Aliah University

Syllabus for
M. Tech
(Applicable from:2021-22)

Dept.of Mechanical Engineering
Aliah University

A. Programme Outcome:

Engineering programs have been designed to prepare M.Tech (Mechanical Engineering) Students, for attaining the following program outcomes (PO):

1 An ability to independently carry out research /investigation and development work to solve practical problems of Manufacturing Technology and Thermal Engineering.

2 An ability to write and present a substantial technical report/document

3 Students should be able to demonstrate a degree of mastery in the area of Manufacturing Technology and Thermal Engineering. The mastery should be at a level higher than the requirements in the bachelor program of Mechanical Engineering

4 An ability to use research-based knowledge and research methods including design of experiments, analysis and interpretation of data for the solution of complex problems of manufacturing industries/institutions

5 An ability to develop and apply computer based software and hardware tools for the analysis of problems related to manufacturing and thermo-fluid fields.

6 An ability to apply the acquired knowledge to assess societal, safety, ethical issues and subsequently design / develop mechanical equipments and systems.

B. Programme Specific Outcome (Specialization: Manufacturing Technology)

On completion of M Tech with Manufacturing Technology specialization, students will able to:
1: gather fundamental technical knowledge and develop analytical skills required for mechanical engineering (manufacturing technology)

2: focus on practical skills and capable of using software and developing program related to core and applied areas of their discipline to expand their knowledge horizon beyond books and to equip them with experimental and industrial practices.

3: improved team building, team working and leadership skills with high regard for ethical values and social responsivities.

4: create and develop innovations in various aspects of manufacturing Technology.

Programme Specific Outcome (Specialization: Thermal Engineering)

On completion of M Tech with thermal Engineering specialization, students will able to:
1. Specification, fabrication, testing, operation or documentation of basic thermo-fluid systems/ processes
2. Analysis, design, development and implementation of more advanced Thermal / Fluid systems or processes.
3: improved team building, team working and leadership skills with high regard for ethical values and social responsivities.

4: create and develop innovations in various aspects of thermal sciences and fluid systems.

1. Specialization: Manufacturing Technology

DETAILED COURSE WITH CREDIT DISTRIBUTION

Semester I:

Sl.	Course Type	Course Offered	Course Code	L-T-P	Credit
		Theory			
1	Professional Core-I	Theory of Machining	MENPGPC01	3-0-0	3
2	Professional Core-II	Advanced Metal Forming	MENPGPC02	3-0-0	3
3	Professional Elective-I	To be selected from the Pool of Electives		3-0-0	3
4	Professional Elective-II	To be selected from the Pool of Electives		3-0-0	3
5	Audit Course-I	Elementary Arabic	UCEPGMC01	2-0-0	0
6	Audit Course-II	Pedagogy Studies	UCEPGAU02	2-0-0	0
		Practical			
6	Lab I	Advance Manufacturing Laboratory-I	MENPGPC51	0-0-4	2
				14-0-4	**14**

Semester II:

Sl.	Course Type	Course Offered	Course Code	L-T-P	Credit
		Theory			
1	Professional Core-III	Advanced Manufacturing Processes	MENPGPC03	3-0-0	3
2	Professional Core-IV	Nanotechnology & Micromachining	MENPGPC04	3-0-0	3
3	Professional Elective-III	To be opted from the Pool of Electives		3-0-0	3
4	Professional Elective-IV	To be opted from the Pool of Electives		3-0-0	3
5	Open Elective	Offered by other departments		3-0-0	3
		Practical			
6	Lab II	Advance Manufacturing Laboratory-II	MENPGPC52	0-0-4	2
7	Mini Project	Project Work	MENPGPR01	0-0-4	2
				15-0-8	**19**

Semester III:

Sl.	Course Type	Course Offered	Course Code	L-T-P	Credit
		Theory			
1	Professional Elective-V	To be opted from the Pool of Electives		3-0-0	3
2	Research Methodology	Research Methodology & IPR	MENPGPR02	2-0-0	2
		Practical			
3	Dissertation - I	Dissertation - I	MENPGPR03	0-0-20	10
				5-0-20	**15**

Semester IV:

Sl.	Course Type	Course Offered	Course Code	L-T-P	Credit
		Practical			
1	Dissertation - II	Dissertation - II	MENPGPR04	0-0-32	16
				0-0-32	**16**

Pool of Elective Papers (Any 5 in semesters- I, II and III) [Manufacturing Technology]

Sl. No.	Paper Code	Paper Name
1.	**MENPGPE01**	Advanced Engineering Mathematics
2.	**MENPGPE02**	Rapid Prototyping
3.	**MENPGPE03**	Finite Element Method in Engineering
4.	**MENPGPE04**	Advanced Material Processing Technology
5.	**MENPGPE05**	Operation Research
6.	**MENPGPE06**	Advanced CAD/CAM
7.	**MENPGPE07**	Machine Tool Design
8	**MENPGPE08**	Optimization Methods in Manufacturing
9	**MENPGPE09**	Reliability and Quality Control
10	**MENPGPE10**	Advanced Industrial Engineering
11	**MENPGPE11**	Micro-Electrical Mechanical System (MEMS)
12	**MENPGPE12**	Design of Mechanical Handling System
13	**MENPGPE13**	Industrial Robotics & Automation
14	**MENPGPE14**	Computer Numerical Control

2. Specialization: Thermal Engineering

DETAILED COURSE WITH CREDIT DISTRIBUTION

Semester I:

Sl.	Course Type	Course Offered	Course Code	L-T-P	Credit
		Theory			
1	Professional Core-I	Advanced Thermodynamics	MENPGPC31	3-0-0	3
2	Professional Core-II	Advanced Fluid Mechanics	MENPGPC32	3-0-0	3
3	Professional Elective-I	To be selected from the Pool of Electives		3-0-0	3
4	Professional Elective-II	To be selected from the Pool of Electives		3-0-0	3
5	Audit Course-I	Elementary Arabic	UCEPGMC01	2-0-0	0
6	Audit Course-II	Pedagogy Studies	UCEPGAU02	2-0-0	0
		Practical			
6	Lab I	Advance Thermal Laboratory-I	MENPGPC53	0-0-4	2
				14-0-4	**14**

Semester II:

Sl.	Course Type	Course Offered	Course Code	L-T-P	Credit
		Theory			
1	Professional Core-III	Applied Thermodynamics	MENPGPC33	3-0-0	3
2	Professional Core-IV	Advanced Heat Transfer	MENPGPC34	3-0-0	3
3	Professional Elective-III	To be opted from the Pool of Electives		3-0-0	3
4	Professional Elective-IV	To be opted from the Pool of Electives		3-0-0	3
5	Open Elective	Offered by other departments		3-0-0	3
		Practical			
6	Lab II	Advance Thermal Laboratory-II	MENPGPC54	0-0-4	2
7	Mini Project	Project Work	MENPGPR01	0-0-4	2
				15-0-8	**19**

Semester III:

Sl.	Course Type	Course Offered	Course Code	L-T-P	Credit
		Theory			
1	Professional Elective-V	To be opted from the Pool of Electives		3-0-0	3
2	Research Methodology	Research Methodology & IPR	MENPGPR02	2-0-0	2
		Practical			
3	Dissertation - I	Dissertation - I	MENPGPC03	0-0-20	10
				5-0-20	**15**

Semester IV:

Sl.	Course Type	Course Offered	Course Code	L-T-P	Credit
		Practical			
1	Dissertation - II	Dissertation - II	MENPGPC04	0-0-32	16
				0-0-32	**16**

Pool of Elective Papers (Any 5 in semesters- I, II and III) [Thermal Engineering]

Sl. No.	Paper Code	Paper Name
1.	MENPGPE01	Advanced Engineering Mathematics
3.	MENPGPE03	Finite Element Method in Engineering
4.	MENPGPE05	Operation Research
5.	MENPGPE33	Jet Propulsion
6.	MENPGPE34	Energy conversion and Management
7.	MENPGPE35	Measurement and Instrumentation
8.	MENPGPE36	Principles of Combustion
9.	MENPGPE37	Heat Exchanger Design
10.	MENPGPE38	Advanced Optimization Techniques
11.	MENPGPE39	Advanced Refrigeration and Air Conditioning
12.	MENPGPE40	Computational Fluid Dynamics

Detailed Course Syllabus

Professional Core papers [Manufacturing Technology]

MENPGPC01 — Theory of Machining

Course objectives:

(i) The main objective of the course is to make the students capable to analyze the conventional machining processes using principles of plasticity and shear, taking into consideration the process parameters such as speed, feed and depth of cut, tool geometry and materials.

(ii) To study the mechanical and thermal aspect of conventional machining and use of coolant.

(iii) To learn about the types of tool wears and their effect on the process performance and techniques to overcome these issues.

(iv) To study mechanism of grinding.

Course content:

Introduction to Machining: Deformation of metal in metal cutting, Mechanism of chip formation.

Mechanics of Machining: Geometry of cutting tools, tool angles, different systems, nomenclature, interrelationships, and concepts of master lines, Orthogonal cutting, oblique cutting, force analysis and velocity analysis in orthogonal cutting and oblique cutting, Effective rake, chip flow direction, use of chip breaker.

Determination of cutting forces: Characteristics and analysis of various machining processes, Measurement of force components, Dynamometers for measuring cutting forces.

Control of cutting temperature: Thermal aspects of machining, cutting fluids, Purposes of application of cutting fluid in machining and grinding.

Machinability: Concept, definition and criteria of perception of Machinability, Failure of cutting tools, tool wear and tool life, Tool materials, Optimization of tool geometry.

Grinding: Mechanics of Grinding, Grinding wheel wear, surface finish, Causes of vibration and chatter, Mechanics of Super finishing: Honning, Lapping, etc.

Course outcome:

At the end of this syllabus, the students would be able to

(i) define the main purpose of machining, demonstrate tool geometry and define tool angles in ASA, ORS and NRS, state the purposes of conversion of tool angles from ORS to NRS,

(ii) identify the condition for different chip forms, state the effects of oblique cutting and orthogonal cutting, identify the need and purposes of chip breaking,

(iii) develop Merchant's Circle Diagram and show the forces and their relations, develop and use equations for estimation of major cutting force and purpose of measurement, state the design requirements of tool-force dynamometers,

(iv) identify the causes of development of heat and temperature in machining and state the possible ways of controlling cutting temperature, state various methods of improvement of machinability, state how the cutting tools fail. Develop and use tool life equation

(v) Identify the needs and cite the chronological development of cutting tool materials and use of advanced cutting tool materials

(vi) State the use of grinding and develop super finish object.

Books:

1. Metal Cutting: Theory And Practice by A Bhattacharyya, New central book agency, 2010
2. Metal Cutting Principles by M C Saw, Oxford University Press, 2002
3. Machining and Machine Tools by A. B. Chattopadhyay, Wiley India, 2011

MENPGPC02 Advanced Metal Forming

Objectives:

1. To study and understand the concept of basic metal forming processes
2. To study the procedure, equipment details, advantages, limitations and applications of basic metal forming processes.
3. To study and understand some advanced metal forming processes, equipment details, applications, advantages and limitations.

Course Content:

Unit I: Introduction of metal forming process, Advantages of metal forming process, Classifications of metal forming processes.

Unit II: Theoretical analysis (theory of plasticity), Stress-strain relationship, Strain hardening, Material incompressibility, Work of plastic deformation, Work hardening, Yield criteria, Flow rule, Initiation and extent of plastic flow (microstructural point of view). stress analysis methods (Tresca, Von-mises Criteria, etc.).

Unit III: Upper and lower bound techniques of load estimation, plasticity and visco-plasticity, Tensor analysis of stress and strain, stress evaluation using slip line analysis, Hanky evaluation for plain strain, deformation & work hardening properties of materials, forming of plastics.

Unit IV: Principle design features of different forming dies, die design for plastic components, Force analysis of different forming processes.

Unit V: Advanced Forming Process: Hot and cold deformation processes, high energy rate forming, Explosive forming, hydraulic forming, superplastic forming, laser beam bending etc.

Course Outcome:

On completion of the course a student will be able to demonstrate the following

(i) An appropriate mastery of the knowledge, techniques, skills and modern forming processes.

(ii) To apply current knowledge and adapt to emerging applications, engineering and technology.

(iii) To conduct, analyze and interpret experiments and apply experimental results to improve processes.

(iv) To apply the technologies of engineering materials, manufacturing processes, automation, production operations.

Text books:

1. Surender Kumar, Technology of Metal Forming Processes, Prentice- Hall, Inc., 2008
2. Avitzur, Metal Forming Processes and Analysis, Tata McGraw - Hill, 2005.

Reference books:

1. Harris, J.N., Mechanical working of Metals - Theory and Practice, Pergamon Press, 1995
2. Dieter, Mechanical Metallurgy, Tata McGraw - Hill, 2005.
3. Fundamentals of Metal Forming Processes, B. L. Juneja, New Age International, 2007.

MENPGPC03 Advanced Manufacturing Processes

Course Objectives:

The main objective of the course is to make the students capable to

(i) Study of various advanced metal casting and joining processes,
(ii) control the process parameters for sound casting and welding,
(iii)learn thermal and fluid transfer mechanism during these processes,
(iv)observe metallurgical effects of casting and joining,
(v) learn the new hybrid non-trational machining processes.

Course Content:

Advances in casting: Continuous Casting, Stir casting process, variables in stir casting process, advantages and application, composite preparation, analysis of composite. High pressure molding, metal injection molding, centrifugal casting, Expendable-pattern casting, Vacuum casting, applications and advantages. Magnetic molding process, Semi-solid casting process; Squeeze casting, Rheocasting, Thixocasting, advantages and application.

Advances in welding: Introduction to solid state welding processes, advantages and applications and imitations. Friction welding processes, advantages, limitations and applications, Friction welding of similar and dissimilar metals, Electron beam welding process, Laser beam welding processes.

Theory of hybridization of non-traditional processes: Electrical discharge wire cutting (EDWC), ECG, ECDG, etc.

Course Outcomes:

At the end of this syllabus, the students would be able to

(i) understand the manufacturing processes including Continuous casting, stir casting, High pressure molding, metal injection molding, centrifugal casting,

(ii) apply advanced casting methods including Vacuum casting, lost foam process, Magnetic molding process and Semi-solid casting.

(iii) Identify suitable hybrid welding process for welding a given material,

(iv) Explain the working principle of Electron beam, laser beam and laser hybrid welding processes and suggest their applications.

Books:

1. Advanced Machining Processes by Prof. Vijay Kumar Jain, Allied Publisher.
2. Principles of Metal Casting by Richard W. Heine, Carl R Loper, Philip C Rosenthal, Tata McGraw-Hill.
3. Nonconventional Machining by P. K. Mishra Narosa Publishing House.

MENPGPC04 Nanotechnology and Micro Machining

Objectives:

1. To study the definition of nanotechnology and needs of nanotechnology in manufacturing environment
2. To study various techniques of nano fabrication and ultra precision manufacturing
2. To study and understand the various conventional and advanced micromachining techniques, with process analyze and parameters for micro manufacturing techniques.
3. To study and understand various nano finishing technologies and their applications

Course Content:

Unit I: Nano-technology Fundamentals and Principles, Survey of Nano-structure, Types and Properties Domain of Ultra precision Machining and Nano-fabrications: Etch stop techniques for Micro machining, surface micro machining.

Unit II: Conventional Methods of Micro machining: Mirror machining of soft materials, ultra-precision Mirror polishing of hard and brittle materials, finish turning, Boring, Grinding & Honning techniques.

Unit III: Definition, need and classification of non-conventional methods of micro machining, advantages and limitations.

Unit IV: Electro Micromachining processes, process variants, laser Micro machining, Electron Beam Lithography (EBL) Plasma Arc Micro machining. Focused Ion Beam(FIB) micro machining, Slim Micro machining.

Unit V: Chemical and Electrochemical techniques for Micro machining : Chemical Micro machining (CMM), Chemical Etching Plasma Etching, Electrochemical Micro machining (EMM) : Pu EMM, EMM through photo resist musk.

Unit VI: Micro and nano surface generation techniques, classifications, Abrasive flow finishing, Magnetorheological finishing, Magnetorheological abrasive flow finishing, chemo mechanical polishing, Application of ultra precision motion controls for Micro Machining, magnetostrictive actuators, piezoelectric systems.

Course Outcome:

On completion of the course a student will be able to demonstrate the following

(i) The students able to know the technology and procedure of each of the micromachining and nano finishing process

(ii) The students can identify and apply particular micromachining process for particular requirement of generation of micro feature and nano finish surface.

(iii) Technology along with requirement of new hybrid micromachining and finishing techniques for manufacturing of high-end products made of wide range of materials.

Text books:

1. G. Kibria, V.U. Rathod, Introduction to Advanced Machining and Finishing Processes, Narosa Publishing House, New Delhi, India, 2019.
2. G. Kibria, B.Bhattacharyya, J. P. Davim, Non-traditional Micromachining Processes-Fundamentals and Applications, Springer International Publishing AG, Switzerland, 2017

Reference books:

1. V.K. Jain, Micro-manufacturing Processes, CRC Press, 2012.
2. Yi Qin, Micro-manufacturing Engineering and Technology, William Andrew, 2015
3. Mark. J. Jackson, Micro and Nano-manufacturing, Springer, 2006.

Professional Elective Papers [Manufacturing Technology]

MENPGPE01 Advanced Engineering Mathematics

Course Objective:

This course has two different modules, namely, (i) Linear Programming Problems (LPP) and (ii) Numerical and Statistical Methods.

The objective of learning LPP is to get an overview of the kinds of problems linear programming has been used to solve, to learn how to solve two variable linear programming models by the graphical method, to understand the importance of extreme points in obtaining the optimal solution, to know the use and interpretation of slack and surplus variables, to be able to interpret the computed solutions of a linear programming problem, to understand how

alternative optimal solutions, infeasibility and unboundedness can occur in linear programming problems, to get an idea how Simplex Method can be implemented for solving linear programming problems.

On the other hand, in the course the Numerical and Statistical Methods, students may become familiar with the ways of solving complicated mathematical problems numerically. They will understand several errors which may appear in approximated solutions while applying different iterative methods. They will study how to fit a curve with some tabulated data set. This course will also make the students aware of popular differentiation and integration rules and different techniques for solving the differential equations in underlying domains

Course Content:

LPP: Formulation, graphical solutions, simplex method (illustrations through problems only). Numerical & Statistical Methods : Interpolations: Lagrange's method, Newton's forward & backward difference formulae; Curve fitting: least square & other curves fitting.

Solution of polynomial equation and simultaneous non linear equations using iterative techniques – methods for solution of simultaneous algebraic equation - Numerical differentiation and integration –

Solution of differential equation using Runge-Kutta method, FDM, etc.

Course Outcome: After the completion of the course the students will be able to

1. develop linear programming models for simple problems,
2. recognize the special features of linear models
3. solve linear programming problems using different methods like Graphical Method, Simplex Method, Big-M Method etc.
4. compute the solution of the mathematically defined real life problems using comparatively time saving Numerical and Statistical methods over other analytical methods,
5. reduce the amount of errors in approximated solutions by using the Numerical and Statistical Methods which will be more acceptable in most cases.

List of Books

1. Introductory Methods of Numerical Analysis by S.S. Sastry, Prentice Hall of India publisher.
2. Linear Programming and Game Theory by J.G. Chakraborty and P.R. Ghosh, Moulik Library publisher.
3. A Ground Book of Linear Programming and Numerical Analysis by Arup Mukherjee.

MENPGPE02 Rapid Prototyping

Objectives:

The main objective of the course is to make the students capable to

(i) learn design, development, and manufacturing using Rapid Manufacturing technologies,

(ii) Learn various Rapid Prototyping techniques,

(iii) identify the methods and techniques required to manufacture any model.

(iv) Learn reverse engineering to make old model.

Course Content:

Introduction: Introduction to rapid prototyping (RP), conventional machining versus Rapid prototyping, Need of RP in context of batch production, advantages of RP.
CAD Modelling and Data Processing for RP: Basic principles of RP, Steps in RP, Process chain in RP in integrated CAD CAM environment, CAD model preparation, STL files.
RP processes: Classification of different RP techniques based on raw materials, and energy sources: Process technology and comparative study of: Stereo-lithography (SL) with photo-polymerisation, SL with liquid thermal polymerisation, Solid foil polymerisation, Selective laser sintering, Selective powder binding, ballistic particle manufacturing both 2-D and 3-D, Fused deposition modelling, Shape melting, Laminated object manufacturing, Solid ground curing,
Rapid Tooling: Principles and typical processes for quick batch production of plastic and metal parts though quick tooling. RP Interfacing with Manufacturing Processes: Investment Casting, Vacuum Casting, Laser Additive Manufacturing. Rapid manufacturing processes like - Vacuum Casting Processes via RP Processes.
Reverse Engineering: Basic concept, Digitization techniques, Model Reconstruction, Data Processing for Rapid Prototyping, Reverse Engineering (RE) Methodologies and Techniques, Selection of RE systems, RE software, RE hardware, RE in product development.

Course Outcome:

At the end of this syllabus, the students would be able to:

(i) Understand and use techniques for processing of CAD models for rapid prototyping.
(ii) Understand and apply fundamentals of rapid prototyping techniques.
(iii) Use appropriate tooling for rapid prototyping process.
(iv) Use rapid prototyping techniques for reverse engineering.

Books:

1. Rapid Prototyping: Principles and Applications By C.K. Chua, K.F. Leong, C.S. Lim, John Wiley, 2010.

2. Noorani R, Rapid Prototyping: Principles and Applications in Manufacturing, John Wiley & Sons.

MENPGPE03 Finite Element Method in Engineering

Course Objective

1. To illustrate the principle of mathematical modeling of engineering problems.
2. To introduce the basics and application of Finite Element Method.

Course Content:

A General Procedure for Finite Element Analysis, History of the Finite Element Method, Examples of Finite Element Analysis., Finite Element of Linear Spring, Elastic Bar, Truss Element, Strain Energy, Castigliano's First Theorem, Minimum Potential Energy.

Truss Structures: The Direct Stiffness Method, Nodal Equilibrium Equations, Element Transformation, Direct Assembly of Global Stiffness Matrix, Boundary Conditions, Constraint Forces, Element Strain and Stress, Three Dimensional Trusses.
Elementary Boundary Theory, Flexure Element Stiffness Matrix, Element Load Vector, Work Equivalence for Distributed Loads, Flexure Element with Axial Loading, General Three Dimensional Beam Element.
Method of Weighted Residuals, Galerkin's Finite Element Method, Application of Galerkin's Method to Structural Elements.
Continuity, Compatibility and Completeness, Polynomial Forms of One-dimensional Elements and Geometric Isotropy, Triangular Elements, Rectangular Elements, Three-dimensional Elements, Iso-parametric Formulation, Numerical Integration: Gaussian Quadrature. Applications.
Structural Dynamics, Simple Harmonic Oscillator, Multiple Degree of Freedom Systems, Bar Elements: Consistent Mass Matrix, Beam Elements.
Applications usingfinite element modeling and programming.
Identification of Physical problems, Differential formulation, Philosophy behind the approximate methods, FE formulation for a general problem in elasticity, Formulation of FE characteristics, Plane stress, Plane strain, Axisymmetric, Plate bending and Shell elements Isoparametric, 3-D elements and their formulation, Modal Analysis

Course Outcome:

Upon completion of the course, students will understand the FEM formulation and its application to simple structural problems.

TEXT BOOKS:

1. David V. Hutton, Fundamentals of Finite Element Analysis.

REFERENCE BOOKS:

2. Rao S.S., The Finite Element Method in Engineering.
3. Reddy J.N., An Introduction to Finite Element Method.
4. O.C. Zeinkiewicz, R.L. Taylor, The Finite Element Method.

MENPGPE04 Advanced Material Processing Technology

Course Objectives:

Its primary purpose is to provide knowledge of different effective and profitable material processing routes to produce a variety of products for engineering industries. The program's main purpose is to accelerate the development of the essential scientific and engineering foundation, in order to establish powder fabrication as a technologically and economically feasible method of materials manufacturing.

The basic objectives are:

i. To impart detailed knowledge in powder production and compaction
ii. To impart knowledge in the mechanism of sintering.
iii. To understand the mechanical alloying for the production of powder alloying.
iv. To impart the physics of various deposition processes

Course Content:

Powder Metallurgy: Powder fabrication methods: preparation of metallic, ceramic and composite powders, Powder Characterization: particle size, shape, distribution, surface area, flow, compressibility, structure, morphology and composition, treatment of powders, Powder mixing and blending, Shaping and compaction: design rules, behavior of powder during compaction, uniaxial and isostatic compaction, extrusion and forging, roll compaction, injection moulding, tape forming, slip casting and sol-gel casting, Sintering and full density processing: Solid state sintering, liquid phase sintering, reaction sintering, hot pressing, hot isostatic pressing and self propagating combustion sintering, sintering maps, sintering furnaces, effect of sintering atmosphere, advanced consolidation methods: SPS, MW, etc., Properties of P/M materials: effect of porosity and alloying

Advanced Coating Technology: Introduction, CVD Coating:CVD reaction.

Course Outcomes:

CO-1: Students will be able to get acquire knowledge of Powder Metallurgy History, Applications, and its importance. They will also be Measure the various powder characteristics like apparent density, tap density, flow rate, friction index.

CO-2: Students will be able to acquaint the knowledge of metal powder production methods and powder characterization techniques.

CO-3: Students will understand the basic methods of Powder compaction for green compact. They will also be familiar with compaction tooling and the role of lubricants in compacting.

CO-4: Students acquire knowledge of the mechanism of sintering and types of sintering for the development of mechanical properties.

CO-5:Students acquire knowledge of causes of defects in Powder metallurgy processed materials and methods to minimize defects

CO-6: Students will Select the appropriate deposition method and material for an application

Suggested Readings:

1. Material Handling Equipment -R.B. Chowdary &G.N.R.Tagore (Khanna Publishers,Delhi)
2. Material Handling (Principles &Practice)-Allegri T.H(CBS Publisher, Delhi)

Supplementary Readings:

1. Material Handling Equipment – N.Rundenko (Peace Publisher, Moscow)

Published Journal articles to be provided to the students as reference materials

MENPGPE05 Operation Research

Course Objectives:

To acquaint students with the construction of mathematical models formanagerial decision situations and to use computer software packages to obtain a solution wherever applicable. The emphasis is on understanding the concepts, formulation and interpretation.

Course Content:

Unit-I: Linear programming:

Assumptions, Basic concepts; LP Formulation Graphical Solution, Feasible Region, Optimum Solution, special cases (unbounded solutions, infeasible solution and

Alternative optima), Standard Form, Canonical form and Simplex method, maximization case, minimization case; Big, M method.

Unit-II: Transportation Problem:

Transportation tableau, Mathematical Form, Methods for Finding Initial basic Feasible, Solution, North West Corner Rule, Least Cost Method, VAM; Test for Optimality, MODI Method.

Unit-III: Assignment Problem:

Mathematical Statement of Problem, Comparison with Transportation Problem; Solution of Assignment Problem, Hungarian Methods, Game Theory: Introduction; Two, person zero, some Games; Games with saddle Point, Pure Strategies; Rules of Dominances

Unit-IV: Decision Theory:

Steps in Decision Theory Approach; Types of Decision Making Environments; Decision Making Under Risk, Expected Monetary Value, Expected Opportunity loss; Decision Making Under Uncertainty, Criterion of optimism, Criterion of Pessimism, Laplace Criterion, Criterion on Regret.

Course Outcomes:

CO-1: Understand the basic operations research concepts and terminology involved in optimization techniques.

CO-2: Understand how to interpret and solve business-related problems.

CO-3: Apply certain mathematical techniques in getting the best possible solution to a problem involving limited resources.

CO-4: Apply the most widely used quantitative techniques in decision making and identify project goals, constraints, deliverables, performance criteria, control needs, and resource requirements in order to achieve project success.

Suggested Readings:

1. Operation Research: An introduction – H. A. Taha; Macmillan.
2. Quantitative Technique in Management – N. D. Vhora; Tata McGraw Hill.

Supplementary Readings:

1. Operation Research – K. Swarup, P. K. Gupta and M. Mohan; Sultan Chand.
2. Operations Research; Theory and Applications – J. K. Sharma; Macmillan.

MENPGPE06 Advanced CAD/CAM

Course Objectives:

The course aims to provide fundamental knowledge of Computer-Aided Design (CAD) and Computer-Aided Manufacturing (CAM).The purpose of this course is to make the students get familiarized with various computer-aided tools that can be implemented in various industrial applications.

The basic objectives are:

i. To understand the concept of the use of computers in design and manufacturing.
ii. To develop the student's skills in understanding the latest technology on Computer-Aided Design and Computer-Aided Manufacturing.
iii. To design, model, and analysis using computer software and tools.
iv. To understand the concept of 3D modelingSkills for product design.

Course Content:

Introduction to CAD/CAM/CAE for manufacturing. Prototyping cycle for product design, manufacture and life management. Competitive design and manufacturing cycles for rapid product realization. CAD tools and industry adoption of standards. Introduction to geometric modelling. Basic modelling and representation of lines, curves, surfaces and solids. Constructive Solids Geometry. Surface modelling techniques. Solids Modelling. Boundary Representation. Spatial enumerative techniques. Object representation. Object validation. Constraints and feature modelling. Feature based data representation. Object visualization. Texturing. Ray tracing and related algorithms. Assembly modelling. Feature based analysis. Disassembly analysis. Manufacturing analysis. Dimensioning, Tolerance and fits representation and analysis. Product manufacturing planning. Design Structure matrix. Data extraction for product design analysis. Elements of primary processes CAD modelling – Casting.

Course Outcomes:

CO-1: Students will be able to get acquire knowledge of Computer-Aided Design (CAD) and Computer-Aided Manufacturing (CAM).
CO-2: Students will be able to develop the product as per customer requirements
CO-3: Students will be able to 3D part model/ part drawings using Computer Aided Manufacturing technology through programming, setup, and ensuring safe operation of Computer Numerical Control (CNC) machine tools.

Suggested Readings:

1. Groover, M. P., and Zimmers, E. W., CAD/CAM: Computer-Aided Design & Manufacturing, 2006, Pearson Education India
2. Zeid, I., Mastering CAD/CAM, Tata McCraw Hill, 2006

Supplementary Readings:

2. Computer-Aided Design / Computer-Aided Manufacturing (CAD/CAM) By Cornelius T. Leonides.

Published Journal articles to be provided to the students as reference materials

MENPGPE07 Machine Tool Design

Objectives:

1. To develop a solution oriented approach by in depth knowledge of Machine Tool Design.
2. To address the underlying concepts, methods and application of Machine Tool Design.

Course Content:

Unit I: Introduction to Machine Tool Drives: Types and capabilities of machine tools, Constructional and operational features, General Requirements of Machine Tool Design, Working and Auxiliary Motions in Machine Tools, Kinematics of Machine Tools, Motion Transmission, mechanical, hydraulic and electric drives.

Unit II: Regulation of Speed and Feed Rates: Aim of Speed and Feed Regulation, Layout of Speed Change Gears, Saw Diagrams for Arithmetic, Geometric, Harmonic and Logarithmic Progression of spindle speeds. Establishment of Gear Ratios, Layout of the Intermediate Reduction Gears, Calculation of Transmission Ratios, Pulley Diameter,

Gear Wheel Diameters and Number of Teeth. Ray Diagram. Speed Chart, Design of Speed Gear Boxes, Feed Drives, Feed Box Design.

Unit III: Design of Machine Tool Structures: Functions of Machine Tool Structures and Their Requirements, Design criteria for Machine Tool Structures, Materials of Machine Tool Structures, Static and Dynamic Stiffness, Profiles of Machine Tool Structures, Basic Design Procedure of Machine Tool Structures, Design of Beds, Columns, saddles, carriages, Bases and Tables.

Unit IV: Design of Guideways and Power Screws : Functions and Types of Guide ways, Design of Slide ways, clearance adjustment in slideways. Design of Anti-Friction Guide ways, Combination Guide ways and Aerostatic guideways. Design of Power Screws and Recirculating ball screws.

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

Unit VI: Dynamics of Machine Tools: Machine Tool Elastic System, Static and Dynamic Stiffness, Effects of vibration, stability analysis. Methods to reduce instability in machine tool like dampers, vibration absorbers etc, Machine Tool Chatter.

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

Course Outcome:

(i) The student can identify different areas of Machine Tool Design.
(ii) The student can find the applications of all the areas in day to day life.

Text books:

1. N K Mehta, "Machine Tool Design and Numerical Control", McGraw-Hill.
2. S.K. Basu, "Machine Tool Design", Oxford and IBH Publishing.

Reference books:

1. CMTI, "Machine Tool Design Handbook", McGraw-Hill
2. Sen and Bhattacharya , "Machine Tool Design" CBS Publications

MENPGPE08 Optimization Methods in Manufacturing.

Objectives:

The main objective of the course is to make the students capable to

(i) Understand the basic fundamentals of optimization methods that can be used in engineering application.

(ii) Learn the about the maximization and minimization problem during optimization of manufacturing processes.

(iii) Learn classical optimization methods.

(iv) Apply multi-objectives optimization techniques for various manufacturing as well as other engineering optimization problems.

Course content:

Introduction: Introduction and overview of optimization problems.

Development of Operation Research models: Review of LPP; Assumptions of LPP, Simplex method for solving maximization and minimization problem, Application of LPP for solving practical problems.

Transportation and assignment problem: Transportation problem: Formulation, optimal solution, unbalanced transportation problem, Degeneracy; Assignment problem, formulation, optimal solution, variants of assignment problem,

Classical optimization Techniques: Unconstrained nonlinear optimization Optimality conditions, Overview of algorithms Line search methods, Constrained nonlinear optimization Optimality conditions, Quadratic programming, Penalty and augmented Lagrangian methods, Sequential quadratic programming, Interior-point methods.

Advanced Optimization Techniques: Genetic Algorithm (GA); Differences and similarities between conventional and evolutionary algorithms, working principle, Genetic Operators-reproduction, crossover, mutation. Fuzzy Systems; Fuzzy set Theory, Optimization of Fuzzy systems (such as, Neural Network, GA, etc.)

Course outcomes:

At the end of this syllabus, the students would be able to:

(i) Recall the theoretical foundations of various issues related to linear programming modeling to formulate real-world problems as a L P model

(ii) develop the knowledge in the basic theory and algorithms for nonlinear optimization (unconstrained and constrained), including: understanding how algorithms work; choosing appropriate method to solve the problem in different situations; interpreting the performance of algorithms and analyzing the solutions for decision making.

(iii) Use of Describe the basics of different evolutionary algorithms

books:

1. *Optimization for Engineering Design-Algorithms and Examples by* K. Deb, Prentice Hall India, 1995.
2. Optimization: *Theory and Applications* by S. S. Rao, 2nd ed. Wiley Eastern, 1984.
3. *Engineering Optimization-Methods and Applications by* G. V. Reklaitis, A. Ravindran and K. M. Ragsdell, Wiley, 1983

MENPGPE09 Reliability and Quality Control

Objectives:

The main objective of the course is to make the students capable to

(i) learn the concept of SQC,

(ii) understand process control and acceptance sampling procedure and their application,

(iii)learn the concept of reliability.

Course content:

Introduction: Quality – Concept, Different Definitions and Dimensions, Inspection, Quality Control, Quality Assurance and Quality Management.

Total Quality Management TQM:
Introduction, Definitions and Principles of Operation, Tools and Techniques, such as, Quality Circles, 5 S Practice, Total Quality Control (TQC), Total Employee Involvement (TEI), Problem Solving Process, Quality Function Deployment (QFD), Failure Mode and Effect analysis (FMEA), Fault Tree Analysis (FTA), Kizen, Poka-Yoke, QC Tools, PDCA Cycle, Quality Improvement Tools, TQM Implementation and Limitations.

Introduction to Design of Experiments: Introduction, Methods, Taguchi approach, Achieving robust design, Steps in experimental design

Just –in –Time and Quality Management: Introduction to JIT production system, KANBAN system, JIT and Quality Production.

Introduction to Total Productive Maintenance (TPM): Introduction, Content, Methods and Advantages

Introduction to ISO 9000, ISO 14000 and QS 9000: Basic Concepts, Scope, Implementation, Benefits, Implantation Barriers

Introduction to Probability Theory: Fundamental laws of probability, Random variables; Probability distribution function; Discrete and continuous distribution; Histogram and Normal distribution curve, Mean, variance and standard deviation of a distribution function. Random samples

Reliability Concepts: Reliability engineering fundamentals; Failure data analysis; Failure rate; mortality curve; Concept of burn in period; Useful life and wear out phase of a system; Mean time to failure (MTTF); Mean time between failure, (MTBF) and mean time to repair (MTTR); Reliability in terms of Hazard rate and failure density, Conditional probability and multiplication rules.

Course outcomes:

At the end of this syllabus, the students would be able to:

(i) Attain the basic techniques of quality improvement,
(ii) Use control charts to analyze for improving the process quality.
(iii) Describe different sampling plans
(iv) Acquire basic knowledge of total quality management
(v) Understand the concepts of reliability and maintainability

Books:

1. Statistical Process Control, by Eugene Grant, Richard Leavenworth, McGraw Hill.
2. Quality Engineering in Production Systems, by G Taguchi , McGraw Hill, 1989.
3. Optimization &Variation Reduction in Quality, byW.A. Taylor,Tata McGraw Hill, 1991.
4. Reliability Engineering, (3rdEdition), by LS Srinath, Affiliated East West Pvt Ltd, 1991.
4. Reliability Engineering, by E.Bala Guruswamy, Tata McGraw Hill, 1994.

MENPGPE10 Advanced Industrial Engineering

Objectives:

1. The develop the basic concept of industrial engineering
2. To develop the forecasting models or scheduling techniques for production system
3. To apply the inventory management models for managing inventory systems

Course Content:

Unit I: Introduction to Industrial Engineering and Productivity: Definition and Functions of Industrial Engineering, Origin and development of factory system, Contribution of Taylor and Gilbreth Productivity: Definition of productivity, Factors Influencing Productivity, Causes of Low Productivity, Productivity Measurement Models, Productivity Improvement Techniques.

Unit II: Work Study: Basic Concept, Steps Involved in Work Study, Techniques of Work Study, Human Factors in the Application of Work Study. Method Study: Basic Concept, Steps Involved in Method Study, Recording Techniques, Operation Process Charts, Flow Process Charts, Two-Handed-Process Charts, Multiple Activity Charts, Flow Diagrams. String Diagrams, Principles of Motion Economy, Micro-Motion Study, Therbligs, SIMO Charts. Work Measurement: Basic Concept, Techniques of Work Measurement, Steps Involved in Time Study, Time Study Equipment, Performance Rating, Basic concept and Procedure of Work Sampling Study.

Unit III: Facility Layout and Planning: Nature, Significance and Scope of Facility layout and design; Steps in facility layout planning, Assembly Line Balancing. Material Handling: Definition, Objective and Principles of Material Handling, Classification of Material Handling Devices.

Unit IV: Production Planning and Control: Introduction to Production Systems, Types of production systems, Need and functions of PPC. Forecasting: Definition and Functions of Forecasting, Forecasting, techniques: linear regression, moving average, exponential smoothing; Analysis of forecast error. Aggregate production planning, Capacity Planning, ERP, Master Production Schedule. Basic sequencing and scheduling techniques

Unit V: Introduction to Inventory Management: Importance and areas of materials management, Introduction to Inventory: Definitions, Need for inventory, Types of inventory, Inventory costs; Structure of inventory models, Deterministic models; safety stock, inventory control systems; Selective inventory management. MRP and JIT-based production systems, Concept of zero inventory, Fundamental concepts of purchasing, storing, distribution, and value analysis & engineering.

Course Outcome:

1. The students will be able to understand different aspect of work sytem design, facility design related to manufacturing industries
2. The student can find and apply the industrial management / technology for managing the industrial aspects like scheduling, inventory and process planning.

Text books:

N. Chary, Production and Operations Management, McGraw-Hill Education, 201

K. Bedi, Production and Operations Management, Oxford University Press.

Reference books:

Essentials of Supply Chain Management, 4th Edition Michael H. Hugos, Wiley
ILO, Introduction to Work Study, Oxford and IBH Publishing

MENPGPE11 Micro Electro Mechanical Systems:

Objectives:

1. To provide knowledge of semiconductors and solid mechanics to fabricate MEMS devices.
2. To educate on the rudiments of Micro fabrication techniques.
3. To introduce various sensors and actuators
4. To introduce different materials used for MEMS
5. To educate on the applications of MEMS various engineering domains.

Course Content:

Unit I: Introduction: Intrinsic Characteristics of MEMS – Energy Domains and Transducers- Sensors and Actuators – Introduction to Micro fabrication - Silicon based MEMS processes – New Materials – Review of Electrical and Mechanical concepts in MEMS – Semiconductor devices – Stress and strain analysis – Flexural beam bending- Torsional deflection.

Unit II: Sensors and Actuators I: Electrostatic sensors – Parallel plate capacitors – Applications – Interdigitated Finger capacitor – Comb drive devices – Micro Grippers – Micro Motors - Thermal Sensing and Actuation – Thermal expansion – Thermal couples – Thermal resistors – Thermal Bimorph - Applications – Magnetic Actuators – Micromagnetic components – Case studies of MEMS in magnetic actuators- Actuation using Shape Memory Alloys.

Unit III: Sensors and Actuators II: Piezoresistive sensors – Piezoresistive sensor materials - Stress analysis of mechanical elements – Applications to Inertia, Pressure, Tactile and Flow sensors – Piezoelectric sensors and actuators – piezoelectric effects – piezoelectric materials – Applications to Inertia , Acoustic, Tactile and Flow sensors.

Unit IV: Micromachining: Silicon Anisotropic Etching – Anisotrophic Wet Etching – Dry Etching of Silicon – Plasma Etching – Deep Reaction Ion Etching (DRIE) – Isotropic Wet Etching – Gas Phase Etchants – Case studies - Basic surface micro machining processes – Structural and Sacrificial Materials – Acceleration of sacrificial Etch – Striction and Antistriction methods – LIGA Process - Assembly of 3D MEMS – Foundry process.

Unit V: Polymers and Optical MEMS: Polymers in MEMS– Polimide - SU-8 - Liquid Crystal Polymer (LCP) – PDMS – PMMA – Parylene – Fluorocarbon - Application to Acceleration, Pressure, Flow and Tactile sensors- Optical MEMS – Lenses and Mirrors – Actuators for Active Optical MEMS.

Course Outcome:

(i) Ability to understand the operation of micro devices, micro systems and their applications.

(ii) Ability to design the micro devices, micro systems using the MEMS fabrication process.

Text books:

1. Chang Liu, 'Foundations of MEMS', Pearson Education Inc., 2012.
2. Stephen D Senturia, 'Microsystem Design', Springer Publication, 2000.
3. Tai Ran Hsu, "MEMS & Micro systems Design and Manufacture" Tata McGraw Hill, New Delhi, 2002.

Reference books:

1. Nadim Maluf," An Introduction to Micro Electro Mechanical System Design", Artech House, 2000.
2. Mohamed Gad-el-Hak, editor, " The MEMS Handbook", CRC press Baco Raton, 2001.
3. Thomas M.Adams and Richard A.Layton, "Introduction MEMS, Fabrication and Application," Springer, 2010.

MENPGPE12 Design of Mechanical Handling Systems

Course Objectives:

The course aims to provide fundamental knowledge of Material Handling Equipment as per industrial needs and also design appropriate systems to move commodities, materials, in order to reduce overall cycle time while taking into account economics and payback period. Design and analysis of Hoisting Equipment Like, Rope, Drum, Hook, Chain, Pulley, and Girder, etc., and design of arresting gear, Conveyors, and Elevators.

The basic objectives are:

i. To impart fundamentals of material handling equipment
ii. To design various hoisting elements like chains, Hemp and wire ropes, Pulley systems, Sprockets & drums, forged hooks, and eye hooks, and Girders
iii. To understand the importance of material handling equipment in the industry

Course Content:

Review of commonly used material handling systems, Design of material handling system, selection of appropriate equipment, pneumatic and hydro-pneumatic handling system.

Rope and ropeways, Mechanical handling system for powerhouse application, Loading and unloading of ships and barges.

System design for various materials- abrasive, electrostatic, sticky, hot, hazardous nuclear materials, Closures, containers and packaging design, case studies.

Course Outcomes:

CO-1: Students will be able to get acquire knowledge of the fundamentals of material handling equipment, Applications, and their importance.

CO-2: Students will be able to design material handling equipment.

CO-3: Students willfamiliar with the design ofconveyors and Selection based on the Application.

Suggested Readings:

3. Material Handling Equipment -R.B. Chowdary &G.N.R.Tagore (Khanna Publishers,Delhi)
4. Material Handling (Principles &Practice)-Allegri T.H(CBS Publisher, Delhi)

Supplementary Readings:

1. Material Handling Equipment – N.Rundenko (Peace Publisher, Moscow)
2. Published Journal articles to be provided to the students as reference materials

MENPGPE13 Industrial Robotics & Automation

Course Objectives:

Technology is changing the way people do things in every part of the world, and the sector continues to expand. Now, teaching robotics is becoming an increasingly indispensable part of the curriculum. The basic objective of studying robotics is to develop the student's knowledge in various robot structures and their workspace as well as to gather the knowledge of the relationship between mechanical structures of industrial robots and their operational workspace characteristics. Also, by studying automation the students will be able to know that how to reduce costs, time, and waste as well as increase productivity, reduce mistakes, and control all the processes of the business in real time.

Course Outcomes:

CO-1: Students will be able to know the basic concepts, parts of robots and types of robots and to understand the basic principles of automation.
CO-2: Students will be able to identify the various drive systems for robot, sensors and their applications in robots, programming of robots.
CO-3: Students will be able to know the programming of robots and to interface software application for auto part programming.
CO-4: Students will be able to discuss about the various applications of robots, justification, implementation and safety of robot.
CO-5: Students will be able to know the recent developments in advanced industrial robotics and the application of automation.

Course Content

Unit I: Fundamentals of Robotics & Automation:

Fundamentals of Robotics: Definition, robot classification, robot arm geometry, power sources etc.

Automation: Principles and strategies, Elements of an automated system, Levels of automation, Automation in production systems, automated manufacturing systems, Types, Reasons for automation

Unit II: Tooling and Sensors:

Characteristics, classification, special purpose tools, typical designs, compliance in Wrists. End Effectors: types, mechanical and other types of griper, types of sensors and applications.

Unit III: Robot Programming and Languages:

Language classification, program commands, arm motion, task point diagram , on line/off line programming, sample programs, program analysis, AI and experts systems.

Unit IV: Robot Applications:

Robot applications in manufacturing, material transfer and machine loading / unloading, processing operations like welding and painting, Assembly operations, Inspection/ Automation. Robot cell layouts, multiple robots and machine interference, Automatic data capture, Barcode technology, Radio frequency identification, Fundaments of automated assembly systems, Coordinate Measuring Machine

Unit V: Recent Developments:

Recent developments in advanced robotics, Modular concept, Special applications of robotics, micro robotics, Bio robotics, technologies and applications of automation.

Suggested Readings:

5. Deb, S.R.: Robotics Technology and Flexible automation, Tata McGraw Hill Pub., New Delhi
6. Mikell P. Groover: Automation, Production Systems and Computer Integrated Manufacturing, Pearson Education Asia
7. Jain, K.C, and Aggarwal, L.N.: Robotics Principles and Practice, Khanna Publishers

Supplementary Readings:

3. Groover, M.P.: Industrial Robotics, McGraw Hill International Editions

MENPGPE14 Computer Numerical Control

Course Objectives:

Its primary purpose is to create a faster production process and components and tooling with more precise dimensions and material consistency, which in some cases, uses only the required amount of raw material (thus minimizing waste), while simultaneously reducing energy consumption. The basic objectives are:

v. To impart training in New product development in CNC Machining
vi. To impart knowledge in CNC machine selection based on the product
vii. To give insight in Cutting Tool selection & cutting parameter calculation &
viii. To provide exposure to CAM Software.

Course Content:

Unit I: Fundamentals of Process Planning

Basis and need of CNC machines: NC, CNC and DNC systems, Applications of CNC machines in manufacturing, advantages of CNC machine, Process planning, Structure of process plan, Factors influencing process plan and Sequence of operation of process plan.

Unit II: CNC Systems

CAM, NC, CNC and DNC, Selection criteria of CNC machines, Adoptive control

Unit III: Constructional Features of CNC Machines

Classifications of CNC Machine, Modes of operation of CNC, Machine Structure, Slideways, Spindle drive, Axis drive, Recirculating ball screw Feedback devices (transducers, encoders), Automatic tool changer ATC), pallet APC), CNC axis and motion nomenclature, CNC tooling's – tool pre setting, qualified tool, tool holders and inserts.

Unit IV: CNC Part Programming

Axes Identification in turning Machining centers, Machine zero, home position, work piece zero, programme zero, CNC part programming: Programming format and Structure of part programme, ISO G and M codes for turning and milling-meaning and applications of important codes, Compensations: Tool length compensation, Pitch error radius compensation, Simple part programming for turning using ISO format having straight turning, taper turning (linear interpolation) and convex/concave turning (circular interpolation), Simple part programming for milling using ISO format, Importance, types, applications and format for: Canned cycles, Macro, Do loops, Subroutine, Mirror image, CNC turning and milling part programming using canned cycles, Do loops and Subroutine, CAD CAM integration, CAM Software.

Unit V: Maintenance of CNC Machine

Types of machine tools maintenance, Systems and Sub systems of CNC machines, CNC Maintenance practice: Tools required, Daily checklist, Problems related to mechanical systems, Backlash, Causes and precautions of electronics system.

Course Outcomes:

CO-1: Students will be able to get the fundamental knowledge about CNC machines and their applications. They will also be able to identify different axes, machine zero, home position, systems and controls CNC machines.
CO-2: Students will be able to select, mount and set cutting tools and tool holders on CNC.
CO-3: Students will prepare part programmes using ISO format for given simple components with and without use of MACRO, CANNED CYCLE and SUBROUTINE using ISO format.
CO-4: Students will be able to interface software application for auto part programming.
CO-5: Students will be able to apply maintenance practices for CNC machines.

Suggested Readings:

1. Pabla, B.S.; Adithan M.: CNC Machines, New Age International, New Delhi,
2. Vishal, S.: Introduction to NC/CNC Machines, S.K.Kataria & Sons., New Delhi
3. Rao,P N; Tiwari, N K; Kundra, T : Computer Aided Manufacturing, Tata McGraw Hill, New Delhi

Supplementary Readings:

1. Ploywka, John & Gabrel, Stanley, "Programming of Computer Numerically Controlled Machines" Industrial Press Inc. New York
2. Pollack Herman W. & Robinson T., "Computer Numerical Control", Prentice Hall NJ
3. Koren, Y. "Computer Control of Manufacturing Systems", McGraw Hill Book co. New Delhi

Practical papers [Manufacturing Technology]

MENPGPC51 Advanced Manufacturing Lab-I

Course objective:

- To familiarize the students with advanced machine tools.
- To demonstrate the nontraditional machining processes.

List of Experiments:

Simple exercises using the following machines:

(i) Electro-discharge Machining
(ii) Wire-cut-EDM
(iii) Ultrasonic Machining
(iv) Laser Beam Machining
(v) Micro-machining
(vi) Electroforming
(vii) Electro Chemical Machining

Course outcomes:

At the end of this course, the students shall be able to:

(i) Acquire knowledge on advanced machine tools.
(ii) Discuss traditional and nontraditional machining process.

MENPGPC52 Advanced Manufacturing Lab-II

Course objective:

- To familiarize the students with the Soft computing Techniques.
- To perform CNC modeling on CAD-CAM software.
- To perform Robot programming.

List of Experiments:

Simple exercises using the following software packages:

(i) Application of Soft computing Techniques with MiniTab,
(ii) Application of Soft computing Techniques with Statistica,
(iii) Application of Soft computing Techniques with MATLAB,
(iv) Application of Soft computing Techniques with Abaqus/ ANSYS,
(v) Solid modeling with CATIA/ Solidworks,
(vi) Casting simulation with pro-CAST,
(vii) Application of Robot (VAL) programming,

Course outcomes:

At the end of this course, the students shall be able to:

(i) Perform statistical analysis with Minitab and staistica,
(ii) Acquire knowledge on simulation based problem solving with Matlab,
(iii) Perform design optimization with Abaqus/ ANSYS,
(iv) Familiar with solid modeling techniques,
(v) Perform simulation for optimized casting procedure,
(vi) Discuss the Robot (VAL) programming.

Professional Core papers [Thermal Engineering]

Advanced Thermodynamics
Course code: MENPGPC31
Credit: 3
3L-0T-0P

Course objectives:

1. To impart knowledge on the principles of energy quality and the significance of the same for industrial and domestic applications of thermal systems.
2. To impart knowledge on different thermodynamic property relations and their applications.
3. To impart knowledge on thermodynamic application in reacting system.

Course content

Properties of Pure Substances: Phase change process of pure substances, PVT surface, P-V & P- T diagrams, Use of steam tables and charts in common use.

Laws of thermodynamics: 2nd law Analysis for Engineering Systems, Entropy flow & entropy generation, Increase of entropy principle, entropy change of pure substances, T-ds relations, entropy generation, thermo electricity, Onsager equation, Exergy analysis of thermal systems, decrease of Exergy principle and Exergy destruction, Third law of thermodynamics, Nerst heat theorem and thermal death of universe.

Thermodynamic Property Relations: Partial Differentials, Maxwell relations, Clapeyron equation, general relations for du, dh, ds, and Cv and Cp, Joule Thomson Coefficient, Δh, Δu, Δs of real gases.

Thermodynamics of Reacting System: Chemical reaction - Fuels and combustion, Enthalpy of formation and enthalpy of combustion, First law analysis of reacting systems, adiabatic flame temperature

Chemical and Phase equilibrium - Criterion for chemical equilibrium, equilibrium constant for ideal gas mixtures, some remarks about Kp of Ideal-gas mixtures, fugacity and activity, Simultaneous relations, Variation of Kp with Temperature, Phase equilibrium,

Course outcomes:

The students will be able to

1. Understand theoretical principles of exergy analysis, thermodynamic property relations and reactive systems.
2. Analyze thermodynamic processes in various industries/case studies (performed individually and in groups and presented in the form of report) and suggest improvements.

Text Books:

1. Thermodynamics – An Engineering Approach, Yunus Cengel and Michael Boles, 7th Ed., Tata McGraw-Hill.

2. Advance Engineering Thermodynamic, Adrian Bejan, Wiley, 2006
3. Fundamentals of Engineering Thermodynamics, M.J.Moran and H.N.Shapiro, John Wiley and Sons
4. Engineering Thermodynamics, PK Nag, Tata McGraw-Hill

Advanced Fluid Mechanics
Course code: MENPGPC32
Credit: 3
3L-0T-0P

Course Objective: To impart the knowledge of governing equation of fluid mechanics problems, low and high Reynolds numbers flows, analysis of potential flow, flow instabilities and onset of turbulence. Also to get familiar with Stokes, Oseen flows and compressible fluid flows.

Course content

Concepts of fluids: Definitions of fluids, concept of continuum, different types of fluid, tensor analysis, governing laws of fluid mechanics in integral form,Reynold's transport theorem, mass, momentum and energy equations in integral form and their applications, differential fluid flow analysis, continuity equation, Navier-Stokes equation and exact solutions.

Potential flow analysis: Two-dimensional flow in rectangular and polar coordinates, continuity equation and the stream function, irrotationality and the velocity potential function, complex potential function, vorticity and circulation, flow over immersed bodies and D' Alembert's paradox.

Viscous flow analysis: Low Reynold's number flow, approximation of Navier-stokes equation, approximate solutions of Navier-Stokes equation, Stokes and Oseen flows, hydrodynamic theory of lubrication, Prandtl's boundary layer equations, Large Reynold's number flow approximation, flow instabilities and onset of turbulence.

Compressible fluid flow: One dimensional isentropic flow, Fanno and Rayleigh flows, choking phenomenon, normal and oblique shocks.

Course Outcomes:

1. Students will be able to solve problems of fluid flows with low and high Reynolds numbers.
2. Students will understand the applications and significance of Navier-Stokes equation
3. Students will be able to solve Fanno and Rayleigh flows
4. Students will be able to solve different types of problems associated with shock waves.

Suggested Readings:

1. F.M.White, Viscous Fluid Flow, McGraw-Hill, New York, 3rd edition 2006.
2. S.K.Som, Gautam Biswas and SumanChakraborty, Introduction to Fluid Mechanics and Fluid Machines, , McGraw-Hill, New York, 3rd edition

Supplementary Readings

3. Bachelor G. K. An introduction to Fluid Dynamics , Cambridge University Press, 2007.
4. Streeter V.L. and Wylie E. B., Fluid Mechanics , Tata McGraw-Hill, Delhi 2001.
5. Shames I. H., Mechanics of Fluids , Tata McGraw Hill, Delhi, 4th edition 2003.
6. Douglas and Swaffield, Fluid Mechanics , Prentice Hall, 5th edition 2006.
7. Yahya S. M., Fundamentals of Compressible Flow , Tata McGraw Hill, Delhi, 3rd edition 2003.

Applied Thermodynamics
Course code: MENPGPC33

Credit: 3

3L-0T-0P

Course Objective: To impart the knowledge of different thermodynamic cycles and its efficiency. Also to get familiar with exergy and exergo-economic analyses..

Course content

Vapour Power Cycles: Carnot cycle, Rankine cycle, reheat cycle, regenerative cycle, steam cycles for nuclear power plant, back-pressure and extraction turbines and cogeneration, low-temperature power cycles, ideal working fluid and binary/multi-fluid cycles;

Gas Power cycle: Air standard cycle, Brayton cycle, Combined Cycle

Heat Pump and Refrigeration Cycles: reversed Carnot cycle and performance criteria, vapour compression and vapour absorption refrigerators, gas cycles, refrigerants and environmental issues;

Air-conditioning; Reciprocating Air Compressors: work transfer, volumetric efficiency, isothermal efficiency, multistage compression with intercooling.

Exergy and Exergo-economic Analyses of Thermodynamic cycle: Evaluation of exergy destruction of individual component of thermodynamic cycle, estimation of exergy efficiency, exergy cost estimation of different fluid streams.

Course Outcomes:

1. Students will be able to solve problems associated with various thermodynamic cycles.
2. Students will understand the applications of different thermodynamic cycles.
3. Students will be able to solve exergy analyses of different thermodynamic cycles.

4. Students will be able to solve exergo-economic analyses of thermodynamic cycles

Texts:

1. G F C Rogers and Y R Mayhew, *Engineering Thermodynamics* Work and Heat Transfer 4e, Pearson, 2003.

2. T D Eastop and A McConkey, *Applied Thermodynamics* for Engineering Technologists, 5e, Pearson, 2003.

3. M J Moran and H N Shapiro, *Fundamentals of Engineering Thermodynamics* 3e, John Wiley, 1995.

4. M M ElWakil, *Power Plant Technology*, McGraw Hill International, 1992.

5. P K Nag, *Powerplant Engineering*, Tata McGraw Hill, 2e, 2002.

Advanced Heat Transfer
Course code: MENPGPC34
3L-0T-O-0P

Course objectives:

1. To know and understand the heat transfer problems.
2. To get familiar with the modes of heat transfer and their mechanics.
3. To establish the analogy between fluid mechanics and heat transfer and also to understand the heat transfer in phase change liquids

Course content

Conduction: Equations and boundary conduction in different coordinate systems; Steady and Transient heat conduction in one-dimensional /multidimensional system, Variable area fin analyses, Analytical Solutions: separation of variables, Laplace Transform, Duhamel's theorem: Non-impulse initial conditions; Interfacial heat transfer; Numerical Methods: Finite difference and flux conservation

Convection: Conservation equations and boundary conditions; Heat transfer in laminar developed and developing boundary layers: duct flows and external flows, analytical and approximate solutions, effects of boundary conditions; Heat transfer in turbulent boundary layers and turbulent duct flows; Laminar and turbulent free convection, jets, plumes and thermal wakes, phase change (boiling and condensation).

Radiation: Intensity, radiosity, irradiance, view factor geometry and algebra; formulations for black and non–black surfaces, spectrally–selective surfaces (solar collectors); Monte Carlo methods for radiation exchange; Radiation in participating medium, The radiative transfer equation, extinction and scattering properties of gases and aerosols, overview of solution methods and applications. Coupled problems; Examples in manufacturing and electronic cooling applications.

Course Outcomes:

The students will be able to

1. Understand about the basics of heat transfer and its role in many thermal processes.
2. Develop the means to tackle the heat transfer problems.
3. Selection of the materials for a particular application based upon its thermal response.
4. Apply the concepts to analyze industrial problems.

Text Books:

1. M N Ozisik, *Heat Conduction*, 2nd ed, John Wiley & Sons, 1993
2. Kakaç, S., Yener, Y., Heat Conduction, 3rd edition, Taylor & Francis, 1993.
3. F P Incropera and D P Dewitt, *Introduction to Heat Transfer*, 3rd ed, John Wiley & Sons, 1996
4. W. M. Kays and E. M. Crawford, *Convective Heat and Mass Transfer*, Mc Graw Hill,1993.
5. Adrian Bejan, *Convective Heat Transfer*, John Wiley and Sons, 1995.
6. M F Modest, *Radiative Heat Transfer*, McGraw-Hill, 1993
7. R Siegel and J R Howell, *Thermal Radiation Heat Transfer*, 3rd ed, Taylor & Francis, 1992

Professional Elective Paper [Thermal Engineering]

Advanced Engineering Mathematics
Course code: MENPGPE01
3L-0T-0P

Course Objective:

This course has two different modules, namely, (i) Linear Programming Problems (LPP) and (ii) Numerical and Statistical Methods.

The objective of learning LPP is to get an overview of the kinds of problems linear programming has been used to solve, to learn how to solve two variable linear programming models by the graphical method, to understand the importance of extreme points in obtaining the optimal solution, to know the use and interpretation of slack and surplus variables, to be able to interpret the computed solutions of a linear programming problem, to understand how alternative optimal solutions, infeasibility and unboundedness can occur in linear programming problems, to get an idea how Simplex Method can be implemented for solving linear programming problems.

On the other hand, in the course the Numerical and Statistical Methods, students may become familiar with the ways of solving complicated mathematical problems numerically. They will understand several errors which may appear in approximated solutions while applying different iterative methods. They will study how to fit a curve with some tabulated data set. This course will also make the students aware of popular differentiation and integration rules and different techniques for solving the differential equations in underlying domains.

Course Content:

LPP: Formulation, graphical solutions, simplex method (illustrations through problems only). Numerical & Statistical Methods : Interpolations: Lagrange's method, Newton's forward & backward difference formulae; Curve fitting: least square & other curves fitting.

Solution of polynomial equation and simultaneous non linear equations using iterative techniques – methods for solution of simultaneous algebraic equation - Numerical differentiation and integration –

Solution of differential equation using Runge-Kutta method, FDM, etc.

Course Outcome: After the completion of the course the students will be able to

1. develop linear programming models for simple problems,
2. recognize the special features of linear models
3. solve linear programming problems using different methods like Graphical Method, Simplex Method, Big-M Method etc.
4. compute the solution of the mathematically defined real life problems using comparatively time saving Numerical and Statistical methods over other analytical methods,
5. reduce the amount of errors in approximated solutions by using the Numerical and Statistical Methods which will be more acceptable in most cases.

List of Books

1. Introductory Methods of Numerical Analysis by S.S. Sastry, Prentice Hall of India publisher.
2. Linear Programming and Game Theory by J.G. Chakraborty and P.R. Ghosh, Moulik Library publisher.
3. A Ground Book of Linear Programming and Numerical Analysis by Arup Mukherjee.

Finite Element Method in Engineering
MENPGPE03

Course Objective

3. To illustrate the principle of mathematical modeling of engineering problems.
4. To introduce the basics and application of Finite Element Method.

Course Content:

A General Procedure for Finite Element Analysis, History of the Finite Element Method, Examples of Finite Element Analysis., Finite Element of Linear Spring, Elastic Bar, Truss Element, Strain Energy, Castigliano's First Theorem, Minimum Potential Energy.

Truss Structures: The Direct Stiffness Method, Nodal Equilibrium Equations, Element Transformation, Direct Assembly of Global Stiffness Matrix, Boundary Conditions, Constraint Forces, Element Strain and Stress, Three Dimensional Trusses.

Elementary Boundary Theory, Flexure Element Stiffness Matrix, Element Load Vector, Work Equivalence for Distributed Loads, Flexure Element with Axial Loading, General Three Dimensional Beam Element.

Method of Weighted Residuals, Galerkin's Finite Element Method, Application of Galerkin's Method to Structural Elements.
Continuity, Compatibility and Completeness, Polynomial Forms of One-dimensional Elements and Geometric Isotropy, Triangular Elements, Rectangular Elements, Three-dimensional Elements, Iso-parametric Formulation, Numerical Integration: Gaussian Quadrature. Applications.
Structural Dynamics, Simple Harmonic Oscillator, Multiple Degree of Freedom Systems, Bar Elements: Consistent Mass Matrix, Beam Elements.
Applications usingfinite element modeling and programming.
Identification of Physical problems, Differential formulation, Philosophy behind the approximate methods, FE formulation for a general problem in elasticity, Formulation of FE characteristics, Plane stress, Plane strain, Axisymmetric, Plate bending and Shell elements Isoparametric, 3-D elements and their formulation, Modal Analysis

Course Outcome:

Upon completion of the course, students will understand the FEM formulation and its application to simple structural problems.

TEXT BOOKS:

5. David V. Hutton, Fundamentals of Finite Element Analysis.

REFERENCE BOOKS:

6. Rao S.S., The Finite Element Method in Engineering.
7. Reddy J.N., An Introduction to Finite Element Method.
8. O.C. Zeinkiewicz, R.L. Taylor, The Finite Element Method.

Operation Research
Course code: MENPGPE05
3L-0T-0P

Course Objectives:

To acquaint students with the construction of mathematical models formanagerial decision situations and to use computer software packages to obtain a solution wherever applicable. The emphasis is on understanding the concepts, formulation and interpretation.

Course Content:

Unit-I: Linear programming:

Assumptions, Basic concepts; LP Formulation Graphical Solution, Feasible Region, Optimum Solution, special cases (unbounded solutions, infeasible solution and Alternative optima), Standard Form, Canonical form and Simplex method, maximization case, minimization case; Big, M method.

Unit-II: Transportation Problem:

Transportation tableau, Mathematical Form, Methods for Finding Initial basic Feasible, Solution, North West Corner Rule, Least Cost Method, VAM; Test for Optimality, MODI Method.

Unit-III: Assignment Problem:

Mathematical Statement of Problem, Comparison with Transportation Problem; Solution of Assignment Problem, Hungarian Methods, Game Theory: Introduction; Two, person zero, some Games; Games with saddle Point, Pure Strategies; Rules of Dominances

Unit-IV: Decision Theory:

Steps in Decision Theory Approach; Types of Decision Making Environments; Decision Making Under Risk, Expected Monetary Value, Expected Opportunity loss; Decision Making Under Uncertainty, Criterion of optimism, Criterion of Pessimism, Laplace Criterion, Criterion on Regret.

Course Outcomes:

CO-1: Understand the basic operations research concepts and terminology involved in optimization techniques.
CO-2: Understand how to interpret and solve business-related problems.
CO-3: Apply certain mathematical techniques in getting the best possible solution to a problem involving limited resources.
CO-4: Apply the most widely used quantitative techniques in decision making and identify project goals, constraints, deliverables, performance criteria, control needs, and resource requirements in order to achieve project success.

Suggested Readings:

1. Operation Research: An introduction – H. A. Taha; Macmillan.
2. Quantitative Technique in Management – N. D. Vhora; Tata McGraw Hill.

Supplementary Readings:

1. Operation Research – K. Swarup, P. K. Gupta and M. Mohan; Sultan Chand.
2. Operations Research; Theory and Applications – J. K. Sharma; Macmillan.

Jet Propulsion

Course code : MENPGPE33

3L-0T-0P

Course Objectives:

1. To study the fundamentals of Gas turbine engine.
2. To study the working principle of various Jet engines.
3. To study the performance parameters of Jet engines.
4. To understand the principle of nozzle theory.
5. To understand the fundamentals of rocket engines.
6. To study the performance of solid propellant, liquid propellant, hybrid rocket and electric rocket propulsion.

Course Content

Gas turbine engine – Fundamentals of gas turbine engine and its working principle, Basic components.

Fundamentals of jet propulsion – Basic principle, Propulsion cycle, Turbojet engine, Turboprop engine, Turbofan engine, Ramjet engine, Scramjet engine, Pulse-jet engine. Thrust equation, Ram efficiency, Thermal efficiency of turbojet engine, Propulsion efficiency and Overall efficiency of a propulsive system.

Fundamentals of rocket propulsion- Rocket principle and rocket equation, Rocket nozzle and performance, Nozzle theory and thermodynamic relations – Isentropic flow through nozzles, Nozzle configurations, Nozzle exhaust jet velocity, Nozzle area ratio, Nozzle mass flow rate

and characteristic velocity, Thrust developed by a rocket, Types of rockets- Chemical rockets (solid propellant, liquid propellant and hybrid rockets), Electrical rockets, Nuclear rockets and Solar rockets.

Course Outcomes:

1. Students will be able to understand the fundamentals of Gas turbine engine.
2. Students will be able to understand fundamentals of Jet engines.
3. Students will be able to analyze the performance parameters of Jet engines.
4. Students will be able to understand the principles of nozzle theory.
5. Students will be able to understand the fundamentals of rocket engines.
6. Students will be able to analyze the performance of solid propellant, liquid propellant and hybrid rockets.

Text Books:

1. S.M. Yahya, *Fundamentals of Compressible Flow with Aircraft and Rocket Propulsion,* New Age International.
2. V. Ganesan, *Gas Turbines*, McGraw-Hill.
3. Ahmed F.EI-Sayed, *Aircraft Propulsion and Gas Turbine Engines,* Taylor & Francis.
4. Ahmed F.EI-Sayed, *Fundamentals of Aircraft and Rocket Propulsion*, Springer.
5. K. Ramamurthi, *Rocket Propulsion*, Macmillan.
6. George P. Sutton and Oscar Biblarz, *Rocket Propulsion Elements,* Wiley.

Energy conversion and Management

Course Code: MENPGPE34

3L-0T-0P

Course objectives:

1. To impart basic knowledge to the students about current energy scenario, energy conservation, audit and management.
2. To inculcate among the students systematic knowledge and skill about assessing the energy efficiency, energy auditing and energy management.

Course content

Present energy scenario: The energy market, energy scenario, planning, utilization pattern and future strategy, Importance of energy management.

Energy Management & Audit: Definition, Energy audit- need, Types of energy audit, Energy management (audit) approach-understanding energy costs, Bench marking, Energy performance, Matching energy use to requirement, Maximizing system efficiencies, Optimizing the input energy requirements, Fuel and energy substitution, Energy audit instruments, Energy economics.

Material and Energy balance: Basic principle, Sankey and Grasmann diagrams, Material balances for different processes, Energy balances, heat balances, Method for preparing process flow chart.
Procedure to carry out the material and energy balance in different processes
Thermal energy management: Energy conservation in boiler and furnaces, waste heat recovery, thermal insulation, energy conservation in building, building heating and cooling load management, building code, solar passive and green building concept.
Financial analysis techniques : simple payback period, return on investment, net present val ue, internal rate of return, cash flows and sensitivity analysis
Environmental Issues and Energy policy: GWP, ODP, Flammability, toxicity, Kyoto protocol, IPCC etc.

Course outcomes:
Students will be able to

1. Apply the knowledge of the subject to calculate the efficiency of various thermal utilities.
2. Design suitable energy monitoring system to analyze and optimize the energy consumption in an organization.
3. Improve the thermal efficient by designing suitable systems for heat recovery and co-generation.
4. Use the energy audit methods learnt to identify the areas deserving tighter control to save energy expenditure.
5. Carry out the cost- benefit analysis of various investment alternatives for meeting the energy needs of the organization.
6. Guide the employees of the organization about the need and the methods of energy conservation.

Reference Books:

1. L.C. Witte, P.S. Schmidt, D.R.Brown, "Industrial Energy Management and Utilization", Hemispherical Publication, 1988.
3. D.A. Reeg, "Industrial Energy Conservation", Pergamon Press, 1980.
4. T.L. Boyen, "Thermal Energy Recovery" Wiley, 1980
5. L.J. Nagrath, "Systems Modeling and Analysis", Tata McGraw Hill, 1982.
6. W.C. Turner, "Energy Management Handbook ", Wiley, New York, 1982.
7. I.G.C. Dryden, "The Efficient Use of Energy ", Butterworth, London,

Measurement and Instrumentation
Course code: MENPGPE35
Credit:3
3L-0T-0P

Course objective:

1. To learn different techniques of instrumentation involved in thermal quantity measurement.
2. To understand the static and dynamic behavior of a measuring system.
3. To learn different kind of errors involved in experimentation and their analysis.
4. To know about the transducers for different types of thermo-physical quantities.

Course content

Introduction: Accuracy, precision, sensitivity and resolution. Characteristics and Response, Static Response, Dynamic Response-zero, First and second order systems.

Analysis of experimental data: Causes and types of experimental errors, Error analysis on a commonsense basis, Uncertainty analysis, Statistical analysis of experimental data probability distributions, The Gaussian or normal error distribution, Probability graph paper, The Chi-square test of goodness of fit, Method of least squares, Standard deviation of the mean, Graphical analysis and curve fitting, General considerations in data analysis.

Basic electrical measurements and sensing devices - Transducers, The variable - Resistance transducers, The differential transformer (LVDT), Capacitive transducers, Piezoelectric transducers, Photoelectric effects, Photoconductive transducers, Photovoltaic cells, Ionization transducers, Magnetometer search coil: Hall-effect transducers.

Pressure measurement: Dynamic response considerations, Mechanical pressure - Measurement devices, Dead-weight tester, Bourdon-tube pressure gauge, Diaphragm and bellows gauges, The Bridgman gauge, Low-pressure measurement. The Mcleod gauge, Pirani thermal-conductivity gauge, The Knudsen gauge, The ionization gauge, The alphatron.

Flow measurement: Positive displacement methods flow - Obstruction methods, Practical consideration for obstruction meters, The sonic nozzle. Flow measurement by drag effects, Hotwire and hot-film anemometers, Magnetic flow meters, Flow- visualization methods, The shadowgraph, The schlieren, The interferometer, The Laser Doppler Anemometer (LDA), Smoke methods, Pressure probes, Impact pressure in supersonic flow.

The measurement of temperature: Temperature scales. The ideal-gas thermometer, Temperature measurement by mechanical effect. Temperature measurement by electrical effects, Temperature measurement by radiation, Effect of heat transfer or temperature measurement, Transient response of thermal systems, Thermocouple compensation, Temperature measurements in high-speed flow.

Thermal and transport Property measurement: Thermal conductivity measurements, Thermal conductivity of liquids and gases, Measurement of viscosity, Gas diffusion, Calorimetry, Convection heat-transfer measurements. Humidity measurements, Heat-flux meters.

Thermal radiation measurements: Detection of thermal radiation, Measurement of emissivity, Reflectivity and transmissivity measurements, solar radiation measurements.

Course outcomes:

Upon successful completion of the course, students should be able to

1. Have good knowledge and understanding of experimental analysis and Instrumentation related to thermal system,
2. Apply general concept of measurement, statistical analysis of experimental data and performance analysis of a measuring system
3. Examine a given experimental requirement and recommend a correct measurement procedure and device pertaining to kinetic and thermo-physical measurement
4. Understand the integration of digital to analog way of measurement

Text Book:

1. Measurement Systems by Doeblin
2. Experimental Methods for Engineers by Holman, J.P.
2. Mechanical Measurements by Thomas G. Beckwith, N. Newis Buck.
3. Measurements in Heat Transfer by Eckert and gold stein.
4. Measurement system by E.O Doeblin and D.M Manik

Principles of Combustion

Course code: MENPGPE36

3L-0P-0T

Course Objectives:

1. To study the fundamentals of reacting systems.
2. To correlate thermodynamics of reacting systems and chemical kinetics.
3. To model the reacting flow systems.
4. To understand premixed and diffusion controlled combustion.
5. To measure the flame properties and emission characteristics.

Course Content

Introduction: Introduction to combustion, Applications of combustion, Types of fuel and oxidizers, Characterization of fuel, Various combustion mode, Scope of combustion.

Thermodynamics of Combustion: Chemistry of Combustion: Fundamentals of combustion kinetics, Governing equations for a reacting flow, Basic Reaction Kinetics, Elementary reactions, Chain reactions, Multistep reactions, simplification of reaction mechanism, Global kinetics, Coupling between thermodynamics and kinetics of reaction: Well stirred reactors etc.

Physics of Combustion: Fundamental laws of transport phenomena, Conservations Equations, Transport in Turbulent Flow.

Premixed Flame: One dimensional combustion wave, Laminar premixed flame, Burning velocity measurement methods, Effects of chemical and physical variables on Burning velocity, Flame extinction, Ignition, Flame stabilizations, Turbulent Premixed flame.

Diffusion Flame: Gaseous Jet diffusion flame, Liquid fuel combustion, Atomization, Spray combustion, Gas phase combustion and droplet equations, Solid fuel combustion.

Combustion and Environment: Atmosphere, Formation & Emission of pollutants from combustion, Quantification of emission, Emission control methods.

Course Outcomes:

1. Students will be able to understand the fundamentals of reacting systems.
2. Students will be able to correlate thermodynamics of reacting systems and chemical kinetics.
3. Students will be able to model the reacting flow systems.
4. Students will be able to understand premixed and diffusion controlled combustion.
5. Students will be able to measure the flame properties and emission characteristics.

Text Books:

1. D.P. Mishra, *Fundamentals of Combustion*, Prentice Hall of India, New Delhi.
2. Stephen R. Turns, *An Introduction to Combustion Concepts and Applications*, McGraw-Hill.
3. Amitava Datta, *Combustion: Fundamentals & Application*, Narosa.
4. A. Mukhopadhyay and S. Sen, *Fundamentals of Combustion Engineering*, CRC Press.
5. Kenneth K. Kuo, *Principles of Combustion*, John Wiley and Sons.
6. Forman A. Williams, *Combustion Theory*, Benjamin-Cummings Publishing Company.

Heat Exchanger Design

Course code: MENPGPE37

Credit:3

3L-0T-0P

Course objective: To impart knowledge on design and operating parameters of various types of heat exchangers involved in process industries.

Course content

Classification of heat exchangers; basic design methods for heat exchangers, double pipe heat exchangers, parallel and counter flow, design of shell and tube heat exchangers; TEMA codes; flow arrangements for increased heat recovery; condensation of single vapors, mixed vapors; design considerations for different plate type heat exchangers; regenerators, steam generators, condensers, radiators for space power plant, cooling towers, power plant heat exchangers, furnace calculations.
Pinch analysis and process integration. Pinch analysis for heat exchanger network

Course outcomes:

Students will be able to

1. Identify various type of heat exchangers based on their application
2. Rate/ design heat exchangers based on requirement of particular industrial application
3. Reduce industrial thermal energy needs applying pinch analysis.

Reference books:

1. Process heat transfer by Donald Kern, Tata McGraw Hill Publishing Company Ltd.
2. Heat Exchanger Selection, Rating and Thermal Design by Sadic Kakac and Hongton Liu, CRC Press
3. Process Heat Transfer by G. F. Hewitt, G.L. Shires, T.R. Bolt, CRC Press

Advanced Optimization Techniques

Course code: MENPGPE38

Credit:3

3L-0T-0P

Course objective: The objective of this course is to provide the students with knowledge on

1. The application of various optimization techniques which can help making decisions for practical problems in industries.
2. Modeling concepts and applications of linear, integer, nonlinear, and dynamic programming.
3. Metaheuristic techniques applied to obtain good solutions for large scale practical problems in a reasonable computational time.

Course Content

Geometric programming (G.P): Solution of an unconstrained geometric programming, differential calculus method and arithmetic method. Primal dual relationship and sufficiency conditions. Solution of a constrained geometric programming problem (G.P.P), Complementary Geometric Programming (C.G.P)

Dynamic programming(D.P): Multistage decision processes. Concepts of sub optimization and Principal of optimality, computational procedure in dynamic programming calculus method and tabular methods. Linear programming as a case of D.P. and continuous D.P.

Integer programming(I.P): Graphical representation. Gomory's cutting plane method. Bala's algorithm for zero-one programming problem. Branch-and-bound method, Sequential linear discrete Programming, Generalized penalty function method.

Stochastic Programming (S.P.): Basic Concepts of Probability Theory, Stochastic Linear programming.

Non-traditional optimization techniques: Multi-objective optimization - Lexicographic method, Goal programming method, Genetic algorithms, Simulated annealing, Neural Networks based Optimization.

Course outcomes:

The students on the completion of this course would be able to

1. Formulate mathematical programs for practical problems in production and supply chain systems
2. Apply appropriate optimization techniques and write codes of optimization models using professional optimization software (i.e., MATLAB, LINGO, or MPL software) to solve single-objective practical problems in
3. Find appropriate trade-off solutions for multi-objective decision making problems in thermal system
4. Use meta-heuristic techniques to solve large scale NP-hard combinatorial problems for both single and multiple objective decision making problems where analytical methods cannot be used

Reference book:

1. Operations Research- Principles and Practice by Ravindran, Phillips and Solberg, John Wiely
2. Introduction to Operations Research by Hiller and Lieberman, Mc Graw Hill
3. Engineering Optimization - Theory and Practice by Rao, S.S., New Age International (P) Ltd. Publishers.
4. Engineering Optimization By Kalyanmanai Deb, Prentice Hall of India, New Delhi.
5. Genetic Algorithms - In Search, Optimization and Machine Learning by David E. Goldberg, Addison-Wesley Longman (Singapore) Pvt. Ltd.

Advanced Refrigeration and Air Conditioning

Course code: MENPGPE39

Credit:3

3L-0T-0P

Course objectives:

1. To impart knowledge about principles of producing low temperatures by using multi-pressure systems and cascade systems.
2. To provide concepts about designing of air conditioning systems in residential, commercial and industrial buildings.

3. To educate about various system components and accessories of refrigeration and air-conditioning systems.

Course content

1. **Analysis of vapour compression refrigeration system:** Effect of various factors on the performance of vapour compression refrigeration system; Multiple evaporator systems; Compound vapour compression systems; Low temperature and multi-temperature systems.
2. Air refrigeration systems-Bell-Coleman Cycle, Aircraft refrigeration-Simple air refrigeration system, Bootstrap air refrigeration system (with and without evaporative cooling), Regenerative air refrigeration system, Reduced ambient air refrigeration system.
3. **Analysis of vapour absorption refrigeration system:** LiBr-H_2O system; Ammonia-Water system, Electrolux systems; Binary mixtures; Analysis of absorption systems using analysis and rectification columns.
4. **Refrigeration equipments:** Compressors (reciprocating and centrifugal); Expansion devices; Condensers; Evaporators; Controls used in refrigeration systems. Properties of refrigerants; Their development and applications; Principles of various other refrigeration systems.
5. **Psychometry & Air conditioning:** Application of psychrometric processes of summer and winter air conditioning (applied psychrometry), Heat load estimation; Human comfort; Comfort chart. Sensible heat factor, Bypass factor, ADP, refrigeration load. Solar heating and cooling, air conditioning through solar system, building designs for air conditioning. Fluid flow and pressure loss, equivalent length system & duct design, air distribution system, basic control system, Indoor Air Quality.
6. **Refrigerants:** Classification and nomenclature, desirable properties of refrigerants, common refrigerants, environmental issues- Ozone depletion and global warming Alternative refrigerants: low GWP and zero ODP newer refrigerants
7. **Types of Air conditioning systems:** Unitary, Split-unit, central air conditioning system, Variable refrigerant volume/flow (VRV/VRF) systems.

Course outcomes:

1. Students should be able design refrigeration systems that can produce low temperatures required in many industrial applications.

2. Students should acquire enough knowledge to design the air conditioning systems for residential, commercial and industrial buildings.
3. Students should acquire expertise on application of various HVACRs equipment.

Reference Books:

1. Arora,C.P., *Refrigeration and Air Conditioning*", Tata McGraw-Hill.
2. Prasad, Manohar, *Refrigeration and Air Conditioning*, New Age International (P) Ltd., New Delhi.
3. Stoecker, W.F., *Refrigeration and Air Conditioning*, McGraw Hill Publication.
4. Ananth Narayanan, *Basic Refrigeration & Air Conditioning*, Tata McGraw-Hill.

Computational Fluid Dynamics
Course code: MENPGPE40
3L-0T-0P

Course Objectives:

1. Place CFD in the context of a useful design tool for industry and a vital research tool for thermo-fluid research across many disciplines.

2) Familiarize students with the basic steps of the conservation laws applied to fluid motion and heat transfer and basic computational methods including explicit, implicit methods, discretization schemes and stability analysis.

3) Develop practical expertise of solving CFD problems with a commercial CFD code.

4) Develop an awareness of the power requirement and limitations of CFD.

Course Outcome

Course Objectives:

1. To impart knowledge about fundamentals of computational fluid dynamics in the context of a research tool for thermo-fluid research across many disciplines.

2) To familiarize students with the basic steps of the conservation laws applied to fluid motion and basic computational methods including explicit, implicit methods, discretization schemes and stability analysis.

3) To develop practical expertise of solving CFD problems with a commercial CFD code.

4) To provide basic concepts about different algorithms, CFD technique and basics of various grid generation.

Course Content

Concept of Computational Fluid Dynamics: Different techniques of solving fluid dynamics problems, their merits and demerits, governing equations of fluid dynamics and boundary conditions, classification of partial differential equations and their physical behavior, Navier-Stokes equations for Newtonian fluid flow, computational fluid dynamics (CFD) techniques, different steps in CFD techniques, criteria and essentialities of good CFD techniques.

Finite Difference Method (FDM): Application of FDM to model problems, steady and unsteady problems, implicit and explicit approaches, errors and stability, analysis, direct and iterative solvers.

Finite Volume Method (FVM): FVM for diffusion, convection-diffusion problem, different discretization schemes, FVM for unsteady problems. Prediction of Viscous Flows: Pressure Poisson and pressure correction methods for solving Navier- Stokes equation, SIMPLE family FVM for solving Navier--Stokes equation, modelling turbulence.

CFD for Complex Geometry: Structured and unstructured, uniform and non-uniform grids, different techniques of grid generations, curvilinear grid and transformed equations.

Lattice Boltzman and Molecular Dynamics: Boltzman equation, Lattice Boltzman equation, Lattice-Boltzman methods for turbulence and multiphase flows, Molecular interaction, potential and force calculation, introduction to Molecular Dynamics algorithms.

Course Outcome

1. Students will be able to understand the fundamentals of computational fluid dynamics and its application, conceptual understanding of mathematical behavior of partial differential equation and its impact on CFD.
2. Students will have in-depth understanding of basic aspect of discretization methods and its applications.
3. Students will be able to acquire enough knowledge of solving real life problems of fluid flow.
4. Students will acquire knowledge of various governing equations of CFD and application to fluid flow problem.
5. Students will be able to apply different algorithms, CFD technique and basics of various grid generation.

Text Books:

1. J. D. Anderson, *Computational Fluid Dynamics*, McGraw-Hill.
2. S. V. Patankar, *Numerical Heat Transfer and Fluid Flow*, Hemisphere.
3. K. Muralidhar, and T. Sundarajan, *Computational Fluid Flow and Heat Transfer*, Narosa.
4. D. A. Anderson, J. C. Tannehill and R. H. Pletcher, *Computational Fluid Mechanics and Heat Transfer*, Hemisphere.
5. M. Peric and J. H. Ferziger, *Computational Methods for Fluid Dynamics*, Springer.
6. H. K. Versteeg and W. Malalaskera, *An Introduction to Computational Fluid Dynamics*, Dorling Kindersley (India) Pvt. Ltd.
7. C. Hirsch, *Numerical Computation of Internal and External Flows*, Butterworth-Heinemann.
8. J. M. Jaile, *Molecular Dynamics Simulation: Elementary Methods*, Willey Professional.
9. A. A. Mohamad, *Lattice Boltzman Method: Fundamentals and Engineering Applications, with Computer Codes*, Springer.
10. Charles Hirsch, *Numerical Computation of Internal and External Flows*, Butterworth-Heinemann.

Practical papers [Thermal Engineering]

Advance Thermal Laboratory-I
Course code: MENPGPC53

Credit:2

0L-0T-4P

Course objective:

1. To impart practical exposure of various thermal engineering systems.
2. To study the concepts, applications of the thermal engineering laboratory
3. To demonstrate and conduct experiments, interpret and analyze results

Course content

Experiment on heat transfer, Refrigeration and Air conditioning and IC engines.

Course outcomes:

Upon successful completion of the course, the students will be able to **experimentally**

1. Analyze different heat transfer mechanism
2. Evaluate the performance of air conditioning and refrigeration systems
3. Evaluate the performance of IC engines

Advance Thermal Laboratory-II
Course code: MENPGPC54

Credit:2

0L-0T-4P

Course objective:

1. To impart computational exposure of various thermal physical situations.
2. To formulate problems followed by conducting simulations and interpretation of results.

Course content

Computational laboratory to handle different simulation software and interfacing with Mat lab.

Course outcomes:

Upon successful completion of the course, the students will be able to

1. Simulate and evaluate advanced thermodynamic systems
2. Simulate complex fluid flow and heat transfer problems

Pool of Open Elective papers (Any One in Semester-II)

Sl no	Code	Course	Offering department
1	CSEPGOE01	Image Processing	CSE
2	CSEPGOE02	Data Analytics	
3	CSEPGOE03	Internet of Things	
4	CSEPGOE04	Operations Research	
5	CENPGOE01	Waste to Energy	CEN
6	CENPGOE02	Remote Sensing& GIS	
7	EENPGOE01	Optimization in Engineering	EEN
8	EENPGOE02	Essentials of Renewable Energy System	
9	EENPGOE03	Industrial Automation & Control	
10	ECEPGOE01	Laser Systems and Applications	ECE
11	ECEPGOE02	Cyber Physical Systems	
12	ECEPGOE03	Signal and Image Processing	
14	MENPGOE02	Fundamentals of FEM	MEN (students of ME department cannot opt)
15	MENPGOE03	Non Conventional Energy Sources	