semester

S. No.	Course Code	Course Title	L	T	P	Credits	Cat. Code
1	ME5251	Advanced Manufacturing Technology	4	0	0	4	PCC
2	ME5252	Precision Engineering	4	0	0	4	PCC
3		Elective - 3	3	0	0	3	DEC
4		Elective - 4	3	0	0	3	DEC
5		Elective - 5	3	0	0	3	DEC
6		Elective - 6	3	0	0	3	DEC
7	ME5291	Precision Engineering Laboratory	0	0	3	2	PCC
8	ME5292	AM & MCT Laboratory	0	0	3	2	PCC
9	ME5293	Seminar – 2	0	0	2	1	PCC
	Total		**20**	**0**	**8**	**25**	

II – Year, I - Semester

S. No.	Course Code	Course Title	L	T	P	Credits	Cat. Code
1	ME5248	Comprehensive Viva-voce	0	0	0	4	PCC
2	ME5249	Dissertation Part-A	0	0	0	8	PCC
		TOTAL	**0**	**0**	**0**	**12**	

II – Year, II - Semester

S. No.	Course Code	Course Title	L	T	P	Credits	Cat. Code
1	ME5299	Dissertation Part-B	0	0	0	18	PCC
		TOTAL	**0**	**0**	**0**	**18**	

List of Electives

I- Year, I- Semester

S. No.	Course Code	Course Title	L-T-P	Credits
1	ME5221	Micro and Nano Manufacturing	3-0-0	3
2	ME5131	Computational Fluid Dynamics	3-0-0	3
3	ME5321	Enterprise Resource Planning	3-0-0	3
4	ME5331	Manufacturing Management	3-0-0	3
5	ME5336	Soft Computing Techniques *	3-0-0	3
6	ME5422	Mathematical Methods in Engineering	3-0-0	3
7	ME5621	Advanced Metal Forming	3-0-0	3
8	ME5721	Integrated Product Design and Development	3-0-0	3
9	ME5731	Additive Manufacturing	3-0-0	3

Courses offered to other Specializations

S. No.	Course Code	Course Title	L-T-P	Credits
1	ME5231	Metrology and Computer Aided Inspection	3-0-0	3

I- Year, II- Semester

S. No.	Course Code	Course Title	L-T-P	Credits
1.	ME5261	High Speed Machining	3-0-0	3
2.	ME5271	Mechatronics and Robotics	3-0-0	3
3.	ME5272	Product Design for Manufacturing and Assembly	3-0-0	3
4.	ME5273	Tool Design	3-0-0	3
5.	ME5274	Fluid Power Systems	3-0-0	3
6.	ME5172	New Venture Creation	3-0-0	3
7.	ME5674	Thermal Coatings	3-0-0	3
8.	ME5186	Energy Systems and Management *	3-0-0	3
9.	ME5168	Renewable Sources of Energy *	3-0-0	3
10.	ME5371	Supply Chain Management	3:0:0	3
11.	ME5372	Mod. & Simulation of Manufacturing Systems	3-0-0	3
12.	ME5373	Flexible Manufacturing Systems	3-0-0	3
13.	ME5374	Lean Manufacturing Systems	3-0-0	3
14.	ME5375	Concurrent Engineering	3-0-0	3
15.	ME5376	Product Life Cycle Management	3-0-0	3
16.	ME5377	Reliability Engineering	3:0:0	3
17.	ME5386	Design and Analysis of Experiments *	3-0-0	3
18.	ME5387	Project Management *	3-0-0	3
19.	ME5471	Tribological System Design	3-0-0	3
20.	ME5474	Composite Materials	3-0-0	3
21.	ME5478	Robotics	3-0-0	3
22.	ME5479	Optimization Methods for Engineering design	3-0-0	3
23.	ME5481	Vibrations	3-0-0	3
24.	ME5482	Finite Element Method	3-0-0	3
25.	ME5686	Non Destructive Testing *	3-0-0	3
26.	ME5771	Re-Engineering	3-0-0	3
27.	MM5170	Powder Metallurgy	3-0-0	3

Courses offered to other Specializations

S. No.	Course Code	Course Title	L-T-P	Credits
1	ME5281	Precision Manufacturing	3-0-0	3

* Proposed as global elective

DETAILED SYLLABUS

ME5201	METAL CUTTING - THEORY AND PRACTICE	PCC	4 – 0 – 0	4 Credits

PRE-REQUISITES: NIL

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

CO1	Develop interrelations among ASA, ORS and NRS systems of tool geometry.
CO2	Analyze cutting forces, temperature, power and specific energy along the shear and rake planes.
CO3	Evaluate shear angle relationships and coefficient of friction in natural and controlled contact cutting.
CO4	Select cutting fluids, cutting tool materials and tool geometry for improving machinability and tool life.
CO5	Select modern machining processes for machining a given material and required part accuracies.

CO-PO Mapping:

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

DETAILED SYLLABUS:

Introduction: Overview of the course, Examination and Evaluation patterns, Classification of Manufacturing Processes, History of Machining, Scope and Significance of Machining

Geometry of Cutting Tools: Geometry of single-point cutting tool: Tool-in hand system, ASA system, Significance of various angles of single point cutting tools, Orthogonal Rake System (ORS), Conversions between ASA and ORS systems – Graphical and Analytical Methods, Normal Rake System (NRS) & relation with ORS

Mechanics of Machining Processes: Orthogonal and Oblique cutting, Mechanics of Chip formation: Types of chips, chip-breakers, Chip reduction coefficient, shear angle, shear strain, Built-Up-Edge and its effect in metal cutting, Merchant's analysis of metal cutting process - Various forces, power and specific energy in cutting, Problems on Tool Geometry and Mechanics of Machining, Theories of Metal Cutting: Ernst & Merchant, theory, Modified Merchant's theory, Lee & Shaffer Theory, Chip-tool Natural Contact Length – Hahn's Analysis, Stress distribution at Chip-Tool Interface – Zorev's Analysis, Machining with controlled contact cutting, Chip breakers.

Thermal aspects in machining: Sources of heat generation, Effects of temperature, Determination of cutting temperature using analytical methods, Determination of cutting temperature using experimental methods, Methods of Controlling Cutting Temperature,

Tool wear, Tool life, Machinability and Machining Economics: Wear Mechanisms, Types of tool wear, Tool Life and Machinability, A brief treatment for single pass turning operations, Problems on Economics of Machining

Cutting Tool Materials: Desirable Properties of tool materials, Characteristics of Cutting Tool Materials, indexable inserts, coated tools

Cutting Fluids: Functions, characteristics and types, selection of cutting fluids

Mechanics of Multipoint Machining processes: Drill geometry & Mechanics of drilling process, Geometry of milling cutters and Mechanics of milling process, Mechanics of grinding (plunge grinding and surface grinding), Grinding wheel wear

Oblique Cutting: Inclination Angle, Chip Flow angle, Mechanics of oblique cutting

Material Removal Mechanism of Advanced Machining Processes:
Mechanical energy based machining processes: Abrasive jet machining, Ultrasonic machining, Water jet machining, Abrasive water jet machining.
Thermo-electric energy based machining processes: Laser beam machining, Electron beam machining, Electric discharge machining, Plasma arc machining.
Chemical energy based machining processes: Chemical machining, Electro-Chemical machining, Bio-Chemical machining.

Reading:

1. Winston A. Knight and Geoffrey Boothroyd, Fundamentals of Machining and Machine Tools, 3/e, Taylor and Francis Group, 2005.
2. M. C. Shaw, Metal cutting-Principles and Practices, Cambridge University press. 2005
3. P.N.Rao, Manufacturing Technology–Metal Cutting and Machine Tools, 3/e, TMH, New Delhi, 2013.
4. A.Bhattacharya, Metal Cutting: Theory and Practice, New Central Book Agency, Kolkata, 2007
5. V. K. Jain, Advanced Machining Processes, Allied Publisher, Mumbai, 2009
6. P.C.Pandey and H.S.Shah, Modern Machining Processes, TMH, 1981

ME5202	DESIGN AND ANALYSIS OF MACHINE TOOLS	PCC	4 – 0 – 0	4Credits

PRE-REQUISITES: NIL

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

CO1	Design and analyze kinematic motions in a machine tool.
CO2	Design and analyze speed and feed gear boxes
CO3	Design guide ways, spindles and lead screws in machine tools
CO4	Analyze machine tool vibration and chatter
CO5	Select alignment tests to be performed on a machine tool for quality assurance

CO-PO MAPPING:

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

Detailed syllabus:

Introduction to Machine Tool Drives and Mechanisms: Introduction to the course, Working and Auxiliary Motions in Machine Tools, Kinematics of Machine Tools, Motion Transmission.

Regulation of Speed and Feed Rates: Aim of Speed and Feed Regulation, Stepped Regulation of Speeds, Multiple Speed Motors, Ray Diagrams and Design Considerations, Design of Speed Gear Boxes, Feed Drives, Feed Box Design.

Design of Machine Tool Structures: Functions of Machine Tool Structures and their Requirements, Design for Strength Design for Rigidity, Materials for Machine Tool Structures, Machine Tool , Constructional Features, Beds and Housings, Columns and Tables, Saddles and Carriages.

Design of Guideways and Power Screws: Functions and Types of Guide ways, Design of Guide ways, Design of Aerostatic, Slide ways, Design of Anti-Friction Guide ways, Combination Guide ways, Design of Power Screws.

Design of Spindles and Spindle Supports: Functions of Spindles and Requirements, Effect of Machine Tool Compliance on machining Accuracy, Design of Spindles, Antifriction Bearings.

Dynamics of Machine Tools: Machine Tool Elastic System, Static and Dynamic Stiffness, Stability Analysis, Machine Tool Chatter, Damping Characteristics, Damping Methods.

Control Systems in Machine Tools: Machine tool control systems, Control Systems for Speed and Feed Changing, Adaptive Control Systems.

Testing of CNC Machine Tools: Alignment tests, Estimation of positional and geometrical accuracies.

Reading:

1. N.K. Mehta, Machine Tool Design and Numerical Control, TMH, New Delhi, 2010
2. G.C. Sen and A. Bhattacharya, Principles of Machine Tools, New Central Book Agency, 2009.
3. D. K Pal, S. K. Basu, “Design of Machine Tools”, 5th Edition. Oxford IBH, 2008

ME 5203	CNC AND AM TECHNOLOGIES	PCC	4 – 0 – 0	4 Credits

PRE-REQUISITES: NIL

COURSE OUTCOMES: At the end of the course, the student shall be acquainted with the knowledge of:

CO1	Classify and distinguish NC, CNC and DNC systems.
CO2	Develop manual and APT part programs for machining of complex parts.
CO3	Design structures for CNC machines.
CO4	Develop and execute interpolation algorithms for control loops.
CO5	Design and develop AM machines and their control strategies.

CO-PO MAPPING:

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

DETAILED SYLLABUS:

CNC TECHNOLOGY: An overview: Introduction to NC/CNC/DNC machine tools, Classification of NC /CNC/DNC machine tools, Advantage, disadvantages of NC /CNC/DNC machine tools, Application of NC/CNC/DNC.

DESIGN OF CNC: Constructional features of CNC machine tools, Designation of axis in CNC systems.

PART PROGRAMMING:CNC programming and introduction, Manual part programming: Basic (Drilling, milling, turning etc..), Special part programming, Advanced part programming, Computer aided part programming (APT).

INTERPOLATORS: Hardware Interpolators, Software Interpolators, NC/CNC controllers.
INTRODUCTION TO ADDITIVE MANUFACTURING: Introduction to AM, AM evolution, Distinction between AM & CNC machining, Advantages and Limitations of AM,

AM PROCESS CHAIN: Conceptualization, CAD, conversion to STL, Transfer to AM, STL file manipulation, Machine setup, build, removal and clean up, post processing.

CONSTRUCTION OF BASIC AM MACHINES: Construction of AM machines, - Axes, linear motion, guide ways, ball screws, motors, bearings, encoders/glass scales, process chamber, safety interlocks, sensors.

READINGS:

1. YoramKoren, *Computer Control of Manufacturing Systems*, McGraw Hill International, Singapore, 2006
2. John Stenerson and Kelly Curran, *Computer Numerical Control: Operation and Programming*, PHI, New Delhi, 2009
3. Tien - Chien Chang, Richard A Wysk and Hsu-Pin Wang, *Computer Aided Manufacturing*, PHI, New Dellhi,2006
4. Chua Chee Kai, Leong Kah Fai, "Rapid Prototyping: Principles & Applications", World Scientific, 2003.
5. Ian Gibson, David W Rosen, Brent Stucker., "Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing", Springer, 2010
6. D.T. Pham, S.S. Dimov, Rapid Manufacturing: The Technologies and Applications of Rapid Prototyping and Rapid Tooling, Springer 2001

ME5204	ADVANCED CAD	PCC	4-0-0	4Credits

PRE-REQUISITES: NIL

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

CO1	Understand geometric transformation techniques in CAD.
CO2	Develop mathematical models to represent curves.
CO3	Design surface models for engineering applications.
CO4	Model engineering components using solid modeling techniques.
CO5	Make use of data exchange format in CAD

CO-PO Mapping:

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

DETAILED SYLLABUS:

Introduction to CAD: Introduction to CAD, CAD input devices, CAD output devices, CAD Software, Display Visualization Aids, and Requirements of Modelling, Transformations and Projections, Developing algorithms/computer codes for transformations.

Design of Curves: Analytic Curves, PC curve, Ferguson, Composite Ferguson, curve Trimming and Blending, Bezier segments, de Casteljau's algorithm, Bernstein polynomials, Bezier-subdivision, Degree elevation, Composite Bezier, Splines, Polynomial Splines, B-spline basis functions, Properties of basic functions, Knot Vector generation, NURBS, Developing algorithms/computer codes for Design of Curves.

Design of Surfaces: Differential geometry, Parametric representation, Curves on surface, Classification of points, Curvatures, Developable surfaces, Surfaces of revolution, Intersection of surfaces, Surface modelling, 16-point form, Coons patch, B-spline surfaces, Developing algorithms/computer codes for Design of Surfaces.

Design of Solids: Solid entities, Boolean operations, B-rep of Solid Modelling, CSG approach of solid modelling, Advancedmodelling methods.

Data Exchange Formats and CAD Applications: Data exchange formats, Finite element analysis, generating finite element meshes, reverse engineering, modelling with point cloud data, working with .STL files, Additive Manufacturing.

Reading:

1. David F. Rogers, J. A. Adams, Mathematical Elements for Computer Graphics, TMH, 2008.
2. Michael E. Mortenson, “Geometric Modeling”, Wiley, NY, 1997.
3. Ibrahim Zeid and Sivasubramanian, R., CAD/CAM Theory and Practice, Tata McGraw Hill Publications, New Delhi, 2009.
4. Anupam Saxena, Birendra Sahay, “Computer Aided Engineering Design”, Springer, 2005

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

PRE-REQUISITES: NIL

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

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

CO-PO MAPPING:

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

DETAILED SYLLABUS:

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

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

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

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

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

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

READING :

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

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

PRE-REQUISITES: NIL

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

CO1	Derive the governing equations and understand the behaviour of the equations.
CO2	Understand the stepwise procedure to completely solve a fluid dynamics problem using computational methods.
CO3	Analyse the consistency, stability and convergence of discretization schemes for parabolic, elliptic and hyperbolic partial differential equations.
CO4	Analyse variations of SIMPLE schemes for incompressible flows and variations of Flux Splitting algorithms for compressible flows.
CO5	Evaluate methods of grid generation techniques and application of finite difference and finite volume methods to thermal problems.

CO-PO MAPPING:

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

DETAILED SYLLABUS:

INTRODUCTION: History and Philosophy of computational fluid dynamics, CFD as a design and research tool, Applications of CFD in engineering, Programming fundamentals, MATLAB programming, Numerical Methods

GOVERNING EQUATIONS OF FLUID DYNAMICS: Models of the flow, the substantial derivative, Physical meaning of the divergence of velocity, 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.

MATHEMATICAL BEHAVIOR OF PARTIAL DIFFERENTIAL EQUATIONS: Classification of quasi-linear partial differential equations, Methods of determining the classification, General behavior of Hyperbolic, Parabolic and Elliptic equations.

BASIC ASPECTS OF DISCRETIZATION: Introduction to finite differences, Finite difference equations using Taylor series expansion and polynomials, Explicit and implicit approaches, Uniform and unequally spaced grid points.

GRIDS WITH APPROPRIATE TRANSFORMATION: General transformation of the equations, Metrics and Jacobians, The transformed governing equations of the CFD, Boundary fitted coordinate systems, Algebraic and elliptic grid generation techniques, Adaptive grids.

PARABOLIC PARTIAL DIFFERENTIAL EQUATIONS: Finite difference formulations, Explicit methods – FTCS, Richardson and DuFort-Frankel methods, Implicit methods – Laasonen, Crank-Nicolson and Beta formulation methods, Approximate factorization, Fractional step methods, Consistency analysis, Linearization.
STABILITY ANALYSIS: Discrete Perturbation Stability analysis, von Neumann Stability analysis, Error analysis, Modified equations, Artificial dissipation and dispersion.

ELLIPTIC EQUATIONS: Finite difference formulation, solution algorithms: Jacobi-iteration method, Gauss-Siedel iteration method, point- and line-successive over-relaxation methods, alternative direction implicit methods.
HYPERBOLIC EQUATIONS: Explicit and implicit finite difference formulations, splitting methods, multi-step methods, applications to linear and nonlinear problems, linear damping, flux corrected transport, monotone and total variation diminishing schemes, tvd formulations, entropy condition, first-order and second-order tvd schemes.
SCALAR REPRESENTATION OF NAVIER-STOKES EQUATIONS: Equations of fluid motion, numerical algorithms: ftcs explicit, ftbcs explicit, Dufort-Frankel explicit, Maccormack explicit and implicit, btcs and btbcs implicit algorithms, applications.GRID GENERATION: Algebraic Grid Generation, Elliptic Grid Generation, Hyperbolic Grid Generation, Parabolic Grid Generation.
FINITE VOLUME METHOD FOR UNSTRUCTURED GRIDS: Advantages, Cell Centered and Nodal point Approaches, Solution of Generic Equation with tetrahedral Elements, 2-D Heat conduction with Triangular Elements.
NUMERICAL SOLUTION OF QUASI ONE-DIMENSIONAL NOZZLE FLOW: Subsonic-Supersonic isentropic flow, Governing equations for Quasi 1-D flow, Non-dimensionalizing the equations, MacCormack technique of discretization, Stability condition, Boundary conditions, Solution for shock flows.

READING:

1. Anderson, J.D.(Jr), *Computational Fluid Dynamics*, McGraw-Hill Book Company, 1995.
2. Hoffman, K.A., and Chiang, S.T., *Computational Fluid Dynamics*, Vol. I, II and III, Engineering Education System, Kansas, USA, 2000.
3. Chung, T.J., *Computational Fluid Dynamics*, Cambridge University Press, 2003.
4. Anderson, D.A., Tannehill, J.C., and Pletcher, R.H., *Computational Fluid Mechanics and Heat Transfer*, McGraw Hill Book Company, 2002.
5. Versteeg, H.K. and Malalasekara, W., *AnIntroduction to Computational Fluid Dynamics*, Pearson Education, 2010.

ME5321	ENTERPRISE RESOURCE PLANNING	DEC	3-0-0	3 Credits

PRE-REQUISITES: NIL

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

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

CO-PO MAPPING:

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

DETAILED SYLLABUS:

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

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

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

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

READING:

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

ME5331	MANUFACTURING MANAGEMENT	DEC	3 – 0 – 0	3 Credits

PRE-REQUISITES: NIL

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

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

CO-PO MAPPING:

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

DETAILED 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.

READING:

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

ME 5336	SOFT COMPUTING TECHNIQUES	DEC	3-0-0	3 Credits

PRE REQUISITES: NIL

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

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

CO-PO MAPPING:

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

DETAILED SYLLABUS:

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

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

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

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

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

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

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

READING:

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

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

PRE-REQUISITES: NIL

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

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

CO-PO MAPPING:

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

DETAILED SYLLABUS:

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

The Algebraic Eigenvalue Problem: The Algebraic Eigenvalue Problem, Canonical Forms, Symmetric Matrices, Methods of Plane Rotations, Householder Method, Tri-diagonal Matrices, QR Decomposition, General Matrices.

Selected Topics in Linear Algebra and Calculus: Singular Value Decomposition, Vector Space: Concepts, Multivariate Calculus, Vector Calculus in Geometry, Vector Calculus in Physics.

An Introductory Outline of Optimization Techniques: Solution of Equations, Introduction to Optimization, Multivariate Optimization, Constrained Optimization: Optimality Criteria, Constrained Optimization: Further Issues.

Selected Topics in Numerical Analysis: Interpolation, Regression, Numerical Integration, Numerical Solution of ODE's as IVP Boundary Value Problems, Question of Stability in IVP Solution, Stiff Differential Equations, Existence and Uniqueness Theory.

Ordinary Differential Equations: Theory of First Order ODE's, Linear Second Order ODE's, Methods of Linear ODE's, ODE Systems, Stability of Dynamic Systems.

Application of ODE's in Approximation Theory: Series Solutions and Special Functions, Sturm-Liouville Theory, Approximation Theory and Fourier Series, Fourier Integral to Fourier Transform, Minimax Approximation.

Overviews: PDE's, Complex Analysis and Variational Calculus: Separation of Variables in PDE's, Hyperbolic Equations, Parabolic and Elliptic Equations, Membrane Equation, Analytic Functions , Integration of Complex Functions, Singularities and Residues, Calculus of Variations.

READING:

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

ME5621	ADVANCED METAL FORMING	DEC	3-0-0	3 Credits

PRE-REQUISITES: NIL

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

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

CO-PO MAPPING:

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

DETAILED SYLLABUS:

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

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

Overview of various metal forming operations: Mechanics of Various Plastic Flow Problems Introduction to; (i). Theory of slip lines, Upper bound theorem, Lower bound theorem.
Forging processes: Metal flow in forging, Analysis of plane strain compression, Analysis of compression of circular disc with slab method.
Extrusion Processes: Calculation of extrusion load using slab method, slip line method and upper bound method. Defects in extrusion. Direct & indirect extrusion.
Wire Drawing Processes: Introduction,wire drawing load calculation using slab method.

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.
Sheet forming: Mechanics – Flow Rules – Anisotropy - Formability of sheet, Formability tests, forming limit diagrams, Case studies.
Pressing and Sintering: Workability Studies – Densification - Problems & Case Studies

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

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

READING:

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

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

PRE-REQUISITES: NIL

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

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

CO-PO MAPPING:

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

DETAILED SYLLABUS:

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

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

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

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

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

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

READING:

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

ME5731	ADDITIVE MANUFACTURING	DEC	3-0-0	3 Credits

PRE-REQUISITES: NIL

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

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

CO-PO MAPPING:

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

DETAILED SYLLABUS:

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

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

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

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

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

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

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

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

Post Processing of AM Parts: Support Material Removal, Surface Texture Improvement, Accuracy Improvement, Aesthetic Improvement, Preparation for use as a Pattern, Property Enhancements using Non-thermal and Thermal Techniques

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

AM Applications: Functional models, Pattern for investment and vacuum casting, Medical models, art models, Engineering analysis models, Rapid tooling, new materials development, Bi-metallic parts, Re-manufacturing. Application examples for Aerospace, defense, automobile, Bio-medical and general engineering industries.

READING:

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

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

PRE-REQUISITES: NIL

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

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

CO-PO MAPPING:

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

DETAILED 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.

Reading:

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

ME5241	MANUFACTURING ENGINEERING LABORATORY	PPC	0–0–3	2 Credits

PRE-REQUISITES: NIL
COURSE OUTCOMES: At the end of the course, the student will be able to:

CO1	Prepare a single point cutting tool as per the ASA and NRS and estimate its tool life.
CO2	Evaluate the effect of process parameters on cutting forces and temperature in machining.
CO3	Evaluate the effect of process parameters on MRR and Surface finish in EDM and WEDM.
CO4	Simulate and machining of complex profiles on a CNC turning and milling machines using manual and auto generated CNC code.
CO5	Evaluate the geometrical accuracies of machined components using CMM.

CO-PO MAPPING:

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

List of Experiments

1. Preparation of a single point cutting tool with a given tool geometry.
2. Estimation of chip reduction coefficient and shear angle in orthogonal cutting.
3. Evaluation of the effect of process parameters on cutting forces, surface finish and average cuttingtemperature in turning process.
4. Evaluation of the effect of process parameters on cutting forces in milling process.
5. Estimation of tool life of a single point turning tool.
6. Evaluation of the effect of process parameters on MRR and Surface finish in EDM
7. Evaluation of effect of process parameters on MRR in WEDM
8. Evaluation of dimensional and geometrical accuracies of a given component on CMM.
9. Manual Part programming for Fanuc and Siemens Controller using CNC Simulator and Sinutrain.
10. CNC programming and simulation using EdgeCAM, Sinutrain and MasterCAM
11. Writing part programs to machine components on CNC machines

Reading:

1. Lab instruction manual
2. M. C. Shaw, Metal cutting-Principles and Practices, Cambridge University press. 2005
3. Rao PN, Manufacturing Technology–Metal Cutting and Machine Tools, 3/e, TMH, 2013.
4. John Stenerson and Kelly Curran, Computer Numerical Control: Operation and Programming, PHI, New Delhi, 2009.

ME5242	CAE LABORATORY	PCC	0 – 0 – 3	2 Credits

PRE-REQUISITES: NIL

COURSE OUTCOMES: At the end of the course, the student shall 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	Finite Element Analysis of structural, heat transfer and fluid-flow problems.

CO-PO Mapping:

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

LIST OF EXPERIMENTS:

1. Introduction to Solid Modeling Packages
2. Working with sketch mode of Solid modeling Package
3. Working with creating features (Extrude & Revolve)
4. Develop MATLAB Code for various analytical curves
5. Develop MATLAB Code for various synthetic curves
6. Working with various editing tools in Solid Modelling
7. Working with advanced modeling tools (Sweep, Blend & Swept Blend)
8. Assembly modeling using appropriate assembly constrains
9. Working with CAD Data Exchange formats: IGES, ACIS, DXF STL, AMF, STEP
10. Finite Element Analysis of Structural Problems
11. Finite Element Analysis of Heat Transfer Problems
12. Finite Element Analysis of Fluid-flow Problems

Reading:

1. Lab instruction manual.

ME5243	SEMINAR -I	0-0-2	1Credit

PRE-REQUISITES: NIL

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

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

CO-PO MAPPING:

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

ME5251	ADVANCED MANUFACTURING TECHNOLOGY	PCC	4 – 0 – 0	4 Credits

PRE-REQUISITES: NIL

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

CO1	Understand the advances in manufacturing processes including stir casting, hybrid welding and high energy rate forming.
CO2	Apply the knowledge in welding of dissimilar materials and characterization by using friction stir welding, laser and hybrid welding process
CO3	Design of cast and welded components
CO4	Apply advanced casting methods including stir casting centrifugal casting for making composite materials and its characterization
CO5	Analyze the forming components using high energy rate forming process

CO-PO MAPPING:

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

DETAILED SYLLABUS:

Advances in casting processes: Introduction to advances in casting processes, Stir casting process, variables in stir casting process, advantages, limitations and application, composite preparation, analysis of composite. Centrifugal casting, production of composites by centrifugal casting process, applications and advantages.

Advances in welding: Classification of solid state and fusion welding processes, Friction welding, process and applications, inertia friction welding, Friction stir welding: process, parameters, tool design, advantages, limitations and applications, Diffusion bonding, advantages and applications, Electron beam welding process, Laser beam welding processes, Laser surfacing, laser hardening and cladding Hybrid welding process;-Process parameters, applications, advantages and limitations.

Advances in forming: Introduction forming processes, advantages,limitations and applications, Vacuum forming, Explosive forming, and hydro forming, advantages and applications, High velocity forming and Mar forming, advantages and applications, Electromagnetic forming, advantages and applications.

Processing of Plastics: Extrusion, injection molding, blow molding and transfer molding, advantages and limitations and applications

Material characterization and design considerations: Optical microscopy, micro hardness, SEM and XRD analysis of cast and welded structures. Design consideration in casting, welding and forming.

READING:

1. R. S. Mishra, *Friction Stir Welding and Processing,* ASM International, 2007.
2. R.S.Parmar, Welding processes and Technology, Khanna Publishers, 2012
3. J Paulo Davim, *Modern Machining Technology, A Practical Guide*, 1st Edition, Woodhead Publishing in Mechanical Engineering
4. Materials Characterization,ASM Handbook, volume No 10, ASM International,1998
5. Casting , ASM Handbook, volume No 15, ASM International,1998
6. Forming , ASM Handbook, volume No 14, ASM International,1998

ME5252	PRECISION ENGINEERING	PCC	4 – 0 – 0	4 Credits

PRE-REQUISITES: ME-5201 Metal Cutting – Theory and Practice

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

CO1	Design and apply fits and tolerances for parts and assemblies according to ISO standards.
CO2	Apply selective assembly concept for quality and economic production.
CO3	Design and allocate tolerances using principles of dimensional chains for individual features of a part or assembly.
CO4	Evaluate the part and machine tool accuracies.

CO-PO MAPPING:

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

Detailed Syllabus:

Accuracy and Precision: Introduction - Accuracy and precision – Need – application of precision machining- alignment testing of machine tools, accuracy of numerical control system, accuracy specification 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, Design of limit gauges.

Theory of dimensional chains: Definitions, concept of dimensional chain or tolerance stack. dimensioning of stepped shaft and holes, machining of a keyway in a bush, assigning tolerances on the constituent dimensions.

Geometric Dimensioning and Tolerancing: Tolerance Zone Conversions-Surfaces, Features of Size, Datum - Datum Feature of Representation-Form Controls, Orientation Controls-Logical Approach to Tolerancing-datum systems, geometrical tolerances.

Errors during machining: Errors due to compliance of machine- fixture-tool-workpiece (MFTW), theory of location, location errors, errors due to geometric inaccuracy of machine tools, errors due to tool wear, errors due to thermal effect, errors due to clamping.

Surface Roughness and Micro-finishing Process: Definitions, relation among various indices of surface roughness, influence of machining parameters on surface roughness, methods of obtaining high quality surfaces, lapping, honing, super finishing and burnishing processes.

Manufacturing methods of machine tool components and tolerance charting technique: Manufacturing methods of spindles, gears and beds, operation sequence for typical shaft type of component, preparation of process drawings for different operations, tolerance worksheets and centrally analysis

READING:

1. R.L.Murty, ”Precision Engineering in Manufacturing”, New Age International Publishers, 1996.
2. V.Kovan, "Fundamentals of Process Engineering", Foreign Languages Publishing House, Moscow, 1975
3. Eary and Johnson, "Process Engineering for Manufacture"
4. J.L.Gadjala, "Dimensional control in Precision Manufacturing", McGraw Hill Publishers.
5. ASME Y14.5M-1994.
6. Venkatesh, V.C. and Sudin, I., “Precision Eengineering”, Tata McGraw Hill Co., NewDelhi, 2007.
7. James, D. and Meadow, S., “Geometric Dimensioning and Tolerancing”, Marcel Dekker Inc.,1995.

ME5291	PRECISION ENGINEERINGLABORATORY	PCC	0– 0 – 3	2 Credits

PRE-REQUISITES: NIL

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

CO1	Estimate type of fit for a given assembly
CO2	Evaluate form errors like straightness, flatness, squareness, roundness and circularity
CO3	Evaluate dimensional and form accuracies of thread and gear profiles
CO4	Estimate the compliance of M-F-T-W system
CO5	Evaluate the effect of process parameters on surface finish during machining

CO-PO MAPPING:

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

List of Experiments

12. Estimation of type of fit in assemblies
13. Estimation of form errors like straightness, flatness and squareness on a machined component.
14. Evaluation of roundness and circularity on a machined component.
15. Production and evaluation of thread and gear profiles for their form and geometrical accuracies.
16. Evaluation of accuracy of machine tools for parallelism of guide ways, spindle runout, etc. in lathe, milling and drilling machines.
17. Estimation of compliance of machine- fixture-tool-workpiece using turned components
18. Evaluation of the effect of process parameters on surface roughness in turning, milling, drilling and grinding.

Reading

5. Lab instruction manual
6. I.C. Gupta, *Engineering Metrology,*DhanpatRai& Sons, 2003
7. R. K. Jain, *Engineering Metrology*, Khanna Publishers, 19/e, 2005.
8. R.L.Murty, ”Precision Engineering in Manufacturing”, New Age International Publishers, 1996.

ME5992	AM & MCT Laboratory	PCC	0 – 0 – 3	2 Credits

PRE-REQUISITES: NIL

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

CO1	Analyze the microstructure in cast, welded and formed components
CO2	Analyze the mechanical properties of various components
CO3	Analyze the defects and correlate them to mechanical properties
CO4	Analyze the Surface roughness of components
CO5	Analyze the additive manufacturing components

CO-PO MAPPING:

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

DETAILED SYLLABUS:

1. The following characterization are to be carried out on cast, welded and formed components (4)

   i) Analyze the microstructure of welded and cast components

   ii) Identify the phases in the microstructure

   iii) Phase/volume fraction

iv Grain size measurement using line intercept method / area method

   v) EDX-analysis using SEM

2. Tensile behaviour of cast and welded and additive manufactured components

3. Fractography of cast and welded samples

4. Microhardness analysis of cast and welded components

5. NDT of cast and welded components

6. Demonstration of XRD Analysis

7. Fabrication and characterization of components using Additive manufacturing process

8. Analysis of additive manufactured components using 3D-microscope

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

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

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

CO-PO MAPPING:

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

ME5261	HIGH SPEED MACHINING	DEC	3 – 0 – 0	3 Credits

PRE-REQUISITES: ME5201 Metal Cutting – Theory and Practice
ME5202 Design and Analysis of Machine Tools

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

CO1	Distinguish between conventional machining and high speed machining.
CO2	Analyze the determinants of high speed machining and improve its performance.
CO3	Evaluate the requirements on machine tool technology to support High Speed Machining.
CO4	Select cutting tool materials for high speed machining.
CO5	Estimate the impact of dry and near dry machining on environment.

CO-PO MAPPING:

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

DETAILED SYLLABUS:

Introduction: Advanced Machining Processes, A new Era.

The Determinants of High-Speed Machining: Weight, Materials, Machine Tools, Simple Processes and Systems, Fast Machining, Response Time, and Throughput, Smart Machines, Tools, and Processes.

Characteristics of High-Speed Machining: Machining Parameters.

Machine-tool Technology: Manufacturing and Multi-task Machining Systems, High-Speed Machining, Support Technology.

Advanced Cutting Tools: Cutting-Tool Materials, Cutting-Tool Design, Tool Guidance and Stability, Chip Control, Burr Control, Stringent Finish Requirements, Cost and Quality, Intelligent Tooling.

Precision Tooling Interface: Connection and Interface, Tool Clamping, Balancing, Run-out.

Dry and Near-dry Machining: Environmental Impact, Dry Machining, Near-dry Machining, Reducing Coolant Use.

Practical Applications: Precision Hard Machining, Machining Compacted Graphite Iron, Precision Roughing, Advanced Milling Operations, Machining with Multi-cut Tools.

READING:

1. Bert P. Erdel, High Speed Machining, SME Publications, Michigan, 2003
2. Dale Mickelson, Hard Milling and High Speed Machining, Industrial Press Inc, United States, 2007.

ME5271	MECHATRONICS AND ROBOTICS	DEC	3 – 0 – 0	3Credits

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

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

CO1	Model analyze and control engineering systems.
CO2	Select appropriate sensors, transducers and actuators to monitor and control the behavior of a process or product.
CO3	Develop PLC programs for a given task.
CO4	Evaluate the performance of mechatronic systems.
CO5	Understand the evolution, classification, structures and drives for robots.

CO-PO MAPPING:

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

DETAILED SYLLABUS:

Introduction: Introduction, elements of mechatronic systems, needs and benefits of mechatronics in manufacturing.

Design of Sensors: Classification of sensors basic working principles, Displacement Sensor - Linear and rotary potentiometers, LVDT and RVDT, incremental and absolute encoders. Strain gauges. Force/Torque – Load cells. Temperature – Thermocouple, Bimetallic Strips, Thermistor, RTD.

Accelerometers, Velocity sensors – Tachometers, Proximity and Range sensors – Eddy current sensor, ultrasonic sensor, laser interferometer transducer, Hall Effect sensor, inductive proximity switch. Light sensors – Photodiodes, phototransistors, Flow sensors – Ultrasonic sensor, laser Doppler anemometer tactile sensors – PVDF tactile sensor, micro-switch and reed switch Piezoelectric sensors, vision sensor. Selection of appropriate sensor for real time applications.

Design of Actuator Circuits: 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. Development of Hydraulic & Pneumatic circuits for automation applications. 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.

Robotics: Introduction to Robotics, Robot anatomy physical configurations, Manipulator, Kinematics, Technical features. Programming of Mobile robot, robot programming language, end effecters.

READING:

1. W. Bolton, "Mechatronics‟, 5 th edition, Addison Wesley Longman Ltd, 2010
2. DevdasShetty& Richard Kolk "Mechatronics System Design", 3rd edition. PWS Publishing, 2009.
3. Alciatore David G &Histand Michael B, "Introduction to Mechatronics and Measurement systems", 4th edition, Tata McGraw Hill, 2006.
4. Saeed B Niku, "Introduction to Robotics: Analysis, Systems, Applications ", 2nd edition, Pearson Education India, PHI, 2003.

VIDEO REFERENCES:

1. http://video_demos.colostate.edu/mechatronics
2. http:// mechatronics.me.wisc.edu

ME5272	PRODUCT DESIGN FOR MANUFACTURING AND ASSEMBLY	DEC	3 – 0 – 0	3 Credits

PRE REQUISITES: NIL

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

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

CO-PO MAPPING:

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

DETAILED SYLLABUS:

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

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

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

Design for Machining and Injection Molding: Machining Using Single-Point & Multi point cutting tools, Choice of Work Material, Shape of Work Material, Machining Basic Component Shapes, Cost Estimating for Machined Components, Injection Molding Materials, The Molding Cycle, Injection Molding Systems, Molding Machine Size, Molding Cycle Time, Estimation of the Optimum Number of Cavities, Design Guidelines.

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

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

READING:

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

ME5273	TOOL DESIGN	DEC	3 – 0 – 0	3 Credits

PRE-REQUISITES: None

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

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

CO-PO Mapping:

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

DETAILED SYLLABUS:

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

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

Design of jigs: Type of Drill bushes, Classification of drill jigs, Design of drill jigs.

Design of fixtures: Design of milling fixtures, Design of turning fixtures

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

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

NC machines work holding devices: Tool design for NC machines- An introduction, Fixture design for NC Machine, Tool holding methods for NC Machine, ATC and APC for NC Machines, Tool presetting for NC Machine.

Reading:

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

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

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

PRE-REQUISITES: NIL

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

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

CO-PO MAPPING:

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

DETAILED SYLLABUS:

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

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

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

Design of Hydraulic circuits: Design of hydraulic circuits for various machine tools.

Servo system: Introduction and types, Hydro mechanical servo valve system, Electro hydraulic servo valve system, Introduction and evolution.

Fluidics: Introduction and evolution, Type of gates and their features, Applications of Fluidics.

Simulation: FPS implementation and analysis.

READING:

1. Esposito, Fluid power with applications, Pearson, 2011

2. M.Galalrabie,Rabie M “Fluid Power Engg.” Professional Publishing, 2009

3. John J Pippenger and W.Hicks, “Industrial hydraulics” Tata McGraw Hill, 1980.

ME5172	NEW VENTURE CREATION	DEC	3 – 0 – 0	3 Credits

PRE-REQUISITES: None (Preferably students should have knowledge of accounting and financial management - undergone a course on Engineering Economics)

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

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

CO-PO MAPPING:

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

DETAILED SYLLABUS:

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

Planning a New Enterprise: Opportunity Scanning and Identification; Creativity and product development process; The technology challenge - Innovation in a knowledge based economy, Sources of Innovation Impulses – Internal and External; Drucker's 7 Sources of Innovation Impulses, General Innovation Tools, Role of Innovation during venture growth; Market survey and assessment; choice of technology and selection of site.

Establishing a New Enterprises: Forms of business organization/ownership; Financing new enterprises -Sources of capital for early-stage technology companies; Techno Economic Feasibility Assessment; Engineering Business Plan for grants, loans and venture capital.

Operational Issues in SSE: Develop a strategy for protecting intellectual property of the business with patent, trade secret, trademark and copyright law; Financial management issues;

Operational/project management issues in SSE; Marketing management issues in SSE; Relevant business and industrial Laws.

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

READING:

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

ME5674	THERMAL COATINGS	DEC	3-0-0	3 Credits

PRE-REQUISITES: NIL

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

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

CO-PO MAPPING:

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

Syllabus

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

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

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

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

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

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

Reading.

1. Lech Pawlowski, The Science and Engineering of Thermal Spray Coatings, Wiley, 2008.

2. Huibin Xu, HongboGuo, Thermal Barrier Coatings, Wood Head Publishing, 2011

ME5186	ENERGY SYSTEMS AND MANAGEMENT *	DEC	3-0-0	3 Credits

PREREQUISITE: Thermodynamics and thermal engineering.

COURSE OUTCOMES:

CO1	Explain the fundamentals of energy management and its influence on environment
CO2	Describe methods of energy production for improved utilization.
CO3	Apply the principles of thermal engineering and energy management to improve the performance of thermal systems.
CO4	Analyse the methods of energy conservation and energy efficiency for buildings, Air conditioning, heat recovery and thermal energy storage systems.
CO5	Assess energy projects on the basis of economic and financial criteria.

CO-PO MAPPING

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

DETAILED SYLLABUS:

Introduction to Thermodynamics, Fluid Flow and Heat Transfer

Heat transfer media: Water, steam, Thermal fluids, Air-water vapour mixtures

Heat transfer equipment: Heat exchangers, Steam plant

Energy storage systems: Thermal energy storage methods, Energy saving, Thermal energy storage systems

Energy conversion systems: Furnaces, turbines

Heat recovery systems: Incinerators, regenerators and boilers

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

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

Economic Analysis: Scope, Characterization of an Investment Project

Case studies

Reading

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

ME5187	RENEWABLE SOURCES OF ENERGY *	DEC	3- 0- 0	3 Credits

PRE-REQUISITES: NIL

COURSE OUTCOMES:

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

CO-PO MAPPING:

CO\PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	1		1		2	1	2	2	2
CO2	2		1		2	2	2	2	2
CO3	-		1		1	2	2	2	2
CO4	-		-		1	-	2	2	2
CO5	2		2		2	1	2	2	2
CO6	2		1		2	1	2	2	2

Detailed Syllabus:

Introduction: Overview of the course, Examination and Evaluation patterns. Classification of energy resources, energy scenario in the world and India

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, sun rise and sun set times & day length. Numerical problems

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, Illustrative problems

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 a solar collectors and the determination of angle of incidence of insolation in different tracking modes. Illustrative problems

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.
Energy storage: Necessity for energy storage. Classification of methods of energy storage. Thermal energy storage; sensible heat storage, latent heat storage. Reversible chemical reaction storage. Electromagnetic energy storage. Hydrogen energy storage. Chemical battery storage. Pumped hydel energy storage etc.
Wind energy : Origin of winds, nature of winds, wind data measurement, wind turbine types and their construction, wind-diesel hybrid system, environmental aspects, 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. Development and performance fuel cells.
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
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
Geothermal energy: Origin, applications, types of geothermal resources, relative merits
Magneto hydrodynamic Power Generation applications; Origin and their types; Working principles
Magneto hydrodynamic Power Generation: Magneto hydrodynamic Power Generation applications; Origin and their types; Working principles

READING:

1. B.H.Khan, Non conventional Energy Resources, Tata McGraw Hill, New Delhi, 2012
2. S.Rao and B.B.Parulekar, Energy Technology: Non-Conventional, Renewable and Conventional, Khanna Publishers, 2010
3. S.P.Sukhatme and J.K.Nayak, Solar Energy-Principles of Thermal Collection and Storage, TMH, 2008
4. J.A.Duffie and W.A.Beckman, Solar Energy Thermal Processes, John Wiley, 2010

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

PRE-REQUISITES: NIL

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

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

CO-PO MAPPING:

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

DETAILED SYLLABUS:

Strategic Framework: Introduction to Supply Chain Management, Decision phases in a supply chain, Process views of a supply chain: push/pull and cycle views, Achieving Strategic fit, Expanding strategic scope.

Supply Chain Drivers and Metrics: Drivers of supply chain performance, Framework for structuring Drivers, Obstacles to achieving strategic fit.

Designing Supply Chain Network: Factors influencing Distribution Network Design, Design options for a Distribution network, E-Business and Distribution network, Framework for Network Design Decisions, Models for Facility Location and Capacity Allocation.

Forecasting in SC: Role of forecasting in a supply chain, Components of a forecast and forecasting methods, Risk management in forecasting.

Aggregate Planning and Inventories in SC: Aggregate planning problem in SC, Aggregate Planning Strategies, Planning Supply and Demand in a SC, Managing uncertainty in a SC: Safety Inventory.

Coordination in SC: Modes of Transportation and their performance characteristics, Supply Chain IT framework, Coordination in a SC and Bullwhip Effect.

READING:

1. Sunil Chopra and Peter Meindl, Supply Chain Management - Strategy, Planning and Operation, 4th Edition, Pearson Education Asia, 2010.
2. David Simchi-Levi, PhilpKamintry and Edith Simchy Levy, Designing and Managing the Supply Chain - Concepts Strategies and Case Studies, 2nd Edition, Tata-McGraw Hill, 2000.
3. John J Coyle, et.al., 'Managing Supply Chains A Logistics Approach', 9th Edition, Cengage Learning, 2013.
4. Jeremy F Shapiro, 'Modeling the Supply Chain', 2nd Edition, Cengage Learning, 2007.

ME5372	MODELING AND SIMULATION OF MANUFACTURINGSYSTEMS	DEC	3-0-0	3Credits

PRE-REQUISITES: NIL

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

CO1	Classify analytical and simulation models used in manufacturing system environment
CO2	Apply probability and simulation languages
CO3	Design and evaluate a given manufacturing system using simulation
CO4	Generate random numbers and variants to execute a simulation model
CO5	Evaluate queuing networks and Markov chains in the context of manufacturing

CO-PO MAPPING:

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

DETAILED SYLLABUS:

Introduction to System and simulation: Concept of system and elements of system, Discrete and continuous system, Models of system and Principles of modeling and simulation, Monte carlo simulation, Types of simulation, Steps in simulation model, Advantages, limitations and applications of simulation, Applications of simulation in manufacturing system

Review of statistics and probability: Types of discrete and continuous probability distributions such as Geometric, Poisson, Uniform, Normal, Exponential distributions with examples.

Random numbers: Need for RNs, Technique for Random number generation such as Mid product method, Mid square method, and Linear congruential method with examples

Test for Random numbers: Uniformity - Chi square test or Kolmogorov Smirnov test, Independency- Auto correlation test

Random Variate generation: Technique for Random variate generation such as Inverse transforms technique or Rejection method

Analysis of simulation data: Input data analysis, Verification and validation of simulation models, Output data analysis

Simulation languages: History of simulation languages, Comparison and selection of simulation languages

Design and evaluation of simulation experiments: Development and analysis of simulation models using simulation language with different manufacturing systems

Queueing models: An introduction**,** M/M/1 and M/M/m Models with examples, Open Queueing and Closed queueing network with examples

Markov chain models and others: Discrete time markov chain with examples, Continues time markov chain with examples, stochastic process in manufacturing, Game theory

READING:

1. J.Banks, J.S. Carson, B. L. Nelson and D.M. Nicol, “Discrete Event System Simulation”, PHI, New Delhi, 2009.
2. A.M. Law and W.D.Kelton, “Simulation Modeling and Analysis”, Tata McGraw Hill Ltd, New Delhi, 2008.
3. N. Viswanadham and Y. Narahari, "Performance Modeling of Automated Manufacturing Systems", PHI, New Delhi, 2007.

ME5373	FLEXIBLE MANUFACTURING SYSTEMS	DEC	3-0-0	3 Credits

PRE-REQUISITES: NIL

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

CO1	Classify and distinguish FMS and other manufacturing systems
CO2	Analyse processing stations and material handling systems used in FMS environments.
CO3	Design and analyze FMS using simulation and analytical techniques.
CO4	Develop management and control systems for tools, materials, handling and configurations in FMS
CO5	Analyze the production management problems in planning, loading, scheduling, routing and breakdown in a typical FMS.

CO-PO MAPPING:

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

DETAILED SYLLABUS:

Understanding of FMS: Evolution of Manufacturing Systems, Definition, objective and Need, Components, Merits, Demerits and Applications Flexibility in Pull and Push type

Classification of FMS Layout: Layouts and their Salient features, Single line, dual line, loop, ladder, robot centre type etc.

Processing stations: Salient features Machining Centers, Turning centre, Coordinate measuring machine (CMM), Washing/ Deburring station

Material Handling System: An introduction, Conveyor, Robots, Automated Guided Vehicle (AGV), Automated Storage Retrieval System (ASRS)

Management technology: Tool Management, tool magazine, Tool preset, identification, Tool monitoring and fault detection, routing, Production Planning and Control, Scheduling and loading of FMS

Design of FMS: Performance Evaluation of FMS, Analytical model and Simulation model of FMS

Case studies: Typical FMS problems from research papers

READINGS:

1 William W Luggen, "Flexible Manufacturing Cells and System" Prentice Hall of Inc New Jersey, 1991
2 Reza A Maleki "Flexible Manufacturing system" Prentice Hall of Inc New Jersey, 1991
3 John E Lenz "Flexible Manufacturing" marcel Dekker Inc New York,1989.
4 Groover, M.P "Automation, Production Systems and Computer Integrated Manufacturing", Prentice Hall of India Pvt.Ltd. New Delhi 2009

ME5374	LEAN MANUFACTURING SYSTEMS	DEC	3-0-0	3 Credits

PRE-REQUISITES: NIL

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

CO1	Understand the concepts in Lean Manufacturing.
CO2	Understand the tools and methods of Lean Manufacturing.
CO3	Analyze the issues in Lean implementation.
CO4	Distinguish between Lean, TPS, ERP and ISO 9001:2000.

CO-PO MAPPING:

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

DETAILED SYLLABUS:

Introduction to lean manufacturing: Objectives of lean manufacturing-key principles and implications of lean manufacturing- traditional vs lean manufacturing.

Lean manufacturing concepts: Value creation and waste elimination- main kinds of waste- pull production-different models of pull production-continuous flow-continuous improvement / Kaizen- worker involvement -cellular layout- administrative lean.

Lean manufacturing tools and methodologies: Standard work -communication of standard work to employees -standard work and flexibility -visual controls-quality at the source- 5S principles preventative maintenance-total quality management-total productive maintenance changeover/setup time -batch size reduction -production leveling.

Value stream mapping: The as-is diagram-the future state map-application to the factory simulation scenario-line balancing -Poke Yoke -Kanban – overall equipment effectiveness.

Just in time manufacturing: Introduction - elements of JIT - uniform production rate - pull versus push method- Kanban system - small lot size - quick, inexpensive set-up - continuous improvement. Optimised production technology.

One-piece flow: Process razing techniques – cells for assembly line – case studies.

Implementing lean: Road map-senior management Involvement-best practices.

Reconciling lean with other systems: Toyota production system-lean six sigma-lean and ERP lean with ISO9001:2000.

READING:

1 Askin R G and Goldberg J B, Design and Analysis of Lean Production Systems, John Wiley and Sons Inc., 2003.
2 Micheal Wader, Lean Tools: A Pocket Guide to Implementing Lean Practices, Productivity and Quality Publishing Pvt Ltd, 2002.
3 Richard B Chase F Robert Jacobs and Nicholas J Aquilano, Operations Management for Competitive Advantage, 10th Edition, McGraw Hill/Irwin, 2003.
4 Masaaki Sato, The Toyota Leaders – An Executive Guide, Vertical Inc, New York, 2008.

ME5375	CONCURRENT ENGINEERING	DEC	3-0-0	3 Credits

PRE REQUISITES: NIL

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

CO1	Understand the need of concurrent engineering and strategic approaches for product design.
CO2	Apply concurrent design principles to product design.
CO3	Design assembly workstation using concepts of simultaneous engineering.
CO4	Design automated fabricated systems – Case studies.

CO-PO MAPPING:

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

DETAILED SYLLABUS:

Introduction: Background and challenges faced by modern production environment, sequential engineering process, Concurrent engineering definition and requirement, meaning of concurrent objectives of CE, benefits of CE, Life cycle design of products, life cycle costs.

Strategic approach and technical aspects of product design: Industrial Design, Quality Function deployment, house of quality, Translation process of quality function deployment (QFD**).** Modeling of Concurrent Engineering Design-Compatibility approach, Compatibility index.

Issues in manufacturing systems design: Design for Manufacturing, role of DFM is CE, DFM methods, e.g. value engineering, DFM guidelines, design for assembly, creative design methods, product family themes, design axioms, Taguchi design methods, Computer based approach to DFM. Evaluation of manufacturability and assemblability.

Assembly Workstation Design: Design for Assembly, Design for reliability, life cycle serviceability design, design for maintainability, design for economics, decomposition in concurrent design, concurrent design case studies.

Design of automated fabrication systems: Virtual reality tools and techniques for product development and interactive modeling and visualization, Rapid Prototyping. Design for manufacturing, integrated concurrent design and product development, Case studies, DYNAMO, STELLA and SD based management games.

READING:

1. James L Nevins and Daniel E Whitney, *Concurrent Design of Product and Processes*, McGraw Hill, 1989.
2. Andrew Kusiak, *Concurrent Engineering: Automation, Tools, and Techniques*, Wiley-Interscience, 1992.
3. D. D. Bedworth, M. R. Henderson and P. M. Wolfe, *Computer Integrated Design and Manufacturing*, 1991. McGraw Hill.

ME5376	PRODUCT LIFE CYCLE MANAGEMENT	DEC	3-0-0	3 Credits

PRE REQUISITES: NIL

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

CO1	Understand product data, information, structures and PLM concepts.
CO2	Apply PLM systems in organization verticals including production, after sales, sales an marketing, and subcontracting.
CO3	Measure benefits of PLM implementation in daily operations, material costs, productivity of labour and quality costs.
CO4	Apply PLM concepts for service industry and E-Business.
CO5	Recognize tools and standards in PLM.

CO-PO MAPPING:

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

DETAILED SYLLABUS:

Fundamentals of PLM: Product data or Product information, Product lifecycle management concept, Information models and product structures-Information model, The product information (data) model, The product model, Reasons for the deployment of PLM systems.

Enterprise solution with PLM: Use of product lifecycle management systems in different organization verticals, Product development and engineering, Impact of Manufacturing with PLMChallenges of product management in the engineering and manufacturing industry, Life cycle thinking, value added services and after sales, Case 1: Electronics manufacturer, Case 2: An engineering product.

Product Structures: Standardized product data and materials data model, Product structure of a ship, Product structure of a customizable product, Product structure of a configurable service product.

PLM service information model: Categorizing services , Rational for building service products, How to make a service more like a tangible product?, Making items out of product functions, PLM challenges in service business, An IT-service provider and a customer-specifically variable product.

PLM for e-manufacturing: electronic business and PLM, Preconditions for electric business from the viewpoint of the individual company, Significance of product management, collaboration and electronic business for the manufacturing industry.

Integration of the PLM system with other applications: Different ways to integrate PLM systems, Transfer file, Database integration, System roles, ERP, Optimization of ERP for PLM and CAD.

Implementing end to end business process management: Product lifecycle management as a business strategy tool, Product lifecycle management as an enabler of cooperation between companies, Contents of collaboration, Successful cooperation, Tools of collaboration, From changes in the business environment to product strategy, Business Benefits of PLM.

PLM applications in process and product industries examples: Case 1: Electronics manufacturer, Case 2: An engineering product, Case 3: Capital goods manufacturer and customer-specifically variable product, Case 4: An IT-service provider and a customer-specifically variable product.

READING:

1. Jaya Krishna S, *Product Lifecycle Management: Concepts and cases*, ICFAI Publications 2011.
2. *SOA approach to Enterprise Integration for Product Lifecycle*, IBM Red books, 2011.

ME5377	RELIABILITY ENGINEERING	DEC	3-0-0	3 Credits

PREREQUISITES: NIL

COURSE OUTCOMES:

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

CO-PO Matrix:

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

Detailed Syllabus:

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

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

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

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

Reliability Analysis & Allocation: Reliability specification and allocation, failure modes and effects and criticality analysis (FMECA), fault tree analysis, cut sets & tie sets approaches; **Maintainability Analysis:** Repair time distribution, MTBF, MTTR, availability, maintainability, preventive maintenance.

Reading:

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

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

PRE-REQUISITES: NIL

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

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

CO-PO MAPPING:

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

DETAILED SYLLABUS

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

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

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

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

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

READING:

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

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

PRE-REQUISITES: 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	Analyze projects from marketing, operational and financial perspectives.
CO3	Evaluate projects based on discount and non-discount methods.
CO4	Develop network diagrams for planning and execution of a given project.
CO5	Apply crashing procedures for time and cost optimization.

CO-PO MAPPING:

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

DETAILED SYLLABUS:

Introduction: Introduction to Project Management, History of Project Management, Project Life Cycle.

Project Analysis: Facets of Project Analysis, Strategy and Resource Allocation, Market and Demand Analysis, Technical Analysis, Economic and Ecological Analysis.

Financial Analysis: Financial Estimates and Projections, Investment Criteria, Financing of Projects.

Network Methods in PM: Origin of Network Techniques, AON and AOA differentiation, CPM network, PERT network, other network models.

Optimisation in PM: Time and Cost trade-off in CPM, crashing procedure, Scheduling when resources are limited.

Project Risk Management: Scope Management, Work Breakdown Structure, Earned Value Management, Project Risk Management.

READING:

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

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

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

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

PRE-REQUISITES: NIL

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

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

CO-PO MAPPING:

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

DETAILED SYLLABUS:

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

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

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

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

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

Text Books:

1. Stachowaik, G.W., Batchelor, A.W., *Engineering Tribology*, 3rd Ed., Elsevier, 2010.
2. Majumdar B.C, *Introduction to bearings*, S. Chand & Co., wheeler publishing, 1999.
3. Andras Z. Szeri, *Fluid film lubrication theory and design*, Cambridge University press, 1998.
4. Neale MJ, *Tribology Hand Book*, CBS Publications, 2012.
5. Williams JA, *Engineering Tribology*, Oxford Univ. Press, 2001.
6. Cameron A, *Basic lubrication theory*, Ellis Horwood Ltd., 2002.

ME5474	COMPOSITE MATERIALS	DEC	3– 0 – 0	3 Credits

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

CO-PO MAPPING:

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

DETAILED 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 in situ processes.

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

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

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

Matrix resins-thermoplastics and thermosetting matrix resins.

Reinforcing fibers- Natural fibers (cellulose, jute, coir etc.), carbon fiber, glass fiber, Kevlar fiber, etc.

Particulate fillers-importance of particle shape and size.

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

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

Rule of mixtures. Stress, strain transformations.

Nano-composites: introduction to Nano-composites, advantages disadvantages

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

READING:

1. Chawla, Composite Materials Science and Engineering, Springer
2. Hull, An introduction to composite materials, Cambridge
3. Steven L. Donaldson, ASM Handbook Composites Volume 21, 2001.
4. Krishan K. Chawla, Composite Materials, Science and Engineering, Springer, 2001.
5. Suresh G. Advani, E. Murat Sozer, Process Modelling in Composites Manufacturing, 2nd Ed. CRC Press, 2009

ME5478	ROBOTICS	DEC	3-0-0	3 Credits

PRE REQUISITES: None

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

CO1	Classify robots based on joints and arm configurations.
CO2	Design application specific End Effectors for robots.
CO3	Compute forward and inverse kinematics of robots and determine trajectory plan.
CO4	Program robot to perform typical tasks including Pick and Place, Stacking and Welding
CO5	Design and select robots for Industrial and Non-Industrial applications.

CO-PO MAPPING:

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

DETAILED SYLLABUS:

Robotics classification, Sensors-Position sensors, Velocity sensors, Proximity sensors, Touch and Slip Sensors, Force and Torque sensors.

Grippers and Manipulators-Gripper joints, Gripper force, Serial manipulator, Parallel Manipulator, selection of Robot-Selection based on the Application

Kinematics-Manipulators Kinematics, Rotation Matrix, Homogenous Transformation Matrix, Direct and Inverse Kinematics for industrial robots for Position and orientation.

Differential Kinematics and static- Dynamics-Lagrangian Formulation, Newton-Euler Formulation for RR & RP Manipulators,

Trajectory planning-Motion Control- Interaction control, Rigid Body mechanics, Control architecture- position, path velocity and force control systems, computed torque control, adaptive control, and Servo system for robot control.

Programming of Robots and Vision System- overview of various programming languages.

Application of Robots in production systems- Application of robot in welding, machine tools, material handling, and assembly operations parts sorting and parts inspection.

READINGS:

1. Fu, K.S., Gonzalez, R.C., and Lee, C.S.G., *Robotics control, Sensing, Vision and Intelligence*, McGraw-Hill Publishing company, New Delhi, 2003.

2. Klafter, R.D., Chmielewski, T.A., and Negin. M, *Robot Engineering-An Integrated Approach*, Prentice Hall of India, New Delhi, 2002.

3. Craig, J.J., *Introduction to Robotics Mechanics and Control*, Addison Wesley, 1999.

ME5479	OPTIMIZATION FOR ENGINEERING DESIGN	DEC	3-0-0	3 Credits

Prerequisites: NIL

Course Objectives:

CO1	Explain an overview of modelling of constrained decision making
CO2	Develop a mathematical model for a given problem
CO3	Solve practical problems using suitable optimization technique
CO4	Analyze the sensitivity of a solution to different variables
CO5	Use and develop optimization simulation software for variety of industrial problems

CO-PO Matrix:

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

DETAILED SYLLABUS:

Introduction to the course, Statement of an Optimization Problem and Classification of Optimization Problems.

Optimization Techniques: Single-Variable Optimization, Multivariable Optimization without any Constraints, with Equality and Inequality Constraints.

Linear Programming: Simplex Methods, Sensitivity Analysis, Transportation Problem

Integer Programming: Graphical Representation, Integer Polynomial Programming

Geometric Programming: Formulation and Solutions of Unconstrained and Constrained geometric programming problem.

Dynamic Programming: Multistage Decision Processes

One-Dimensional Minimization Methods: Elimination methods: Fibonacci Method, Golden Section Method, Interpolation methods: Quadratic Interpolation Method, Cubic Interpolation Method

Unconstrained Optimization Techniques: Univariate, Conjugate Gradient Method and Variable Metric Method.

Constrained Optimization Techniques: Characteristics of a constrained problem; Direct Method of feasible directions; Indirect Method of interior and exterior penalty functions.

Text Books:

1. Rao, S. S., Optimization Theory and Applications, Wiley Eastern Ltd., 2nd Edition, 2004.
2. Fox, R. L., Optimization Methods for Engineering Design, Addison Wesley, 2001.

ME5481	VIBRATIONS	DEC	3-0-0	3 Credits

PRE-REQUISITES: NIL

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

CO1	Exemplify and summarise the causes and effects of vibration in mechanical systems and identify discrete and continuous systems.
CO2	Model the physical systems in to schematic models and formulate the governing equations of motion.
CO3	Infer the role of damping, stiffness and inertia in vibratory systems
CO4	Analyze the Rotating/reciprocating systems and compute the critical speeds.
CO5	Analyze and design machine supporting structures, Vibration Isolators, Vibration Absorbers.

CO-PO MAPPING:

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

DETAILED SYLLABUS:

Introduction: Causes and effects of vibration, Classification of vibrating system, Discrete and continuous systems, degrees of freedom, Identification of variables and Parameters, Linear and nonlinear systems, linearization of nonlinear systems, Physical models, Schematic models and Mathematical models.

SDF systems: Formulation of equation of motion: Newton –Euler method, De Alembert's method, Energy method, Free Vibration: Undamped Free vibration response, Damped Free vibration response, Case studies on formulation and response calculation. Forced vibration response: Response to harmonic excitations, solution of differential equation of motion, Vector approach, Complex frequency response, Magnification factor Resonance, Rotating/reciprocating unbalances, Force Transmissibility, Motion Transmissibility, Vehicular suspension, Vibration measuring instruments, Case studies on forced vibration.

Two degree of freedom systems: Introduction, Formulation of equation of motion: Equilibrium method, Lagrangian method, Case studies on formulation of equations of motion Free vibration response, Eigen values and Eigen vectors, Normal modes and mode superposition, Coordinate coupling, decoupling of equations of motion, Natural coordinates, Response to initial conditions, free vibration response case studies, Forced vibration response, undamped vibration absorbers, Case studies on undamped vibration absorbers.

Multi degree of freedom systems: Introduction, Formulation of equations of motion, Free vibration response, Natural modes and mode shapes, Orthogonally of model vectors, normalization of model vectors, Decoupling of modes, model analysis, mode superposition technique, Free vibration response through model analysis, Forced vibration analysis through model analysis, Model damping, Rayleigh's damping, Introduction to experimental model analysis.

Continuous systems: Introduction to continuous systems, Exact and approximate solutions, free vibrations of bars and shafts, Free vibrations of beams, Forced vibrations of continuous systems Case studies, Approximate methods for continuous systems and introduction to Finite element method.

READING:

1. L. Meirovich, Elements of Vibration analysis, 2nd Ed. Tata Mc-Graw Hill 2007:
2. Singiresu S Rao, Mechanical Vibrations. 4th Ed. , Pearson education 2011
3. W.T. Thompson, Theory of Vibration, CBS Publishers, 2012
4. Clarence W. de Silva , Vibration: Fundamentals and Practice, CRC Press LLC, 2000

ME5482	FINITE ELEMENT METHOD	DEC	3 – 0 – 0	3 Credits

PRE-REQUISITES: NIL

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

CO1	Understand the Finite Element Formulation procedure for structural Problems.
CO2	Understand the representation and assembly considerations for Beam and Frame elements.
CO3	Analyze Plane stress, Plane strain, axi-symmetric Problems.
CO4	Formulate and solve simple heat transfer and fluid mechanics problems
CO5	Identify significant applications of FEM inManufacturing.

CO-PO MAPPING:

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

DETAILED SYLLABUS:

Introduction: Historical Perspective of FEM and applicability to mechanical engineering problems.

Mathematical Models and Approximations: Review of elasticity, mathematical models for structural problems, Equilibrium of continuum-Differential formulation, Energy Approach-Integral formulation, and Principle of Virtual work - Variational formulation. Overview of approximate methods for the solution of the mathematical models; Ritz, Rayleigh-Ritz and Gelarkin'smethods.Philosophy and general process of Finite Element method.

Finite Element Formulation: Concept of discretisation, Interpolation, Formulation of Finite element characteristic matrices and vectors, Compatibility, Assembly and boundary considerations.

Finite element Method in One Dimensional Structural problems: Structural problems with one dimensional geometry. Formulation of stiffness matrix, consistent and lumped load vectors. Boundary conditions and their incorporation: Elimination method, Penalty Method, Introduction to higher order elements and their advantages and disadvantages. Formulation for Truss elements, Case studies with emphasis on boundary conditions and introduction to contact problems.

Beams and Frames: Review of bending of beams, higher order continuity, interpolation for beam elements and formulation of FE characteristics, Plane and space frames and examples problems involving hand calculations.

Two dimensional 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. General considerations in finite element analysis of two dimension problems.Introduction plate bending elements and shell elements.

Three Dimensional Problems: Finite element formulation for 3-D problems, mesh preparation, tetrahedral and hexahedral elements, case studies.

Dynamic Analysis: FE formulation in dynamic problems in structures using LagragianMethod , Consistent and lumped mass models, Formulation of dynamic equations of motion and introduction to the solution procedures.

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

Algorithmic Approach for problem solving: Algorithmic approach for Finite element formulation of element characteristics, Assembly and incorporation of boundary conditions. Guidelines for code development.Introduction to commercial FE packages.

READING:

1. Seshu P, Textbook of Finite Element Analysis, PHI. 2004
2. Reddy, J.N., Finite Element Method in Engineering, Tata McGraw Hill, 2007.
3. SingiresuS.Rao, Finite element Method in Engineering, 5ed, Elsevier, 2012
4. Zeincowicz, The Finite Element Method for Solid and Structural Mechanics, 4th Edition, Elsevier 2007.

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

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 nondestructive testing methods for failure identification
CO3	Utilize radiography to identify underlying failure sites
CO4	Analyze flaws using advanced eddy current methods
CO5	Utilize acoustic emission to identify leaks

CO-PO MAPPING:

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

DETAILED SYLLABUS:

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

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

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

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

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

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

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

READING:

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

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

PRE-REQUISITES: NIL

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

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

CO-PO MAPPING:

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

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

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

READING:

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

MM5170	**POWDER METALLURGY**	**DEC**	**3 – 0 – 0**	**3 Credits**

PRE-REQUISITES: NIL

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

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

CO-PO MAPPING:

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

DETAILED SYLLABUS:

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

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

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

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

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

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

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

READING:

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

ME5281	PRECISION MANUFACTURING	DEC	3 – 0 – 0	3 Credits

PRE-REQUISITES: NIL

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

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

CO-PO MAPPING:

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

DETAILED SYLLABUS:

Accuracy and Precision: Introduction - Accuracy and precision – Need – application of precision machining- alignment testing of machine tools, accuracy of numerical control system, specification of accuracy of parts and assemblies.

Tolerance and fits: Tolerance and fits, hole and shaft basis system, types of fits- Types of assemblies-probability of clearance and interference fits in transitional fits.

Concept of part and machine tool accuracy: Specification of accuracyof parts and assemblies, accuracy of machine tools, alignment testing of machine tools.

Errors during machining: Errors due to compliance of machine-fixture-tool-work piece (MFTW) System, theory of location, location errors, errors due to geometric inaccuracy of machine tool, errors due to tool wear, errors due to thermal effects, errors due to clamping. Statistical methods of accuracy analysis.

Surface roughness: Definition and measurement, surface roughness indicators (CLA, RMS, etc,.) and their comparison, influence of machining conditions, methods of obtaining high quality surfaces, Lapping, Honing, Super finishing and Burnishing processes.

READING:

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