# MECHANICAL ENGINEERING DEPARTMENT
# M. M. M. UNIVERSITY OF TECHNOLOGY
# GORAKHPUR

## COURSES OFFERED

### Program Core (Computer Integrated Manufacturing)

| S.N. | Paper Code | Subject | Prerequisite Subject | L | T | P | Credits |
|---|---|---|---|---|---|---|---|
| 1. | MAS-101 | Numerical Methods & Engineering Optimization | - | 3 | 1 | 2 | 5 |
| 2. | MME-101 | Advanced Computer Aided Design | Computer Aided Design | 3 | 1 | 2 | 5 |
| 3. | MME-102 | Simulation, Modelling and Analysis | - | 3 | 1 | 0 | 4 |
| 4. | MME-103 | Machining Science | Manufacturing Science | 3 | 1 | 0 | 4 |
| 5. | MME-104 | Advanced Computer Aided Manufacturing | Basic Machining Science | 3 | 1 | 2 | 5 |
| 6. | MME-105 | Advance Machining Processes | Machining Science | 3 | 1 | 0 | 4 |
| 7. | MME-120 | Minor Project | - | 0 | 0 | 8 | 4 |
| 8. | MME-130 | Dissertation Part-I | - | 0 | 0 | 8 | 4 |
| 9. | MME-140 | Seminar | - | 0 | 0 | 4 | 2 |
| 10. | MME-150 | Dissertation Part-II | Dissertation Part-I | 0 | 0 | 28 | 14 |

### Program Electives (Computer Integrated Manufacturing)

| S.N. | Paper Code | Subject | Prerequisite Subject | L | T | P | Credits |
|---|---|---|---|---|---|---|---|
| | | **PE1 & PE2 (Semester-II)** | | | | | |
| 1. | MME-151 | Machine Tool Design | Manufacturing Science | 3 | 1 | 2 | 5 |
| 2. | MME-152 | Computer Aided Process Planning | - | 3 | 1 | 0 | 4 |
| 3. | MME-153 | Design for Manufacture | - | 3 | 1 | 0 | 4 |
| 4. | MME-154 | Robotic Engineering | - | 3 | 1 | 0 | 4 |
| 5. | MME-155 | Robust design | - | 3 | 1 | 0 | 4 |
| 6. | MME-156 | Micro-Machining and Precision Engineering | Manufacturing Science | 3 | 1 | 0 | 4 |
| 7. | MME-157 | Production and Operations Management | - | 3 | 1 | 0 | 4 |
| 8. | MME-158 | Rapid Prototyping and Tooling | Manufacturing Science | 3 | 1 | 0 | 4 |
| | | **PE3 & PE4 (Semester-III)** | | | | | |
| 9. | MME-161 | Finite Element Method | - | 3 | 1 | 0 | 4 |
| 10. | MME-162 | Industrial Automation & Robotics | - | 3 | 1 | 0 | 4 |
| 11. | MME-163 | Advanced Materials Technology | Material Science & Engineering | 3 | 1 | 0 | 4 |
| 12. | MME-164 | Flexible Manufacturing System | Manufacturing Science | 3 | 1 | 2 | 5 |
| 13. | MME-165 | Concurrent Engineering & Product Lifecycle Management | - | 3 | 1 | 0 | 4 |
| 14. | MME-166 | Quality Assurance | - | 3 | 1 | 0 | 4 |
| 15. | MME-167 | Materials Management | - | 3 | 1 | 0 | 4 |
| 16. | MME-168 | Work Science | - | 3 | 1 | 0 | 4 |

# SYLLABI

**MME-101 ADVANCED COMPUTER AIDED DESIGN 5 Credits (3-1-2)**

**UNIT I**

**Graphic Systems** **5**

Introduction, Graphics systems, Graphics hardware input devices, Display devices, Color displays, Solid state monitors, Output devices, Software configuration and functions, Graphics software standards

**Output Primitives** **4**

Scan conversion of primitives, Bresenham's Circle generating algorithm and Ellipse generating algorithms, problems.

**UNIT II**

**3D Transformation** **4**

Linear transformations, translation, rotation, scaling, reflection and shear, Matrix representation, Overall scaling, Composite transformations, Rotation about local axes parallel to global axes, Rotation about an arbitrary axis, Scaling with respect to fixed point, Reflection through an arbitrary plane

**Projections** **5**

Plane geometric projection, Parallel projections–Matrix equations for Orthographic projection, Oblique projection-Cavalier and Cabinet projections, Axonometric projections-isometric, diametric and trimetric projections, Perspective projections-vanishing point, Equation for one point, two point and three point perspective projections, Stereographic projections-monocular and binocular depth perceptions

**UNIT III**

**Curves** **9**

Classical representation of curves, Parametric analytic curves, Space curves, Hermite curves-Blending functions, properties, Bezier curves-Blending functions, properties, Composite Bezier curves and drawbacks, Non-rational B-spline curves-spline blending functions, blending function formulation, knot vector, uniform, open uniform and non uniform non rational spline blending functions, B-splines curve generation for various control points, Shape control of spline curves, properties, Rational B-spline curves-open uniform, periodic uniform and non uniform knot vector, Conic sections generation

**UNIT IV**

**Surface Description and Generation** **4**

Parametric representation, Surfaces of revolution, Sweep surfaces, Bilinear surface, Ruled and developable surfaces, Coons bicubic surfaces, Bezier and B-spline surfaces

**3D Graphics** **5**

Polygon surfaces-polygon meshes, Wire frame and Solid models-Regularized Boolean set operations, Sweep and boundary representations, Constructive Solid Geometry- unbounded and bounded primitives

**EXPERIMENTS**

**Note: Minimum Eight experiments are to be performed**

1. Understanding and use of drafting software AutoCAD
2. Sketching and solid modeling of a machine component in CAD software such as ProE/Solidworks etc.
3. Writing and validation of circle drawing algorithm
4. Writing and validation of ellipse drawing algorithm
5. Writing and validation of computer program for individual geometric transformation such as translation/rotation/ scaling
6. Writing and validation of computer program for combined geometric transformations such as translation/rotation/ scaling
7. Writing and validation of computer program for design of shaft under the combined bending and torsional loading
8. Experiments on generation of analytic curves
9. Experiments on generation of space curves
10. Experiments on generation of surfaces
11. Experiments on generation of solid models in CAD software

12. Experiments on projection of an object

**Books & References:**


1. Computer Graphics-Hearn & Baker, Prentice Hall of India
2. Computer Aided Engineering Design-Anupam Saxena & B. Sahay, Anamaya Publishers
3. CAD/CAM Theory and Practice- Ibrahim Zeid & R Sivasubramaniam, McGraw Hill
4. Mathematical Elements for Computer Graphics- DF Rogers & JA Adams, McGraw Hill
5. CAD/CAM-HP Groover & EW Zimmers Jr, Prentice Hall India Ltd
6. Computer Aided Design-S.K. Srivastava, IK International Publications
7. Computer Aided Design-R.K. Srivastava, Umesh Publications


## MME-102 SIMULATION, MODELLING AND ANALYSIS 4 Credits (3-1-0)

**UNIT I** **9**

**Introduction and Probability Concepts in Simulation:** Models and Simulation, A review of basic probability and statistics, Estimation of means variances and correlation**,** Stochastic variables, discrete and continuous probability functions, Random numbers, Generation of Random numbers, properties of random numbers ,generation of random variate, Variance reduction techniques.

**UNIT II** **9**

**Physical Modelling:** Concept of System and environment, Continuous and discrete systems, Linear and non-linear systems, Stochastic activities, Static and Dynamic models, Principles of modeling, Role of simulation in model evaluation and studies, advantages and disadvantages of simulation

**UNIT III** **9**

**System Simulation:** Techniques of simulation, Monte Carlo method, Experimental nature of simulation, Numerical computation techniques for Continuous and discrete system models, Analog simulation, Computers in simulation studies, Simulation software packages.

**UNIT IV** **9**

**System Dynamics:** Exponential Growth and Decay models, modified exponential growth models, Logistic curves, causal loop diagram, types of equations in system dynamics, System dynamics diagrams.

**Simulation of Mechanical Systems:** Simulation of translational and rotational mechanical systems, Simulation of hydraulic systems, Simulation of waiting line systems, simulation of material handling and manufacturing systems, Simulation software for manufacturing.

**Books & References:**


1. System Simulation- Geoffrey Gordon (Prentice Hall)
2. System Simulation: The Art and Science- Robert E. Shannon (Prentice Hall)
3. System Modelling and Control- J. Schwarzenbach and K.F. Gill (Edward Arnold)
4. Modelling and Analysis of Dynamic Systems- Charles M Close and Dean K. Frederick (Houghton Mifflin)
5. Simulation of manufacturing- Allan Carrie (John Wiley & Sons)


## MME-103 MACHINING SCIENCE 4 Credits (3-1-0)

**UNIT 1** **9**

Mechanics of metal cutting-Tool geometry, Mechanics of orthogonal and oblique cutting, Shear angle relations in orthogonal cutting, Shear angle and chip flow direction in oblique cutting, Chip control methods, Analysis of cutting process, Machining with rotary tools

**UNIT II** **9**

Thermodynamics of chip formation, Machining at super high speeds, Theories of tool wear, Basic action of cutting fluids, tool life, Factors governing tool life, Machinability-definition and evaluation.

**UNIT III** **9**

Economics of metal cutting-Single and multipass machining operations, Criteria, variables, and restrictions for the economical conditions

**UNIT IV** **9**

Dynamic metal cutting-Comparison of steady and dynamic process, Shear angle and force relationships, Grinding mechanics, Wheel characteristics and theory of wheel wear, Lapping, Honning, High speed grinding theory, Grinding of drills, form cutters etc., Problems associated with machining of plastics, Tools for plastic cutting, Analysis of non-conventional machining processes ECM, EDM, LBM, WJM, USM etc.

**Books & References:**


1. Metalwork and Machining Hints and tips (Workshop Practice)- Arnold Throp
2. Machining Fundamentals- Walker John R (Goodheart)
3. Introduction to Machining Science- GK Lal (New Age International)
4. Non-Conventional Machining- P K Mishra (Narosa)


## MME-104 ADVANCED COMPUTER AIDED MANUFACTURING 5 Credits (3-1-2)

**UNIT I** **9**

**Introduction:** Introduction to CAM, CAD/CAM interface, Introduction to Automation, Historical developments and future trends, automation in production system, automation strategies, advantages and disadvantages of automation, Need of NC system, fundamental of NC machine tool, Classification of NC machine tool, suitability and limitations, applications of NC system.

**UNIT II** **9**

**Features of CNC machine tool:** Development in MCU technology, Principle of operation of CNC, standard controllers, Design considerations of CNC machines for improving machining accuracy – structural members, slideways, spindle drive, feed drive, lead screws; Methods for improving productivity , work holding device, automatic tool changer, features of CNC machining centres

**Control of CNC Systems:** Open and Closed loop control systems, feedback devices, interpolators, Adaptive control systems.

**UNIT III** **9**

**CNC Part Programming:** Part programming fundamentals**,** Manual Programming for turning, milling, drilling, etc., Tool length compensation, cutter radius compensation, canned cycle, Do loops, Subroutine and Macro; Concept of computer aided part programming, APT language structure, Geometry, motion and post processor commands, APT part program.

**UNIT IV** **9**

**FMS, CIMS & CAPP:** Building blocks of flexible manufacturing systems (FMS), tool management systems, workpiece handling systems, FMS control, computer integrated manufacturing systems, computer aided process planning- variant and generative process planning.

**EXPERIMENTS**

1. Study on Retrofitting of Conventional Milling Machine to CNC Milling Machine.
2. To study the characteristics features of CNC lathe trainer (Model SS-PT-100).
3. To study the characteristics features of CNC Turning (XLTURN)
4. To study the characteristics features of CNC Milling (XLMILL)
5. Write a manual part program for turning operations and prepare the component on CNC Turning.
6. Write a manual part program for Grooving and threading operations and prepare the component on CNC Turning.
7. Write a manual part program for Peck drilling operations and prepare the component on CNC Turning.
8. Write a manual part program using linear and circular interpolation for CNC Milling and prepare the component.
9. Write a manual part program for rectangular pocket milling operation for CNC Milling and prepare the component.
10. Study and perform operations of Flexible Manufacturing System.

**Books & References:**

1. Computer Control of Manufacturing Systems- Koren (McGraw- Hill)
2. CAD/CAM- Groovers (Prentice Hall)
3. NC Machine Tools- S J Martin
4. CAD/CAM- P N Rao (Tata McGraw Hill)
5. CAD/CAM- P Radhakrishnan, S Subramanyam, V Raju
6. Computer Aided Manufacturing- Chang, Wysk & Wang (Prentice Hall of India)

## MME-105 ADVANCE MACHINING PROCESSES 4 Credits (3-1-0)

**UNIT I** **9**

**Introduction:** Limitations of Conventional machining processes, Need of advanced machining processes and its classification.

**UNIT II** **9**

**Mechanical Type Metal Removal Processes:** Ultrasonic machining; Elements of the process; Tool design and economic considerations; Applications and limitations, Abrasive jet and Abrasive water jet machining principles; Mechanics of metal removal; Design of nozzles; applications, Abrasive finishing process, Magnetic abrasive finishing process

**UNIT III** **9**

**Thermal Type Advance Machining Processes:** Classification, General principles and applications of Electro discharge, Plasma arc, Ion beam, Laser beam, Electron beam machining, Mechanics of metal removal in EDM, selection of EDM pulse generator dielectric, machining accuracy, surface finish and surface damage in EDM, Generation and control of electron beam for machining applications, advantages and limitations

**UNIT IV** **9**

**Chemical and Electro-chemical Type Metal Removal Processes:** Principle, working advantages, disadvantages and applications of Electrochemical, Chemical machining, Economy aspects of ECM, Electro-chemical deburring and honning

**Hybrid Unconventional Machining Processes:** Introduction to ECDM, ECAM, Abrasive EDM etc.

**Books & References:**

1. Advance Machining Processes- V.K. Jain (New Age)
2. Modern Machining Processes- P.C. Pandey (New Age)
3. Manufacturing Processes- Degarmo
4. Manufacturing Processes- Kalpakjian (Tata McGraw-Hill International)

## MME-151 ADVANCE MACHINING PROCESSES 4 Credits (3-1-0)

**UNIT I** **9**

**Machine Tool Drive:** working and auxiliary motion in machine, Machine tool drives, Hydraulic transmission, Mechanical transmission, General requirements of machine tool design, Layout of machine tools.

**Regulation of Speed and Feed Rates:** Aim of speed feed regulation, stepped regulation of speed, design of speed box, Design of feed box, Special cases of gear box design, Set stopped regulation of speed and feed rates.

**UNIT II** **9**

**Design of Machine Tool Structure:** Fundamentals of machine tool structures and their requirements, Design criteria of machine tool structure, Static and dynamic stiffness, Design of beds and columns, Design of housing models, Techniques in design of machine tool structure.

**UNIT III** **9**

**Design of Guide-ways and power Screws:** Function and type of guide-ways, design of slide-ways, Protecting devices for slide-ways, Design of power screws.

**UNIT IV**

**Design of Spindles and Spindle Supports:** Materials for spindles, Design of spindles, Antifriction bearings, sliding bearings. **Dynamics of Machines Tools:** General procedure of assessing dynamic stability of EES, Cutting processing, closed loop system, Dynamic characteristics of cutting process, Stability analysis.

**Books & References:**


1. Machine Tool Design- N.K. Mehta (Tata McGraw Hill)
2. Machine Tool design Handbook (CMTI Bangalore)


## MME-152 COMPUTER AIDED PROCESS PLANNING 4 Credits (3-1-0)

**UNIT I** **9**

Introduction to CAPP: Information requirement for process planning system, Role of process planning, advantages of conventional process planning over CAPP, Structure of Automated process planning system, Feature recognition, Generative CAPP system: Importance, principle of Generative CAPP system, automation of logical decisions, Knowledge based systems, Inference Engine, implementation, benefits. Retrieval CAPP system: Significance,

**UNIT II** **9**

Group technology, structure, relative advantages, implementation, and applications, Selection of manufacturing sequence: Significance, alternative-manufacturing processes, reduction of total set-up cost for a particular sequence, quantitative methods for optimal selection, examples. Determination of machining parameters: reasons for optimal selection of machining parameters, effect of parameters on production rate, cost and surface quality, different approaches, advantages of mathematical approach over conventional approach, solving optimization models of machining processes.

**UNIT III** **9**

Determination of manufacturing tolerances: design tolerances, manufacturing tolerances, methods of tolerance allocation, sequential approach, integration of design and manufacturing tolerances, advantages of integrated approach over sequential approach

**UNIT IV** **9**

Determination of optimal index positions for executing fixed sequence, Quantitative methods, Implementation techniques for CAPP: MIPLAN system, Computer programming languages for CAPP, criteria for selecting a CAPP system and benefits of CAPP. Computer integrated planning systems, and Capacity planning system.

**Books & References:**


1. Mikell P. Groover, Automation, Production systems and Computer Integrated Manufacturing System, Prentice Hall, 2007.
2. Sadhu Singh, Computer Aided Design and Manufacturing, Khanna Publishers, New Delhi, 2003.


## MME-153 DESIGN FOR MANUFACTURE 4 Credits (3-1-0)

**UNIT I** **9**

**Introduction:** Introduction, Concept and need of concurrent Engineering, Automation of design and manufacturing functions in CIM, Computer Aided Process Planning, Design for X, Approach to DFM & DFM, Design for automated manufacturing and design for economic manufacturing.

**Effect of Materials & manufacturing processes on Design:** Major phases in design & Manufacture, Effect of material properties on design, Effect of manufacturing process on design, Material selection process, Cost per unit property & Weighted properties method.

**UNIT II** **9**

**Design Quality:** Quality by Design, QFD, Taguchi's concept of Quality Loss function parameter design, comparing alternate designs, tolerance design, system optimization, Robust design.

**Design for Reliability:** Basic concepts, reliability analysis during design phase, failure mode analysis, reliability analysis of mechanical systems, design guidelines for reliability, reliability tests, quality and reliability assurance during production phase.

**UNIT III** **9**

**Design Knowledge Representation: D**esign for manufacturing and re-design considerations in automated CAD/CAM systems. Design and manufacturing knowledge representation, Knowledge representation for DFM support, Intelligent evaluation of design for manufacturing cost.

**UNIT IV** **9**

**Evaluation for Manufacturability:** Evaluation of the manufacturability of a part design, methods for defining manufacturability index, Interpretation of the MI value, Manufacturability evaluation, a multi criteria approach.

**Books & References:**


1. Integrated Product Development- M.M. Anderson and L Hein (IFS Publications)
2. Product Design for Manufacture -G Boothroyd, P Dewhurst and W Knight (Marcel Dekker)
3. Design for Manufacture- Harry Peck (Pitman Publications)
4. Handbook of Product Design for Manufacture: A Practical Guide to Low Cost Production- J.G. Bralla (McGraw Hill)
5. Concurrent Engineering- Kusiak (Wiley Eastern)
6. Engineering Design A Materials and Processing Approach- G Dieter (McGraw Hill)
7. Competitive Product design for Manufacturability- Barkan and Ishvi (McMillan)
8. Engineering Design Products, Process and Systems- Kusiak (Academic Press)


## MME-154 ROBOTIC ENGINEERING 4 Credits (3-1-0)

**UNIT I**

**Introduction** **5**

Definition, Classification of Robots, Geometric classification and control classification, Robot Components-manipulator, controller and its elements, sensory devices, Functions of a robot system, Robot specifications and applications,

**Robot Sensors** **4**

Introduction, Classification, Non-optical position sensors, Optical position sensors, Velocity sensors, Acceleration sensors, Contact and non-contact type proximity sensors

**UNIT II**

**Mechanical Systems: Components, Dynamics and Modelling** **9**

Introduction, Linear motion, Rotational motion, Moment of Inertia-calculation and measurement, Mechanical work and power, Motion conversion, Rotary-to-rotary motion, Rotary-to-linear motion, Problems with real world components, Modelling of mechanical systems, elements, examples

**UNIT III**

**Robot Control** **5**

Introduction, Closed-loop control in position servo, Effect of friction and gravity, DC servomotor, position with no friction or gravity, position with nonzero friction and/or gravity, PID control of position servo, Frequency domain characteristics-Bode plots

**Robot Programming** **4**

Robot control sequencing, Language based programming, Program algorithm, examples, robot programming for foundry, welding, machine tools, material handling, warehousing assembly, etc.

**UNIT IV**

**Manipulator Kinematics** **4**

Homogeneous coordinates, Coordinate transformations-translational, rotational, Matrix operators, Coordinate reference frames, Homogeneous transformations and the manipulator, forward solution, inverse solution, examples.

**Robot Design** **5**

Introduction, Egg packing problem, Robot design and process specifications-system specifications, mechanical description, motion sequence, motor and drive selection, encoder selection, Vision system consideration, Robot economics and safety

**Books & References:**


1. Robotic Engineering-R.D. Kaftler, T.A. Chmielewski and M. Negin, Prentice-Hall International
2. Robotic Technology-Phillipe Collet, Prentice Hall of India
3. An Introduction to Robot Technology- Coiffet and Chirooza, Kogan Page
4. Robotics for Engineers- Y. Koren, McGraw Hill
5. Robotics - K.S. Fu, R.C. Gonzalez & CSG Lee, McGraw Hill International
6. Introduction to Robotics - J.J. Craig, Pearson Education
7. Industrial Robots- Groover, Mitchell Weiss, Nagel Octrey- McGraw Hill
8. Robots & Manufacturing Automation - Asfahl , Wiley Eastern
9. Robotics-K.C. Jain and L.N. Aggrawal, Khanna Publishers


## MME-155 ROBUST DESIGN 4 Credits (3-1-0)

**UNIT I** **9**

**Quality by Experimental Design:** Quality, western and Taguchi quality philosophy, Elements of cost, Noise factors causes of variation, Quadratic loss function and variation of quadratic loss functions.

**Robust Design:** Steps in robust design: parameter design and tolerance design, reliability improvement through experiments, Illustration through numerical examples.

**UNIT II** **9**

**Experimental Design:** Classical experiments: factorial experiments, terminology, factors. Levels, Interactions, Treatment combination, randomization, 2-level experimental design for two factors and three factors, 3-level experiment deigns for two factors and three factors, factor effects, factor interactions, Fractional factorial design, Saturated design, Central composite designs, Illustration through numerical examples

**UNIT III** **9**

**Analysis and interpretation of experimental data:** Measures of variability, Ranking method, column effect method and plotting method, Analysis of variance (ANOVA), in factorial experiments: YATE's algorithm for ANOVA, Regression analysis, Mathematical models from experimental data, illustration through numerical examples

**UNIT IV** **9**

**Taguchi's Orthogonal Arrays:** Types orthogonal arrays, Selection of standard orthogonal arrays, Linear graphs and interaction assignment, dummy level technique, Compound factor method, modification of linear graphs, Column merging method, Branching design, Strategies for constructing orthogonal arrays.

**Signal to Noise ratio (S-N Ratios) :** Evaluation of sensitivity to noise, Signal to noise ratios for static problems, Smaller – the – better types, Nominal – the – better – type, larger – the- better – type. Signal to noise ratios for dynamic problems, Illustrations through numerical examples.

**Parameter Design and Tolerance Design :** Parameter and tolerance design concepts, Taguchi's inner and outer arrays, Parameter design strategy, Tolerance deign strategy, Illustrations through numerical examples**.**

**Books & References:**


1. M. S. Phadake - Quality Engineering using Robust Design, Prentice Hall, Englewood Clifts, New Jersey, 1989.
2. Douglas Montgomery, Design and analysis of experiments, Willey India Pvt. Ltd., 5th Edition, 2007.
3. P. J. Ross, Taguchi, Techniques for Quality Engineering, 2nd Edition. McGraw Hill Int. Edition, 1996.
4. T. B. Barker, M. Dekker, Quality by Experimental Design, Inc ASQC Quality Press, 1985.
5. C. F. Jeff Wu, Michael Hamada, Experiments planning, analysis and parameter design optimization, John Willey Ed., 2002.
6. W. L. Condra, Marcel Dekker, Reliability improvement by Experiments, Inc ASQC Quality Press, 1985.

## MME-156 MICRO-MACHINING AND PRECISION ENGINEERING 4 Credits (3-1-0)

**UNIT I** **9**

Introduction to micromachining technologies, bulk micromachining, LIGA, Surface Micromachining, Characterization of micro-machining, Tool making, Micromachinability of materials, Diamond micro-machining: machining principles, diamond turning, diamond grinding, accuracy and dimensional control, , future trends in ultrahigh speed machining

**UNIT II** **9**

Microelectro discharge Machining: Principles of micro-EDM, micro-EDM by Die-sinking and WEDG, micro-WEDM, micro-WEDG, micro-ECM, Principles of micro-turning, micro-drilling and micro-milling, hybrid micro-machining method, on-line measurement by machine vision and integrated probe. ;

**UNIT III** **9**

Abrasive micromachining and micro grinding: Abrasive micromachining mechanisms, micro-grinding mechanism, micro-machining rate, micro-machining cooling media; Laser micromachining: Principles of laser material removal, laser micro-drilling, laser micro-adjustment, laser surface structuring, laser micro-cutting;

**UNIT IV** **9**

Micro-machining by finishing techniques: micro-lapping, microhoning, magneto-abrasive micromachining and finishing (MAF), ELID Grinding, Measuring Techniques in micro-machining: stylus instruments, scanning tunneling microscopes, atomic force microscope, measurement of micromoles and slots using optical method, elastic transmission method, computer aided measurement testing, surface integrity and other related measurements

**Books & References:**


1. J. M. Geough, Micro-machining of Engineering Materials, Edited by Marcel Dekker, 2002
2. R.W. Johnstone, M. Parameswaran, An introduction to surface-micromachining, Kluwer Academic Publishers, 2004
3. N. P Mahalik. Micro-manufacturing and nano-technology, edited by, Springer Publication, 2006
4. M. P. Groover, Automation, Production Systems and Computer-Integrated Manufacturing, 2003


## MME-157 PRODUCTION & OPERATIONS MANAGEMENT 4 Credits (3-1-0)

**UNIT I** **9**

**Introduction:** Operations strategy, Framework for operations strategy in manufacturing, Operations strategy services, Meeting the competitive challenges. Selection of forecasting method, Focus forecasting, Aggregate planning techniques, Inventory systems for independent demand, Fixed order quantity and fixed time period models, Inventory systems for independent time period models, Inventory systems for dependent demand, MRP type systems, Embedding JIT into MRP, Lot sizing in MRP, Advanced MRP Systems

**UNIT II** **9**

**Operations Scheduling:** Scheduling & control functions, Priority rules and techniques, Single machine scheduling problems, Scheduling in jobs on 'm' machines, Personal scheduling, Simulation methodology, Two assembly simulation

**UNIT III** **9**

**Design of Facilities & Jobs:** Strategic capacity planning concepts, determining capacity requirements, Planning service capacity, JIT production systems, JIT implementation requirements, Facility location, Plant location methods, Facility, Process and Product layout, GT layout, Retail service layout, Computer aided layout techniques, Job design and work measurement, Considerations in job design, Work measurements and standards, Financial incentive plans, Learning curves and its applications

**UNIT IV** **9**

**Product Design & Process Selection:** Product design process, Designing for the customer QFD, Value analysis, designing products for manufacturer & assembly. Process selection, product process matrix, Choosing from alternative processes & equipment, Virtual factory, Waiting line management & models, Quality management,

Quality specifications & costs, Tolls and procedures for continuous improvement, Shingo system of fail-safe design, Review of SQC models

**Books & References:**


1. Operations management- Buffa (John Wiley)
2. Operations management- Starr (Prentice Hall)
3. Production and Operations management- Adam & Ebert (Prentice Hall India)


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**MME-158 RAPID PROTOTYPING AND TOOLING 4 Credits (3-1-0)**

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**UNIT I** **9**

**Introduction:** Historical developments, Fundamentals of RP Systems and its Classification, Rapid prototyping process chains, 3D modeling and mesh generation, Data conversion and transmission

**UNIT II** **9**

**RP Systems:** Liquid polymer based rapid prototyping systems, Teijin Seikis' solid form and other similar commercial RP systems, Solid input materials based rapid prototyping systems, laminated object manufacturing (LOM) and fused deposition modelling systems etc., Power based rapid prototyping systems, selective Laser sintering, Soligen Diren's shell production casting (DSPC), Fraunhofer's multiphase jet solidification (MJS) and MIT's 3D printing (3DP) etc.

**UNIT III** **9**

**RP Database:** Rapid prototyping data formats, STL format, STL file problems, STL file repair, Network based operations, Digital inspection, Data warehousing and learning from process data.

**UNIT IV** **9**

**RP Applications:** Development of dies for moulding, RP applications in developing prototypes of products, application in medical fields, Development of bone replacements and tissues, etc., RP materials and their biological acceptability.

**Books & References:**


Rapid Prototyping Of Digital Systems: A Tutorial Approach- Hamblen James O (Kluwer Aca)
Rapid Prototyping: Principles And Applications- Kai Chua Chee (World Scie)
Rapid System Prototyping With Fpgas: Accelerating The Design Process- R C Cofer (Newnes)
Rapid Prototyping of Digital Systems- James O Hamblen (Springer)

# MECHANICAL ENGINEERING DEPARTMENT
# M. M. M. UNIVERSITY OF TECHNOLOGY
# GORAKHPUR

## COURSES OFFERED

### Program Core (Energy Technology and Management)

| S.N. | Paper Code | Subject | Prerequisite Subject | L | T | P | Credits |
|---|---|---|---|---|---|---|---|
| 1. | MAS-101 | Numerical Methods & Engineering Optimization | - | 3 | 1 | 2 | 5 |
| 2. | MME-201 | Energy Conversion Systems | Applied Thermodynamics | 3 | 1 | 2 | 5 |
| 3. | MME-202 | Renewable Energy Systems | NCER | 3 | 1 | 0 | 4 |
| 4. | MME-203 | Energy Scenario and Policy | Alternate Energy | 3 | 1 | 0 | 4 |
| 5. | MME-204 | Advanced Heat Transfer | Heat Transfer | 3 | 1 | 2 | 5 |
| 6. | MME-205 | Energy Management and Audit | - | 3 | 1 | 0 | 4 |
| 7. | MME-220 | Minor Project | - | 0 | 0 | 8 | 4 |
| 8. | MME-230 | Dissertation Part-I | - | 0 | 0 | 8 | 4 |
| 9. | MME-240 | Seminar | - | 0 | 0 | 4 | 2 |
| 10. | MME-250 | Dissertation Part-II | Dissertation Part-I | 0 | 0 | 28 | 14 |

### Program Electives PE1 & PE2 (Energy Technology and Management)

| S.N. | Paper Code | Subject | Prerequisite Subject | L | T | P | Credits |
|---|---|---|---|---|---|---|---|
| 1. | MME-251 | Economics and Planning of Energy Systems | - | 3 | 1 | 0 | 4 |
| 2. | MME-252 | Power Plant Engineering | Applied Thermodynamics | 3 | 1 | 0 | 4 |
| 3. | MME-253 | Computer Aided Design of Thermal Systems | Computer Aided Design | 3 | 1 | 0 | 4 |
| 4. | MME-254 | Combustion Engineering | Applied Thermodynamics | 3 | 1 | 0 | 4 |
| 5. | MME-255 | Wind Energy and Hydro Power Systems | NCER | 3 | 1 | 0 | 4 |
| 6. | MME-256 | Energy Storage Systems | NCER | 3 | 1 | 0 | 4 |
| 7. | MME-257 | Hydrogen Energy | NCER | 3 | 1 | 0 | 4 |

### Program Electives PE3 & PE4 (Energy Technology and Management)

| S.N. | Paper Code | Subject | Prerequisite Subject | L | T | P | Credits |
|---|---|---|---|---|---|---|---|
| 1. | MME-261 | Finite Element Method | - | 3 | 1 | 0 | 4 |
| 2. | MME-262 | Energy Modeling and Project Management | - | 3 | 1 | 0 | 4 |
| 3. | MME-263 | Advanced Materials Technology | Material Science | 3 | 1 | 0 | 4 |
| 4. | MME-264 | Alternative Fuels for Transportation | I.C. Engines | 3 | 1 | 0 | 4 |
| 5. | MME-265 | Nuclear Science and Engineering | - | 3 | 1 | 0 | 4 |
| 6. | MME-266 | Gas Turbines and Compressors | Applied Thermodynamics | 3 | 1 | 0 | 4 |
| 7. | MME-267 | Environmental Impact of Energy Systems | - | 3 | 1 | 0 | 4 |

# SYLLABI

**MME-201 ENERGY CONVERSION SYSTEMS 5 Credits (3-1-2)**

**UNIT I** **9**

**Classification of Energy Sources:** Classification of Energy Sources, Principle fuels for energy conversion: Fossil fuels, Nuclear fuels. Energy Sources: prospecting, extraction and resource assessment and their peculiar characteristics, Direct use of primary energy sources, Conversion of primary into secondary energy sources such as Electricity, Hydrogen, Nuclear energy etc., Energy Conversion through fission and fusion, Nuclear power generation etc

**UNIT II** **9**

**Thermal and Mechanical Energy:** Thermal energy using fossil fuels. Conversion of Thermal Energy to Mechanical energy & Power, Turbines: Steam turbines, Hydraulic turbines

**Thermal and Mechanical Energy Utility systems:** Boilers -Types, combustion in boilers, performance evaluation, analysis of losses, feed water treatment, blow down.

FBC Boilers: Introduction, mechanism of fluidized bed combustion, advantages, types of FBC boilers, operational features, retrofitting FBC system to conventional boilers

**UNIT III** **9**

Refrigeration and Air Conditioning: Vapor compressor refrigeration cycle, refrigerants, coefficient of performance, capacity, factors affecting refrigeration and air conditioning system performance, Vapor absorption refrigeration systems: Working principle, type and comparison with vapor compressor system.

**Basics of Mechanical Engineering (Energy Related) :** Sterling Engines, Steam Engine, Internal Combustion systems and external combustion system, Power Transmission: Concepts of Belts Drives, Gearing, Coupling etc. Bearing and Lubricants as Energy Saving Measures

**UNIT IV** **9**

**Co-generation, Tri-generation & Waste Energy Recovery:** Co-generation & Tri-generation: Definition, need, application, advantages, classification, saving Potential. Waste Heat Recovery: Concept of conversion efficiency, energy waste, waste heat recovery classification, advantages and applications, commercially viable waste heat recovery devices. Thermal Energy Measurements

**EXPERIMENTS**

**Note: Minimum Eight experiments are to be performed**

1. Experiment on Boilers
2. Experiment on Steam Turbines
3. Experiment on Hydraulic Turbines
4. Experiment on Vapour compressor Refrigeration
5. Experiment on Vapour absorption Refrigeration
6. Experiment on Sterling Engine
7. Experiment on Steam Engines
8. Experiments on Internal Combustion systems
9. Experiments on Power Transmission

**Books & References:**


1. Direct Energy Conversion : W.R. Corliss
2. Aspects of Energy Conversion : I.M. Blair and B.O. Jones
3. Principles of Energy Conversion : A.W.Culp ( McGrawHill International
4. Energy conversion principles : Begamudre , Rakoshdas
5. Fuel Economy Handbook, NIFES,
6. Industrial Furnaces (Vol I & II) and M.H. Mawhinney, (John Wiley Publications)
7. Refractories – F.H. Nortan,(John Wiley Publication.)
8. Domestic and commercial oil Burners Charles H. Burkhadt ( McGraw Hill Publication)
9. The efficient use of steam – Oliver Lyle, (HMSO London)
10. Boilers – Types, Characteristics and functions – Carl D. Shields (McGraw Hill book )

11. The Efficient use of steam generation – General editor – P.M. Goodall

## MME-202 RENEWABLE ENERGY SYSTEM 4 Credits (3-1-0)

**UNIT I** **9**

**Solar Energy:** Sun as Source of Energy, Availability of Solar Energy, Nature of Solar Energy, Solar Energy & Environment. Various Methods of using solar energy –Photothermal, Photovoltaic, Photosynthesis, Present & Future Scope of Solar energy

Hybrid wind energy systems - wind + diesel power, wind + conventional grid, wind + Photovoltaic system etc

**Bio-mass energy:** Biomass: Generation and utilization, Properties of biomass, Agriculture Crop & Forestry residues used as fuels. Biochemical and Thermo-chemical Conversion, Combustion, Gasification, Biomass gasifiers and types etc., Applications of Gasifiers to thermal power and Engines, Biomass as a decentralized power generation source for villages

**UNIT II** **9**

**Wind Energy:** Wind Energy: Basics & Power Analysis, Wind resource assessment, Power Conversion Technologies and applications, Wind Power estimation techniques, Principles of Aerodynamics of wind turbine blade, Various aspects of wind turbine design, Wind Turbine Generators: Induction, Synchronous machine, constant V & F and variable V & F generations, Reactive power compensation. Site Selection, Concept of wind form & project cycle, Cost economics

**UNIT III** **9**

**Geothermal, Tide and Wave Energy :** Availability of Geothermal Energy-size and Distribution, Recovery of Geothermal Energy, Various Types of Systems to use Geothermal Energy, Direct heat applications, Power Generation using Geothermal Heat, Sustainability of Geothermal Source, Status of Geothermal Technology, Economics of Geothermal Energy.

**UNIT IV** **9**

**Fuel Cell:** Fuel cell – Principle of working, construction and applications

**Hydel Energy:** Hydro power: Potential, Hydropower Generation and Distribution, Mini and Microhydel Power (MHP) Generation: Classification of hydel plants, Concept of micro hydel, merits, MHP plants: Components, design and layout, Turbines, efficiency, Status in India.

**Books & References:**


1. Renewable Sources of Energy and Conversion Systems: N.K. Bansal and M.K. Kleeman
2. Principles of Thermal Process: Duffie -Beckman.
3. Solar Energy Handbook: Kreith and Kreider (McGraw Hill)
4. Solar Cell : Marteen A. Green
5. Solar Hydrogen Energy Systems -T. Ohta (Ed.) (Pergamon Press)
6. Biomass Renegerable Energy – D.O.hall and R.P. Overeed
7. Handbook : Batteries and Fuel cell – Linden (McGraw Hill)
8. Wind energy Conversion Systems – Freris L.L. (Pr entice Hall1990)


## MME-203 ENERGY SCENARIO AND POLICY 4 Credits (3-1-0)

**UNIT I** **9**

Role of energy in economic development and social transformation: Energy & GDP, GNP and its dynamics. Discovery of various energy, Energy Consumption in various sectors and its changing pattern, Exponential increase in energy consumption and future demands, Future Energy Options

**UNIT II** **9**

Energy resources & Consumption: Commercial and noncommercial forms of energy, Fossil fuels, Renewable sources including Bio-fuels in India, their utilization pattern in the past, present and future projections of consumption pattern, Sector wise energy consumption

**UNIT III** **9**

Energy Policy Issues: Fossil Fuels, Renewable Energy, Power sector reforms, restructuring of energy supply sector, energy strategy for future. Energy Conservation Acts, Global Energy Issues, National & State Level Energy Issues,

**UNIT IV** **9**

Energy Security, International Energy Policies of G-8 Countries, G-20 Countries, OPEC Countries, EU-Countries International Energy Treaties (Rio, Montreal, Kyoto), INDO-US Nuclear Deal

**Books & References:**


1. Energy for a sustainable world: Jose Goldenberg, Thomas Johansson, A.K.N. Reddy, Robert Williams (Wiley Eastern).
2. Energy policy: B.V. Desai (Wiley Eastern)
3. Modeling approach to long term demand and energy implication: J.K. Parikh
4. Energy Policy and Planning: B. Bukhootsow
5. TEDDY Year Book Published by Tata Energy Research Institute (TERI)
6. World Energy Resources : Charles E. Brown, Springer, 2002


## MME-204 ADVANCED HEAT TRANSFER 5 Credits (3-1-2)

**UNIT I** **9**

**Review:** Reviews of basic laws of Conduction, Convection and Radiation

**Conduction:** One dimensional steady state conduction with variable thermal conductivity and with internal distributed heat source, Local heat source in non-adiabatic plate, Thermocouple conduction error, Extended Surfaces-Review, Optimum fin of rectangular profile, straight fins of triangular and parabolic profiles, Optimum profile, Circumferential fin of rectangular profile, spines, design considerations.

**UNIT II** **9**

2D steady state heat conduction, semi -infinite and finite flat plates, Temperature fields in finite cylinders and in infinite semi-cylinders, spherical shells, Graphical method, relaxation technique, Unsteady state conduction, Sudden changes in the surface temperatures of infinite plates, cylinders and spheres using Groeber's and Heisler charts for plates, cylinders and spheres suddenly immersed in fluids.

**UNIT III** **9**

**Radiation:** Review of radiation principles, Diffuse surfaces and the Lambert's cosine law. Radiation through non-absorbing media, Hottel's method of successive reflections, Gebhart's unified method, Poljak's method. Radiation through absorbing media, Logarithmic decrement of radiation, Apparent absorptive of simple shaped gas bodies, Net heat exchange between surfaces separated by absorbing medium, Radiation of luminous gas flames.

**UNIT IV** **9**

**Convection:** Heat transfer in laminar flow, free convection between parallel plates, Forced internal flow through circular tubes, Fully developed flow, Velocity and thermal entry length, solutions with constant wall temperature and with constant heat flux, Forced external flow over a flat plate, two-dimensional velocity and temperature boundary layer equations, Karman Pohlhousen approximate integral method. Heat transfer in turbulent flow, Eddy heat diffusivity, Reynold's analogy between skin friction and heat transfer, Prandtl-Taylor, Von Karman and Martineli's analogies, Turbulent flow through circular tubes.

**EXPERIMENTS**

**Note: Minimum Eight experiments are to be performed**

1. Experiment on Conduction - Composite wall experiment
2. Experiment on Conduction - Composite cylinder experiment
3. Experiment on Convection - Pool Boiling experiment
4. Experiment on Convection - Experiment on heat transfer from tube-natural convection.
5. Experiment on Convection - Heat Pipe experiment.
6. Experiment on Convection - Heat transfer through fin-natural convection .
7. Experiment on Convection - Heat transfer through tube/fin-forced convection.
8. Experiment on Any experiment on Stefan's Law, on radiation determination of emissivity, etc.
9. Experiment on Any experiment on solar collector, etc.

10. Experiment on Heat exchanger - Parallel flow experiment
11. Experiment on Heat exchanger - Counter flow experiment
12. Experiment on Any other suitable experiment on critical insulation thickness.
13. Experiment on Conduction - Determination of thermal conductivity of fluids.
14. Experiment on Conduction - Thermal Contact Resistance Effect.

**Books & References:**


1. Advances in Heat Transfer- James P Hartnett (Academic Press)
2. Principles of Heat Transfer- Kaviany M (Wiley-International)
3. Heat Transfer: Principles and Applications-B.K. Datta (Prentice Hall of India)
4. Heat Transfer Calculations- Myer Kutz (McGraw-Hill)
5. Convective Heat Transfer- Burmeister Louis (Wiley-International)


## MME-205 ENERGY MANAGEMENT AND AUDIT 4 Credits (3-1-0)

**UNIT I** **9**

**Energy Management:** Definition & Objectives of Energy Management; Importance; Indian need of Energy Management; Duties and responsibilities of energy managers, Energy conservation in boilers, steam turbines and industrial heating systems; Application of FBC; Cogeneration and waste heat recovery; Thermal insulation; Heat exchangers and heat pumps; Building Energy Management.

**UNIT II** **9**

**Energy Audit:** Energy Audit: Types and Methodology; Energy Audit Reporting Format; Understanding Energy Costs; Benchmarking and Energy Performance; Matching Energy Usage to Requirement; Maximising System Efficiency; Fuel and Energy Substitution; Energy Audit Instruments; Duties and responsibilities of energy auditors.

**UNIT III** **9**

**Material and Energy Balance:** Basic Principles; The Sankey Diagram and its Use; Material Balances; Energy Balances; Method for Preparing Process Flow Chart; Facility as an Energy System; How to Carryout Material and Energy (M & E) Balance.

**UNIT IV** **9**

**Energy Action Planning:** Key elements; Force field analysis; Energy policy purpose, perspective, contents, formulation, ratification; Organizing the management: location of energy management, top management support, managerial function, accountability; Motivation of employees: Information system-designing barriers, strategies; Marketing and communicating: Training and planning.

**Books & References:**


1. Energy Management: W.R. Murphy, G. Mckay (Butterworths).
2. Energy Management Principles: C.B. Smith (Pergamon Press).
3. Efficient Use of Energy : I.G.C. Dryden (Butterworth Scientific)
4. Energy Economics -A.V. Desai (Wieley Eastern)
5. Industrial Energy Conservation : D.A. Reay (Pergammon Press)
6. Energy Management Handbook – W.C. Turner (John Wiley and Sons, A Wiley Interscience Publication)
7. Industrial Energy Management and Utilization–L .C. Witte, P.S. Schmidt, D.R. Brown (Hemisphere Publication, Washington)


## MME-251 ECONOMICS AND PLANNING OF ENERGY SYSTEMS 4 Credits (3-1-0)

**UNIT I** **9**

Relevance of financial and economic feasibility, Evaluation of energy technologies and systems, Basics of engineering economics, Financial evaluation of energy technologies, Social cost benefit analysis, Case studies on techno-economics of energy conservation and renewable energy technologies.

**UNIT II** **9**

Energy demand analysis and forecasting, Energy supply assessment and evaluation, Energy demand – supply balancing, Energy models, Software for energy planning,

**UNIT III** **9**

Energy – economy interaction, Energy investment planning and project formulation. Energy pricing, Policy and planning implications of energy – environment interaction, clean development mechanism, technology transfer and its financing

**UNIT IV** **9**

Carbon credits and trading opportunities, Financing of energy systems, Energy policy related acts and regulations

**Books:**

1. Economic Issues of Renewable Energy Systems Gerhard Oelert, Falk Aner & Klaus Pertz
2. Energy Policy: B. G. Desai

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## MME-252 POWER PLANT ENGINEERING 4 Credits (3-1-0)

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**UNIT I** **9**

**Introduction:** Rankine cycle with reheat & regeneration; Binary vapour cycle and flow through nozzles; Energy resources & development of power in India; Hydro, thermal and nuclear energy; present power position & Future planning of policies in India.

**Thermal Power Plants:** Introduction, Fossil fuel & its resources; Fuel properties and storage, Classification of coal; Use of high ash coal, Lignite coal, Drying, Storage and handling of liquid fuels, Types of petroleum fuels; Producer gas; Fuel firing; Furnaces construction; Grates; Pulverizes; Oil & gas burners and fluidized bed combustion system, Ash handling and flue gas analysis; High pressure boilers; Super critical boilers; Steam plant accessories; Effect of component characteristics on the plant performance and variable load problem.

**UNIT II** **9**

**Diesel Electric Power Plants**: Field of use, Outline of diesel power plant, different systems, Super charging, Diesel plant efficiency & heat balance, Research in diesel power plant.

**Gas Turbine Plants:** Introduction, Classification; Types of gas turbine plants; Analysis of closed and open cycle, Constant pressure gas turbine plants; Methods to improve the thermal efficiency of a simple open cycle constant pressure gas turbine plant; Auxiliaries & controls. Environmental impact of gas turbine power plants

**UNIT III** **9**

**Hydro Electric Power Plants:** Hydrology-rainfall, Runoff & its measurement, Hydrograph & storage of water; Classification of Hydro units; Design, construction & operation of different components of hydroelectric power stations. **Nuclear Power Plants:** Principles of nuclear energy; Classification, Main parts of nuclear reactors; Types of reactors; PWR, BWR, Heavy water reactors, gas cooled reactor, Liquid metal cooled reactors; Organic moderated cooled reactors, Breeder reactors plant operation, safety features & Radioactive waste disposal.

**Non-Conventional Power Generation:** Introduction; Geo thermal power; Tidal; solar & Wind power plants and direct energy conversion systems.

**UNIT IV** **9**

**Economic analysis of Power Plants and its Tariffs:** Instrumentation & control in thermal power plants, energy conservation & management.

**Environmental aspects of Power Generation:** Pollutants from fossils fuels and health hazards, Control of emissions and particulate matter, desulfeorization, Coal gasification & Introduction to greenhouse effect.

**Books & References:**


1. Power Plant Engineering- Drbal Larry F (Kluwer Aca)
2. Plant Genetic Engineering-Dodds John H (Cambridge)
3. Plant Design and Economics for Chemical Engineers- Peters Max Stone (McGraw-Hill)
4. Plant Engineering's Fluid Power Handbook, Volume 2: Hehn Anton H (Gulf Profe)

## MME-253 COMPUTER AIDED DESIGN OF THERMAL SYSTEMS 4 Credits (3-1-0)

**UNIT I** **9**

Study of the design aspects, Review of Computer aided design, fluid flow and heat transfer characteristics and material requirements of heat exchange equipments,

**UNIT II** **9**

Liquid-to-liquid and Liquid –to-gas heat exchange systems, Familiarity with use of design related International/National and other codes.

**UNIT III** **9**

Design of any of the subsystems using compressor, condenser, evaporator and optimization for minimum cost and maximum performance etc

**UNIT IV** **9**

Development of computer programs for designing the systems
Environmental considerations in design of thermal systems

**Books & References:**

1. CAD/CAM , Computer Aided Design and Manufacturing-M P Groover & E W Zimmers Jr (Prentice-Hall of India)
2. Computer Aided Design- Software And Analytical Tools -C S Krishnamoorthy (Narosa Publishing )
3. Developments In The Design Of Thermal Systems - Robert F Boehm (Cambridge University)
4. Design Analysis Of Thermal Systems - R F Boehm (John Wiley)

## MME-254 COMBUSTION ENGINEERING 4 Credits (3-1-0)

**UNIT I** **9**

**Introduction:** Importance of combustion; Combustion equipments, Hostile fire problems, pollution problems arising from combustion.

**Thermodynamics of Combustion:** Enthalpy of formation; Enthalpy of reaction; Heating values; First & second laws; Analysis of reaction system, Chemical equilibrium, Equilibrium composition; Adiabatic & equilibrium, Flame temperature.

**UNIT II** **9**

**Kinetics of Combustion:** Law of mass action; Reacting rate; Simple and complex reaction; Reaction order & molecularity, Arhenius laws; Activation Energy; Chain reaction; Steady rate & Partial equilibrium approximation; chain explosion; Explosion limit and oxidation characteristics of hydrogen, Carbon monoxide, Hydrocarbons.

**Flames:** Remixed flame structure & propagation of flames in homogeneous mixtures; Simplified Rankine Hugoniot relation, Properties of Hugoniot curve, analysis of Deflagration & detonation branches, Properties of Chapmen Jouguet wave, Laminar flame structure; Theories of flame propagation & calculation of flame speed measurements.

Stability limits of laminar flames; Flammability limits & quenching distant, Burner design, Mechanism of flame stablization in laminar & turbulent flows, Flame quenching, Diffusion flames; Comparison of diffusion with premixed flame, combustion of gaseous fuel, jets burke & Schumann development.

**UNIT III** **9**

**Burning of Condensed Phase:** General mass burning considerations, Combustion of fuels droplet in a quiescent and convective environment, Introduction to combustion of fuel sprays

**Ignition:** Concept of ignition, Chain ignition, Thermal spontaneous ignition, Forced ignition.

**UNIT IV** **9**

**Combustion Generated Pollution & its Control:** Introduction, Nitrogen oxide, Thermal fixation of atmospheric nitrogen prompts, NO, Thermal NOx & control in combustors. Fuel NOx & control, post combustion destruction of NOx, Nitrogen dioxide, carbon monoxide Oxidation-Quenching, Hydrocarbons, Sulphur oxide.

**Books & References:**

1. Internal Combustion Engines: Applied Thermo sciences- Ferguson Colin R (John Wiley)
2. Engineering Fundamentals of the Internal Combustion Engine- Pulkrabek (Pearson Education)

3. Instrumentation for Combustion and Flow in Engines- Durao D F G (Kluwer Aca)
4. Energy From Biomass: A Review of Combustion and Gasification Technologies - Quaak Peter

## MME-255 WIND ENERGY AND HYDRO POWER SYSTEM 4 Credits (3-1-0)

**UNIT I** **9**

**Introduction, General theories of wind machines, Basic laws and concepts of aerodynamics, Micro-siting,** Description and performance of the horizontal–axis wind machines

**UNIT II** **9**

Blade design, Description and performance of the vertical–axis wind machines, The generation of electricity by wind machines, case studies, Overview of micro mini and small hydro, Site selection and civil works, Penstocks and turbines, Speed and voltage regulation

**UNIT III** **9**

Investment issues, load management and tariff collection, Distribution and marketing issues, case studies,

**UNIT IV** **9**

Wind and hydro based stand-alone / hybrid power systems, Control of hybrid power systems, Wind diesel hybrid systems.

**Books & References:**

1. Wind Energy Technology - John F. Walker & Nick Jenkins
2.Wind Energy - Sathyajith & Mathew

## MME-256 ENERGY STORAGE SYSTEM 4 Credits (3-1-0)

**UNIT I** **9**

**Need of energy storage**; Different modes of Energy Storage

**Potential energy**: Pumped hydro storage; KE and Compressed gas system: Flywheel storage, compressed air energy storage; Electrical and magnetic energy storage: Capacitors, electromagnets; Chemical Energy storage: Thermo-chemical, photo-chemical, bio-chemical, electro-chemical, fossil fuels and synthetic fuels, Hydrogen for energy storage. Solar Ponds for energy storage

**UNIT II** **9**

**Electrochemical Energy Storage Systems**

Batteries: Primary, Secondary, Lithium, Solid-state and molten solvent batteries; Lead acid batteries; Nickel Cadmium Batteries; Advanced Batteries. Role of carbon nano-tubes in electrodes

**Sensible Heat Storage**

SHS mediums; Stratified storage systems; Rock-bed storage systems; Thermal storage in buildings; Earth storage; Energy storage in aquifers; Heat storage in SHS systems; Aquifers storage.

**UNIT III** **9**

**Latent Heat Thermal Energy Storage**

Phase Change Materials (PCMs); Selection criteria of PCMs; Stefan problem; Solar thermal LHTES systems; Energy conservation through LHTES systems; LHTES systems in refrigeration and air-conditioning systems; Enthalpy formulation; Numerical heat transfer in melting and freezing process.

**UNIT IV** **9**

Some Areas of Application of Energy Storage

Food preservation; Waste heat recovery; Solar energy storage; Green house heating; Power plant applications; Drying and heating for process industries.

**Books & References:**

1. Energy storage Robert Huggins Springer
2. Solar Energy Handbook: Kreith and Kreider (McGraw Hill)

**MME-257 HYDROGEN ENERGY 4 Credits (3-1-0)**

**UNIT I** **9**

Hydrogen pathways introduction – current uses, General introduction to infrastructure requirement for hydrogen production, storage, dispensing and utilization, and hydrogen product ion power plants.

Thermal-Steam Reformation – Thermo Chemical Water Splitting – Gasification – Pyrolysis, Nuclear thermo catalytic and partial oxidation methods. Electrochemical – Electrolysis – Photo electro chemical, Biological – Photo Biological – Anaerobic Digestion Fermentative Micro- organisms

**UNIT II** **9**

Physics and chemical properties – General storage methods, compressed storage – composites cylinders – Glass micro sphere storage – Zeolities, Metal hydride storage, chemical hydride storage and cryogenic storage.

**UNIT III** **9**

Overview of hydrogen utilization: I.C. Engines, gas turbines, hydrogen burners, power plant, refineries, domestic and marine applications. Hydrogen fuel quality, performance, COV, emission and combustion characteristics of Spark Ignition engines for hydrogen, back firing, knocking, volumetric efficiency, hydrogen manifold and direct injection, fumigation, NOx controlling techniques, dual fuel engine, durability studies, field trials, emission and climate change.

**UNIT IV** **9**

Safety barrier diagram, risk analysis, safety in handling and refueling station, safety in vehicular and stationary applications, fire detecting system, safety management, and simulation of crash tests.

**Books & References:**


1. Fuel Cells and Hydrogen Energy Bansal, Narottam P.
2. Industrial Hydrogen Hugh S. Taylor D.Sc
3. Hydrogen Generator Gas for Vehicles and Engines John D Cash; Martain Cash