**UNIVERSITY INSTITUTE OF ENGINEERING & TECHNOLOGY MAHARSHI DAYANAND UNIVERSITY, ROHTAK SCHEME OF STUDIES & EXAMINATIONS**

**Doctor of Philosophy (Ph.D.) –MECHANICAL ENGINEERING**
**Jan,17 to Dec,17**

i) The duration of the Ph.D. course will be of one semester.
ii) The Department concerned shall design the Ph.D. course as per latest guide lines of UGC which are:
"The Ph.D. course must include a course on research methodology which may include quantitative methods and computer applications. It may also involve review of published research in relevant area".
iii) The scheme for Ph.D. course work is as under:
a) Common course:
17MENPCC1: Research Methodology (Quantitative Techniques and Computer Applications in Research)
b) Departmental course:
17MENPCC2: Review of Literature and Seminar (in Relevant Research Area)
Elective Subject (Departmental Elective Subject)

iv) The qualifying marks in each paper of the course work shall be 50%.
vi) It is only on satisfactory completion of Ph.D Programme, which shall be an essential part and parcel of the Ph.D. programme that a candidate shall be eligible to apply for registration in Ph.D. Programme.

| Sr. No. | Course No. | Course Title | Marks** of Internal | Examination Marks | | Total Marks | Duration of Exam |
|---|---|---|---|---|---|---|---|
| | | | | Theory | Practical | | |
| 1 | 17MENPCC1 | Research Methodology (Quantitative Techniques and Computer Applications in Research) | 20 | 80 | - | 100 | 3 |
| 2 | 17MENPCC2 | Review of Literature and Seminar (in Relevant Research Area) | 20 | - | 80 | 100 | 3 |
| 3 | | Elective Subject(Departmental Elective Subject) any one from the list attached | 20 | 80 | - | 100 | 3 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Total | | 60 | 160 | 80 | 300 | |

** Based ontwo assignments of 10 marks each

## Program Specific Outcomes

At the end of the programme, the student shall be able to

PSO1: acquire the necessary theoretical tools as well practical tools to undertake the research in various fields of Mechanical Engineering.

PSO2: Get expertise in understanding, formulating and solving new and cutting edge problems in various fields of Mechanical Engineering.

PSO3 : Address the problems of society and industrial interests in various applicable themes.

PSO4 :Produce and disseminate the new knowledge in high quality, peer reviewed research journals and Ph.D. thesis.

PSO5: conduct scholarly or professional activities in an ethical manner.

## 17MENPCC1: RESEARCH METHODOLOGY
## (Quantitative Techniques and Computer Applications in Research)

**Note:** Total 9 questions are to be set by the examiner/teacher covering the entire syllabus uniformly. A candidate is required to attempt any five questions taking at least one question from each unit. Question no. 1 is Compulsory. All questions shall carry equal marks.

| L | T | P/D | | |
|---|---|---|---|---|
| 3 | - | - | **Marks of Internal:** | **20** |
| | | | **Examination:** | **80** |
| **Duration of Exam: 3 Hrs** | | | **Total Marks:** | **100** |

**Course Outcomes (COs):** After studying this course, students will be able:
**CO 1-** understand basic elements of research like types of research, significance, necessity and techniques of defining research problem etc.
**CO 2-** Understand hypothesis and statistical analysis
**CO 3-** Knowledge of writing research paper
**CO 4-** Knowledge of computer applications in research.

**UNIT I: Element of Research**
Scientific process meaning and definition, a brief history of scientific process. Introduction to research methodology- Meaning of research, objective of research, types of research, significance of research, problem encountered by researchers in india, Research problem- Definition, necessity and techniques of defining research problem, formulation of research problem, objective of research problem, research design- Meaning, need and features of good research design, types of research designs, basic principles of Experimental design.Sampling design, census and sample surveys, different types of sample designs, characteristics of good sample design, Techniques of selecting a random sample. Data collection-primary and secondary data, methods of selecting primary and secondary data,

**UNIT II: Hypothesis&Statistical Analysis**
Hypothesis- definition, testing of hypothesis, procedures of hypothesis testing, flow diagram for hypothesis testing, parametric and non-parametric tests for testing of hypothesis, limitations of tests of hypothesis.Hypothesis tests- One sample test-two sample tests/ chi square tests, association of attributes. T-tests, statistical analysis, correlation and regression analysis- analysis of variance, completely randomized design, randomized complete block design, Latin square design-partial and multiple correlations – discriminent analysis - cluster analysis – principle component and factor analysis, repeated measure analysis.Probability and probability distributions; Binomial, Poisson, distribution, Basic ideas of testing of hypotheses; Tests of significance based on normal distributions.

**UNIT III: Paper Writing and Report Generation**
Basic concepts of paper writing and report generation, review of literature, concepts of bibliography and references, significance of report writing, steps of report writing, types of research reports, methods of presentation of report.

**UNIT IV: Computer Applications in Research**
Computer Applications: Fundamentals of computers-Definition, types of computers, RAM, ROM, CPU, I/O devices, Number systems-Binary, octal and hexadecimal, base

conversion, logic gates- AND, OR, NOT, Operating system-definition, types of operating system, Database system – definition & applications, Networks – definition & applications, Internet & its applications, Web Searching, Email, Uses of software's MS-Office-Power Point, Word, Excel and Access.

**Text Books:**

1. C. R. Kothari – Research Methodology Methods and Techniques – Wishwa Prakashan Publishers – Second Edition.

## 17MENPCC2: REVIEW OF LITERATURE AND SEMINAR (in Relevant Research Area)

**Course Outcomes (COs):** After studying this course, students will be able:
**CO 1-** understand basic elements of research and write a relevant paper after reviewing literature
**CO 2-** Understand hypothesis and statistical analysis
**CO 3-** Knowledge of writing research paper
**CO 4-** present/communicate a research paper in a conference/journal.

1. The research student is required to prepare a concept paper/working, paper/review paper by reviewing at least 50 research papers / references books / unpublished doctoral dissertations / other reports etc.

2. To qualify the paper the research student is required either to present the prepared paper in an International Conference/ Seminar/ Workshop or publish the same in a research journal. Acceptance for publication or presentation will be considered as published/ presented.

3. A duly constituted committee of three teachers of the department by the Director/Head shall evaluate the completion of the paper.

**SYLLABUS (Pre PhD-ME)**

**List of Electives:**

| | |
|---|---|
| 17MENPCD1 | COMPUTER AIDED DESIGN |
| 17MENPCD2 | DESIGN OF MECHANISMS |
| 17MENPCD3 | ADVANCED MECHANICAL VIBRATIONS |
| 17MENPCD4 | APPLIED NUMERICAL METHODS |
| 17MENPCD5 | ADVANCED MECHANICS OF SOLIDS |
| 17MENPCD6 | INDUSTRIAL ROBOTICS |
| 17MENPCD7 | MEASUREMENT AND CONTROL |
| 17MENPCD8 | EXPERIMENTAL STRESS ANALYSIS |
| 17MENPCD9 | ADVANCED TRIBOLOGY |
| 17MENPCD10 | OPTIMIZATION TECHNIQUES |
| 17MENPCD11 | COMPUTER AIDED ENGINEERING |
| 17MENPCD12 | FINITE ELEMENT METHODS |
| 17MENPCD13 | ADVANCED FLUID ENGINEERING |
| 17MENPCD14 | COMPUTATIONAL FLUID DYNAMICS |
| 17MENPCD15 | ADVANCED HEAT AND MASS TRANSFER |
| 17MENPCD16 | REFRIGERATION ENGINEERING |
| 17MENPCD17 | AIR-CONDITIONING |
| 17MENPCD18 | RENEWABLE ENERGY & ENERGY MANAGEMENT |
| 17MENPCD19 | GAS TURBINE AND JET PROPULSION |
| 17MENPCD20 | PRODUCTION PLANNING & CONTROL |
| 17MENPCD21 | MECHATRONICS |
| 17MENPCD22 | MATERIALS MANAGEMENT |
| 17MENPCD23 | OPERATIONS MANAGEMENT |
| 17MENPCD24 | STRATEGIC ENTREPRENEURSHIP |
| 17MENPCD25 | MACHINE VISION |
| 17MENPCD26 | PRODUCTIVITY MANAGEMENT |
| 17MENPCD27 | ERGONOMICS |
| 17MENPCD28 | ADVANCED MANUFACTURING TECHNIQUES |
| 17MENPCD29 | COMPUTER AIDED MANUFACTURING |
| 17MENPCD30 | NON-CONVENTIONAL MACHINING |
| 17MENPCD31 | EXPERIMENTAL DESIGNS |
| 17MENPCD32 | THERMO FABRICATION |
| 17MENPCD33 | QUALITY & RELIABILITY MANAGEMENT |
| 17MENPCD34 | ADVANCED INTERNAL COMBUSTION ENGINES |
| 17MENPCD35 | DIRECT ENERGY CONVERSION |
| 17MENPCD36 | GAS DYNAMICS |
| 17MENPCD37 | CRYOGENICS |
| 17MENPCD38 | NUCLEAR ENGINEERING |
| 17MENPCD39 | SOLAR ENERGY |

**Note:** The departmental elective subjects will be offered as per availability of expertise and the required infrastructure in the department.

## (17MENPCD01)COMPUTER AIDED DESIGN

**Note:** Total 9 questions are to be set by the examiner/teacher covering the entire syllabus uniformly. A candidate is required to attempt any five questions at least one question from each unit. Question no. 1 is Compulsory. All questions shall carry equal marks.

| L | T | P/D | | |
|---|---|---|---|---|
| 3 | - | - | **Examination:** | 80 |
| **Duration of Exam: 3 Hrs** | | | **Total Marks:** | 100 |

**Course Outcomes (COs):** At the end of the course, the student shall be able to:

**CO 1- U**nderstand the basic fundamentals of computer aided designing.

**CO 2-** Learn Transformations and types of surfaces.

**CO 3- E**xplore the techniques of 3D modeling of various mechanical parts.

**CO 4-** Expedite the procedure and benefits of FEA and CAE

UNIT-I

**Introduction**

Introduction, Review of vectors & Matrices, Basics of geometric and solid modeling, explicit, implicit, intrinsic and parametric equations, coordinate systems.

**Transformations**

Introduction, transformation of points and line, 2-D translation, shearing, rotation, reflection, scaling and combined transformation, homogeneous coordinates, 3-D scaling, shearing, rotation, reflection and translation, combined transformations, orthographic, axonometric, oblique and perspective projections.

**UNIT-II**

**Curves**

Geometry and topology, algebraic and geometric forms of straight lines, circles, conics, cubic splines, Ferguson curve, Hermite curve, bezier curves and B-spline curves, NURBS, composite curves, tangents and normal, blending functions, reparametrization.

**UNIT-III**

**Solids**

Solid models and representation schemes, their properties, boundary representation, constructive solid geometry, sweep representation, cell decomposition, octree encoding, spatial occupancy enumeration.

**Analytical properties:**

Analytical properties (Intersection & development) of curves and surfaces.

**UNIT-IV**

**Surfaces**

Algebraic and geometric forms, tangents and twist vectors, normal, blending functions, reparametrization. Plane surface, sixteen point form, four curve form, ruled surface, surface of revolution, tabulated cylinder, lofted surface, bi-cubic surface, bezier surface, B-spline surfaces, Coons' patch, blending surface, offset surface, rational surface.

**Reference Books:**


1. CAD/CAM by Groover and Zimmer, Prentice Hall
2. CAD/CAM: Theory and Practice by I. Zeid, McGraw Hill
3. Geometric Modeling by M.E. Mortenson

## (17MENPCD02)DESIGN OF MECHANISMS

**Note:** Total 9 questions are to be set by the examiner/teacher covering the entire syllabus uniformly. A candidate is required to attempt any five questions at least one question from each unit. Question no. 1 is Compulsory. All questions shall carry equal marks.

| L | T | P/D | | |
|---|---|---|---|---|
| 3 | - | - | **Marks of Internal:** | **20** |
| | | | **Examination:** | **80** |
| **Duration of Exam: 3 Hrs** | | | **Total Marks:** | **100** |

**Course Outcomes (COs):** At the end of the course, the student shall be able to:

**CO 1-** Understand the TRANSMISSION ANGLES AND OTHER TERMS IN MECHANISMS

**CO 2-** Explore the concept of Balancing of rotating and reciprocating masses.

**CO 3-** Knowledge of concept of CAM DYNAMICS

**CO 4-** Develop the concept of KINEMATICS OF INDUSTRIAL ROBOTS

**CO 5-** explore the concept of FORCE ANALYSIS OF MECHANISMS.

**UNIT-I**

**Mechanisms**

Reviews of concepts, transmission angle, methods of velocity and acceleration analysis, relative velocity and Instantaneous centre methods, Kennedy's theorem.

**Path Curvature**

Centrodes or polodes, fixed and moving centrodes, centrode normal and tangent, Euler-Savary equation, conjugate points, Hartmann construction, inflection point, inflection circle, Bobilliar construction, Collineation axis, Cubic of stationary curvature.

**UNIT-II**

**Synthesis of Mechanisms**

Introduction, number synthesis, dimensional synthesis, spacing of accuracy points, motion generation, path generation and function generation, graphical and analytical methods, Freudenstein's equation, coupler points.

**Complex-number Modeling in Kinematic Synthesis**

Complex number notation, the dyad or standard form equation, four-bar motion generation, maximum number of solutions for unknown dyads, path and function generation, triad loops, synthesis of multi-loop linkages, Burmester theory, synthesis of geared mechanisms, Computer program.

**UNIT-III**

**Dynamics of mechanisms**

Analytical methods for force analysis of mechanisms, complex number methods, Kinetostatic analysis using matrix method, time response of four-bar mechanisms, computer program.

**Balancing**

Force and shaking moment balancing of linkages, Optimization of shaking moments, Effect of moment balance on input torque, balancing of flexible rotors, field balancing, computer program.

**UNIT-IV**

**Cam Dynamics**

Rigid and elastic-body cam systems, analysis of eccentric plate cam, jump or float, torque-displacement diagram, analysis of an elastic cam system, follower command, spring surge, unbalance and windup.

**Kinematics of industrial robots**

Absolute and moving reference systems, direction cosines, Eulerian angles, Denavit-Heartenberg parameters, Transformation-matrix position analysis, matrix velocity and acceleration analysis. Computer programs.

**Reference Books :**

1. Theory of Machines by Shigley and Uicker Jr., McGraw-Hill
2. Advanced Mechanism Design, by Sandor and Erdman, Prentice Hall of India
3. Theory of machines by S S Rattan, Tata McGraw-Hill Publishing Co. Ltd., New Delhi
4. Theory of mechanisms and Machines by Ghosh and Malik, Affiliated East-West Press, Pvt. Ltd., New Delhi.

## (17MENPCD03) ADVANCED MECHANICAL VIBRATIONS

**Note:** Total 9 questions are to be set by the examiner/teacher covering the entire syllabus uniformly. A candidate is required to attempt any five questions at least one question from each unit. Question no. 1 is Compulsory. All questions shall carry equal marks.

| L | T | P/D | | |
|---|---|---|---|---|
| 3 | - | - | **Marks of Internal:** | **20** |
| | | | **Examination:** | **80** |
| **Duration of Exam: 3 Hrs** | | | **Total Marks:** | **100** |

**Course Outcomes (CO'S):** At the end of the course, the student shall be able to:

CO1 Understand the fundamentals of mechanical vibrations leading to analysis of first degree of freedom

CO2 To understand the concept of two degree of vibration and vibration isolation and transmissibility

CO3 Analyse experimental methods for vibration analysis.

CO4 Understanding the influence and stiffness coefficients.

CO5 Analyse the concept of the non-linearity in vibrations

**UNIT-I**

**Introduction to vibrations**

Brief introduction to vibrations, its causes, advantages and disadvantages, classification: un-damped and damped vibrations, single and two degree of freedom models. Introduction to lateral, torsional and bending vibrations. Harmonic and harmonic analysis. Free and harmonically excited vibrations. Vibrations under general forcing conditions.

**Vibrations of continuous system**

Transverse vibrations of a cable, longitudinal and torsional vibrations of a rod, lateral vibrations of a beam, vibrations of membranes. Reyleigh's method. Rayleigh-Ritz method.

**UNIT-II**

**Vibration Control**

Introduction, vibration nomograph and vibration criteria, reduction of vibration at the source, balancing of rotating machines, whirling of rotating shafts, balancing of reciprocating engines, control of vibrations, control of natural frequencies, vibration isolation, vibration absorbers.

**Vibration measurement and applications**

Introduction, transducers, vibration pickups, frequency measuring instruments, vibration exciters, signal analysis, dynamic test of machines an structures, experimental modal analysis, machine condition monitoring and diagnosis.

**UNIT-III**

**Numerical Integration methods in vibration analysis**

Introduction, Finite difference method, central difference method, Runge-Kutta methods for single, multi and continuous systems. Houbolt method, Wilson method, Newmark method. The finite element method.

**Non linear vibration**

Introduction, examples of non-linear vibration problems, exact methods, approximate analysis methods, sumharmonic and superharmonic oscillations, systems with time-dependent coefficients (Mathieu equations), graphical methods, stability of equilibrium states, limit cycles, chaos.

**UNIT-IV**

**Random Vibrations**

Random vibrations and random processes, probability distributions, mean value and standard deviation, joint probability distribution of several random variables, correlation

function of a random process, Gaussian random process, fourier analysis, power spectral density, wide and narrow band process, response of a single degree of freedom system, response due to stationary random excitations, response of a multidegree system.

**Reference Books:**


1. Mechanical Vibrations by S.S. Rao, Pear and on Publication.
2. Mechanical Vibration by Thomson, Printice Hall.
3. Mechanical Vibration by Den Hartog, McGraw-Hill

## (17MENPCD04)APPLIED NUMERICAL METHODS

**Note:** Total 9 questions are to be set by the examiner/teacher covering the entire syllabus uniformly. A candidate is required to attempt any five questions at least one question from each unit. Question no. 1 is Compulsory. All questions shall carry equal marks.

| L | T | P/D | | |
|---|---|---|---|---|
| 3 | - | - | **Examination:** | 80 |
| **Duration of Exam: 3 Hrs** | | | **Total Marks:** | 100 |

**Course Outcomes (COs):** At the end of the course, the student shall be able to:

**CO 1 –** Analyses of Numerical solution of partial differential equations.

**CO 2 –** Solution to the linear simultaneous equations.

**CO 3 –** Expedite Numerical solution of ordinary differential equations.

**CO 4 –** Conceptualizations of optimization.

**UNIT-I**

**Approximations and Errors in Computations**

Introduction, Numbers and their Accuracy, Errors and their Computation, Error in Series Approximation.

**Numerical Solution of Ordinary Differential Equations**

Introduction, Solution by Taylor's Picard's Method, Euler's Method, Runge-Kutta Methods, Predictor-Corrector Methods, the Cubic Spline Method, Simultaneous and Higher Order Equations, Boundary Value Problems: Finite-Difference Method, The Shooting Method, The Cubic Spline Method.

**UNIT-II**

**Numerical Solution of Partial Differential Equations**

Introduction, Finite-Difference Approximations, Laplace's Equation: Jacobi's Method, Gauss-Seidel Method, SOR Method, ADI Method, Parabolic Equations, Iterative Methods, Hyperbolic Equations.

**Numerical Differentiation and Integration**

Introduction, Numerical Differentiation, Numerical Integration, Euler-Maclaurin Formula, Adaptive Quadrature Methods, Gaussian Integration, Singular Integrals, Fouries Integrals, Numerical Double Integration.

**UNIT-III**

**Least- square Curve Fitting and Function Approximation**

Introduction, Least-square Curve Fiting, Spline Inaterpolation,Cubic Splines, Chebyshev Minimax Approximation, Chebyshev Polynomials.

**Numerical Solution of Nonlinear Systems**

Introduction, Picard Iteration, Newton's Method, Perturbed Iterative Scheme.

**UNIT-IV**

**System of Linear Algebraic Equations**

Introduction, Methods for Large Linear Systems, Direct Methods, LU- Decomposition Methods, Iterative Methods, III-conditioned Systems.

**Reference Books :**


1. Niyogi, Pradip, "Numerical Analysis and Algorithms", Tata McGraw –Hill
2. Balagurusamy,E., "Numerical Methods", Tata McGraw –Hill

3. Sastry, S.S., “Introduction Methods of Numerical Analysis”, PHI
4. Chapra, S.C. and Canale, R.P., “Numerical Methods for Engineers”, Tata McGraw –Hill
5. Gerald, F. Curtis, “Applied Numerical Analysis”, Peason Educatio

## (17MENPCD05) ADVANCED MECHANICS OF SOLIDS

**Note:** Total 9 questions are to be set by the examiner/teacher covering the entire syllabus uniformly. A candidate is required to attempt any five questions at least one question from each unit. Question no. 1 is Compulsory. All questions shall carry equal marks.

| L | T | P/D | | |
|---|---|---|---|---|
| 3 | - | - | **Marks of Internal:** | **20** |
| | | | **Examination:** | **80** |
| **Duration of Exam: 3 Hrs** | | | **Total Marks:** | **100** |

**Course Outcomes (COs):** After studying this course, students will be able:

**CO 1-** Apply and use energy methods to find force, stress and displacement in simple structures and springs.

**CO 2-** Understand and determine the stresses and strains in pressure vessels.

**CO 3-** Knowledge of stress functions, and calculate stresses in rotating rings, discs, and curved beams.

**CO 4-** Evaluate the behaviour and strength of structural elements subjected to three dimensional stress system.

**UNIT-I**

**Three Dimensional Stress and Strain:**
Principal stresses and Principal strains, Mohr's circle representation of tri-axial stresses and strains.

**Unsymmetrical Bending:**
Shear centers for sections with one axis of symmetry. Shear center for any unsymmetrical section, stress and deflection of beams subjected to unsymmetrical bending.

**UNIT-II**

**Bending of Plates:**
Basic definitions, Stress, Curvature and Moment relations, Basic Equation of plate deflection. Different boundary conditions, simply supported rectangular plates, axis symmetric loaded circular plates.

**Contact Stresses:**
Due to Two Spherical Surfaces in Contact, Due to Two Parallel Cylindrical Rollers in Contact, Due to Two Curved Surfaces of Different Radii.

**UNIT-III**

**Buckling of Columns:**
Beam columns with single concentrated load, number of concentrated loads, continuous lateral load, end couple, couples at both ends of the column, triangular loads and combined loads.

**UNIT-IV**

**Beam on Elastic Foundations:**
General Theory, Infinite, Semi-infinite, and Finite beams, Classification of Beams.
Beam supported by equally spaced elastic elements.

**Reference Books :**

1. ‘Advanced Strength and Applied Elasticity’ by Ugural & Fenster, Prentice Hall.
2. ‘Advanced Mechanics of Solids’ by L., Srinath, TMH
3. ‘Intermediate Mechanics of Materials’ by J. R. Barber, McGraw-Hill
4. ‘Introduction to Solid Mechanics’ by Shames & Pitarresi, PHI
5. ‘Advanced Topics of Strength of Materials’ by U.C. Jindal, Galgotia Publication.

## (17MENPCD06) INDUSTRIAL ROBOTICS

**Note:** Total 9 questions are to be set by the examiner/teacher covering the entire syllabus uniformly. A candidate is required to attempt any five questions at least one question from each unit. Question no. 1 is Compulsory. All questions shall carry equal marks.

| L | T | P/D | | |
|---|---|---|---|---|
| 3 | - | - | **Examination:** | 80 |
| **Duration of Exam: 3 Hrs** | | | **Total Marks:** | 100 |

**Course Outcomes (CO's)**: At the end of the course, the student shall be able to:

CO1 Understand the robotic automation strategies.
CO2 Analyze dynamics of robot manipulator.
CO3 Task programming of robots.
CO4 Understand vision and sensing characteristics of robots.
CO5 General design consideration on trajectories motion of robots

**UNIT-I**

**Introduction to Robotics**

Evolution of Robots and Robotics, Laws of Robotics, Progressive advancement in Robots. Robot anatomy, Human Arm Characteristics, Design and Control issue, Manipulation and Control, Programming Robots.

**Coordinate Frames, Mapping and Transforms**

Coordinate Frames, Description of objects in space, Transformation of Vectors, Inverting a Homogeneous Transform, Fundamental Rotation matreies.

**UNIT-II**

**Direct Kinematic Model**

Mechanical structure and notations, Kinematic modeling of the manipulator, Denavit Hartenberg Notation, Manipulator Transformation Matrix.

**The Inverse Kinematies**

Manipulator workspace, solvability of Inverse kinematics model, solution techniques, closed form solution.

**Manipulator Differential Motion and Statics**

Linear and angular velocity of a rigid body, relationship between transformation matrix and angular velocity, manipulator Jacobian, Jacobian Inverse, Jacobian Singularities, Static Analysis.

**UNIT-III**

**Dynamic Modeling**

Largrangian Mechanies, Two Degree of Freedom manipulator-Dynamic Model, Lagrange-Euler formulation Newton-Euler formulation, Inverse Dynamics.

**Control of Manipulators**

Open and Close loop control, linear control schemes, linear second order SISO model of a manipulator joint. Joint Actuators, Computed Torque Control, force control of Robitics, Manipulators, Hybrid position/force control, Impedance Force/Torque Control.

**Robotic Sensors**

Sensors in Robitcs, classification of Robotic sensors, kinds of sensors used in robotics-Acoustic sensors optic, Pneumatic, force/Torque sensors.

**UNIT-IV**

**Robot Applications**

Industrial Applications -Material Handling, Processing Applications, Assembly applications, inspection application, Principles for Robot application and application planning, Robert safety, Non-Industrial Application.

**Robert Languages and Programming**

The Textual Robot Languages, Generations of Robot Programming Languages, Methods of Robot Programming.

**Reference Books :**


1. Fundamental of Robotics by Robert J. Sehilling Prentice Hall of India.
2. Introduction to Robotics by Saeed B. Niku Pearson Education Asia.
3. Robot Modeling and kinematics by Rachid Manseur, Luxmi Publications.

## (17MENPCD07) MEASUREMENT AND CONTROL

**Note:** Total 9 questions are to be set by the examiner/teacher covering the entire syllabus uniformly. A candidate is required to attempt any five questions at least one question from each unit. Question no. 1 is Compulsory. All questions shall carry equal marks.

| L | T | P/D | | |
|---|---|---|---|---|
| 3 | - | - | **Marks of Internal:** | **20** |
| | | | **Examination:** | **80** |
| **Duration of Exam: 3 Hrs** | | | **Total Marks:** | **100** |

### Course Outcomes

Students would be able

CO1 To understand about the applications of measurement systems.

CO2 To understand about the basics and working principle of pressure, temperature and flow measurement.

CO3 Identify the different variation of measurement parameter with various input conditions.

CO4 To analyze the primary, secondary and tertiary measurements.

CO5 To learn about the various control devices and parts of measurement systems

**UNIT-I**

**Measurements and Measurement Systems:**

Introduction, significance of measurement, methods of measurement, primary secondary and tertiary measurements, mechanical electrical and electronics instruments, applications of measurement system, elements of a generalized measurement system and its functional elements, classifications of standards, primary, secondary and working standards.

**Instrumentation Characteristics:**

Static and dynamic characteristics, first and second order systems response, classification & sources of error, loading facts, mechanical, electrical.

**UNIT-II**

**Analysis of Experimental Data:**

Errors and uncertainties in experiments, role of statistics and variance types of data, presentation of the observations, criteria for rejecting data, specifying result of experiments, confidence level, uncertainty analysis, overall uncertainty. graphical analysis and curve fitting, theory of least squares, application in calibration, goodness of fit, significant figures and rounding off. (

**Transducers:**

General criteria for selection, strain gauge, rosettes; types, applications. Variable inductance transducers, capacitive, piezo-electric transducers transducers.

Advantages and limitations of digital transducers over analog transducers, digital encoding transducers, classification of encoders, construction of encoders, shaft encoder, optical encoder.

**UNIT-III**

**Control systems:**

Introduction, types of control systems, performance analysis, mathematical modeling, block diagram representation, representation of systems or processes, comparison elements, transfer function, representation of temperature control systems, signal flow graphs.

**UNIT-IV**

**Types of controllers**

Introduction, types of control action, hydraulic controllers, electronic controllers, controllers.

**Transient and steady state response**

Time domain representation, laplace transform representation, system with proportional control, proportional cum derivative control, proportional cum integral control, error constants.

**Reference Books :**


1. A course in Mechanical Measurement & Instrumentation by A.K. Sawhney, Dhanpat Rai & Sons.
2. Mechanical Measurement by Beckwith & Buck
3. Instrumentation for Measurement in Engineering by S. Gupta
4. Theory and application of Automatic Controls by B.C.Nakra.

## (17MENPCD08) EXPERIMENTAL STRESS ANALYSIS

**Note:** Total 9 questions are to be set by the examiner/teacher covering the entire syllabus uniformly. A candidate is required to attempt any five questions at least one question from each unit. Question no. 1 is Compulsory. All questions shall carry equal marks.

| L | T | P/D | | |
|---|---|---|---|---|
| 3 | - | - | **Marks of Internal:** | **20** |
| | | | **Examination:** | **80** |
| **Duration of Exam: 3 Hrs** | | | **Total Marks:** | **100** |

**Course Outcomes (COs):** At the end of the course, the student shall be able to:

**CO 1-** understand stress-strain relationship ,coating stresses,crack detection etc.
**CO 2-** Understand the characteristics of theories of elasticity.
**CO 3-** understand the characterstics of optical instruments.
**CO 4-** understand 3-D stress.

**UNIT-I**

Introduction
Introduction to elementary Elasticity, Strain and the Stress-Strain relations, Basic equations of strain, and Plane Elasticity theory.
Brittle-Coating Methods
Introduction, Coating Stresses, Brittle-Coating Crack Patterns, Crack Detection, Ceramic-based Brittle Coatings, Resin-based Brittle Coatings, Test Procedures, Calibration.

**UNIT-II**

Strain Measurement using Strain Gages
Introduction, Strain Sensitivity in Metallic Alloys, Gage Construction, Strain-Gage Adhesive and Mounting Methods, Gage Sensitivities and Gage Factor, Piezoresistive Properties of Semiconductors, Performance Characteristics of Foil Strain Gages and Semiconductor Gages. Strain-Gage Circuits, Analysis of Strain-Gage Data.

**UNIT-III**

Optical Methods
Basic Optics- Introduction, Optic Laws, Optical Instruments- the Polariscope, the Interferome Moire Methods- Introduction, Mechanism of Formation of Moire Fringes, Different approach to Moire Fringe Analysis;

**UNIT-IV**

Theory of Photoelasticity- Introduction, the Stress-optic Law, Effects of a Stressed Model in a Plane and in a Circular Polariscope, Fringe Manipulation, Isochromatic and Isoclinic Fringe Patterns, Compensation Techniques, Separation Method, Calibration Methods, Photoelastic Materials
2-D & 3-D Photoelasticity- Shear Difference Method in 3-D Stress, the Scattered-Light Method, Frozen-Stress Method; Bi-Refringent Coatings- Coating Stresses and Strains, Coating Sensitivity, Coating Materials, Effects of Coating Thickness.

**Reference Books :**


1. Experimental Stress Analysis by Dally, J. W. & Riley, W. F.
2. Strain Gauges by Lissner, H.R and Perry, C. C.
3. Photoelastic Separation of Principle Stress by Drucker, D.C.
4. Work on General B-D Photoelasticxity by Froncht, M. M.

## (17MENPCD09)ADVANCED TRIBOLOGY

**Note:** Total 9 questions are to be set by the examiner/teacher covering the entire syllabus uniformly. A candidate is required to attempt any five questions at least one question from each unit. Question no. 1 is Compulsory. All questions shall carry equal marks.

| L | T | P/D | | |
|---|---|---|---|---|
| 3 | - | - | **Marks of Internal:** | **20** |
| | | | **Examination:** | **80** |
| **Duration of Exam: 3 Hrs** | | | **Total Marks:** | **100** |

### COURSE OUTCOMES

CO1 Students will understand the concepts of Tribology and industrial maintenance.
CO2 Students would be able to understand the concept of various maintenance strategies, processes and importance of maintenance.
CO3 Students would be able to understand the methods of Condition Monitoring of various equipments used in industry.
CO4 Students will get familiar with NDT techniques.

**UNIT-I**

**Introduction**
Introduction to tribology and its historical background. Industrial importance. Factors influencing tribological phenomena.

**Engineering Surfaces-Properties and Measurement**
Engineering surfaces - surface characterization, computation of surface parameters. Surface measurement techniques. Apparent and real area of contact. Contact of engineering surfaces.

**UNIT-II**

**Surface Contact**
Hertzian and Non-hertzian contact. Contact pressure and deformation in non-conformal contacts.

**Frition**
Genesis of friction, friction in contacting rough surfaces, sliding and rolling friction, Various laws and theory of friction. Stick slip friction behaviour, frictional heating and temperature rise. Friction measurement techniques.

**UNIT-III**

**Wear**
Wear and wear types. Mechanisms of wear -Adhesive, abrasive, corrosive, erosion, fatigue, fretting, etc., wear of metals and non -metals. Wear models – asperity contact, constant and variable wear rate, geometrical influence in wear models, wear damage. Wear in various mechanical components, wear controlling techniques.

**Lubrication**
Introduction to lubrication. Lubrication regimes. Lubricants and their properties. Solid Lubricants.

**UNIT-IV**

**Nanotribology**
Introduction to micro and nano tribology. Measurement tools used in nanotribology: SFA, STM, AFM microscale and nanoscale wear Nanofabrication/nanomachining Nanohydrodynamics Nanolubrication Tribological issues in MEMS.

**Reference Books :**

1. “Engineering Tribology” by Prasanta Sahoo, PHI.
2. “Engineering Tribology” by Stachowiak & Batchelor, Elsevier.
3. “Nanotribology and Nanomechanics: An Introduction” by Bharat Bhushan, Springer.
4. “Nanotribology” by Hsu & Ying, Springer.

## (17MENPCD10) OPTIMIZATION TECHNIQUES

**Note:** Total 9 questions are to be set by the examiner/teacher covering the entire syllabus uniformly. A candidate is required to attempt any five questions at least one question from each unit. Question no. 1 is Compulsory. All questions shall carry equal marks.

| L | T | P/D | | |
|---|---|---|---|---|
| 3 | - | - | **Marks of Internal:** | **20** |
| | | | **Examination:** | **80** |
| **Duration of Exam: 3 Hrs** | | | **Total Marks:** | **100** |

**Course Outcomes (COs):** At the end of the course, the student shall be able to:

**CO 1 –** USE OPTIMIZATION TECHNIQUES FOR SINGLE VARIABLE AND MULTI VARIABLE

**CO 2 –** USE OPTIMIZATION TECHNIQUES WIT OR WITHOUT CONSTRAINTS.

**CO 3 –** UNDERSTAND DYNAMIC PROGRAMMING AND INTEGER PROGRAMMING

**UNIT-I**

**Introduction**

Need of Optimization and Historical Development, Engineering Applications, Classification and Formulation of Optimization Problem.

**Classical Optimization Techniques**

Single- Variable and Multi-Variable Optimization, With and Without Constraints, Kuhn-Tucker Conditions.

**UNIT-II**

**Non-Linear Programming**

Introduction, One-Dimensional Optimization Methods, Unconstrained and Constrained Optimization Techniques; Elimination Methods, Exhaustive Search, Interval Halving, Fiboniacci, Golden Section Methods; Random Search Methods, Hooke and Jeeves Method, Powell's Method; Indirect Search Methods: Steepest Descent, Fletcher-Reeves, Newton's Method, DFP, BFGS Method; Internal and External Penalty Approach.

**UNIT-III**

**Other Optimization Techniques**

Introduction and Basic Concepts of Geometric Programming, Dynamic Programming, Integer Programming, Stochastic Programming, Their Applications.

**UNIT-IV**

**Advance Topics in Optimization**

Multi-Objective Programming, Introduction to Genetic Algorithms, Simulated Annealing and ANN Based Optimization.

**Reference Books:**


1. Engineering Optimization Theory and Practice by S.S. Rao, New Age International.
2. Optimization for Engineering Design by Kalyanmoy Deb, PHI.
3. Optimization Techniques by J.S. Arora, John Wiley.

## (17MENPCD11) COMPUTER AIDED ENGINEERING

**Note:** Total 9 questions are to be set by the examiner/teacher covering the entire syllabus uniformly. A candidate is required to attempt any five questions at least one question from each unit. Question no. 1 is Compulsory. All questions shall carry equal marks.

| L | T | P/D | | |
|---|---|---|---|---|
| 3 | - | - | **Marks of Internal:** | **20** |
| | | | **Examination:** | **80** |
| **Duration of Exam: 3 Hrs** | | | **Total Marks:** | **100** |

**Course Outcomes (COs):** At the end of the course, the student shall be able to:

**CO 1 –** know and understand various CAE methods and meshing

**CO 2 –** understand the properties of materials and linear and nonlinear analysis

**CO 3 –** Understand dynamic and thermal analysis and also post processing techniques

### UNIT-I

**Introduction:**
Introduction to CAE, Methods for solving any engineering problem, Advantages of CAE.

**Meshing :**
Need for meshing, Types of elements, Meshing techniques, 1-D meshing, 2-D meshing, 3-D meshing, Special elements and special techniques. rs)

### UNIT-II

**Material properties and Boundary Conditions :**
Material classification, Material properties, Boundary conditions, Applying constraints.

**Linear Static Analysis:**
Definition, Design modifications based on linear static analysis, Linear static solvers.

**Non Linear analysis :**
Introduction, Comparison of linear and nonlinear FEA, Types of nonlinearity, Solution techniques for nonlinear analysis, Essential steps to start with nonlinear FEA, General procedure for nonlinear static analysis.

### UNIT-III

**Dynamic Analysis :**
Static vs. Dynamic Analysis, Transient Response analysis (single DOF system), Dynamic analysis solvers, PSD.

**Thermal analysis :**
Introduction, Meshing for thermal analysis, Practical applications of thermal analysis.

### UNIT-IV

**Post Processing Techniques :**
Validation and checking accuracy of results, Viewing results, Interpretation of results and design modifications, CAE reports.

**Experimental Validation and Data Acquisition :**
Strain gauge, Photo-elasticity, Load cells, Torque sensors, Evaluating acceleration, fatigue life, natural frequency etc.

**Reference Books :**


1. Practical Finite Element Analysis by Nitin S Gokhale. (Finite to Infinite Publishers).

**2.** CAC/CAM Theory & Practice by I, Zeid. McGraw Hill
**3.** The Finite Element Method for Engineers by Huebner, John Wiley

## (17MENPCD12) FINITE ELEMENT METHODS

**Note:** Total 9 questions are to be set by the examiner/teacher covering the entire syllabus uniformly. A candidate is required to attempt any five questions at least one question from each unit. Question no. 1 is Compulsory. All questions shall carry equal marks.

| L | T | P/D | | |
|---|---|---|---|---|
| 3 | - | - | **Marks of Internal:** | **20** |
| | | | **Examination:** | **80** |
| **Duration of Exam: 3 Hrs** | | | **Total Marks:** | **100** |

**Course Outcomes (CO's)**: At the end of the course, the student shall be able to:

CO1 Understand the theories of linear system for finite element analysis.
CO2 Understand the theories of non-linear system for finite element analysis.
CO3 Develop the formulation of problem for analysis.
CO4 Analyse non-linear problem solution procedure.
CO5 Understand modeling of system with load, displacement and boundary Conditions

**UNIT-I**

Introduction to Finite Element Method:
Basic Concept, Historical background, Engineering applications, general description, Comparison with other methods.

**Integral Formulations And Variational Methods:**
Need for weighted-integral forms, relevant mathematical concepts and formulae, weak formulation of boundary value problems, variational methods, Rayleigh-Ritz method, and weighted residual approach.

**UNIT-II**

**Finite Element Techniques:**
Model boundary value problem, finite element discretization, element shapes, sizes and node locations, interpolation functions, derivation of element equations, connectivity, boundary conditions, FEM solution, post- processing, compatibility and completeness requirements, convergence criteria, higher order and isoparametric elements, natural coordinates, Langrange and Hermite polynomials.

**UNIT-III**

**Applications To Solid and Structural Mechanics Problems:**
External and internal equilibrium equations, one-dimensional stress-strain relations, plane stress and strain problems, axis-symmetric and three dimensional stress-strain problems, strain displacement relations, boundary conditions, compatibility equations, Analysis of trusses, frames and solids of revolution, computer programs.

**Applications To Heat Transfer Problems:**
Variational approach, Galerkin approach, one- dimensional and two-dimensional steady-state problems for conduction, convection and radiation, transient problems.

**UNIT-IV**

**Applications To Fluid Mechanics Problems:**

Inviscid incompressible flow, potential function and stream function formulation, incompressible viscous flow, stream function, velocity-pressure and stream function-vorticity formulation, Solution of incompressible and compressible fluid film lubrication problems.

**Additional Applications :**
Steady-state and transient field problems.

**Reference Books:**


1. The Finite Element Method by Zienkiewicz, Tata McGraw Hill
2. The Finite Element Method for Engineers by Huebner, John Wiley
3. An Introduction to the Finite Element Method by J.N.Reddy, McGraw Hill
4. The Finite Element Method in Engineering by S.S. Rao, Pergamon Press

## (17MENPCD13) ADVANCED FLUID ENGINEERING

**Note:** Total 9 questions are to be set by the examiner/teacher covering the entire syllabus uniformly. A candidate is required to attempt any five questions at least one question from each unit. Question no. 1 is Compulsory. All questions shall carry equal marks.

| L | T | P/D | | |
|---|---|---|---|---|
| 3 | - | - | **Marks of Internal:** | **20** |
| | | | **Examination:** | **80** |
| **Duration of Exam: 3 Hrs** | | | **Total Marks:** | **100** |

**Course Outcomes (COs):** At the end of the course, the student shall be able to:

**CO 1-** Expedite the properties of fluid along with pressure measurement techniques and concept of stability.

**CO 2-** Understand the characteristics of fluid and application of continuity and Bernoulli's equation.

**CO 3-** Conceptualisation of boundary layer, laminar and turbulent flow.

**CO 4-** Analyse flows through pipes and open channels.

### UNIT-I

**Introduction**

Review of basic concepts.

**Integral analysis of flow**

Basic laws in integral form; transport theorem; continuity, momentum and energy equations in integral form and their applications.

**Differential analysis of flow**

Continuity equation; derivation of Navier Stokes equation and exact solution energy equation.

### UNIT-II

**Ideal fluid flow**

Kinematics of fluid flow; potential flow; Bernoulli's equation and applications; sources, sinks, doublets and vortices; superimposition of uniform stream with above; flow around comers; Rankine ovals; flow around uniform cylinders with and without circulation; pressure distribution on the surface of these bodies and D'Alemberts paradox.

### UNIT-III

**Viscous flow**

Exact solution; plane Poiselle and Coutte flows; Hagon-Poiselle flow through pipes; flows with very small Reynold's numbers; Stokes flow around a sphere; elements of hydrodynamic theory of lubrication. Flows with very large Reynold's numbers; elements of two dimensional boundary layer theory; displacement thickness and momentum thickness; skin friction; Blaussius solution for boundary layer on a flat plate without pressure gradient; Karman-Porausen integral method for obtaining approximate solutions. Drag on bodies; form drag and skin friction drag; profile drag and its measurement.

### UNIT-IV

**Transition flows**

Transition from laminar to turbulent flows, Reynold's stresses, turbulent boundary layer over a flat plate; transition for flat plate flow.

**Compressible fluid flows**

One dimensional isentropic flow; Fanno and Rayleigh lines; choking; shocks (normal and oblique).

**Vortex Motion**

Definitions; vortex lines; surfaces and tubes; vorticity; circulation; Kelvins circulation theorem; Helmholtzs vorticity theorem; Biot-savart law for induced vorticity; system of vortex filaments;

**Reference Books:**


1. Fundamentals of Mechanics of Fluid by Curriec, Mcgraw-Hill
2. Foundation of Fluid Mechanics, Yuan, Prentice Hall
3. Engineering fluid mechanics, K.L.Kumar, Eurasia
4. Fluid Mechanics and its applications, Gupta and Gupta, Willey Eastern

## (17MENPCD14) COMPUTATIONAL FLUID DYNAMICS

**Note:** Total 9 questions are to be set by the examiner/teacher covering the entire syllabus uniformly. A candidate is required to attempt any five questions at least one question from each unit. Question no. 1 is Compulsory. All questions shall carry equal marks.

| L | T | P/D | | |
|---|---|---|---|---|
| 3 | - | - | **Examination:** | 80 |
| **Duration of Exam: 3 Hrs** | | | **Total Marks:** | 100 |

**Course Outcomes (COs):** After studying this course, students will be able:

**CO 1-** Apply and use various equations like navier-stokes,energy equation,continuity equation.
**CO 2-** Understand Discritization method
**CO 3-** Knowledge of heat conduction problems.
**CO 4-** Knowledge of convection and diffusion problems.

### UNIT-I

**Introduction**
Introduction to C.F.D. , models of the flow, governing differential equations – continuity equation, momentum equation, energy equation, Navier- stokes equation, physical boundary conditions.

**Mathematical behavior of governing equation**
Classification of quasi linear partial differential equation, General method of determining the Classification of partial differential equation, hyperbolic, parabolic, elliptic equations.

### UNIT-II

**Discritization methods**
Finite difference methods, difference equations, explicit & implicit approach, errors & of analysis of stability. Basics finite control volume method, errors & analysis of stability.

### UNIT-III

**Heat conduction problem**
Solution of One dimensional heat conduction through a pin fin by F.D.M solution of two dimensional heat conductional in a plate by F.D.M. Control volume formulation of the heat conduction problem and its solution.

### UNIT-IV

**Heat conduction with convection & diffusion**
Steady state one dimensional convection and diffusion, unwinding, exact solution, exponential scheme, hybrid scheme, power law scheme, Discritization equation for two dimensions & three dimensions, false diffusion.

**Fluid flow problem**
Viscous incompressible flow, solution of the couette flow problem by F.D.M., calculation of the flow field using stream function –vorticity method numerical algorithms for solving complete navier stokes equation – MAC method; SIMPLE method.

**Reference Books:**

1. Numerical heat transfer and fluid flow by suhas. V. patankar
2. Computational fluid dynamics by John.d.Anderson, Jr
3. Introduction to Computational fluid dynamics by Anil .W. Date

## (17MENPCD15) ADVANCED HEAT AND MASS TRANSFER

**Note:** Total 9 questions are to be set by the examiner/teacher covering the entire syllabus uniformly. A candidate is required to attempt any five questions at least one question from each unit. Question no. 1 is Compulsory. All questions shall carry equal marks.

| L | T | P/D | | |
|---|---|---|---|---|
| 3 | - | - | **Marks of Internal:** | **20** |
| | | | **Examination:** | **80** |
| **Duration of Exam: 3 Hrs** | | | **Total Marks:** | **100** |

**Course Outcome (COs):** At the end of the course, the student shall be able to:

**CO 1-** Understand the basic concept of conduction, convection and radiation heat transfer.

**CO 2-** Formulation of one dimension conduction problems.

**CO 3-** Application of empirical correlations for both forced and free convection for determines the value of convection heat transfer coefficient.

**CO 4-** Expedite basic concept of the radiation heat transfer for black and grey body.

**CO 5-** Learning of thermal analysis and sizing of Heat exchangers.

### UNIT-I

**Conduction**

Review of the basic laws of conduction, convection and radiation. General heat conduction equation in different co-ordinates. One dimensional steady state conduction with variable. Thermal conductivity and with internal distributed heat sources, extended surfaces review, Tapered fins, design considerations. Two dimensional steady-state conduction, semi-infinite and finite flat plates and cylinders, graphical method, relaxation technique. Unsteady state conduction in solids with infinite thermal conductivity, infinite thick-solids, periodic variation, solutions using Grolber's and Heisfer's charts.

### UNIT-II

**Convection**

Hydrodynamic and thermal boundary layers, differential equations, momentum and energy and their solutions, heat transfer in turbulent flow, eddy heat diffusivity, Reynold's analogy between skin friction and heat transfer. Free convection, empirical correlations, regimes of boiling, Nucleate and film boiling.

### UNIT-III

**Heat Exchangers**

Introductions, effectiveness and number of transfer units, design of heat exchangers.

**Radiation**

Introduction, laws of radiation, heat exchange between black bodies and non-black bodies, shape factor algebra, Radiation shields, electrical net-work approach of radiation heat exchange.

### UNIT-IV

**Mass Transfer**

Introduction, Fick's law, General equation of mass diffusion steady state, diffusion through a plain membrane, diffusion of water vapour through air, Mass transfer coefficient, convective mass transfer.

**Heat Pipe**

Introduction, Working of Heat pipe, Different types of Heat Pipe, Detail of Heat Pipe components, Advantages of Heat Pipe, Application of Heat Pipe, Performance of Heat Pipe, Limitation of Heat Pipe, Analysis and Design of Heat Pipe.

**Reference Books :**


1. Principles of Heat Transfer by Kreith
2. Heat Transfer by Holman
3. Fundamentals of Heat and Mass-transfer by D.S. Kumar
4. Heat and mass transfer by Eckert Darke.

(**17MENPCD16**) **REFRIGERATION ENGINEERING**

**Course Outcomes (COs):** At the end of the course, the student shall be able to:

**CO 1-** Understand the air refrigeration, vapour compression refrigeration, vapour absorption, steam jet refrigeration systems and different type of refrigerants.

**CO 2-** Expedite the working of single stage, multistage and cascade refrigeration.

**CO 3-** Develop and design RAC systems and evaluate different expansion and control devices.

**Note:** Total 9 questions are to be set by the examiner/teacher covering the entire syllabus uniformly. A candidate is required to attempt any five questions at least one question from each unit. Question no. 1 is Compulsory. All questions shall carry equal marks.

| L | T | P/D | | |
|---|---|---|---|---|
| 3 | - | - | **Marks of Internal:** | **20** |
| | | | **Examination:** | **80** |
| **Duration of Exam: 3 Hrs** | | | **Total Marks:** | **100** |

**UNIT-I**

**Introduction**

Lubrication of reverse control cycle with vapour as a refrigerant, simple vapour compression cycle, pressure-Enthalpy diagram, Ewing's construction, Suction state for maximum COP. Standard rating cycle and effect of operating conditions, (Evaporator pressure, condenser pressure, suction vapour super heat, liquid sub cooling liquid vapour regenerative heat exchanger) Deviation of actual vapour compression cycle with that of theoretical.

**Air Refrigeration System**

Reverse Carnot cycle, most efficient refrigerator, Bell- Colman cycle, advantages and disadvantages of air refrigeration system, necessity of cooling the auroplanes, simple cooling and simple evaporative type, Bootstrap and Bootstrap evaporative type, regenerative type, reduced ambient. Limitation, merits and comparison.

**UNIT-II**

**Multi Temperature**

Method of improving the COP, optimum inter state pressure for two stages refrigeration system, Multi stage or compound compression with flash inter cooler, single expansion valve and multi expansion valve. Multi evaporator system with single compressor, individual compressor with compound compression, single expansion valve and multi-expansion valve.

**UNIT-III**

**Production of Low Temperature**

Limitations of simple vapour compression system, multistage system, cascade system, production of solid carbon dioxide, Joule-Thomson effect, liquification of gases, hydrogen, helium, application of low temperature, Cryogenic insulation.

**Steam Jet Refrigeration**

Steam Jet Refrigerator, component of steam Jet refrigeration plant, advantages and limitations of steam jet refrigeration system, performance of the system

**UNIT-IV**

**Vapour Absorption System**

Simple vapour absorption system, Maximum co -efficient of performance, modification of simple vapour absorption system, acxtual vapour absorption cycle and its representation on Enthelpy –composition diagram, absorption system calculation. Richy and poor solution concentration. Lithium – Bromide water system.

**Application**

Manufacture and treatment of metal, industrial mideical, civil engineering, solar refrigeration and ice manufacturing. Properties of refrigerants and mixture of refrigerant. Design

consideration of compressors, condensers, expansion devices, evaporators, ice manufacture, food presentation.

R**eference Books :**


1. Mechanical Refrigeration by Sporks and Diffio.
2. ASHARE Handbook (Fundamentals) by ASHARE.
3. Thermal Environment Engineering by Threlkeld.
4. Regrigeration and Air-conditioning by C.P. Arora.
5. Refrigeration and Air –conditioning by Stocker.

## (17MENPCD17) AIR-CONDITIONING

**Note:** Total 9 questions are to be set by the examiner/teacher covering the entire syllabus uniformly. A candidate is required to attempt any five questions at least one question from each unit. Question no. 1 is Compulsory. All questions shall carry equal marks.

| L | T | P/D | | |
|---|---|---|---|---|
| 3 | - | - | **Marks of Internal:** | **20** |
| | | | **Examination:** | **80** |
| **Duration of Exam: 3 Hrs** | | | **Total Marks:** | **100** |

**Course Outcomes (COs):** At the end of the course, the student shall be able to:

**CO 1** Knowledge of psychrometry and different psychrometric processes.
CO2Understand and evaluate cooling and heating load and design of HVAC system.
**CO 3-** Develop and design RAC systems and evaluate different expansion and control devices.

**UNIT-I**

**Introduction and Human Comfort**
Psychometric and psychometric properties, psychometric relations and processes, adiabatic temperature, psychometric chart, summer and winter air-conditioning system, year-round air-conditioning, factors influencing-human comfort, effective temperature, factors governing optimum effective temperature.

**Cooling Load Calculations**
Types of loads, building heat transmission, solar- radiation infiltration, occupants, electric lights, products load, other internal heat sources, fresh-air miscellaneous steams, design of air-conditioning systems.

**UNIT-II**

**Air Conditioning Systems**
Central station, unitary, distinct, self-contained direct expansion, all water, all air, air-water system, arrangement of components, air-cleaning and air filters, humidifiers, dehumidifiers air-washers, fan and blowers, grills and registers.

**UNIT-III**

**Air Conditioning Control System**
Heating and cooling coils, basic principles of control system, temperature humidity, pre-heating and humidification, cooling and dehumidification, reheat and all-year conditioning control systems. Elements of control, Deflective element (bimetallic, bulbs and below, electrical resistance, electro magnetic sensitive and pressure sensitive, controlling room conditions at partial load (ON-OFF control), by pass control, reheat control and volume control).

**UNIT-IV**

**Miscellaneous**
Evaporative cooling, heating system, ventilation and ventilation standards, thermal insulation duct design and air-distribution system, noise and noise control, solar air-conditioning. Transport air conditioning, air conditioning of special type of buildings, air conditioning of textile industry, photographic industry, theatre auditorium, hospitals etc.

**Reference Books:**

1. Refrigeration and air conditioning by C.P. Arora.

2. Refrigeration and air conditioning by Jordan and Priester
3. Refrigeration and air conditioning by William
4. ASHARAE Hand Book (Fundamentals) ASHARAE
5. Elementary Refrigeration and air conditioning Stoecjer McGraw Hill
6. Air Conditioning Engineering Jones Arnold.

## (17MENPCD18) RENEWABLE ENERGY & ENERGY MANAGEMENT

Course Outcomes:

CO1 Understanding of energy conservation and identification of energy conservation opportunities in various industrial processes

CO2 Knowledge of various tools and components energy auditing
know about solar system, solar radiation measurement system

CO3 know effect of solar radiation on structures, WIND ENERGY,TIDAL ENERGY

**Note:** Total 9 questions are to be set by the examiner/teacher covering the entire syllabus uniformly. A candidate is required to attempt any five questions at least one question from each unit. Question no. 1 is Compulsory. All questions shall carry equal marks.

| L | T | P/D | Marks of Internal: | 20 |
|---|---|---|---|---|
| 3 | - | - | Examination: | 80 |
| Duration of Exam: 3 Hrs | | | Total Marks: | 100 |

**UNIT-I**

**Solar Energy**

The sun as a perennial source of energy, direct solar energy utilization; solar thermal applications – water heating systems, space heating and cooling of buildings, solar cooking, solar ponds, solar green houses, solar thermal electric systems; solar photovoltaic power generation; solar production of hydrogen.

**Energy from Oceans**

Wave energy generation – energy from waves; wave energy conversion devices; advantages and disadvantages of wave energy; Tidal energy – basic principles; tidal power generation systems; estimation of energy and power; advantages and limitations of tidal power generation; ocean thermal energy conversion (OTEC); methods of ocean thermal electric power generation.

**UNIT-II**

**Wind energy**

Basic principles of wind energy conversion; design of windmills; wind data and energy estimation; site selection considerations.

**Hydro power**

Classification of small hydro power (SHP) stations; description of basic civil works design considerations; turbines and generators for SHP; advantages and limitations.

**UNIT-III**

**Biomass and bio-fuels**

Energy plantation; biogas generation; types of biogas plants; applications of biogas; energy from wastes.

**Geothermal energy**

Origin and nature of geothermal energy; classification of geothermal resources; schematic of geothermal power plants; operational and environments problems.

**UNIT-IV**

**Energy conservation management**

The relevance of energy management profesion; general principles of energy management and energy management planning; application of Pareto's model for energy management; obtaining management support; establishing energy data base; conducting energy audit; identifying, evaluating and implementing feasible enrgy conservation opportunities; energy audit report; monitoring, evaluating and following up energy saving measures/projects.

**Reference Books:**


1. 'Renewable energy resources'. John W Twidell and Anthony D Weir.
2. 'Renewable energy – power for sustainable future'. Edited by Godfrey Boyle. Oxford University Press in association with the Open University, 1996.

**3.** ‘Renewable energy sources and their environmental impact’. S.A.Abbasi and Naseema Abbasi. Prentice-Hall of India, 2001.
**4.** ‘Non-conventional sources of energy’. G.D. Rai. Khanna Publishers, 2000.
**5.** ‘Solar energy utilization’. G.D. Rai. Khanna Publishers, 2000.
**6.** ‘Renewable and novel energy sources’. S.L.Sah. M.I. Publications, 1995.
**7.** ‘Energy Technology’. S.Rao and B.B. Parulekar. Khanna Publishers, 1999.

## (17MENPCD19) GAS TURBINE AND JET PROPULSION

**Note:** Total 9 questions are to be set by the examiner/teacher covering the entire syllabus uniformly. A candidate is required to attempt any five questions at least one question from each unit. Question no. 1 is Compulsory. All questions shall carry equal marks.

| L | T | P/D | | |
|---|---|---|---|---|
| 3 | - | - | **Marks of Internal:** | **20** |
| | | | **Examination:** | **80** |
| **Duration of Exam: 3 Hrs** | | | **Total Marks:** | **100** |

**Course Outcomes (COs):** After studying this course, students will be able:

**CO 1-** understand efficiencies and specific work output of heat exchanger cycles

**CO 2-** Understand axial and radial flow turbines

**CO 3-** Knowledge of typical engine performance

**CO 4-** Knowledge of turboprop& ramjet engine and rocket engine.

**UNIT-I**

**Introduction**

Introduction to simple gas turbine; open cycles considering heat exchanger; reheater; multispool arrangement; combined cycles and cogeneration scheme; closed cycle; industrial applications of gas turbine.

**Power Cycles**

Efficiencies & specific work output of heat exchanger cycles; reheat cycles; cycles with intercooled compression; various component loses.

**UNIT-II**

**Combustion Systems**

Combustion process; types of combustion systems; operational requirements; combustion chamber performance.

**Turbine**

Axial Flow Turbine- Elementary theory of axial flow turbine; swirl angle; total to total stage efficiency; flow coefficient; floe coefficient; loss coefficient for the nozzle blades; methods of blade cooling.

Radial flow turbine- specific work output; various efficiencies **UNIT-III**

**Jet Propulsion & Turbojet Engine**:

Introduction; net thrust; propulsion efficiency; intake & propelling nozzle efficiency; turbojet engine -actual cycle analysis ; typical engine performance; corrected engine performances; thrust augmentation.

**Turboprop & Ramjet Engine:**

Turboprop Engine process & cycle analysis; engine performances; Ramjet engine; jet expansion; overall process and performance

**UNIT-IV**

**Rocket Engine**

Solid and liquid propellant rocket motor cooling; propellant section; performance and design.

**Reference Books:**


1. Gas turbine theory by H. Cohen & GFC Rogers
2. Jet propulsion and gas turbine theory gy Zucrow, John Wiley
3. Jet propulsion by Hesse, Pitman
4. Theory and design of gas turbine & jet engine by Vincent, Mcgraw Hill

## (17MENPCD20) PRODUCTION PLANNING & CONTROL

**Note:** Total 9 questions are to be set by the examiner/teacher covering the entire syllabus uniformly. A candidate is required to attempt any five questions at least one question from each unit. Question no. 1 is Compulsory. All questions shall carry equal marks.

| L | T | P/D | | |
|---|---|---|---|---|
| 3 | - | - | **Marks of Internal:** | **20** |
| | | | **Examination:** | **80** |
| **Duration of Exam: 3 Hrs** | | | **Total Marks:** | **100** |

**COURSE OUTCOMES**: Towards the end of the course, the students should be able to:

CO1 Develop life cycle approach to new product development and production system.

CO2 Develop the concept of break-even analysis, line balancing and relate it with practical industrial work.

CO3 Understand and generate MRP-I, MRP-II and ERP models for production and enterprise resource planning.

CO4 Estimating production requirement using various forecasting techniques.

CO5 Understand the criteria for sequencing & accordingly schedule the job on machines

**UNIT-I**

**General**

Functions of production planning and control, preplanning planning, control, plant layout, simplification and standardization, time and motion study.

**Product Development and Design**

Effect of competition on design, Long-range Planning, Company policy, product analysis, marketing aspects, the product characteristics, functional aspect, operational aspect, durability and dependability, Aesthetic aspect; Economic analysis, Profit and competitiveness, The three S's:- Standardization, Simplification and Specialization. Break Even Analysis.

**UNIT-II**

**Inventory Control**

Definition, classification, objectives of inventory control, functions, economic order quantity various inventory models. Numericals on inventory control. Inventory carrying costs, factors affecting inventory costs. V.E.D. analysis, S-D-E analysis, F-S-N analysis H-M-L analysis and ABC analysis. Safety stocks, their objectives safety stocks and service levels.

**UNIT-III**

**Evaluation of Material and Processes**

Introduction, value analysis, consideration of new techniques and materials, value analysis tests, material utilization of a product or assembly. Numerical problems on material utilization of a product. Value engineering job plan and various phases of job plan in systematic value engineering approach.

**UNIT-IV**

**Routing, Loading and Scheduling**

Introduction, Scheduling Procedure, Master Schedule, its objectives, Order scheduling, Loading by scheduled period, Dispatching, Job card, Job order. Commercial Loading & Scheduling Devices.

**Reference Books:**

1. Production Planning and control: Samuel Eilon
2. Production Planning and Control: K.C. Aggarwal & K.C. Jain
3. Industrial Engg. & Operation Management by S.K. Sharma & Savita Sharma.
4. Production Planning and Control: King J.R.
5. Production Planning and Control: Sharma, Hari Rraghu Rama.
6. Production Planning and Control: Narasimhan Seetha-rama L.

## (17MENPCD21) MECHATRONICS

**Course Outcomes (CO's):** At the end of the course, the student shall be able to:

CO1 Understand conceptual design for mechatronics products based on potential custom requirements.

CO2 Analyze appropriate sensors and transducers and devise an instrumentation system

CO3 Understand design of a control system for effective functioning of mechatronics systems using digit electronics, microprocessors, microcontrollers and PLC.

CO4 Develop system model for mechanical system.

CO5 Calculate transfer function for first order and second order system.

**Note:** Total 9 questions are to be set by the examiner/teacher covering the entire syllabus uniformly. A candidate is required to attempt any five questions at least one question from each unit. Question no. 1 is Compulsory. All questions shall carry equal marks.

| L | T | P/D | Marks of Internal: | 20 |
|---|---|---|---|---|
| 3 | - | - | Examination: | 80 |
| Duration of Exam: 3 Hrs | | | Total Marks: | 100 |

**UNIT-I**

**Introduction:**
Definitions, trends, control systems, microprocessor / micro controller based controllers, PC based controllers, applications: SPM, robot, CNC machine, FMS, CIM.

**Sensor Technology:**
Sensor and transducers, terminology, displacement, position, proximity – encoders, velocity – tachogenerators, force - strain gauges, pressure, temperature – thermocouples, RTDs, thermistors, light sensors – photoelectric sensors, IR sensors, sensor selection.

**Signal Conditioning:**
Introduction, the operational amplifier, protection, filtering, Wheatstone bridge, digital signals, multiplexers, data acquisition, digital signal processing, pulse – modulation.

**UNIT-II**

**Precision Mechanical Actuation:**
Pneumatic actuation systems, electro-pneumatic actuation systems, hydraulic actuation systems, electro-hydraulic actuation systems, mechanical systems, types of motion, kinematics, inverse kinematics, timing belts, ball screw and nut, linear motion guides, linear bearings, harmonic transmission, bearings, motor / drive selection.

**Electronic Devices and Circuits:**
Semiconductor devices, diodes and LEDS, zener diodes and voltage regulator, inductive kick, bandwidth, frequency %& response of a measurement system, bipolar transistor circuits, amplifiers.

**UNIT-III**

**Electromechanical Drives:**
Relays and solenoids, stepper motors, DC brushed and brushless motors, DC servo motors, AC / DC motors for non-servo motion drives, braking methods, pulse width modulated, Bipolar driver, Mosfet drives, SCR drives, variable frequency drives.

**Digital Electronics:**
Digital logic, number systems, logic gates, Boolean algebra, Karnaugh maps, sequential logic.

**UNIT-IV**

**Microprocessors:**
Control, microcomputerstructure, microcontrollers, digital interfacing, analog interfacting, DAC, ADC, applications.

**Input / Output Systems:**
Interfacing, input / output ports, interface requirements, peripheral interface adapters, serial communication interface, direct memory access.

**Control System:**

System transfer function, Laplace transformation and its applications, continuous and discrete processes, proportional control, integral control, differential control, PID control, digital controllers, control system performance, controller tuning, adaptive control, frequency response, PLC, PMC, introduction to fuzzy logic and neural networks.

**Reference Books:**

1. Understanding Electro-Mechanical Engineering – An Introduction to Mechatronics by Kamm, Prentice-Hall of India.

## (17MENPCD22)MATERIALS MANAGEMENT

**Note:** Total 9 questions are to be set by the examiner/teacher covering the entire syllabus uniformly. A candidate is required to attempt any five questions at least one question from each unit. Question no. 1 is Compulsory. All questions shall carry equal marks.

| L | T | P/D | | |
|---|---|---|---|---|
| 3 | - | - | **Marks of Internal:** | **20** |
| | | | **Examination:** | **80** |
| **Duration of Exam: 3 Hrs** | | | **Total Marks:** | **100** |

**Course Outcomes (CO):** At the end of the course, the students will be able to:

CO1 Understand the basic FEATURES OF MATERIALS MANAGEMENT.

CO2 Understand the basic feature of VENDORS AND INVENTORY MANAGEMENT

CO3 Learn the CONCEPT OF STORE MANAGEMENT

**UNIT-I**

**Integrated approach to materials management:**

Introduction, materials productivity and role of materials management techniques in improved materials productivity. Cost reduction and value improvement, value analysis for right choice and rationalization of materials.

**Purchasing function:**

Objectives, purchase requisitions, types of specification, centralized versus decentralized purchasing, timing of purchases. Purchasing research, identification of right sources of supplies. Make or buy decisions, vender selection and vender rating. Negotiations, purchase price analysis and price determination. Purchasing organization, procedures, forms, records and reports. Purchasing as a dynamic profession, transition to supply management.

**UNIT-II**

**Inventory management:**

Inventory concepts, reasons for holding inventory, types of inventory, inventory reduction tactics. Inventory turnover ratio. Selective Inventory management: ABC, VED, and FSN analysis etc., identifying critical items with selective inventory management.

**Operating policies:**

continuous review system, periodic review system, comparative advantages and disadvantages of continuous and periodic review systems, hybrid systems. Inventory management across the organization.

**UNIT-III**

**Optimising Inventory:**

Assumptions for Wilson's lot size model, inventory costs, hidden costs, composition of costs, estimation of inventory related costs, lead time, stock out point, number of time periods, calculating Economic Order Quantity (EOQ), sensitivity analysis of EOQ model.

**Special inventory models:**

Finite replenishment rate model, lot size models with planned backlogging, generalized model with uniform replenishment rate, inventory model with lost sales, quantity discount model, one period decisions. Determination of safety stock, service level and uncertainty in demand. Information systems for inventory management.

**UNIT-IV**

**Stores management**

Introduction, stores functions, stores organization, stores systems and procedures, stores accounting and verification systems, stores address systems, stores location and layout, store equipment.

**Standardization and codification:**

Classification of materials. Codification, objectives of codification, essential features of codification system, Brisch and Kodak systems, colour coding systems. Standardisation and variety reduction.

**Reference Books:**


1. Arnold and Chapman "*Introduction to Materials Management*", Pearson Education Asia, Fourth Edition, (2001)
2. Narsimhan, Mcleavey & Billington, "*Production Planning & Inventory Control*", Prentice Hall of India, Second Edition (2003)
3. Dobler Donald W., Burt David N., "*Purchasing and Supply Management*", Tata McGraw Hill, Sixth Edition (2001)
4. Menon K S, "*Purchasing and Inventory Control*", Wheeler Publishing New Delhi, Third Edition (1997)

## (17MENPCD23)OPERATIONS MANAGEMENT

**Note:** Total 9 questions are to be set by the examiner/teacher covering the entire syllabus uniformly. A candidate is required to attempt any five questions at least one question from each unit. Question no. 1 is Compulsory. All questions shall carry equal marks.

| L | T | P/D | | |
|---|---|---|---|---|
| 3 | - | - | **Marks of Internal:** | **20** |
| | | | **Examination:** | **80** |
| **Duration of Exam: 3 Hrs** | | | **Total Marks:** | **100** |

**Course Outcomes (CO):** At the end of the course, the students will be able to:

CO1 Understand the basic FEATURES OF operation MANAGEMENT.

CO2 Understand the basic concept of product life cycle .

CO3 understand the concept of ERP.

CO4 Learn the CONCEPT OF waste MANAGEMENT

**UNIT-I**

**Basics of Production Management:**

Types of production, life cycle approach to production system, Productivity and Productivity measures, types of productivity index, productivity improvement, production scheduling, MRP v/s JIT, requirements and problems in implementing JIT, Benefits of JIT, Introduction to JIT purchasing and JIT quality management

**UNIT-II**

Supply chain management, its importance, objectives and applications. Tenabled supply chain supply chain drives concepts of stockless, VRM and CRM.

**Business Process:**

Re-engineering-characteristics, organizational support, responsibility of re-engineering, re-engineering opportunities, choosing the process to re-engineer, success factors and advantages.

**UNIT-III**

**ERP:**

Evolution of ERP, Characteristics, approaches, methodology for implementation, Success factors.

**UNIT-IV**

**Waste Management:**

Introduction, classification of waste, systematic approach to waste reduction, waste disposal.

**Reference Books:**


1. Operation Research by D. S. Hira & P. K. Gupta,
2. Introduction to Operation Research by Hiller & Liebeman
3. Production and Operations Management by S.A.Chunawalla and D.R.Patel

(**17MENPCD24**) **STRATEGIC ENTREPRENEURSHIP**

**Note:** Total 9 questions are to be set by the examiner/teacher covering the entire syllabus uniformly. A candidate is required to attempt any five questions at least one question from each unit. Question no. 1 is Compulsory. All questions shall carry equal marks.

| L | T | P/D | | |
|---|---|---|---|---|
| 3 | - | - | **Marks of Internal:** | **20** |
| | | | **Examination:** | **80** |
| **Duration of Exam: 3 Hrs** | | | **Total Marks:** | **100** |

**Course Outcomes (CO):** At the end of the course, the students will be able to:

CO1 Understand the basic qualities of entrepreneurs.

CO2 Understand the basic concept of EDP

CO3 understand the types of industries

CO4 understand the various agencies for finance generation.

**UNIT-I**

**Small Scale Industries**

Definition and types of SSI's ; Role, scope and performance in national economy; Problems of small scale industries.

**Industrial Sickness**

Definition; Causes of sickness; Indian scenario, Government help; Management strategies; Need for trained entrepreneurs

**UNIT-II**

**Entrepreneurship Development Programmes**

Introductioin, Origin of EDP's , Organizations involved in EDP's, Objectives of EDPs, Implementation of EDP's, Short comings of EDP's, Role in entrepreneruship development.

**STEP**

Inroduction, Origin, Status in India, Success and failure factors, Govt. polices and incentives, future prospects in India.

**UNIT-III**

**Business Incubation**

Introduction, Origin and development of business incubators in India and other countries, types of incubators, success parameters for a business incubator, Benefits to industries, institutes, government and society; future prospects. A few case studies (at least 2

**Special Aspects of Entrepreneurship**

Intrapreneurship, Social entrepreneurship, International entrepreneurship, Rural entrepreneurship, Community Development, Women entrepreneurship.

**UNIT-IV**

**Network Marketing**

Introduction, E-business, E-commerce, E-auction, A basic internet e-business architecture, A multi tier e-business architecture.

**Reference Books:**


1. Strategic Entrepreneurship by P.K. Gupta, (Everest Publishing House)
2. Project Management – Strategic Design and Implementation by David Cleland (McGraw Hill)
3. Entrepreneurship-New Venture Creation by David H Holl (Prentice Hall of India)
4. Sustainable Strategic Management by Steed & Steed (Prentice Hall of India)
5. Marketing Management by Kotler (Prentice Hall of India)

**6.** Management of Technology by Tarek Khalil (McGraw Hill)
**7.** Engineering Economic Principles by Henry Steiner (McGraw Hill)

## (17MENPCD25) MACHINE VISION

**Note:** Total 9 questions are to be set by the examiner/teacher covering the entire syllabus uniformly. A candidate is required to attempt any five questions at least one question from each unit. Question no. 1 is Compulsory. All questions shall carry equal marks.

| L | T | P/D | | |
|---|---|---|---|---|
| **3** | **-** | **-** | **Marks of Internal:** | **20** |
| | | | **Examination:** | **80** |
| **Duration of Exam: 3 Hrs** | | | **Total Marks:** | **100** |

**Course Outcomes (CO):** At the end of the course, the students will be able to:

CO1 Understand the basic FEATURES OF machine vision system.

CO2 Understand the basic concept of image processing and image analysis

CO3 understand the concept of boundary descriptors and pattern recognition.

**UNIT-I**

**Introduction**

Machine vision, Elements of machine vision system, Basic relationship between pixels (Neighbors of a pixel, Connectivity, Labeling of connected components, Distance measures).

**UNIT-II**

**Image Processing**

Digitization, Noise, Introduction to spatial domain and frequency domain, Spatial filters (mean, median, gaussian smoothing filters, high pass filters), Image enhancement techniques (LUT, Histogram Equalization, Histogram specification, contrast stretching, intensity transformations)

**UNIT-III**

**Image Analysis**

Segmentation of images, Techniques for detecting point, line, edges (Roberts, Prewitt, Sobel, Laplacian operators), Edge linking and boundary detection, Thresholding, Region oriented segmentation (Region growing by pixel aggregation, Region splitting and merging

**UNIT-IV**

**Description**

Boundary Descriptors (Chain code, Signatures, Polygon approximation, Shape numbers, Fourier descriptors) Regional descriptors -simple descriptors (Perimeter, area, minimum and maximum radii, no. Of holes, corner, bending energy, compactness), Moment based descriptors (center of mass, bounding rectangle, Best fit ellipse, Eccentricity, moment invariants), Texture

. **Pattern Recognition**

Artificial Neural network (Perceptron, Hebb net, Feed forward back-propagation net), Template matching.

**Reference Books:**


1. Digital image processing by Rafael C. Gonzalez and Richard E. Woods
2. Fundamentals of Digital image processing by Anil K. Jain
3. Digital image processing–Concepts, Algorithms and Scientific Applications by Bernd Jahne

4. Machine vision by Ramesh Jain, Rangachar Kasturi, Brian G. Schunck

## (17MENPCD26) PRODUCTIVITY MANAGEMENT

**Note:** Total 9 questions are to be set by the examiner/teacher covering the entire syllabus uniformly. A candidate is required to attempt any five questions at least one question from each unit. Question no. 1 is Compulsory. All questions shall carry equal marks.

| L | T | P/D | | |
|---|---|---|---|---|
| 3 | - | - | **Marks of Internal:** | **20** |
| | | | **Examination:** | **80** |
| **Duration of Exam: 3 Hrs** | | | **Total Marks:** | **100** |

**Course Outcomes (CO):** At the end of the course, the students will be able to:

CO1 Understand the basic FEATURES OF productivity MANAGEMENT.

CO2 Understand the basic concept of productivity measurement in manufacturing and service industry.

CO3 understand the role of external environment in productivity management.

CO4 Learn the strategies for implementation.

**UNIT-I**

**Introduction: Productivity Basics**

Concern and the Significance of Productivity Management, the Rationale of Productivity Measurement, Productivity: Some Perspectives, Productivity Measurement: A Case for Re-appraisal

**Productivity Measurement: A Conceptual Framework**

Objectives of Productivity Measurement, Management by Objectives (MBO) and Productivity Measurement, Systems Approach to Productivity Measurement, Performance Objectives – Productivity (PO-P) : The Concept, PO-P: The Model, PO-P: The Methodology.

**UNIT-II**

**Productivity Measurements in Manufacturing Sector**

Productivity Measurement in Manufacturing Sector, Productivity Measurement in a Medium Sized Organisation, Productivity Measurement in a Large Sized Organisation.

**UNIT-III**

**PO-P Application : Productivity Measurement in Service Sector**

Need for measuring Productivity in Service Sector, Difficulties in measuring productivity, Productivity of an R&D System, Productivity of an Educational Institution.

**Productivity Management : The Role of External Environment**

External Environment and Organisation, Impact of external Environment, External Environment: Its Sub-systems, Approaches to measure Impact of External Environment.

**UNIT-IV**

**Productivity Management and Implementation Strategies**

Productivity Management System, Productivity Policy, Productivity: Organisation & Planning, Productivity Measurement, Productivity Measurement Evaluation, Productivity Improvement Strategies, Productivity Audit and Control

**Reference Books:**

1. Productivity Management by Prem Vrat, G.D.Sardana and B.S.Sahai
2. Production and Operations Management by S.A.Chunawalla and D.R.Patel

## (17MENPCD27) ERGONOMICS

**Note:** Total 9 questions are to be set by the examiner/teacher covering the entire syllabus uniformly. A candidate is required to attempt any five questions at least one question from each unit. Question no. 1 is Compulsory. All questions shall carry equal marks.

| L | T | P/D | | |
|---|---|---|---|---|
| 3 | - | - | **Marks of Internal:** | **20** |
| | | | **Examination:** | **80** |
| **Duration of Exam: 3 Hrs** | | | **Total Marks:** | **100** |

**Course Outcomes (CO):** At the end of the course, the students will be able to:

CO1 Understand the basic FEATURES OF ergonomics

CO2 Understand the basic concept of man-machine system.

CO3 understand the role of external/internal environment in ergonomics.

**UNIT-I**

Introduction, history of development, Domains of Ergonomics Physical ergonomicsCognitive ergonomics Macro ergonomics Organizational ergonomics Engineering psychology,man-machine system and its components.

**UNIT-II**

Introduction to structure of the body- features of the human body, stress and strain, metabolism, measure of physiological functions- workload and energy consumption, biomechanics, types of movements of body members, strength and endurance, speed of movements. Applied anthropometry - types, use, principles in application,

**UNIT-III**

Ergonomics in the workplace, design of work surfaces and seat design. Visual displays for static information, visual displays of dynamic information, auditory, tactual and olfactory displays and controls. Effect of vibration, noise, temperature and illumination on performance,

**UNIT-IV**

Work-Related Musculoskeletal Disorders, Properties of Musculoskeletal Disorders, Work Factors of Musculoskeletal Disorders, Back injury, Carpal tunnel syndrome, Cognitive load, Industrial Design ,Environmental design, Human factors, Human computer interaction, Industrial hygiene ,Industrial noise, Light ergonomics ,Occupational therapy, Participatory Ergonomics and Ergonomics Change Teams.

**Reference Books:**


1. Sanders Mark S and McCormick Ernert J, “Human Factors in Engineering and Design”, McGraw-Hill Inc., 1993.
2. Salvendy, Gavriel. Handbook of Industrial Engineering: Technology and Operations Management. New York, NY: John Wiley & Son Inc, 2001.
3. Hendrick, Hal W., and Brian M. Kleiner. Marcoergonomics: Theory, Methods, and Applications. 1st ed. Mahwah, NJ: Lawrence Erlbaum Associates, Inc., Publishers, 2002.
4. Brookhuis, K., Hedge, A., Hendrick, H., Salas, E., and Stanton, N. (2005). Handbook of Human Factors and Ergonomics Models. Florida: CRC Press.

(**17MENPCD28**) **ADVANCED MANUFACTURING TECHNIQUES**

**Note:** Total 9 questions are to be set by the examiner/teacher covering the entire syllabus uniformly. A candidate is required to attempt any five questions at least one question from each unit. Question no. 1 is Compulsory. All questions shall carry equal marks.

| L | T | P/D | | |
|---|---|---|---|---|
| 3 | - | - | **Marks of Internal:** | **20** |
| | | | **Examination:** | **80** |
| **Duration of Exam: 3 Hrs** | | | **Total Marks:** | **100** |

**Course Outcomes (CO):** At the end of the course, the students will be able to:

CO1 Understand the basic features of SCM,JIT.

CO2 Understand the basic feature of AJM, USM ,EDM etc.

CO3 Learn the MRR of various micro machining process

**UNIT-I**

**Different Techniques:**

Manufacturing Change in manufacturing system, manufacturing strategies, Advanced manufacturing Technologies for Indian Industries, Robust design methodology for Quality Engineering and management

**UNIT-II**

Six Sigma, Taguchi concepts, Quality function deployment, Rapid proto typing: Technology and challenges, Introduction and concepts of JIT, CAPP, MRP, CIMS, FMS, SCM, TPM, Kaizan,

**UNIT-III**

Agile manufacturing, Lean Manufacturing, Virtual manufacturing system, kanban, Theory of constrains, synchronous manufacturing, concurrent Engineering

**UNIT-IV**

**Advanced Techniques:**

Manufacturing and Environmental issues, Advanced materials and their application in manufacturing, Abrasive flow machining , Advanced welding processes (New Solid state Welding, Arc welding and Radiation welding Processes).

**Reference Books:**


1. Modern Machining Processes, P.C. Pandey and H.S. Shan, TMH
2. Machining Science, Ghosh and Mallik, AEW
3. Non-Traditional Manufacturing Processes by G.F. Benedit, Marcel Dekker.
4. Advanced Machining Processes by V.K. Jain, Allied Puiblishers.

(**17MENPCD29**) **COMPUTER AIDED MANUFACTURING**

**Note:** Total 9 questions are to be set by the examiner/teacher covering the entire syllabus uniformly. A candidate is required to attempt any five questions at least one question from each unit. Question no. 1 is Compulsory. All questions shall carry equal marks.

| L | T | P/D | | |
|---|---|---|---|---|
| 3 | - | - | **Marks of Internal:** | **20** |
| | | | **Examination:** | **80** |
| **Duration of Exam: 3 Hrs** | | | **Total Marks:** | **100** |

**Course Outcomes (COs):** At the end of the course, the student shall be able to:

**CO 1-** Understand the basics of NC, CNC, DNC and adaptive control systems.
**CO 2-** Develop CNC programs to manufacture industrial components.
**CO 3-** Acquire knowledge about advanced manufacturing systems like FMS and CIM.
**CO 4-** Demonstrate the knowledge of Robotics in manufacturing industries.
**CO 5-** Knowledge of basic principle and elements of automation and control in Manufacturing

**UNIT-I**

**Introduction to Manufacturing**
Basic definitions, design activities for manufacturing systems, Planning and control activates for manufacturing system, Manufacturing control, Types of production – low, Medium and high quantity production.

**Group Technology and Cellular Manufacturing**
Part families, parts classifications and coding, Production flow Analysis, cellular Manufacturing- composite part concept, machine cell design, applications of group technology, Grouping parts and machines by Rank order clustering technique, Arranging machines in a G.T. cell.

**UNIT-II**

**Process Planning**
Introduction, Manual process planning, Computer aided process planning – variount, generative, Decision logic- decision tables, decision trees, Introduction to Artificial intelligence.

**UNIT-III**

**Flexible Manufacturing**
Introduction, FMS components, Flexibility in Manufacturing – machine, Product, Routing, Operation, types of FMS, FMS layouts, FMS planning and control issues, deadlock in FMS, FMS benefits and applications.

**UNIT-IV**

**CNC Basics and Part Programming**
Introduction, Principle of CNC, Classification of CNC/NC – point to point and continuous path, positioning system- fixed zero and floating zero, Dimensioning- absolute and incremental, Coordinate system, Basic requirements of CNC machine control, CNC/NC words, Manual part programming, (G&M codes only) canned cycles, tool length and radius compensation.

## Reference Books:

1. Automation, Productions systems and Computer-Integrated Manufacturing by M.P. Groover, Prentice – Hall
2. Computer Aided Manufacturing by Chang, Wang & WySK
3. Numerical Control and Computer – Aided Manufacturing by Kubdra, Rao and Tiwari, Tata Mc Graw Hill.
4. International Journal of Production Research
5. International Journal of Flexible Manufacturing system.

## (17MENPCD30) NON-CONVENTIONAL MACHINING

**Note:** Total 9 questions are to be set by the examiner/teacher covering the entire syllabus uniformly. A candidate is required to attempt any five questions at least one question from each unit. Question no. 1 is Compulsory. All questions shall carry equal marks.

| L | T | P/D | | |
|---|---|---|---|---|
| 3 | - | - | **Marks of Internal:** | **20** |
| | | | **Examination:** | **80** |
| **Duration of Exam: 3 Hrs** | | | **Total Marks:** | **100** |

**Course Outcomes (CO):** At the end of the course, the students will be able to:

CO1 Understand the basic features of EDM . ECM.

CO2 Understand the basic feature of AJM, USM etc.

CO3 Learn the MRR of various micro machining process

**UNIT-I**

**Introduction:** Need for advanced machining processes; An Overview of Modern machining processes

**UNIT-II**

**Mechanical processes:** Abrasive Jet Machining; Ultrasonic Machining; Abrasive Flow Finishing; Magnetic Abrasive Finishing; Abrasive Water Jet Machining

**UNIT-III**

**Thermoelectric advanced machining processes:** EDM; EleGtric Discharge Diamond Grinding; Wire EDM; Laser beam Machining; Plasma Arc Machining; Electron Beam Machining

**UNIT-IV**

**Electrochemical and Chemical Processes:** ECM; ECG; Electro stream Drilling; Electrochemical Deburring; Chemical Machining

## Reference Books:


1. Advanced Machining Processes by V.K. Jain. Allied Publishers Pvt Ltd
2. Model:n Machining Processes by P.C. Pandey and H.S. Shan. Tata McGraw- Hill

## (17MENPCD31) EXPERIMENTAL DESIGNS

**Note:** Total 9 questions are to be set by the examiner/teacher covering the entire syllabus uniformly. A candidate is required to attempt any five questions at least one question from each unit. Question no. 1 is Compulsory. All questions shall carry equal marks.

| L | T | P/D | | |
|---|---|---|---|---|
| 3 | - | - | **Marks of Internal:** | **20** |
| | | | **Examination:** | **80** |
| **Duration of Exam: 3 Hrs** | | | **Total Marks:** | **100** |

**Course Outcomes (COs):** After studying this course, students will be able:

**CO 1-** understand types of experimental designs.
**CO 2-** Understand completely randomized design.
**CO 3-** Knowledge of Taguchi approach
**CO 4-** Knowledge of S/N ratio and ANOVA

**UNIT-I**

**Introduction:** Objectives for experimental designs. Basic design concepts. Steps for the design of experiments. types of experimental designs. Analysis of Means. Experimental designs and six sigma

**Completely Randomized Design:** Model for a completely randomized design \vith a single factor. ANOM for a completely randomized design. ANOM with unequal variances. Randomized Block Design. Incomplete Block Designs. Latin Square Design. Graeco - Latin Square Design

**UNIT-II**

**Full Factorial Designs with Two Levels:** Nature of Factorial Designs. Deleterious Effects of Interactions. Effect Estimates. The $2_3$ Design. Built-in-Replication. Role of expected mean squares in experimental design

**Fractional Factorial Designs with Two Levels:** $2_{k-1}$ Designs. Effect Estimates and Regression Coefficients; $2k_{-2}$ Designs. Basic Concepts; Design Efficiency; John's 3/4 Designs

**UNIT-III**

**Designs with more than two levels:** $3_k$ Designs; Conditional Effects; 3"-P Designs; Orthogonal Arrays with mixed levels

**UNIT-IV**

**Robust Designs:** DOE and Taguchi Approach; Experimental Design using orthogonal arrays; Experimental Designs with Two-Level Factors only; Experimental Designs with Three and Four Level Factors; ANOV A; Analysis using Signal- to- Noise Ratios; Some case studies; QT4 Software Response Surface Methodology; Response surface experimentation; Process improvement with Steepest Ascent; Analysis of Second-order response surfaces; Central Composite Designs; Box -Behnken Designs; Analyzing the fitted surface; Design-Expert Software

## Reference Books:

1. Modern Experimental Design by Thomas P Ryan. John Wiley

2. Response Surface Methodology by Myers R H and Montgomery Dc. John Wiley
3. Design of Experiments using the Taguchi Approach by Ranjit K Roy. John Wiley

## (17MENPCD32) THERMO FABRICATION

**Course Outcomes (COs):** After studying this course, students will be able:

**CO 1-** understand types of welding like arc welding, gas welding,laser welding etc
**CO 2-** Understand completely gating design including runner and riser
**CO 3-** Knowledge of casting machines
**CO 4-** Knowledge of casting defects

**Note:** Total 9 questions are to be set by the examiner/teacher covering the entire syllabus uniformly. A candidate is required to attempt any five questions at least one question from each unit. Question no. 1 is Compulsory. All questions shall carry equal marks.

| L | T | P/D | | |
|---|---|---|---|---|
| 3 | - | - | **Marks of Internal:** | **20** |
| | | | **Examination:** | **80** |
| **Duration of Exam: 3 Hrs** | | | **Total Marks:** | **100** |

**UNIT-I**

**Classification:**
Arc welding processes: carbon arc welding; shielded metal arc welding; submerged arc welding; gas tungsten arc welding; gas metal arc welding; plasma are welding; atomic hydrogen welding; stud welding; electoslag welding; electrogas welding. Resistance welding Processes: various techniques used in Industry; Friction welding ultrasonic welding; diffusion welding; electron beam welding; laser welding; thermit welding; pressure and non-pressure type.

**Arc Welding Power Sources:**
Requirements for an arc welding power source; constant current characteristics; constant voltage characteristics, duty cycle. A.C. welding power source D.C. welding power sources.

**UNIT-II**

**Welding Electrodes:**
Types of welding eldctrodes, electrode details, non non-consumable or refactory electrodes, consumable electrodes, light, medium and heavy coated electrodes, categories of coated electrodes, electrode coating ingredients and their functions, selection of electrodes.

**Weldability and Welding of Various Metals:**
Weldability of metals, effect of alloying element on weldability. Welding of cast iron, welding of carbon steels, welding of stainless steel, welding of aluminum and its alloys.

**UNIT-III**

**Foundry Mechanization:**
Definition, advantages and disadvantages. Moulding machines, functions, advantages and disadvantages. Various types of moulding machines.

**Principle of Gating**:
Gating system, requiremenmts, functions of gating system, pouring cups and basins, sprues, gates their characteristics and different types, design of gating system, defects occurring due to improper design of gating system.

**UNIT-IV**

**Principle of Risering:**
Functions of riser, types of risers, riser and directional solidification, design, general principle riser shape and size, riser location and riser feeding distance.

**Defects in Castings & Special Casting Techniques:**
Classification of defects, main types, their causes and remedies. Techniques of die casting centrifugal casting, investment casting their limitations advantages and disadvantages.

**Reference Books:**


1. Principle of Foundry Technology by P.L. Jain
2. Fundamentals of Metal Casting by P.C. Mukherjee.
3. Foundry Engineering by Tayloir Howard F.

4. Welding and its applications by Rossi, B.E
5. Metallurgy of Welding by Lancaster J.F
6. Modern Welding Technology by Cary Howard B.,
7. Welding Processes and Technology by R.S. Parmar.

## (17MENPCD33) QUALITY & RELIABILITY MANAGEMENT

**Note:** Total 9 questions are to be set by the examiner/teacher covering the entire syllabus uniformly. A candidate is required to attempt any five questions at least one question from each unit. Question no. 1 is Compulsory. All questions shall carry equal marks.

| L | T | P/D | | |
|---|---|---|---|---|
| 3 | - | - | **Marks of Internal:** | **20** |
| | | | **Examination:** | **80** |
| **Duration of Exam: 3 Hrs** | | | **Total Marks:** | **100** |

COURSE OUTCOMES:

Upon completion of this course the student will be able to:

CO1.Attain the basic concepts of QUALITY, Reliability, Probability, important parameters MTTF and MTBF

CO2. appreciate the choice of different distributions.

CO3 .Describe system reliability and improvement systems

CO4.Acquire basic knowledge of fault tree analysis

CO5.Understand the concepts of maintainability and availability.

**UNIT-I**

**Introduction:**

Concept of quality, Need, Factor influencing quality, Types of quality, Quality control, Cost of quality control, Quality assurance, Benefits, Modern concept, Inspection and quality control, Quality characteristics, Quality circles.

**Statistical Concepts and Control Charts:**

Review of fundamental statistical concept, Frequency distribution, Central tendency, measures of dispersion, Probability distributions, statistical quality control, Theory of control charts, Control charts for variables and attributes ( $\overline{x}$, R, P, np and C chart), their advantages and disadvantages, Applications.

**UNIT-II**

**Acceptance Sampling:**

Introduction, Advantages and Disadvantages, Operating Characteristics curve, Producer's and consumer's risk, Quality indices for acceptance sampling plans, Types of sampling Plans-single double sequential sampling plan, Sampling plan for variables, continuous sampling plans, Skip lot sampling plans, Chain sampling plan.

**UNIT-III**

**Total Quality Management:**

Introduction, Concept of Total quality, Quality function, Deployment tools for continuous quality improvement, The ISO 9000 family of standards, Six Sigma and other extensions of TQM.

**UNIT-IV**

**Reliability:**

Introduction, Factor effecting Reliability, Failure and its types, Failure curve, Majors of reliability, MTBF, MTTF, Relationship b/w reliability failure rate and MTBF and its characteristics, System reliability (components in series and parallel) System reliability with stand by components, Redundancy, Operating characteristics curve, Reliability and life testing plans, Types of test, Maintainability, Availability.

**Reference Books:**

1. Statistical Quality control by C. Gupta.
2. Modern Methods for Quality Control and Improvement by Harrism M. Wadsworth.
3. Statistical Quality control by E.L. Grant.
4. Reliability Mathematics by B.L.Ams Tadter.
5. Fundamental of Quality Control and Improvement by Amitava Mitra.

## (17MENPCD34) ADVANCED INTERNAL COMBUSTION ENGINES

**Note:** Total 9 questions are to be set by the examiner/teacher covering the entire syllabus uniformly. A candidate is required to attempt any five questions at least one question from each unit. Question no. 1 is Compulsory. All questions shall carry equal marks.

| L | T | P/D | | |
|---|---|---|---|---|
| 3 | - | - | **Marks of Internal:** | **20** |
| | | | **Examination:** | **80** |
| **Duration of Exam: 3 Hrs** | | | **Total Marks:** | **100** |

**Course Outcomes (CO):** At the end of the course, the students will be able to:

CO1 Understand the basic features of 4s and 2s engines

CO2 Understand various combustion processes

CO3 Learn about various pollution contents

CO4 understand various cycles and calculate various parameters

**UNIT-I**

**Cycle Analysis**

Thermodynamic properties of gases and combustion products, combustion charts, Fuel-air cycle, calculations for Otto, Diesel and dual cycles, Losses due to dissociation, burning time and heat flow. Combustion processes for SI and CI engines; flame propagation and spray burning processes; energy release calculations; actual Vs fuel air cycle, effects of various operating conditions, two and four stroke engine cycles.

**UNIT-II**

**Heat Transfer**

Instantaneous heat transfer calculations, engine heat transfer equations, overall heat loss-radiative and convective heat transfers.

**Gas Exchange**

Generalised equations for in-flow and outflow processes; filling and emptying methods and wave action calculations; two stroke engines, gas exchange processes; types and phases of scavenging, Kadney effect. Super charging of SI 7 CI engines; super charger and turbocharger systems, matching of atomization and spray formation; pump characteristics.

**UNIT-III**

**Fuel Injection**

Fuel injection: fuel line hydraulics; compressibility effects; wave and nozzle ends; mechanism of atomization and spray formation; pump characteristics.

**UNIT-IV**

**Flow Processes**

Characterisation of flow in the cylinder, Swirl, Squish and turbulence calculations.

**Fuels**

Petroleum fuels, Gasoline grades, desirable properties of SI & CI engines fuels, rating of fuels.

**Reference Books:**

1. I.C. Engine Vol. 1 & II by Taylor.

2. Thermodynamics and Gas Dynamic of I.C. Engine, Vol. I & II by Horlock and Winterbone.
3. I.C. Engine , Vol. I & II by Benson and Whitehouse.
4. Thermodynamic Analysis of Combustion Engines, by Campbell.

## (17MENPCD35) DIRECT ENERGY CONVERSION

### Course Outcomes:

CO1 Understanding of energy conservation and identification of energy conservation opportunities in various industrial processes
CO2 Knowledge of various types of photo electric cells
CO3 Knowledge of thermo electric generators
CO4 Principle of fuel cell.

**Note:** Total 9 questions are to be set by the examiner/teacher covering the entire syllabus uniformly. A candidate is required to attempt any five questions at least one question from each unit. Question no. 1 is Compulsory. All questions shall carry equal marks.

| L | T | P/D | | |
|---|---|---|---|---|
| 3 | - | - | **Marks of Internal:** | **20** |
| | | | **Examination:** | **80** |
| **Duration of Exam: 3 Hrs** | | | **Total Marks:** | **100** |

**UNIT-I**

**General**
Conversion of energy from one form to another, Direct energy conversion, Application of direct energy conversion.

**M.H.D. Generator**
Introduction, Principle of working, Different types of M.H.D. generators, M.H.D. materials, M.H.D. power generation systems, Economic aspects of M.H.D. generation.

**UNIT-II**

**Solar Energy**
An introduction to solar energy, Heat transfer through solar energy, Solar radiation analysis, Solar energy measuring instruments, Solar collectors, Flat plate collectors, Focussing type collectors, Advantages of focusing type collectors over flat plate type collectors.

**Photo-voltaic Power Generation**
Introduction, Photo -voltaic effect, Different types of photo-voltaic cells, Cell fabrication, Solar batteries and systems, Solar energy applications, Economic aspects of solar energy utilization.

**UNIT-III**

**Thrmoelectric Generators**
Introduction, Thermoelectric effects, Thermoelectric generator, Types of thermoelectric generators, Economic aspects of thermoelectric generation.

**UNIT-IV**

**Fuel Cells**
Introduction, Principle of fuel cells, Thermodynamic analysis of fuel cells, Types of fuel cells, Fuel cell batteries, Applications of fuel cells.

**Reference Books:**

1. Renewable Energy Sources and Conversion Technology by N.K.Bansal, M.Kleeman andM. Mieles.
2. Direct Energy Conversion by G.W.Sutton.
3. Energy Conversion by S.S.L.Chang
4. Fuel Cells for Electric Utility Power generation
5. Advances in Energy Systems and Technology, Vol. 5 by A.P.Fickett

## (17MENPCD36) GAS DYNAMICS

**Course Outcomes (COs):** After studying this course, students will be able:

**CO 1-** understand basic concepts of momentum and energy
**CO 2-** Understand completely flow through nozzles and diffusers
**CO 3-** Knowledge of Shock waves
**CO 4-** Knowledge of wind tunnel and its instrumentation.

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**Note:** Total 9 questions are to be set by the examiner/teacher covering the entire syllabus uniformly. A candidate is required to attempt any five questions at least one question from each unit. Question no. 1 is Compulsory. All questions shall carry equal marks.

| L | T | P/D | | |
|---|---|---|---|---|
| 3 | - | - | **Marks of Internal:** | **20** |
| | | | **Examination:** | **80** |
| **Duration of Exam: 3 Hrs** | | | **Total Marks:** | **100** |

**UNIT-I**

**Introduction**

General differential equations of continuity; momentum and energy applied to compressible inviscid fluids; sonic velocity.

**UNIT-II**

Mach number and propagation of disturbance in a fluid flow; isentropic flow and stagnation properties; flow through nozzles and diffusers; Fanno, Rayleigh and isothermal flows through pipes.

**UNIT-III**

**Shock Waves**

Normal and oblique shocks; supersonic expansion by turning; Prandtle-Mayer function, Reflection, refraction and intersection of oblique sock waves; detached shocks.

**UNIT-IV**

**Supersonic and Subsonic Flow**

Linearisation and small pertuburation theory; general solutions of supersonic flow; elements of supersonic thin airfoil theory; method of characteristics for solving non-linear equations; Hodograph method for mixed subsonic and supersonic flow. Wind tunnel and its instrumentation.

**Reference Books:**


1. Gas Dynamics by E. Rathakrishnan
2. Fundamentals of Gas Dynamics by S.M. Yahya
3. Gas Dynamics by Cambell and Jennings

4. Gas Dynamics by Becker
5. Fundamentals of Gas Dynamics by R.D.Zucker
6. Fluid Mechanics by A.K. Mohanty

## (17MENPCD37) CRYOGENICS

**Note:** Total 9 questions are to be set by the examiner/teacher covering the entire syllabus uniformly. A candidate is required to attempt any five questions at least one question from each unit. Question no. 1 is Compulsory. All questions shall carry equal marks.

| L | T | P/D | | |
|---|---|---|---|---|
| 3 | - | - | **Marks of Internal:** | **20** |
| | | | **Examination:** | **80** |
| **Duration of Exam: 3 Hrs** | | | **Total Marks:** | **100** |

**Course Outcomes (COs):** After studying this course, students will be able:

**CO 1-** understand basic concepts of thermodynamically ideal sytems.

**CO 2-** Understand gas separation and purification process in detail.

**CO 3-** Knowledge of cryogenic refrigeration system including pump down time,rocket and space simulation

**CO 4-** Knowledge of vacuum technology.

**UNIT-I**

Gas liquefaction systems, thermodynamically ideal systems, Joule Thomson effect, adiabatic expansion; liquefaction system for air, Neon, hydrogen and helium, effect of component efficiencies on system performance.

**UNIT-II**

Gas separation and purification – principles, plant calculation, air, hydrogen, and helium separation systems.

**UNIT-III**

Cryogenic refrigeration systems, ideal and practical systems, cryogenic temperature measurement; cryogenic fluid storage and transfer systems, storage vessels and insulation, two-phase flow in cryogenics transfer systems, cool down process.

**UNIT-IV**

Introduction to vacuum technology, low temperature properties of materials, pump down time, application of cryogenic systems, super-conductive devices, rocket and space simulation, cryogenics in biology and medicine, cryopumping.

**Reference Books:**


1. Barron, R., Cryogenic Systems, McGraw-Hill, 1966.
2. Timmerhaus, K. D. and Flynn, T. M., Cryogenic Process Engineering, Plenum Press, 1989.
3. Scott, R. B., Cryogenic Engineering, D'Van-Nostrand, 1962.
4. Vance, R. W. and Duke, W. M., Applied Cryogenic Engineering, John Wiley, 1962.
5. Sitting, M. Cryogenic, D' Van-Nostrand, 1963.

## (17MENPCD38) NUCLEAR ENGINEERING

**Note:** Total 9 questions are to be set by the examiner/teacher covering the entire syllabus uniformly. A candidate is required to attempt any five questions at least one question from each unit. Question no. 1 is Compulsory. All questions shall carry equal marks.

| L | T | P/D | | |
|---|---|---|---|---|
| 3 | - | - | **Marks of Internal:** | **20** |
| | | | **Examination:** | **80** |
| **Duration of Exam: 3 Hrs** | | | **Total Marks:** | **100** |

**Course Outcomes (COs):** After studying this course, students will be able:

**CO 1-** understand basic concepts of nuclear physics.
**CO 2-** Understand energy release in fission and fusion process
**CO 3-** Knowledge of Reactor materials and reactor technology.
**CO 4-** Knowledge of safety considerations and waste disposals.

**UNIT-I**

**Concepts of Nuclear Physics**
The atom, structure, the nucleus, nuclear structure, atomic transmutation of elements, detection of radio-activity, particle accelerator, decay, natural of elements, nucleus interactions, decay rates, half-life, transuranic elements.

**Neutorn Interaction**

Advantages of using neutron, neutron moderation, fission chain reaction, thermalisation of neutrons, fast neutrons, prompt and delayed neutrons, fission products.

**UNIT-II**

**Energy Release**
Mass energy equivalence, mass defect, binding energy, energy release in fission & fusion,thermonuclear reasction, fusion bomb.

**Reactor Materials**
Fissile & fertile materials, cladding & shielding materials, moderators, coolants.

**UNIT-III**

**Reactor Technology**
Basic principles, fuel assembly, neutron balance, reactor kinetics, reactor coefficients, reactor stability, excess reactivity, Xenon poisoning, burnable absorbers, reactivity control, heat balance, production& transfer of heat to the coolant, structural considerations.

**Nuclear Reactors**
Types of nuclear reactors, pressurized water reactors, boiling water reactors, CANDU type reactors, gas cooled & liquid metal cooled reactors, fast breeder reactors.

**UNIT-IV**

**Safety Considerations & Waste Disposal**
Hazards, plant site selection, safety measures incorporated in; plant design, accident control, disposal of nuclear waste.

**Health Physics & Radio-isotopes**
Radiation: units, hazards, prevention, preparation of radio-isotopes & their use in medicine, agriculture & industry.

**Reference Books:**

1. Nuclear Power Engineering by M.M. El-Wakel
2. Nuclear Power Plant by Taylor
3. Introduction to Nuclear Engineering by Stephenson.

## (17MENPCD39) SOLAR ENERGY

**Note:** Total 9 questions are to be set by the examiner/teacher covering the entire syllabus uniformly. A candidate is required to attempt any five questions at least one question from each unit. Question no. 1 is Compulsory. All questions shall carry equal marks.

| L | T | P/D | | |
|---|---|---|---|---|
| 3 | - | - | **Marks of Internal:** | **20** |
| | | | **Examination:** | **80** |
| **Duration of Exam: 3 Hrs** | | | **Total Marks:** | **100** |

COURSE OUTCOMES:

Upon completion of this course the student will be able to:

CO1 know about solar system, solar radiation measurement system, effect of solar radiation on structures

CO2 understand the solar collectors, solar pumps, solar lighting systems and solar cookers

CO3 understand the cooling applications of solar systems

CO4 know the solar electric conversion systems

### UNIT-I

**Solar Radiation**

Characteristics, Earth-sun relation, Estimation on horizontal and tilted surfaces, Radiation characteristics of opaque and transparent material.

**Flat Plate Collectors**

Description, theory, Heat capacity effects, Time constant, Measurement of thermal performance, Air heaters.

### UNIT-II

**Evacuated Tubular Collectors**

One axis, Two axis, Solar tracking, Cylinderical, Spherical and Parabolic and Paraboloid concentrators. Composite collectors, Central receiver collectors.

**Heat Storage**

Sensible and latent heat storage, Chemical energy system, performance calculations.

### UNIT-III

**Flow Systems**

Natural and forced flow systems, Water heating systems for domestic, industrial and space heating requirements, Solar distillation.

**Solar Heating and Cooling**

Direct, indirect and isolated heating concepts, Cooling concepts, Load calculation methods, Performance evaluation methods.

### UNIT-IV

**Solar Thermal Power Generation**

Introduction, Paraboloidal concentrating systems, Cylinderical concentrating systems, Central receiver system.

**Solar Refrigeration and Air Conditioning Systems**

Introduction, Solar refrigeration and air conditioning systems, Solar desiccant cooling

**Reference Books:**


1. Solar Thermal Engineering Process by Duffie and Beckman.
2. Advanced Solar Energy Technology by H.P. Garg.
3. Solar Energy by S.P. Sukhatme.
4. Solar Energy by J.S. Hsieh.
5. Solar Thermal Engineering by P.J. Lunde.