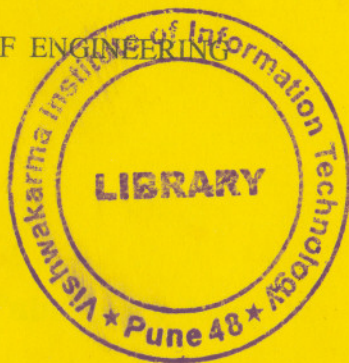


FACULTY OF ENGINEERING

No. 259



**Revised Syllabus for the  
T.E. (Mechanical)  
(From Academic Year 2005-2006)**



**UNIVERSITY OF PUNE**

**Price : Rs. 20/-**

## University of Pune

### T. E. (Mech)

#### 302041 Design of Machine Elements

Teaching Scheme:	Examination Scheme:
Lectures - 4 Hrs/Week	Paper-100 Marks (4 Hrs)
Practical - 2 Hrs/Week	Term Work-50Marks

#### Unit - 1

##### Design Process :

Machine Design, Traditional design methods, Basic procedure of Machine Design, Requisites of design engineer, Design of machine elements, Sources of Design data, Use of standards in design, Selection of preferred sizes, Design Synthesis, Creativity in design.

##### Design of Simple Machine parts :

Factor of safety, Service factor, Design of simple machine parts - Cotter joint, Knuckle joint and Levers, Eccentric axial loading, Stresses in curved beams (for circular cross-section only).

#### Unit - 2

##### Shafts, Keys and couplings :

Transmission shaft, Shaft design on strength basis, Shaft design on torsional rigidity basis, A.S.M.E. code for shaft design, Keys - saddle, sunk, feather and Woodruff keys, Design of square, flat and Kennedy keys, Splines, Couplings - Muff coupling, Flange coupling and Flexible bushed pin coupling.

Design of shaft on the basis of lateral rigidity—Castigliano's theorem.

**Unit - 3****Threaded joints :**

Basic types of screw fastenings-Cap screws and set screws, Bolts of uniform strength, Locking devices, I.S.O. Metric screw threads, Bolts under tension, Eccentrically loaded bolted joint in shear, Eccentric load perpendicular to axis of bolt, Eccentric load on circular base, Torque requirement for bolt tightening, Dimensions of standard fasteners, Design of cylinder bolts and turn buckle.

**Welded joints :**

Advantages and limitations of welded joints, Butt and fillet welds, Stresses in butt and fillet welds, Strength of butt parallel and transverse fillet welds, Axially loaded unsymmetrical welded joint, Eccentric load in plane of welds, Welded joint subjected to bending and torsional moments, Welding symbols.

**Unit - 4****Power screws :**

Forms of threads, Multiple threaded screws, Torque analysis with square and trapezoidal threads, Self locking screw, Collar friction torque, Stresses in power screws, Screw jack and C-Clamp design.

**Unit - 5****Design for Fluctuating Loads :**

Stress concentration - causes and remedies, Fluctuating stresses, Fatigue failure, S-N curve, Endurance limit, Notch sensitivity, Endurance strength modifying factors, Reversed stresses, Design for finite and infinite life, Cumulative damage in fatigue failure, Solderberg and Goodman diagrams, Modified Goodman diagram, Fatigue design of components under combined stresses such as shafts, bolts and springs.

**Unit - 6****Mechanical Springs :**

Types, Applications and materials of springs, Stress and deflection equations for helical Springs, Style of ends, Design of helical compression and tension springs, Springs in series and Parallel, Concentric helical springs. Helical torsion Spring, Multi-leaf spring (theoretical treatment only), Shot peening,

*Reference Books*

1. Shigley J.E. and Mischke C.R. – “Mechanical Engineering Design” – McGraw Hill Publication Co. Ltd.
2. Spotts M.F. and Shoup T.E. – “Design of Machine Elements” – Prentice Hall International.
3. Bhandari V.B. – “Design of Machine Elements” – Tata McGraw Hill Publication Co. Ltd.
4. Black P.H. and O. Eugene Adams - “Machine Design” – McGraw Hill Book Co. Inc.
5. Willium C. Orthwein – “Machine Components Design” – West Publishing Co. and Jaico Publications House.
6. “Design Data” – P.S.G. College of Technology, Coimbatore.
7. Juvinal R.C. – “Fundamentals of Machine Components Design” – John Wiley and Sons.
8. Hall A.S., Holowenko A.R. and Laughlin H.G. – “Theory and Problems of Machine Design” – Schaum's Outline Series.

**Term Work :**

1. Term work shall consist of TWO design projects. Each design project shall consist of two imperial size sheets -one involving assembly drawing with a part list and overall dimensions and other sheet involving drawings of individual components. Manufacturing tolerances, surface finish symbols and geometric tolerances should be specified so as to make it working drawing. A design report giving all necessary calculations of the design of components and assembly should be submitted in a separate file.

Design projects should be in the form of 'Design of Mechanical System' comprising of machine elements studied and topics covered in the syllabus. Design data book shall be used wherever necessary to achieve selection of standardized components.

**Recommendation :**

As far as possible, preference should be given to prepare drawing sheets using computer.

**(311046) Workshop Practice - IV****Class:** T.E. Mechanical**Semester:** I**Term Work:** 50Marks**Practical:** 2 hrs/week

Each candidate is required to complete and submit any two of following :

**Part A:** One composite job consisting of machining of components covering operations on - Lathe, Drilling, Milling Machines and essentially consists of Thread Assembly.

**Part B:** Demonstration/Job on CNC machine which should consist of Step Turning and Taper Turning Operations/

**Part C:** One job on milling machine consisting of Gear Cutting Operations.

Journal should contain the report of above jobs.

**302042 Heat Transfer**

Teaching scheme : (hrs/week)

Examination scheme :

Lectures - 4

Paper : 100 marks

Practical - 2

Oral : 50 Marks

**Unit I****Introduction:**

Applications of Heat Transfer in different fields of engineering. Modes of heat transfer, Fourier's law of conduction, Newton's law of cooling. Stefan-Boltzmann's law of radiation. Isotropic and anisotropic materials. Three dimensional heat conduction equation in Cartesian coordinate for anisotropic material for unsteady state condition, thermal diffusivity and reduction to Fourier equation. Laplace equation and Poisson's equation. Three dimensional form of heat conduction equation in cylindrical and spherical co-ordinates (no derivation).

**One dimensional steady state heat conduction :** One dimensional steady state heat conduction through a plane wall, cylindrical wall and sphere, Analogy between Heat flow and electricity, heat conduction through a composite slab, cylinder and sphere, overall heat transfer coefficient, Concept of thermal resistance and conductance..

### Unit II

Critical radius of insulation, thermal contact resistance. Economic thickness of insulation.

Physical interpretation of Thermal conductivity and its variation with temperature for metals, non metallic solids, gases and liquids. One dimensional problems of variable thermal conductivity.

### One dimensional steady state heat conduction with heat generation:-

Symmetrical and asymmetrical boundary condition in plane wall, Conduction in solid and hollow cylinder and sphere. Practical problems of heat generation.

### Unit III

#### Extended Surfaces:

Heat transfer through extended surfaces. Fins of different shapes. Derivation of differential equation for fins with constant cross section with different boundary conditions. Effectiveness and efficiency of a fin. Error in the measurement of temperature in a thermowell. Heat sinks-types and applications.

**Unsteady state Heat Conduction:** System with negligible internal resistance. Biot and Fourier numbers. Criteria for neglecting internal temperature gradient.

### Unit IV

#### Convection :

Introduction to hydrodynamic and thermal boundary layer. Laminar and turbulent flow over and inside a surface.

Convective heat transfer coefficients and their order of magnitude, Dimensional analysis of free and forced convection. Physical significance of the dimensionless parameters - Nusselt's number, Reynold's number, Prandtl's number, Grashoff's number, Stanton number, Rayleigh number.

**Forced convection :** Empirical correlations for heat transfer in laminar and turbulent flow over a flat plate and in a circular pipe. Concept of hydraulic diameter.

**Natural convection:** Empirical correlations for free convection heat transfer over horizontal, vertical plate and cylinder.

### Unit V

#### Thermal Radiation:

Fundamental concepts, Black body radiation, Kirchoff's law, Planck's distribution law, Wien's displacement law and Stefan Boltzmann's law. Surface emission, radiative properties of a surface. Grey, black, white and real surface. Solid angle and intensity of radiation, Lambert's cosine law. Heat exchange by radiation between two finite black surfaces. Radiation shape factor, use of shape factor charts. Irradiation, radiosity, electrical network method of solving problems. Heat exchange between non-black bodies, Heat exchange between two infinitely parallel planes, cylinders and spheres. Radiation Shields, Gas radiation (elementary treatment only). Solar radiation.

## Unit VI

**Condensation and boiling :**

Film and drop wise condensation. Derivation of heat transfer coefficient for Laminar film condensation on vertical and inclined plate, correlations for condensation on and inside tubes.

Regimes of pool boiling and pool boiling curve and critical heat flux.

Forced Convection boiling.

**Heat exchangers :** Classification, Applications of heat-exchangers.

Heat Exchanger analysis – Logarithmic Mean Temperature Difference for parallel and counter flow heat exchangers. LMTD correction factors, fouling factor.

The Effectiveness – NTU method for parallel and counter flow heat exchangers. Design considerations for heat exchanger. Introduction to compact heat exchanger and heat pipe heat exchanger.

**List of Practicals :**

The term Work shall consist of any “eight” experiments out of the following :

**Note :** One of the experiments listed below must have computer interfacing.

1. Determination of thermal conductivity of insulating powder
2. Determination of thermal conductivity of metal rod.
3. Temperature distribution through a composite wall.
4. Temperature distribution along the length of a fin and determination of fin effectiveness and fin efficiency

5. Natural convection heat transfer from a heated vertical cylinder.
6. Heat transfer in forced convection for a pipe losing heat to air flowing through it.
7. Determination of emissivity of a metal surface.
8. Determination of Stefan-Boltzmann constant.
9. Determination of critical heat flux in pool boiling.
10. Performance of a parallel flow and counter flow heat exchanger.

*Reference Books*

1. J.P. Holman, “Heat Transfer”, McGraw hill.
2. Frank P Incropera, David P De Witt, (1990), “Fundamentals of Heat Transfer”, Wiley, Eastern Limited.
3. Sachdeva, R.C, (1988), “Fundamentals of Engineering Heat and Mass Transfer, Wiley Eastern Limited III<sup>rd</sup> Edition.
4. Sukhatme S.P. (1989), “A text book on Heat Transfer”, III<sup>rd</sup> Edition, Orient Longmans Ltd, New Delhi.
5. Arora S C and Domkundwar.S. (1994), “A Course in Heat and Mass Transfer”, Dhanpat Rai & Sons, IV<sup>th</sup> Edition.
6. Gupta and Prakash, (1994), “Engineering Heat Transfer”, Nemchand and Brothers.
7. Karlekar & Desmond, “Principles of Heat Transfer”, Prentice hall of India Ltd, New Delhi.
8. M. Necati Ozisik, “Heat Transfer”.

**302043 : Theory of Machines and Mechanisms-II**

Teaching Scheme

Lectures : 4Hrs/Week

Pract : 2Hrs/Week

Examination Scheme

Paper : 100 Marks

Oral : 50 Marks

**Unit-I :**

- (a) **Friction** - Dry friction, Inclined Plane theory, Friction between Screw and Nut, Friction in turning pairs, Friction Circle, Friction axis, Friction in Mechanisms.
- (b) **Belt and Rope Drives** - Flat and Vee belt, Rope, Limiting tension ratio, Power transmitted, Centrifugal effect, Maximum power transmitted by belt, Slip, Creep and Initial tension.

**Unit-II :**

- (a) **Friction Clutches** - Pivot and Collar friction, Plate clutches, Cone clutch, Centrifugal clutch, Torque transmitting capacity, Clutch operating mechanisms
- (b) **Brakes and Dynamometers** - Different types of brakes, Shoe brakes, External and Internal shoe brakes, Block brakes, Band brakes, Band and Block brakes, Braking torques, Different types of absorption and transmission type dynamometers.

**Unit-III :**

**Cams and Followers** - Types of cams and followers, Analysis of standard motions to the follower, Determination of cam profiles for given follower motions, Analysis of cams with specified contours- circular arc cam, tangent cam, eccentric cam, Kinematically equivalent system, Jump phenomenon, Introduction to Advanced cam curves.

**Unit-IV**

- (a) **Flywheel** - Turning moment diagram, Fluctuation of energy and speed, Determination of flywheel size for different types of engines and machines.
- (b) **Governors** - Function, Inertia and centrifugal type governors, Different types of centrifugal governors (Watt, Porter, Proell and Hartnell only), Controlling force analysis, Governor effort and governor power, sensitivity, stability, Isochronism and hunting, Friction, Insensitiveness.

**Unit-V**

**Gears** - Classification of gears,

**Spur Gears**-terminology of gearing, conjugate action, involute and cycloidal profile, path of contact, arc of contact, contact ratio, interference, undercutting, Methods to avoid interference and undercutting, Rack shift, Effect of center distance variation, friction between gear teeth, internal gears,

**Helical Gears** : Normal and transverse module, Torque transmitted by helical gears on parallel shafts. Virtual number of teeth.

**Unit-VI**

- (a) **Spiral Gears** - Spiral angle, shaft angle, Efficiency of spiral gears.

**Worm and worm gears & Bevel Gears** : Terminology, geometrical relationships, applications and tooth forces. Torque transmitted.

- (b) **Gear trains** : Types of gear trains. Velocity ratio, Tooth load, torque transmitted. Holding torque.

## Reference Books

1. Hannah and Stephans : Mechanics of Machines, Edward Arnold Publication.
2. Beven T : Theory of Machines, Longman Publication
3. Shigley J. E. and Uicker, J J. 1995, Theory of Machines and Mechanisms, International Edition, MacGraw Hill Inc.
4. Ballaney P. L. Theory of Machines, Khanna Publications.
5. Jagdish Lal : Theory of Machines, Metrapolitan Book Co. Pvt. Ltd. N. Delhi.
6. Khurmi, R. S. and Gupta, J. K. 1996, Theory of Machines, Eurasia Publishing House (Pvt.) Ltd., New Delhi.
7. A. Ghosh Malik, "Theory of Mechanism and Machines", East-West Pvt. Ltd.

**List of Practicals :**

The practical shall consist of any **eight** of the following experiments

1. Study of belt drive systems and measurement of slip.
2. Study of various types of friction clutches and to measure torque transmitting capacity.
3. Study of various types of brakes and dynamometers and to measure the power transmitted.
4. Study of various types of cam and follower systems and Verification of cam jump phenomenon.
5. To draw cam profiles for various types of follower motions.

6. To determine the characteristics curve for centrifugal governor and to find its coefficient of insensitiveness and stability.
7. Study of various types of gearboxes such as Industrial gear box, Synchromesh gearbox, Differential gearbox, PIV gearbox.
8. To draw conjugate profile for any general type of gear tooth.
9. To generate involute gear tooth profile and to study the effect of undercutting and rackshift using models.
10. To study epicyclic gear trains and to measure torques-torque transmitted and holding torques.

**302044 Industrial Engineering and Management**

Teaching Scheme:

Lectures: 4 Hours / week

Examination Scheme:

Theory: 100 Marks

**Unit 1****Introduction :**

Industrial Engineering. Basic Techniques involved. Method Study: Need for recording the activities, Symbols used in charting, various charts, Questioning Technique, Process Improvements, Installation of Improved Processes. Work Measurement: Aim, Time Study, Work / Activity Sampling, Predetermined Time Standards, computer applications in industrial engineering.

**Unit 2****Ergonomics :**

Definition and importance. Historical Background. Human Machine Systems - interfaces. Anthropometry: Need, Important Body Dimensions, Data Collection, Statistical

Analysis, Percentile. Applied Anthropometry and Work Space Design & Seating, ergonomics and safety.

### Unit 3

#### Management And Productivity :

Basic concepts of management, Management factors: Planning, Organizing, Leadership, Motivation and Control. Maslow's hierarchy of needs, Form of business organizations, long and short term perspective for growth, Diversification in the context of changing environment: Social, economic, technological, etc. Productivity; Definitions, Scope and measurement, Productivity improvement methods for organizations, job evaluation and merit rating.

### Unit 4

#### Management controls & Systems :

Standard costing: variance analysis, budgetary control, zero-based budgeting, and contribution analysis. Profit centre, cost centre, investment centre concepts: transfer pricing. Financial planning and control: Working capital, investment, financial structure, dividend decisions, Capital evaluation techniques.

### Unit 5

#### Facility Layout And Design :

Introduction: Nature, Significance and Scope of Facility layout and design. Facility Location: Location analysis, Single-facility and Multi-facility location problems. Steps in layout planning, Quantitative techniques. Material Handling: Principles of Material Handling, Equipment Selection. Storage and Warehousing: Functions, Objectives and Principles. Facility Services like air, water, electricity, drainage etc. computerised layout planning.

### Unit 6

#### Production Planning And Inventory Control :

Materials management : Meaning, Functions and objectives. Production Planning and Control: Aggregate production planning and control, Hierarchical production planning and control, Desegregation of aggregate plan. Inventory Control : Purpose, types, functions, EOQ concept, ABC, VED & FMS analysis. Modern Techniques: Introduction to MRP & MRP II, JIT, Kanban, sales forecasting and techniques.

#### References

1. Maynard, Industrial Engineering Handbook, Mc Graw Hill Book Company.
2. ILO, Introduction to Work study
3. Curie R. M. & Faraday, Work study
4. M. S. Sanders and Ernest J. McCormick, McGraw Hill Inc., Human Factors Engineering and Design.
5. E. Grad jean, Fitting Task to the Man.
6. Khanna O. P., Industrial Engineering and Management, Dhanapat Rai Publications, New Delhi.
7. Gopalkrishnan P. and Sudarshan, Materials Management, Prentice Hall India Ltd.
8. Arnold J R I: Intro To Materials Management. Prentice Hall Inc New Jercey, 1996. (658.7 ARN 015979)
9. Rathnam P V : Costing Adviser. Allahabad. Kitab Mahal, 2003. (658.155 RAT 023519)
10. Eilon S : Elements Of Production Planning And Control. Universal Publishing Bombay, 2001. (658.503 EIL 018303)

11. Tompkins J A & White J A : Facilities Planning. New York. John Wiley & Sons, 1984. (658.2 TOM 011425).
12. Aswathappa K : Organisational Behavior : Text, Cases, Games. Mumbai. Himalaya Publishing House, 2004. 81-7866-849-1 (658.4 ASW M01389).

### 302045 Computer Oriented Numerical Methods

Teaching Scheme:	Examination Scheme:
Lectures: 4 Hrs/Week	Theory: 100 Marks
Practical : 2 Hrs/Week	Practical : 50 Marks

#### Unit I

##### Errors and approximations :

Types of Errors, Absolute, Relative, Algorithmic, Truncation, Round off Errors. Error Propagation, Concept of Convergence, Relevance to Numerical Methods, Direct and Iterative Methods.

**Linear Programming :** Simplex Method

#### Unit II

##### Interpolation :

Langrange's Interpolation, Newton's forward, backward and central difference method, divided difference method, Inverse Interpolation.

**Curve Fitting :** least square criteria- 1<sup>st</sup> and 2<sup>nd</sup> Degree.

#### Unit III

##### Solution of linear simultaneous equations :

Homogeneous/Non-homogeneous systems, Gauss Elimination, Gauss-Jordan, Gauss-Seidel Methods, LU-Decomposition, Cholesky Method

**Numerical Differentiation :** Forward, Backward and Central Difference Methods.

#### Unit IV

##### Numerical Solution of Algebraic and Transcendental equations :

Bisection Method, Secant Method, Regula-Falsi Method, Newton-Raphson Method, Successive Approximation Method

**Numerical integration :** Trapezoidal Rule, Simpson 1/3<sup>rd</sup> and 3/8<sup>th</sup> Rule, Weddle's Rule, Gauss Quadrature - Two and Three Point Formula, Double Integration.

#### Unit V

##### Numerical Solution of Ordinary Differential Equation:

Taylor Series Method, Euler Method, Modified Euler Method, Predictor-Corrector Methods - Milne's Method, Adam-Bashforth Method, Runge Kutta 2<sup>nd</sup> and 4<sup>th</sup> order method, Simultaneous Differential Equations and Second Order Differential Equations

#### Unit VI

##### Numerical Solution of Partial Differential Equation:

Finite Difference Method, Laplace's Equation. Poisson's Equation, One and Two Dimensional Heat Equations, Wave Equation.

##### Reference Books

1. Chapra, S.C. & Canal, R. P., "Numerical Methods for Engineers", 4<sup>th</sup> Ed., Tata McGraw Hill Pub. Co. Ltd., New Delhi
2. Balagurusamy, E., "Numerical Methods", Tata McGraw Hill Pub. Co. Ltd., New Delhi
3. Rajaraman, V., "Computer Oriented Numerical Methods", Prentice Hall of India Ltd, New Delhi.

4. Sastry, S.S., "Introductory Methods of Numerical Analysis", Prentice Hall of India Ltd, New Delhi
5. Jain, M.K., Iyengar, S.R.K. AND Jain, R.K., "Numerical Methods for Scientific and Engineering Computations", 5<sup>th</sup> Ed., New Age International Ltd, New Delhi
6. Rajasekaran, S., "Numerical Methods in Science and Engineering - A practical Approach", S. Chand and Co. Ltd., New Delhi.
7. Rao, S.S., "Optimization - Theory and Applications", New Age International Ltd, New Delhi

#### List of Practicals :

Minimum **NINE** programming assignments shall be completed and submitted as term work in the form of a journal comprising of flowcharts, program listing and results. Out of these, **MINIMUM ONE** programming assignment must be based on **EACH** of the topics Listed Below:

1. Linear Programming
2. Interpolation
3. Curve Fitting
4. Linear simultaneous equations
5. Numerical Differentiation
6. Algebraic and Transcendental equations
7. Numerical integration
8. Ordinary Differential Equation
9. Partial Differential Equation

**Note :** At least 3 of the above assignments will be carried out using a mathematical solver such as MATLAB, TK Solver, Mathematica, etc. The remaining assignments will be completed using C/C++ language.

### 302047 Transmission System Design

Teaching Scheme :	Examination Scheme:
Lectures : 4 Hrs/Week	Paper : 100 Marks (4 Hrs Duration)
Practical : 2 Hrs/Week	Term work : 25 Marks
	Oral : 50 Marks

#### Unit 1

##### Rolling contact bearings :

Types of rolling contact Bearings, Static and dynamic load carrying capacities, Stribeck's equation, Equivalent bearing load, Load-life relationship, Selection of bearing life, Selection of rolling contact bearings from manufacturer's catalogue, Taper roller bearing, Design for cyclic loads and speed, Bearing with probability of survival other than 90%, Lubrication and mounting of bearings, Preloading of rolling contact bearings, Types of failure in rolling contact bearings - causes and remedies.

#### Unit 2

##### Friction Clutches :

Classification and selection of friction clutches, Torque transmitting capacities and design of single-plate, multi-plate, Cone and Centrifugal clutches, Types of friction materials, their advantages, limitations and selection criteria, Concept of temperature rise in clutch operation.

##### Brakes :

Energy absorbed by brake, Design considerations in Pivoted block brake with long shoe, Internal expanding shoe brake and Disk brake, Temperature rise in brake operation.

**Unit 3****Belts, Chain and Rope drives :**

Materials and construction of flat and V belts, Geometric relationships for length of belt, Power rating of belts, Maximum power condition, Selection of flat and V belts from Manufacturer's catalogue, Belt tensioning methods, Relative advantages and limitations of flat and V belts, Construction and applications of timing belts.

Construction and materials of roller chain, Length of chain and number of links, Polygonal effect, Power rating of roller chains, Construction of sprocket wheels, Silent chains, Relative advantages and limitations of chain drives.

Rope drives, Construction of wire ropes, Lay of wire ropes, Stresses in wire rope, Selection of wire ropes, Rope drum construction and design.

**Unit 4****Gear Drives :**

Classification of gears, Selection of types of gears, Standard systems of gear tooth.

**Spur gear :**

Number of teeth and face width, Types of gear tooth failure, Desirable properties and selection of gear material, Constructional details of gear wheel, Force analysis, Beam strength (Lewis) equation, Velocity factor, Service factor, Load concentration factor, Effective load on gear, Wear strength (Buckingham's) equation, Estimation of module based on beam and wear strength, Estimation of dynamic tooth load by velocity factor and Buckingham's equation, Methods of gear lubrication, Introduction to addendum modification and its advantages.

**Unit 5****Helical gears :**

Transverse and normal module, Virtual no of teeth, Force analysis, Beam and wear strengths, Effective load on gear tooth, Estimation of dynamic load by velocity factor and Buckingham's equation, Design of helical gears.

**Bevel Gears :**

Straight tooth bevel gear terminology and geometric relationship, Formative number of teeth, Force analysis, Design criteria of bevel gears, Beam and wear strengths, Dynamic tooth load by Velocity factor and Buckingham's equation, Effective load, Design of straight tooth bevel gears, Selection of materials for bevel gears, Introduction to spiral bevel gears and hypoid gears and comparison with straight tooth bevel gears, Lubrication and mounting of bevel gears, Bearing reactions, Types of failures in bevel gears.

**Unit 6****Worm Gears :**

Worm and worm gear terminology and geometrical relationship, Types of worm and worm gears, Standard dimensions, Force analysis of worm gear drives, Friction in Worm gears and its efficiency, Worm and worm-wheel material, Strength and wear ratings of worm gears, Thermal consideration in worm gear drive, Types of failures in worm gearing, Methods of lubrication.

*Reference Books*

1. Shigley J.E. and Mischke C.R. - "Mechanical Engineering Design" McGraw Hill Pub. Co. Ltd.
2. Spott's M.F. and Shoup T.E. - "Design of Machine elements" - Prentice Hall International.

3. Bhandari V.B. - "Design of machine elements" - Tata McGraw Hill Public Co. Ltd.
4. Black P.H. and O. Eugene Adams - "Machine Design" - McGraw Hill Book Co. Ltd.
5. William C. Orthwine - "Machine Components Design" - West-Pub. Co. an Jaico Pub. House.
6. "Design Data" - P.S.G. College of Technology, Coimbatore.
7. Juvinal R.C. - "Fundamentals of Machine Components Design" - John Wiely and Sons.
8. Hall A.S., Holowenko A.R. and Laughlin H.G. - "Theory and Problems of Machine Design" - Schaum's outline series.

### Term Work

1. Term work shall consist of "ONE" design project. The design project shall consist of two imperial size sheets - one involving assembly drawing with a part list and overall dimensions and the other sheet involving drawing of individual components. Manufacturing tolerances, surface finish symbols and geometric tolerances should be specified so as to make it working drawing. A design report giving all necessary calculations of the design of the components and assembly should be submitted in a separate file.

Design projects should include selection of prime mover and design of mechanical systems comprising of machine elements : 1) spur gears and helical/bevel/worm gears OR 2) belt/chain/rope and clutch/brake  
Design data book shall be used extensively for the selection of the components.

The ORAL shall be based on Term Work done during the second term under the subject Transmission System Design Since there are no separate marks for Term Work under the subject Transmission System Design, due considerations should be given for this term work under the heading of oral examination of 50 marks.

### Recommendations :

1. As far as possible, preference should be given to prepare drawing sheets using computer.
2. A study visit to industry may be arranged to see manufacture of machine elements and assemblies during the semester. During the same visit, the students are expected to visit design office to see design and drafting aids. A report of this visit may be included in the term work.

### 302049 : Tribology

Teaching Scheme

Lectures : 4Hrs/Week

Examination Scheme

Paper : 100 Marks

### Unit I

Introduction to Tribology, tribology in design, Tribology in industry, Recycling of used oil & oil Conservation. Disposal of Scrap oil & oil emulsion. Lubricants - Properties- physical and chemical, Types of additives, extreme pressure lubricants.

Lubrication-introduction, basic modes of lubrication.

Types of sliding contact bearings. Comparison of Sliding and Rolling contact bearings.

### Unit II

Friction : Introduction, Laws of friction, kinds of friction, causes of friction, friction measurement, theory of friction.

Wear : Types of wear, various factors affecting wear, measurement of wear, wear between solids and liquids, theory of wear.

### Unit III

Hydrodynamic Lubrication : Theory of hydrodynamic lubrication. Mechanism of pressure development in oil film. Two dimensional Reynolds equation. Infinitely long journal bearing. Infinitely short journal bearing. Sommerfeld number, Raimondi and Boyd method, Temperature rise. Parameters of bearing design - Length to diameter ratio, Unit bearing pressure, Radial clearance and minimum oil film thickness.

### Unit IV

Hydrostatic Lubrication : Basic concept, advantages and limitations. Viscous flow through rectangular slot. Load carrying capacity and flow requirement of hydrostatic step bearing, energy losses. Optimum design of step bearing.

### Unit V

Hydrostatic squeeze film: Introduction, circular and rectangular plates approaching a plane.

Gas Lubrication : Introduction, Merits and demerits, Applications.

Lubrication in metal working : Rolling, Forging, Drawing and extrusion.

### Unit VI

Hydrodynamic Thrust bearing : Introduction, flat plate thrust bearing, pressure equation, load, centre of pressure. Friction in tilting pad thrust bearing.

Elastohydrodynamic Lubrication : Principle and Application.

Bearing Materials and bearing constructions.  
Oil seals & shields, Gaskets.

### Reference Books

1. Fuller D. D., "Theory and Practice of Lubrication for Engineers". John Wiley and Sons.
2. Halling J., "Principles of Tribology", McMillan Press Ltd.
3. Cameron A. "Basic Lubrication Theory", Wiley Eastern Ltd.
4. Neale M. J. "Tribology Hand Book", Butterworths.
5. B. C. Majumdar "Introduction to Tribology and Bearings", H. Wheeler and Company Pvt. Ltd.
6. O. P. Orlov, "Fundamentals of Machine Design", Vol.IV, MIR.
7. Bhandari V.B., Design of Machine Elements, Tata-McGrawHill Publication Co. Ltd.
8. Handbook of Tribology by Bharat Bhushan.

**302050 : Fluid Machinery**

Teaching Scheme	Examination Scheme
Lectures : 4 Hrs/Week	Theory : 100 Marks
Practicals : 2 Hrs/Week	Oral: 50 Marks

**Unit 1**  
**Introduction to Hydrodynamic machines :**

Classification, general theory, centrifugal heads, fundamental equations, degree of reaction, head on machines, various efficiencies, condition for maximum hydraulic efficiency.

**Impulse Momentum equation and its application :**

Impulse momentum principle, fixed & moving flat plates & curved vanes, series of plates & vanes, water wheels, velocity triangles & their analysis, work done, efficiency etc.

**Unit 2**  
**Impulse Turbines :**

Main components & constructional features of Pelton wheel, velocity diagrams & analysis, number of buckets, jets, non-dimensional parameters like speed ratio, flow ratio, condition for maximum efficiency. Introduction to other impulse turbines.

**Unit 3**  
**Reaction Turbines :**

Types of reaction turbines Francis, Kaplan, Deriaz, bulb, reversible and low head turbines. Main components & constructional features, draft tube- types, efficiency, limitations for use of draft tubes, cavitation in reaction turbines.

**Unit 4**  
**Governing, Performance & Selection of Turbines :**

Governing mechanism for Pelton wheel, Francis, Kaplan turbine, safety devices for turbine, pressure regulators, surge tanks, forebay. Performance of water turbines- characteristic curves, unit quantities, specific speed & shape of runner. Selection of turbine.

**Similarity & Model analysis :**

Similitude - geometric, Kinematic, dynamic similarity. Model analysis - various model laws, model testing, scale effect. Similarity applied to turbines and pumps.

**Unit 5**  
**Hydrodynamic Pumps :**

Classification, components of centrifugal pump. Various terms associated with centrifugal pump, various heads, velocity triangles & their analysis, effect of outlet blade angle, cavitation, NPSH, Thomas cavitation factor, priming of pumps, installation, specific speed & pump classification. Performance characteristics of centrifugal pump. Axial thrust, maintenance, troubles & remedies, series & parallel operation of pumps, system resistance curve, water hammer problem in pumping system.

**Unit 6**  
**Reciprocating and Special Pumps :**

Reciprocating pump, Airlift pump, Hydraulic ram, deep well pump, submersible pumps, vertical turbine pump, regenerative pump, construction, principle of operation, energy analysis, performance characteristics.

**Fluid coupling & torque converter :**

Construction, working, characteristics curves, applications.

*Reference Books*

1. Modi P N & Seth S N, "Hydraulics, Fluid Mechanics and Machinery", Standard Book House, New Delhi.
2. V.P. Vasandani, "Theory of Hydraulic Machinery", Khanna Publishers, Delhi.
3. Dr. J. Lal, "Hydraulic Machines", Metropolitan Book Co. Pvt. Ltd., Delhi.
4. Karassik, "Hand Book of Pumps", Tata McGraw Hills Ltd., New Delhi.
5. R. K. Srivastava, Critical Aspects in Rotodynamics Pumps & Systems, Techno Economic Research Institution, New Delhi.

**List of Experiments**

Minimum 8 experiments shall be performed out of which experiments at serial number 1, 2, 3 or 4, 5 are compulsory. Record of 8 experiments shall be submitted in the form of journal.

1. Verification of impulse momentum principle using flat, inclined & curved plates.
2. Study & trial on a Pelton wheel & plotting of operating characteristics.
3. Study & trial on a Francis turbine & plotting of main/operating characteristics.
4. Study & trial on a Kaplan turbine & plotting of main/operating characteristics.
5. Study & trial on a centrifugal pump & plotting of operating & variable speed characteristics.
6. Study & demonstration of different non conventional pumps such as air lift pump, jet pump, deepwell pump, hydraulic ram etc.

7. Study & trial on a torque converter & plotting operating characteristics.
8. Study and trial on reciprocating pump & plotting of operating characteristics
9. Design of a complete pumping system installation using standard tables, charts supplied by pump manufactures.
10. Visit to Hydro-electric power station & writing a report based on the visit.
11. Visit to pumping station & writing a report based on the visit.

**302051 Refrigeration And Air-Conditioning**

Teaching Scheme:

Examination Scheme:

Lectures: 4Hrs/Week

Theory: 100 Marks

Practical: 2 hours per week

Oral: 50 Marks

**Unit 1****Methods of Refrigeration :**

Ice refrigeration, evaporative refrigeration, Refrigeration by expansion of air, refrigeration by throttling of gas, vapour refrigeration system, steam jet refrigeration system, and refrigeration by using liquid gases. Thermoelectric and ultrasound Refrigeration. Concept of COP, EER, SEER, IPLV.

**Air Refrigeration Systems :** Definition, refrigeration load, unit of refrigeration, reverse Carnot cycle, Bell-Coleman cycle, methods of air refrigeration systems, simple air cooling system, boot-strap system, reduced ambient system, regenerative system.

**Unit 2****Simple Vapour Compression system :**

Limitations of air refrigeration system, development of vapour compression cycle (VCC), effect of operating parameters on VCC, use of P-h charts, actual vapour compression cycle. Various capacity control methods and its merits/demerits.

**Refrigerants:-** Desirable properties of refrigerants, classification of refrigerants, secondary refrigerants, alternative refrigerants for CFC's and HCFC's, ozone depletion Potential (ODP) Global Warming Potential (GWP), atmospheric life, total equivalent warming impact (TEWI), Refrigerant, reclaim, recycle methods.

**Unit 3****Multi Pressure Systems :**

Introduction, multistage compression, two stage compression with flash gas removal, with liquid intercooler, complete two stage compression system multiple evaporator systems, cascade systems, Thermodynamic evaluation of various systems for two refrigerants (using properties).

**Vapour Absorption System :-** Introduction, simple vapour absorption system, practical vapour absorption system, COP of an ideal vapour absorption system, selection criteria of refrigerant-absorbent mixture, water ammonia system, Electrolux refrigerator, lithium bromide absorption system, comparison between VCC and VAC. Cycle used in absorption refrigeration (half effect, single effect, double effect, single-double effect). Thermodynamic analysis for simple single effect cycle for  $\text{NH}_3$  -  $\text{H}_2\text{O}$

**Unit 4****Psychrometry :**

Introduction, psychrometric terms, use of psychrometric chart, psychrometric processes, adiabatic saturation temperature, evaporative cooling, by-pass factor of coil, efficiency of coil, adiabatic mixing of two air streams. Air washers, Thermodynamics of human body with environment, effective temperature, comfort chart, factors influencing human comfort, indoor air quality requirements, ventilation requirement.

**Unit 5****Air- Conditioning Systems :**

Definition, factors, equipment used, classification, all air system, all water system, air water system, unitary and central air conditioning, infiltration and ventilation loads, concept of SHF, RSHF, GSHF, ERSHF, ADP

**Components of Refrigeration and Air Conditioning System:** Compressors, condensers, evaporators, expansion devices such as capillary tubes, automatic expansion valves, thermostatic expansion valves and controls such as thermostats, humidistat, solenoid. Installation, charging, testing, and maintenance, and trouble shooting of system.

**Unit 6****Ducts :**

Introduction, classification of ducts, duct material, pressure in ducts, flow through duct, pressure losses in duct, friction losses, dynamic losses, air flow through simple duct system, equivalent diameter, methods for determination of duct size, equal friction, velocity reduction, static regain method.

FOOD PRESERVATION – Cold storages, control and modified atmosphere(CAMA) storages, mobile refrigeration, and air conditioning, refrigerant piping selection, pressure drop, valves, fittings, accessories, etc....., insulating materials.

### Term Work :

The term shall consist of record of minimum eight experiments from the followings.

1. Test on vapour compression test rig.
2. Test on air conditioning test rig.
3. Test on ice plant test rig.
4. Test on vapour absorption test rig.
5. Study of non- conventional refrigeration systems
7. Determination of cooling load of air conditioning system (case study).
8. Study of installation/operation/maintenance practices for refrigeration systems.
9. Determination of refrigeration load in cold storage (case study/visit).
10. Visit to any refrigeration or air conditioning plant.

### Reference Books

1. Arora and Domkundwar : Refrigeration and airconditioning, Dhanpatrai and Company.
2. C P Arora : Refrigeration and Airconditioning, Tata McGraw Hill.
3. Dossat Ray J., "Principal of refrigeration" S.I. Version, Wiley Eastern Limited, 2000.

4. Manohar Prasad, "Refrigeration and Air-conditioning", Wiley Eastern Limited, 1983
5. Ballaney PL. "Refrigeration and Air-conditioning" Khanna Publishers, New Delhi, 1992.
6. Khurmi R.S. and Gupta J.K., "Refrigeration and Air-conditioning" Eurasia publishing house (P) Ltd., New Delhi, 1994.
7. Stocker W.F. and Jones J.W. "Refrigeration and Air-conditioning", mcgraw Hill international editions 1982
8. Threlkeld J.L. "Thermal environmental engineering", Prentice hall Inc. New Delhi.
9. ISHRAE Handbook.

### 302052 Technical Paper Presentation

Teaching scheme : (hrs/week) Examination scheme  
 Practical : 2 Term work : 50 Marks

Technical Paper Presentation is a seminar which is expected to be on a state - of - the - art technical topic, related to Mechanical Engineering discipline but outside syllabus. The seminar report and its presentation is to be based on material, mainly collected and analysed from the latest papers in technical journals. The report is expected to be of about 15 A4 size pages, including figures and plates, in addition to certificate, synopsis and reference pages. The presentation is expected to be in front of the audience which must include at least two internal examiners one of them being a guide and both being university approved teachers. The marks distribution is equally divided between the report and presentation/oral examination.

### 311048 Metrology And Quality Control

Class: T.E. Mechanical Semester : II  
Theory : 4 hrs/week Paper : 100 Marks  
Practical : 2 hrs/week Term Work : 25 Marks

#### Metrology

##### Unit - I [8 hrs]

- 1.1. Introduction to measurement, errors, standards, various precision measuring instruments, straightness, flatness, squareness, roundness measurement, angular measurement.  
Calibration of all measuring instruments.

- 1.2. Principles of gauge design- types of gauges, Taylor's Principle of gauge design, Limits, Fits, Tolerances.

##### Unit - II [8 hrs]

- 2.1. Comparators - Types and working principle of mechanical, pneumatic, electronic, optical, electrical comparators and their applications.
- 2.2. Interferometer - Principles, Sources of light, Optical Flat, Fringe Patterns, Calibration of Optical Flat and It's applications, Tool Maker's Microscope, Profile Projector.
- 2.3. Surface Finish Measurement - Surface texture terminology, measurement of surface roughness and instruments

##### Unit - III [8 hrs]

- 3.1. Machine Tool Metrology - Alignment Test, Performance Test of Lathe, Milling and Drilling Machine.

- 3.2. Metrology of Screw Thread - Screw Thread Terminology, Thread Gauges, Measurement of Thread Element - Floating Carriage Micrometer.
- 3.3. Gear Metrology - Gear Terminology and its measurement, Measurement of Tooth Thickness by Gear Tooth Vernier Caliper- Base Tangent Method, Constant Chord Method, Span Micrometer method, Roller Method.
- 3.4. Advances in Metrology - Coordinate Measuring Machine, Universal Measuring Machine, Application of Laser in Measurement, Meteroscope, Automatic Inspection System.

#### Quality Control

##### Unit - IV [8 hrs]

- 4.1. Concept of Quality - Definitions of Quality, Dr. Deming and Juran's Contributions, Elements/Characteristics of Quality, Value of Quality, Cost of Quality, Quality Policy, Vision, Mission.
- 4.2. Quality Control - Definitions, Scope and Applications, Quality Assurance, Causes of Variation.

##### Unit - V [8 hrs]

- 5.1. Statistical Quality Control - Basic Statistics, Mean, Mode, Standard Deviation, Frequency Distribution, Control Chart for Variables, Attributes, Process Capability.
- 5.2. Acceptance Sampling - Sampling Inspection, Operational Characteristics Curve, Consumer's Risk, Producer's Risk, AQL, LTPD, AOQL, Types of Sampling Plan - Single, Double, Multiple, Sequential Sampling Plan.

**Unit - VI** [8 hrs]

- 6.1. Six Sigma - Types of defects, DMAC, Six Sigma Program, Zero Defect.
- 6.2. Quality Standards - ISO 9000:2001, TS 16949 Standard, FMECA (Failure Mode Effect Criticality Analysis), FTA (Fault Tree Analysis).
- 6.3. Quality Circle - Kaizen Practice, Cause and Effect Diagram, Pareto Analysis, Total Quality Management (TQM).

Term Work shall be in the form of the following

**(A) Experiments** - Any eight of the following.

1. Determination of Linear/Angular dimensions of a part using precision/non-precision measuring instruments.
2. Precision Angular Measurement using Sine Bar/Sine Center, Autocollimator/Angle Dekkor.
3. Machine Tool Alignment Test on any machine like-Lathe, Milling, Drilling.
4. Measurement of Screw Thread using Floating Carriage Micrometer.
5. Measurement of Gear Tooth Thickness by Gear Tooth Vernier Caliper/Constant Chord/Span Micrometer.
6. Measurement of Circularity/Roundness using Mechanical Comparator.
7. Calibration of Dial Gauge using Dial Calibration Tester.
8. Interferometry- Study of Surfaces using Optical Flat.
9. Study and applications of profile projector and Tool Maker's Microscope.
10. Inspection of Production Job by Statistical Process Control.

**(B) Assignment** – At least two assignments based on Syllabus of Quality Control.

**(C) Industrial Visit Report** on study of Metrology Subject.

*References*

1. Jain R.K. – Engineering Metrology, Khanna Publication
2. Hume K.J – Engineering Metrology
3. Juran J.M. – Quality Handbook - McGraw Hill Publication
4. Grant S. P. – Statistical Quality Control - Tata McGraw Hill Publication.

**302065 Theory of Machines And Machine Design II****T.E.Mechanical Sandwich (2003 Course)**

Teaching Scheme	Examination Scheme
Lectures : 4 Hrs./Week	Theory : 100 Marks
	Drawing : 2 Hrs./Week
	TW : 25 marks
	Oral : 50 Marks

**Unit I****Synthesis of Mechanisms :**

Type, number & dimensional synthesis, Freudenstines equation, precision points, function generation, path generation. Analytical and graphical synthesis of four bar mechanism and slider crank mechanism. Body guidance, coupler curves.

**Cams And Followers :**

Types, kinematic equivalent systems, follower motions, kinematic analysis and profile construction of radial cams. Introduction to specified contour cams.

**Unit II****Spur & Helical Gears :**

Spur gear - terminology, involute and cycloidal profile, conjugate action, interference, undercutting. Friction between gear teeth.

Helical gears - Normal and transverse module, virtual number of teeth, force analysis, torque transmitted by helical gears.

**Gear & Gear Trains :**

Spiral gears, worm and worm gears & bevel gears - terminology, applications, torque transmitted & efficiency.

Gear trains : Types, velocity ratio, torque transmitted, holding torque.

**Unit III****Friction & Friction Clutches :**

Pivot and collar friction, plate clutches, cone clutches, centrifugal clutches, torque transmitting capacity.

**Brakes And Dynamometers :**

Different types of brakes - shoe brakes, external and internal shoe brakes, band brakes, band and block brakes, braking torque.

Dynamometers - absorption and transmission type, construction, working principle, torque measurement.

**Machine Design****Unit IV****Spur And Helical Gears**

Gear tooth loads, formative number of teeth, effective load, estimation of module based on different equations. Types of gear teeth failures, gear materials and constructional details.

**Mechanical Springs :**

Types, applications, materials, design of helical compression and tension spring, torsion spring, leaf spring, springs in series and parallel.

**Unit V****Clutches :**

Design requirements of friction clutches, selection criteria, materials. Design of single plate and multi plate clutches and cone clutches. Energy consideration and temperature rise.

**Flywheel :**

T- $\theta$  diagrams, speed and energy fluctuation, determination of flywheel size for different types of engines and machines, torque analysis, stresses in rim and spokes, design of solid rimmed flywheel.

**Unit VI****Rolling Contact Bearings :**

Types, static and dynamic load capacity, stribeck's equation, load life relationship, selection of bearings. Design for variable loads and speeds. Lubrication, oil seal and packing, preloading, failure causes and remedies.

**Sliding Contact Bearings :**

Basic modes of lubrication, hydro-static step bearing - load carrying capacity, flow requirement, energy losses. Hydrodynamic lubrication - Reynold's equation, Sommerfeld number, Raimondi and Boyd method, temperature rise, minimum oil film thickness. Sintered metal bearings.

**Term Work**

- A - Three assignments on Theory of Machine part
- B - Computer program on flywheel design using T- $\theta$  diagram

- C – The term work shall consist of ONE design project. The design project shall consist of two imperial size sheets - one involving assembly drawing with a part list and overall dimensions and the other sheet involving drawings of individual components, manufacturing tolerances, surface finish symbols and geometric tolerances should be specified so as to make it working drawing. A design report giving all necessary calculations of the design of components and assembly should be submitted in a separate file. (Preference should be given to Autocad)

#### Reference Books

1. Hannah and Stephans : Mechanics of Machines, Edward Arnold Publication.
2. Bevan T. : Theory Theory of Machines, Longman Publication.
3. Shigley J.E. and Uicker.J.J., 1995, Theory of Machines and Mechanisms, International Edition, McGraw HILL INC.
4. Ballaney P.L. Theory of Machines, Khanna Publications.
5. Jagdish Lal : Theory of Machines, metropolitan Book Co. Pvt. Ltd., New Delhi.
6. Khurmi R.S.and Gupta J.K. Theory of Machines Eurasia Publishing House (Pvt.) Ltd., New Delhi.
7. Shigley J.E. and Mischke C.R. - Mechanical Engineering Design McGraw Hill Publication Co. Ltd.
8. Spotts M.F. and Shoup T.E.-“Design of Machine Elements”- Prentice Hall International.

9. Bhandari V.B. - “Design of Machine Elements” Tata - McGraw Hill Publication Co.Ltd.
- 10 Black P.H. and O. Eugence Adams - “Machine Design McGraw Hill Book Co. Inc
- 11 “Design Data” - P.S.G. College off Technology, Coimbtore.
- 12 Juvinal R.C.- “Fundamentals of Machine Components Design” - John Wiley and Sons.
- 13 Denavit & Hartenberg - Kinematic Analysis and Synthesis - Tata McGraw Hill Publication
- 14 A. S. Hall - Kinematic Linkage Design - Pretice Hall Publication

#### 302042 Heat Transfer (Mech S/W)

Teaching scheme : (hrs/week)	Examination scheme
Lectures : 4	Paper : 100 marks,
Practical : 2	TW : 25 marks
	Oral : 50 Marks

#### Unit I

##### Introduction :

Applications of Heat Transfer in different fields of engineering. Modes of heat transfer, Fourier’s law of conduction, Newton’s law of cooling. Stefan-Boltzmann’s law of radiation. Isotropic and anisotropic materials. Three dimensional heat conduction equation in Cartesian coordinate for anisotropic material for unsteady state condition, thermal diffusivity and reduction to Fourier equation. Laplace equation and Poisson’s equation. Three dimensional form of heat conduction equation in cylindrical and spherical co-ordinates (no derivation).

**One dimensional steady state heat conduction :**

One dimensional steady state heat conduction through a plane wall, cylindrical wall and sphere, Analogy between Heat flow and electricity, heat conduction through a composite slab, cylinder and sphere, overall heat transfer coefficient, Concept of thermal resistance and conductance,.

**Unit II**

Critical radius of insulation, thermal contact resistance. Economic thickness of insulation.

Physical interpretation of Thermal conductivity and its variation with temperature for metals, non metallic solids, gases and liquids. One dimensional problems of variable thermal conductivity.

**One dimensional steady state heat conduction with heat generation :**

Symmetrical and asymmetrical boundary condition in plane wall, Conduction in solid and hollow cylinder and sphere. Practical problems of heat generation.

**Unit III****Extended Surfaces :**

Heat transfer through extended surfaces. Fins of different shapes. Derivation of differential equation for fins with constant cross section with different boundary conditions. Effectiveness and efficiency of a fin. Error in the measurement of temperature in a thermowell. Heat sinks-types and applications.

**Unsteady state Heat Conduction :** System with negligible internal resistance. Biot and Fourier numbers. Criteria for neglecting internal temperature gradient.

**Unit IV****Convection :**

Introduction to hydrodynamic and thermal boundary layer. Laminar and turbulent flow over and inside a surface.

Convective heat transfer coefficients and their order of magnitude, Dimensional analysis of free and forced convection. Physical significance of the dimensionless parameters - Nusselt's number, Reynold's number, Prandtl's number, Grashoff's number, Stanton number, Rayleigh number.

**Forced convection :** Empirical correlations for heat transfer in laminar and turbulent flow over a flat plate and in a circular pipe. Concept of hydraulic diameter.

**Natural convection :** Empirical correlations for free convection heat transfer over horizontal, vertical plate and cylinder.

**Unit V****Thermal Radiation :**

Fundamental concepts, Black body radiation, Kirchoff's law, Planck's distribution law, Wien's displacement law and Stefan Boltzmann's law. Surface emission, radiative properties of a surface. Grey, black, white and real surface. Solid angle and intensity of radiation, Lambert's cosine law. Heat exchange by radiation between two finite black surfaces. Radiation shape factor, use of shape factor charts.

Irradiation, radiosity, electrical network method of solving problems.

Heat exchange between non-black bodies, Heat exchange between two infinitely parallel planes, cylinders and spheres.

Radiation Shields, Gas radiation (elementary treatment only). Solar radiation.

**Unit VI****Condensation and boiling :**

Film and drop wise condensation. Derivation of heat transfer coefficient for Laminar film condensation on vertical and inclined plate, correlations for condensation on and inside tubes.

Regimes of pool boiling and pool boiling curve and critical heat flux.

Forced Convection boiling.

**Heat exchangers :** Classification, Applications of heat-exchangers.

Heat Exchanger analysis - Logarithmic Mean Temperature Difference for parallel and counter flow heat exchangers. LMTD correction factors, fouling factor.

The Effectiveness - NTU method for parallel and counter flow heat exchangers. Design considerations for heat exchanger. Introduction to compact heat exchanger and heat pipe heat exchanger.

**List of Practicals :**

The term Work shall consist of any "eight" experiments out of the following:

**Note :** One of the experiments listed below must have computer interfacing.

1. Determination of thermal conductivity of insulating powder
2. Determination of thermal conductivity of metal rod.
3. Temperature distribution through a composite wall.
4. Temperature distribution along the length of a fin and determination of fin effectiveness and fin efficiency.

5. Natural convection heat transfer from a heated vertical cylinder.
6. Heat transfer in forced convection for a pipe losing heat to air flowing through it.
7. Determination of emissivity of a metal surface.
8. Determination of Stefan-Boltzmann constant.
9. Determination of critical heat flux in pool boiling.
10. Performance of a parallel flow and counter flow heat exchanger.

*Reference Books*

1. J.P. Holman, "Heat Transfer", McGraw hill.
2. Frank P Incropera, David P De Witt, (1990), "Fundamentals of Heat Transfer", Wiley, Eastern Limited.
3. Sachdeva, R.C, (1988), "Fundamentals of Engineering Heat and Mass Transfer, Wiley Eastern Limited III<sup>rd</sup> Edition.
4. Sukhatme S.P. (1989), "A text book on Heat Transfer", III<sup>rd</sup> Edition, Orient Longmans Ltd, New Delhi.
5. Arora S C and Domkundwar.S. (1994), "A Course in Heat and Mass Transfer", Dhanpat Rai & Sons, IV<sup>th</sup> Edition.
6. Gupta and Prakash, (1994), "Engineering Heat Transfer", Nemchand and Brothers.
7. Karlekar & Desmond, "Principles of Heat Transfer", Prentice hall of India Ltd, New Delhi.
8. M. Necati Ozisik, "Heat Transfer".

**402043 : Mechartronics**

Teaching Scheme	Examination Scheme
Lectures : 4 Hrs/Week	Paper : 100 Marks
Practicals : 2 Hrs/Week	TW : 50 Marks

**Unit 1**

Introduction to Mechatronics : Mechatronic system, measurement systems, control systems and response of systems.

Measurement systems : static characteristics.

Flow measurement : Rotameter, anemometer and comparison of characteristics of different flow meters.

Pressure measurement : Mcleod gauges, comparison of characteristics of different pressure measuring devices.

**Unit 2**

Level measurement, strain measurement - strain gauges, theory, types, strain gauge circuits, temperature compensation, load cells.

Temperature measurement : RTD, Thermocouples, pyrometers.

Displacement and position sensors : LVDT, optical encoders - transnational and rotary.

**Unit 3**

System Models : Mathematical models, introduction to mechanical, electrical, fluid and thermal systems. Rotational and transnational systems, electro - mechanical, hydraulic - mechanical systems.

Control Systems : open loop, closed loop systems, transfer functions, feed back and feed forward control systems and their applications.

**Unit 4**

System Response, modeling of dynamic systems, dynamic response of first order, second order systems to step, ramp and impulse inputs. Transfer functions, Bode plots, stability of systems.

Control Actions : On - Off, proportional, proportional + integral, P + D . proportional + integral + derivative control actions.

Control systems Components : Transmitters, controllers/pressure/flow/level/temperature/limit/proximity/magnetic switches and relays.

**Unit 5**

Analog signal processing, introduction, principle, passive circuits, operational amplifiers - characteristics and specifications. Op - amp circuits for inverting, non inverting, difference amplifiers, integrator, differentiator, comparator and sample and hold applications (no analytical treatment.)

Digital Signal Processing : Timing diagrams, sequential logic, flip flops, D flip flop, JK flip flop, master slave flip flop. Applications of flip flop, decade counters, Schmitt trigger, 555 timers. A/D and D/A converters.

**Unit 6**

Programming Logic Controllers : Relay logic, basic structure, input/output processing, timers, internal relays and counters, shift registers, ladder diagram and programming, selection of PLCs, introduction to microcontroller.

**List of Experiments :**

Minimum of 10 experiments from the following; out of which experiment no. 12 is compulsory, four shall be from serial no. 1 to 5, three from serial no. 6 to 11 and two from

13 to 17. Record of experiments and assignments shall be submitted in the form of journal.

1. Calibration of flow meters.
2. Calibration of Thermocouples/ RTD.
3. Study of Load Cells.
4. Vibration measurement using accelerometers.
5. Displacement measurement/ level measurement.
6. Verification of P, P+I, P+D, P+I+D control actions.
7. Study of XY position control systems.
8. Study of linear conveyor control system.
9. Study of rotary table positioning systems.
10. Study of different switches and relays.
11. Analysis of control system using software like MATLAB/SIMULINK or equivalent.
12. Development of ladder diagram/programming PLC for level control, position control or any other mechanical engineering application.
13. Study of A/D and D/A converters.
14. Study of Flip Flops and Timers.
15. Study of Application of Op - Amp circuits.
16. Study of Data acquisition system.
17. Study of Microcontrollers.

*Reference Books*

1. Doebelin E. O., Measurement System - Application and Design, Tata McGraw Hill Publications Ltd, New Delhi.

2. Bolton W. , Mechatronics - Electronics Control Systems in Mechanical and Electrical Engineering, Pearson - Education (Singapore) Pte. Ltd.
3. Rangan C. S., Sarma G. R., Mani V. S., Instrumentation - Devices and Systems, Tata McGraw Hill Publishing Company Ltd., New Delhi.
4. Histan B. H., Alciatore D. G., Introduction to Mechatronics and Measurement Systems.
5. Johnson C. D. 'Process Control Instrumentation Technology, Prentice Hall of India Pvt Ltd., New Delhi.
6. HMT, Mechatronics, HMT.
7. Mahalik N. P., Mechatronics - Principles, concepts and applications, Tata McGraw Hill Publishing Company Ltd, New Delhi.
8. Kolk R. A., Shetty D., Mechatronics Systems Design, Vikas Publishing Manual, Delhi.

### 302045 Computer Oriented Numerical Methods (Mech S/w)

Teaching Scheme: Examination Scheme:  
Lectures : 4Hrs/Week Theory : 100 Marks  
Practica I: 2Hrs/Week Practical : 50 Marks

#### Unit I 8 Hrs Errors and approximations :

Types of Errors, Absolute, Relative, Algorithmic, Truncation, Round off Errors. Error Propagation, Concept of Convergence, Relevance to Numerical Methods, Direct and Iterative Methods.

**Linear Programming :** Simplex Method.

#### Unit II 8 Hrs Interpolation :

Langrange's Interpolation, Newton's forward, backward and central difference method, divided difference method, Inverse Interpolation,

**Curve Fitting :** least square criteria - 1<sup>st</sup> and 2<sup>nd</sup> Degree.

#### Unit III 8 Hrs Solution of linear simultaneous equations :

Homogeneous/Non-homogeneous systems, Gauss Elimination, Gauss-Jordan, Gauss-Seidel Methods, LU-Decomposition, Cholesky Method.

**Numerical Differentiation :** Forward, Backward and Central Difference Methods.

#### Unit IV 8 Hrs Numerical Solution of Algebraic and Transcendental equations :

Bisection Method, Secant Method, Regula-Falsi Method, Newton-Raphson Method, Successive Approximation Method

**Numerical integration :** Trapezoidal Rule, Simpson 1/3<sup>rd</sup> and 3/8<sup>th</sup> Rule, Weddle's Rule, Gauss Quadrature - Two and Three Point Formula, Double Integration.

#### Unit V 8 Hrs Numerical Solution of Ordinary Differential Equation :

Taylor Series Method, Euler Method, Modified Euler Method, Predictor-Corrector Methods - Milne's Method, Adam-Bashforth Method, Runge Kutta 2<sup>nd</sup> and 4<sup>th</sup> order method, Simultaneous Differential Equations and Second Order Differential Equations

#### Unit VI 8 Hrs Numerical Solution of Partial Differential Equation: Finite Difference Method, Laplace's Equation. Poisson's Equation, One and Two Dimensional Heat Equations, Wave Equation.

#### Reference Books

1. Chapra, S.C. & Canal, R. P., "Numerical Methods for Engineers", 4<sup>th</sup> Ed., Tata McGraw Hill Pub. Co. Ltd., New Delhi.
2. Balagurusamy, E., "Numerical Methods", Tata McGraw Hill Pub. Co. Ltd., New Delhi.
3. Rajaraman, V., "Computer Oriented Numerical Methods", Prentice Hall of India Ltd, New Delhi.

4. Sastry, S.S., "Introductory Methods of Numerical Analysis", Prentice Hall of India Ltd, New Delhi
5. Jain, M.K., Iyengar, S.R.K. AND Jain, R.K., "Numerical Methods for Scientific and Engineering Computations", 5<sup>th</sup> Ed., New Age International Ltd, New Delhi
6. Rajasekaran, S., "Numerical Methods in Science and Engineering - A practical Approach", S. Chand and Co. Ltd., New Delhi.
7. Rao, S.S., "Optimization - Theory and Applications", New Age International Ltd, New Delhi

#### List of Practicals :

Minimum **NINE** programming assignments shall be completed and submitted as term work in the form of a journal comprising of flowcharts, program listing and results. Out of these, **MINIMUM ONE** programming assignment must be based on **EACH** of the topics Listed Below :

1. Linear Programming
2. Interpolation
3. Curve Fitting
4. Linear simultaneous equations
5. Numerical Differentiation
6. Algebraic and Transcendental equations
7. Numerical integration
8. Ordinary Differential Equation
9. Partial Differential Equation

**Note :** At least 3 of the above assignments will be carried out using a mathematical solver such as MATLAB, TK Solver, Mathematica, etc. The remaining assignments will be completed using C/C++ language.

#### Elective I (1)

#### 302061 WELDING TECHNOLOGY

Teaching scheme	Examination scheme
Self Study	Theory : 100 marks

#### Unit I

#### Processes and types of joints :

Classification of fusion welding processes, heat source intensity, heat input rates, shielding methods. heat sources. Metal transfer Arc, definition, physics of arc, characteristic of arc, column, weld pool base metal. Metallurgical effect of weld thermal cycle, residual stresses, formation and relieving. Types of weld joints, Edge preparation, cleaning of edges, tack welding.

#### Unit II

#### Arc Welding :

Electrodes, types of covering, welding techniques for manual welding, power Sources, arc cutting, Carbon arc, submerged arc welding, gas tungsten arc (GTA) and gas metal arc (GMA) welding, electric slag welding, carbon dioxide (CO<sub>2</sub>) welding, plasma arc welding.

Heat affected Zone and its significance in welding. Metallurgical aspects of welding pre and post heat treatment. Pre heating, vibratory stress relieving

**Unit III****Thermal Cutting Of Metal :**

Oxygen cutting, flame cut ability of metals, effect of cutting on structure and properties of steel, oxygen lancing machine cutting.

Welding of different types of materials, like carbon and alloy steels, cast iron non-ferrous metals and alloys, aluminum.

**Soldering and Brazing :** Capillary and welding action, temperature range, filler metals and fluxes, processes and application, design and strength of joints.

**Unit IV****Resistance Welding :**

Spot welding, electrode, nugget size, resistance and force, current and time, types of equipment, rocker arm press type, multiple welding guns and portable welders, applications, seam welding, projection welding, flash and butt welding, applications.

**Gas Welding :** Gas welding, fuel gases, flames, torches, filler metal, fluxes, backward and forward welding, filler rod diameter, atomic hydrogen welding, termite welding.

**Unit V****Solid Phase Welding :**

Cold pressure welding, weld formation, techniques for lap and butt welding, applications; diffusion joining; process variables, applications, forge welding, ultra sonic welding; process characteristics, equipment and application, explosive welding, nature of bond, velocity of impact, angle of contact and application

**Radiation Welding :** Laser welding, electron beam welding types of electron gun, spot size beam power, operating voltage, pulse technique, deep penetration and applications.

**Unit VI****Weldability :**

Design, process and metallurgical consideration, testing and improvement of weld ability, microstructure of welds, welding defects and remedies.

**Inspection and testing of welding fixture:** I.S. Codes for welding, destructive and non-destructive test for welds, tension, bend, hardness, fatigue, controlled thermal severity test, tongue bend test for pipes, liquid penetrate testing, fluorescent penetrate test, magnetic particle inspection, eddy current testing, ultrasonic techniques and radiography. Estimation of welding cost, Application of welding for aluminum & stainless steel.

*References*

1. Welding and welding Technology - Richard L. Little, 1973.
2. Welding Technology - S.W. Nadkarni.
3. Metallurgy of Welding, Soldering and Brazing - J.F. Lancaster, Pergamon press.
4. Physics of Arc - Ed. J.F. Lancaster; Pergamon press.
5. Welding Handbooks - American Welding Society.
6. Metal Hand Books - American Society of Metals.
7. CO<sub>2</sub> Welding - British Welding Society.

8. Rational Welding Design - Gray, Spence and Phillips.
9. Modern Arc welding Technology - S.C. Nadkarni, Admioerlikon Ltd. Oxffrd, PBH pub. Co. 1992
10. Text book of welding technology, O.P. Khanna, Dhanpat Rai & Sons
11. Modern Welding Technology, Carry, Prientice Hall

**Elective I (2)**

**302061 Manufacturing Management**

Teaching scheme Examination scheme  
Self Study Theory : 100 marks

**Unit I**

- (A) : Definition of production, value adding conversion process, recourses and optimum allocation; systems approach different elements/functions of production,
- (B) : PPC and its interrelationship with other functions such as marketing, finance, R&D organization for production systems; job order, batch production, their salient features.

**Unit II**

**(A) : Economic Analysis of production :**

Factors to be considered in product design. Economics of scales fixed Cost, variable cost, break even chart, P-V chart, multiple product P-V chart, make-buy decision.

**(B) : Plant Location and Plant Layout :**

Factors to be considered in plant location, process layout. Techniques of plant layout, concept of Group technology, Group layout.

**Unit III**

**(A) : PPC function:**

Scheduling, Progress monitoring, job order scheduling, dispatching rules, batch size Decision, production range. Aggregate planning, capacity planning.

**(B) : MRP :** an integrated approach requirement, planning and scheduling, JIT system: SMED, Kanban pull system of scheduling, line balancing.

**Unit IV**

**(A) : Demand Forecasting :**

Methods, Time Series Analysis, Exponential Smoothing, Fitting a straight line, fitting a curve, Moving average method, seasonal variation. selection of forecasting method. Accuracy of forecast.

**(B) : Material Management :**

Bill of material, Quantity planning, Inventory control, Economic order quantity (EOQ) lead time consumption rate, different ordering systems, Q system, P system, S system Two and three bin systems, the store's function ABC analysis

**Unit V**

**Project Management :**

Programme evaluation and review techniques and critical path method (CPM / PERT), float, critical path, three time estimates, probability of completion before due date, crashing and optimum duration, resource levelling

**Unit VI****Management information system :**

Data and information, feed back system, information system link between different functions, computer applications, ERP, Introduction to SAP, RFID applications, supply chain management.

*References*

1. Elements of production planning and control —Samuel Eilon; University Publicity Corpo.1991
2. Modern Production /Operation Management—E.S. BUFFA, Wiley Estem Ltd. 7<sup>th</sup> edition
3. Operation Management —Mclain J.O. and Thomal L.J. Prentice Hall of India Ltd.,1987.
4. Operation management ,theory and problems—Monks J.G. Mcgraw Hill Int. 3<sup>rd</sup> edition
5. Production and Inventory Control—G.W. Plossal; Prentice hall of India Ltd; 2<sup>nd</sup> edition
6. Production Systems Planning Analysis and Control—  
—Riggs J.L., John Wiley and Sons
7. Production Management—Hazra Chodhary S.K., Media Promoters and Publishers Pvt Ltd.,1993.
8. Production Control—Biegel J.E.; Prentice Hall of India Ltd.
9. Statical Quality Control—Ugene L.Grant, McGraw Hill,1964.
10. Operation Management—Chary S.N.
11. Production and Operations Management—Chase Jacob, Acquino.

**Elective I (3)****302061 BEHAVIOURAL SCIENCE**

Teaching scheme

Examination scheme

Self Study

Theory : 100 marks

**Unit I****Factors affecting the operations of an Enterprise :**

The purpose of an industrial enterprise in different industrial sectors - public, private, co-operative and small scale. External factors influencing and governing the enterprise - economic, political, technological and social. Statutory controls -licensing, price control, wage legislation's and other industrial laws, trade union's role. Environment in the urban and rural sectors.

**Unit II****Organisation :**

Organisational structure, Organisational theories, Planning and design. Typical industrial organisation and main functions of management-Production, Sales Finance and Personal Management of work through committees, Systems and Procedure. The influence of people on the performance of the enterprise.

**Unit III****Industrial Behavior :**

Theories of motivation - Stimulus response, achievement, Affiliation and Maslow, Personality Traits, learning theories and self-improvement, effect on social and political environment.

**Unit IV****Organizational and Group Behavior :**

Small Group Behavior, formal and informal groups - group dynamics. Organisational culture - Nature and causes of conflict -Interpersonal and inter-group conflicts -Resolution of conflicts. Role playing exercise - Transitional Analysis.

**Unit V****Leadership :**

Leadership processes and styles - Theory X and theory Y-Managerial Grid, continuous versus breakthrough improvements, Management of change, Quality award models and role of self assessment.

**Unit VI****Communication and interviewing skills :**

Written communication - Oral and Nonverbal Communication. Different types of interview-Conducting an Interview.

*Reference Books*

1. ILO Publication : The Enterprises and Factors Affecting its Operation.
2. Fred Luthans, Organisational Behavior, McGraw Hill.
3. Davies and Newstrom. Organisational Behavior.
4. R. L. Sharma and Krishna Mohan, Business Correspondence and Report Writing, Tata McGraw Hill.
5. Peter Druncker, The Practice of Management.

**302062 : TECHNICAL PAPER PRESENTATION -I.****T.E. (Mechanical Sandwich)****Examination scheme**

Oral : 50 Marks

Technical Paper Presentation is a seminar which is expected to be on a state - of - the - art technical topic, related to Mechanical Engineering discipline but outside syllabus. The seminar report and its presentation is to be based on material, mainly collected and analysed from the latest papers in technical journals. The report is expected to be of about 15 A4 size pages, including figures and plates, in addition to certificate, synopsis and reference pages. The presentation is expected to be in front of the audience which must include at least two internal examiners one of them being a guide and both being university approved teachers. The marks distribution is equally divided between the report and presentation/oral examination.

**302063 : Industrial Inplant Training**

Teaching Scheme:

Examination Scheme:

2 Hours /week/student

Term work: 150 Marks

Duration of Training in

Industry : 6 Month

Oral : 100 Marks

General Guidelines to The Institutions Running Mechanical-SW.

Degree Course and to The Students opted for Sandwich Course.

Students are expected to learn following things during the Industrial Inplant Training of 6 months.

He shall be given training in large or medium size manufacturing unit in various departments.

**1. Orientation / Rotational Training :**

Organizational structure of the Company, scale and type of production, type of production, types of products, functional departments, like Manufacturing Process Planning and Control, Quality Assurance. Assembly. Testing. Maintenance. Stores, Purchase Marketing. Human resources Department, Design and Drawing Department, General Administration, Packing and Dispatching. Tool Engineering, materials and Material Handling etc.

**2. Industrial Design and Drawing Practice :**

Design and Drawing standards, study of Mechanical components and component design such as gears, gear boxes, chain and belt drives, electric motor selection, couplings, shaft, keys bearings, brackets, bolted and welded connections.

Sub-assembly and assembly drawings. Simple assignments based on the above items, selection of material specification, heat treatment, and properties of materials.

**3. Study of Manufacturing Processes :**

Study of processes such as casting, forging, sheet metal working, plastic moulding, extrusion, rolling, and machining operations on various machines, study of finishing processes like grinding, lapping, honing, burnishing, buffing, etc. Chipless manufacturing processes.

**4. Study of Various Manufacturing Machine Tools such as lathes, capstan and turret lathes planer, shaper, and milling. Mechanical and Hydraulic presses, Gear hobbing, shaping and grinding machines.**

5. Study of special purpose machines, Jig boring machines, NC/CNC machines, work centers, and transfer lines and automatic machines.
6. Study of single point cutting tools and multipoint tools form tools, Jig and fixtures, special purpose machine tools. Tool material and tool selection, Study of cutting parameters.
7. Study of material handling methods and equipment.
8. Study of various inspection gauge, selection of type of gauge, comparators, calibration of gauges, standards room etc. Product performance test procedures.
9. Study of processes and operation planning
10. Study of safety gadgets used on machines, personal safety equipment, plant safety.

The students shall be asked to do simple assignments in various departments where he is taking training. Industries shall be required to prepare training program beforehand, covering as much as possible from above mentioned topics depending upon the types of industry.

**Term work :**

Term work shall consist of a comprehensive report based on his observations, training received and assignments completed during 6 months of training. The report shall also include good drawings, figures, process sheets and machine and product specifications. Sandwich students shall obtain a certificate of successful completion of his training and his attendance from concerned industry and attach it to his report.

**Examination :**

Oral examination shall be conducted after training by appointing one internal examiner and one external examiner from industry.

**Elective I (4)**

**302061 Plant Engineering**

Teaching scheme                      Examination scheme  
Self Study                              Theory : 100 marks

**Unit I**

**Introduction :**

Scope of plant engineering function- location, layout, material handling & maintenance, Importance, of this function & its effect on productivity, Various types of layouts-product, process, layout by fixed position, cellular layouts, mixed layouts.

Advantages disadvantages and specific applications of various layouts. Concept of flow, types of flow.

**Unit II**

**Location :**

Site location, factors affecting site selection.

**Layout :**

Planning for layout, type of production & their influence on layout, , PQ analysis, Introduction to Group technology, Grouping of cells using Kings Rank order clustering.

Systematic layout analysis, PQRST Analysis, material flow, REL chart, space requirement analysis & space diagram, planning for layout, operation & maintenance of auxiliary services.

Use of computer in planning & evolving layouts.

**Unit III**

**Material Handling :**

Planning, principles of materials handling, systematic handling analysis, data collection, and analysis, analysis & development of new system.

Various types of materials handling equipment, their classification, unit load concepts, introduction to AGVs.

**Maintenance :**

Types of maintenance, and their classification .introduction to TPM, repair cycle analysis, repair complexity, organization of maintenance function. Product life cycle concept and spare parts management. Manpower planning, training, budgeting, data collection, data analysis and creation of standard data, maintenance manuals, history cards, work measurement and incentives for maintenance workers, computerized maintenance and housekeeping.

**Unit IV**

**Plant Safety :**

Introduction to safety, safety against chemical hazards, mechanical hazards, accident prevention practices, fire fighting, fire trample, pollution and environmental considerations, training in safety, introduction to safety and codes, noise pollution control.

**Auxillary Services :**

Estimation of capacity for auxiliary services like water, steam, power compressed air, Planning and maintenance of

equipment required for various industrial services, Waste disposal, effluent water treatment, sewage water treatment & its disposal, scrap disposals & recycling of it.

### Unit V

#### Workpiece Control

Equilibrium theory, concept of location, geometry control, dimensional control, mechanical control, alternate location theory.

#### Concepts of Systems Engineering :

Its structure, constraints and plant engineering decision based on its structure and constraint.

### Unit VI

#### PFA ANALYSIS

CRAFT and CORELAP Location of new plant equipment in an existing plant. PERFORMANANCE MODELLING

- A. Failure rate and hazard rate, hazard rate as a basis of bathtub curve and modelling life cycle
- B. Evaluation techno-economic life of a plant, Replacement strategy based of MAPI approach, and game theoretic model, modelling total life cycle cost (L.C.C.).

#### Reference Books

1. Kosakov V.S.: Fundamental of Manufacturing Engineering M.I.R. Publications.
2. Gupta R.B. & Kaithal Anita: Design of production processes, Satya Prakashan.

3. Bredin H.W.: Tooling method and ideas, industrial press Inc.
4. Ary Johnson : Process planning
5. Aks Jardine : Maintenance Replacement and Reliability, Pitman Publishing London , 1978.
6. R.A.Collacott: Mechanical Fault Diagnosis & Condition Monitoring, Chapman & Hall London, 1977.
7. Irson & Grant : Industrial Engineering Handbook.
8. Higgins & Marrow : Industrial Maintenance Handbook.
9. Richard Muthor : Systematic layout & Handling Analysis.
10. Rajgopal : Maintenance Organization & Planning
11. H.P.Garg : Industrial Maintenance

#### Thermal Engineering-II

Teaching Scheme:

Lecturers: 4Hrs/Week

Practical: 2 hours per week

Examination Scheme:

Theory: 100 Marks

Practical: 50 Marks

Term Work: 25 Marks

### Unit 1

#### Refrigeration :

Definition, refrigeration load, unit of refrigeration, reverse carnot cycle, systems of refrigeration, Bell-Coleman cycle, vapour compression cycle (VCC), effect of operating parameters on VCC, use of P-h charts, refrigerants, properties of refrigerants, alternative refrigerants, simple vapour absorption system, comparison of vapour compression and vapour absorption cycle.

**Unit 2****Air-Conditioning:**

Psychrometry, properties, relations, use of chart, processes, air conditioning equipments, air-conditioning systems; comfort and industrial air conditioning, factors affecting human comfort, effective temperature and comfort chart, central and unitary air conditioning systems, applications of air conditioning.

**Unit 3****Reciprocating Air Compressor:**

Uses of compressed air, classification of compressors, constructional details of single and multistage compressor, computation of work done, isothermal work done, isothermal efficiency, effect of clearance, volumetric efficiency, need of multi staging, intercooling and after cooling.

**Rotary Air Compressor :** Basic principles, classification, construction, working of roots, vane, scroll compressors. Rotodynamic compressors, static and total head, work done, efficiencies, velocity diagram, rection factor etc. Selection of compressors for various applications.

**Unit 4****Combustion in S.I. engines:**

Stages of combustion, flame propagation, factors influencing, flame speed, abnormal combustion- preignition and detonation, rating of S.I. engine fuels, octane number and dopes, evolution of combustion and types of combustion chambers in S.I. engines.

**Combustion in C.I. engines :** Stages of combustion, ignition delay and factors affecting delay period, diesel knock, rating of C.I. engine fuels, cetane number, comparison of diesel knock and detonation, evolution of combustion chamber and types of combustion chambers for C.I. engines.

**Unit 5****Supercharging :**

Need for supercharging, supercharging and turbocharging, types of superchargers (Descriptive treatment). Limitations of supercharging in S.I. and C.I. engines.

**Emission and pollution control :** Emissions from S.I. and C.I. engines and their harmful effects. Catalytic converters - construction and working (elementary treatment). Contemporary and proposed emission norms.

**Unit 6****Gas Turbines :**

Theory and fundamentals of gas turbines, principles, classifications, thermodynamic cycles, assumptions for simple gas turbine cycle analysis, work ratio, concept of optimum and maximum pressure ratio, actual cycle, effect of operating variables on thermal efficiency, regeneration, intercooling, reheating and their effect on performance, close and semi close cycle gas turbine plant, application of gas turbine.

**Jet Propulsion :** Introduction, theory of jet propulsion, types of jet engines, energy flow through jet engines, thrust, thrust power, propulsive, thermal and overall efficiency, turbo jet, turboprop, turbofan and ducted fan engines, pulse jet and ramjet engines, applications of jet engine, method of thrust, augmentation, introduction to rocket engines (elementary treatment only).

**Term Work :**

The term shall consist of record of minimum eight experiments from the followings.

1. Trial on refrigeration test rig.
2. Trial on air conditioning test rig.
3. Trial on reciprocating air compressor.
4. Study of positive displacement compressors.
5. Trial on rotary air compressor.
6. Study of combustion chambers in SI and CI engines.
7. Study of supercharging and turbocharging.
8. Study and demonstration of exhaust gas analyzer and smoke meter.
9. Study of jet engines.
10. Visit to any refrigeration or air conditioning plant.

*Reference Books*

1. Ganesan V. : Internal combustion engines. Tata McGraw Hill.
2. Mathur and Sharma : Internal combustion engines, Dhanpatrai and Company.
3. P L Ballaney : Thermal engineering, Khanna Publishers.
4. Kumar Vasandani : Thermal engineering,
5. Domkundwar and Domkundwar : Internal combustion engines, Dhanpatrai and Company.
6. Arrora and Domkundwar : Refrigeration and airconditioning, Dhanpatrai and Company.
7. C P Arrora : Refrigeration and Airconditioning, Tata McGraw Hill.