

Computer Aided Design and Finite Element Analysis

T.E. Sem. V [PROD]

EVALUATION SYSTEM

| | Time | Marks |
|----------------|--------|-------|
| Theory Exam | 3 Hrs. | 100 |
| Practical Exam | – | 25 |
| Oral Exam | – | – |
| Term Work | – | 25 |

SYLLABUS

1. Computer Aided Design :

- Introduction : Need and Utility of CAD systems in Industry, Product Cycle, Definition of CAD tools based on their constituents and Implementation constituents and Implementation in a design environment.
- CAD Hardware : Types of systems, system consideration, I/O devices, Hardware integration & Networking.

2. Computer Graphics :

Pixel plotting, Scan conversion of lines & circles; 2D & 3D transformations; 2D Viewing and Clipping; Parallel Projection. Elementary treatment of Hidden lines and Surfaces; Cubic spines Bezier curves & B-spines; Animation; Color models.

3. Solid Modeling, Types of representation of solid models, Interactive tools available with solid modeling software's. Introduction to surface modeling.

- CAD Data Exchange: File Structure and Format of IGES, STEP, DXF
- Introduction to Rapid Prototyping

4. Finite Element method:

- **Introduction:** General procedure of finite element method, Applications to Structural analysis and Manufacturing processes.
- **Static Analysis:**
Formulation: Based on Principal of stationary total potential.
 - **1–D FEA:** Generic form of FE equations for Linear & quadratic bar and Beam Elements
 - **2–D FEA:** Dimensionality of a problem. Simple three noded triangular elements, four noded rectangular elements. Natural coordinates and coordinate transformation. 2D element formulation for structural analysis derive Stress – displacement and Stress strain matrix. Numerical integration by Gauss quadrature method. Meshing and compatibility of elements. Incorporation of boundary conditions and solution of static equilibrium equations.

5. Introduction to Dynamic, Thermal analysis and computational Fluid Dynamics using FEM.

- **Dynamic Analysis using FEM (No numerical)**
Equations of motion and formulation of FE equations using 1D element for vibration problems. (Introductory)
- **Thermal Analysis using FEM (No numerical)**
Basics steps for Thermal Analysis, Importance of Thermal analysis giving practical steady state conduction and convection examples.
e.g. Pin fin, Expansion of railway track, Flow through engine water jacket, Heat Exchanger etc.
Computational Fluid Dynamics using FEM (No Numerical)
- The Navier – stokes equations; The continuity equation and Law of conservation of mass and their application to CFD Typical Applications e.g. Aerospace Engineering, Automobile Engineering

- 6 FEA software : Features of commercial soft ware's : Preprocessor, solver and Postprocessor.
Types of elements available with commercial software for different FEA applications (No Numerical.)

References:

1. CAD/CAM (*P.N.Rao*) Tata McGraw Hill
2. Mathematical and Procedural Elements for computer graphics (*Roger and Adams*)
3. Computer graphics (*Hearn and Baker (PHI)*)
4. Computer graphics (*Plastock and Gordon*) Schaums outline series
5. FEM (*Fagan*)
6. FEM (*J.N.Reddy*) McGraw Hill
7. A first course in FEM (*daryl L. Logan*) Cengage
8. Concepts and applications of FEA (*Cook, Malkus*) Jhon Wiley
9. Mastering CAD/CAM (*Ibrahim Zeid*) Tata–Mcgraw Hill
10. Computer graphics (*ISRD group*) Tata–Mcgraw–Hill
11. Finite element analysis (*P.Seshu*) Prentice Hall of India



Metrology and Instrumentation

T.E. Sem. V [PROD]

EVALUATION SYSTEM

| | Time | Marks |
|-----------------------|--------|-------|
| Theory Exam | 3 Hrs. | 100 |
| Practical Exam | – | 25 |
| Oral Exam | – | 25 |
| Term Work | – | 25 |

SYLLABUS

1. Introduction to metrology

Need for inspection; precision and accuracy; fundamental principles and definition, standards of measurement; line, end and wave length standards, primary secondary and tertiary standards.

2. Limits, Fits and Tolerances

Requirement of interchangeable manufacture, allowance and tolerance, limits and fits, hole based and shaft based systems, IS 919 : 1963 tolerance grades IT 01 to IT 05, types of fits, general requirements of GO & NO GO gauging; Taylor's principle, Design of go & no-go gauges.

3. Comparators

Need of comparators, amplifying system; mechanical, mechanical-optical, electrical, electronic and pneumatic comparators; principle, construction and operation of various comparators, advantages; limitations and application of above comparators.

4. Interferometry

Principles of interference, monochromatic source, concept of flatness, flatness testing, optical flats, interference patterns and their significance, optical interferometer, laser interferometer.

Surface Texture Measurement

Profile geometry, importance of surface condition, roughness and waviness, definition and significance of terms, band width selection, roughness standards specifying surface roughness parameters. Ra Ry Rz etc. RMS value, surface roughness measuring instruments such as Tomlinson surface meter. Taylor Hobson Talysurf, Measuring surface roughness, symbols.

5. Measurement of Screw Threads

Types of screw threads, definitions, measurement of major and pitch diameters, two wire and three wire methods, floating carriage micrometer, and their applications.

Measurement and Gauging of Gears

Types of gears, gear terminology and standard proportions : pitch circles diameter, circular pitch, diametral pitch and module, base pitch, addendum, dedendum, tooth thickness and width, base tangent method, gear tooth comparator, gear measurement using rollers, master gears and Parkinson tester.

6. Special Measuring Machines and Methods

Profile Projector, 3 D coordinate measuring machine, Tool Maker's Microscope.

Mechanical Measurements and Instrumentation :

Transducers (applications only) for measurement of displacement, velocity, acceleration, force, torque, temperature and fluid flow

References:

1. Metrology (*Shotbolt*)
2. Practical Engineering Metrology (*K.W.P. Sharp*)
3. Engineering Metrology (*I.C.Gupta*)
4. Experimental Methods for Engineers (*J.P.Holman*)
5. Instrumentation Devices and System (*C.S.Rangan, G.R. Sarma, V.S.Mani*)
6. Industrial Instrumentation and Control (*S.K. Singh*)



Design of Jigs and Fixture

T.E. Sem. V [PROD]

EVALUATION SYSTEM

| | Time | Marks |
|----------------|--------|-------|
| Theory Exam | 4 Hrs. | 100 |
| Practical Exam | – | – |
| Oral Exam | – | 25 |
| Term Work | – | 25 |

SYLLABUS

1. Component Analysis Operation planning, sequencing of operations, locating faces, geometry, accuracy, material, machinability, quantity, modifications so as to assist production.
2. Design Analysis Selection of location and clamping faces/points, component distortion under clamping and cutting forces, compensation for component variation, choice of cutting tools and means of guiding and supporting.
Jigs and fixture details, jacks and supporting devices, drill and tool guide bushes, multiple clamping and equalizing devices, quick acting clamping mechanisms such as link, toggle, cam, eccentric, pneumatic, hydraulic and electric devices. Mathematical derivations & Numerical on them for clamping elements.
3. Types and construction of jigs and fixture Cast, fabricated and welded; standard components and details, cost consideration with respect to quantity and effectiveness, Economics & Costing of jigs & Fixtures.
4. Jigs and fixture, Principles of design and construction with reference to interchangeability, simplicity, ease of operation, economy of motion, rigidity, durability, swarf disposal, study of typical examples and geometric location.
Design applications of typical jigs and fixtures plate, channel, latch and box type drill jigs and jigs for drilling combined with reaming, tapping, counterboring and spot facing.
5. Milling fixtures including multistation and indexing types (for given component). Fixture for turning and grinding operations if needed balancing of the fixture also to be considered. Modular fixtures details and fixture design using computer software.
6. Case studies for practice for Jigs and Fixtures.

References:

1. Jigs and Fixture Handbook (*A.K.Goroshkin*) Mir Publication 1988
2. Jigs and Fixtures ASTME
3. Non-Standards Clamping Devices (*Hiram E. Grant*) TMH New Delhi 1989
4. Jig and Fixture Design Manual (*Erik K. Henrikson*) Industrial Press 1973
5. An Introduction to Jig and tool Design (*M.H.A. Kempster*) III Ed. Pub ELBS 1985
6. Jigs and Fixtures (*P.H. Joshi*) TMH 1988
7. Tool Design (*C.Donaldson, George H.Lecain V.C.Goold*) THM 1980



Machining Science and Technology

T.E. Sem.V [PROD.]

EVALUATION SYSTEM

| | Time | Marks |
|----------------|--------|-------|
| Theory Exam | 4 Hrs. | 100 |
| Practical Exam | – | – |
| Oral Exam | – | 25 |
| Term Work | – | 25 |

SYLLABUS

1. Mechanics of metal cutting Various types of chips. Discontinuous continuous. With built up edge; shear plane angle. Cutting ratio; orthogonal cutting and oblique cutting. Merchant's circle of forces and expression of shear stress and strain, normal forces on shear plane in terms of measurable cutting forces and shear plane angle, velocity relations.

$$\Phi = \frac{\Pi}{4} - \frac{(\lambda - \alpha)}{2} \quad \text{Merchant's Theory}$$

$$\Phi = C - \frac{(\lambda - \alpha)}{2} \quad \text{Merchant's modified Theory}$$

$$\Phi = \frac{\Pi}{4} - \lambda + \frac{\alpha}{2} \quad \text{Earnst – Merchant Equation}$$

Cutting forces Gross net power in machining, efficiency of machine tools. Tangential cutting force; effect of speed, feed, depth of cut, tool material and angles, material variables on cutting forces; empirical formula for estimating cutting forces and power, concept of specific power consumption and metal removal factor.

Surface finish Height of feed ridges and built up edge as primary factors effecting surface finish; effect of speed, feed, depth of cut, tool material and angle, and material variables on surface finish.

Coolant Function of coolant, effects on cutting forces, tool life and surface finish, types of coolants, choice of coolants for various machining processes.

Materials for cutting tools Properties of cutting tool materials. Carbon tool steel; plain and alloyed, oil hardening, water hardening, properties, fields of application, limitations, high speed steel, standard and special H.S.S., properties, fields of application and limitations. Carbides; Method of manufacturing, different grades, I.S.O. specification, fields of application and limitations. Ceramics; manufacturing method, properties, different compositions, fields of applications and limitations.

2. Tool life Definition, flank wear and crater wear, preliminary failure and ultimate failure mechanism of tool wear, effect of speed, feed, depth of cut, tool material and geometry on tool life, Taylor's tool life equation, Taylor exponent and constant, Experimental methods to find Taylor exponents.

Economics of machining – components of machining cost, machine cost, non production cost, tool cost; components of tool costs; tool change cost; tool regrinding cost; tool inventory cost, tool depreciation cost Optimum cutting speed and tool life for maximum production as well as minimum cost of production.

3. Design of cutting tools : Nomenclature of Single point tools, Machine Reference and Tool Reference Systems, definition of various angle of single pint tool as per Machine Reference and Tool Reference Systems; (Americal nomenclature will be followed in further discussion); Inter-relationship among different systems of nomenclature for tool angles.

Factors influencing the choice of shape, size, and angle of single point cutting tool for various machining conditions, constructional features of solid tool, tipped tools, mechanically held regrindable insert type tools throw away tip type–tools. Design of shanks and cutting part details for HSS and Carbide tools.

4. Form Tools: various types such as flat form tool, tangential form tool, circular form tool; constructional details and fields of application; profile correction in all types of form tools with and without rake angle.

Broaches : Details and nomenclature, design steps for pull and push broaches, design of internal and external broaches.

5. Drills : Constructional features of two fluted drills, nomenclature, choice of point angle, helix angle for different machining conditions, rake and clearance angles in drills, web thinning, margin relieving, double point angle, spiral lip and special grinding to reduce the effect of chisel edge; carbide tipped drills, design features of core drills, countersinks, counter bores and spot facers.

Reamers : Constructional features of hand reamer, machine reamer, adjustable reamer, expansion reamer, carbide tipped and insert type. Nomenclature. Design of reamer diameter, chamfer, choice of helix angle, number of teeth, tooth form, back taper, shank etc.

Taps : Hand taps and machine taps, constructional features, nomenclature, design of thread profile, number of flutes, flute shape, chamfer, length, helical fluted taps, collapsible taps.

6. Milling cutters : Peripheral milling cutters, various types, choice of diameter and number of teeth, rake angle, clearance and form of flutes, helix angle of flutes and relief angle, form milling cutters, design of form relieved milling cutters. Constructional features of inserted blade milling cutters.

Gear teeth cutters. Gear milling cutters, standard set of cutters, limitations on accuracy, design of gear teeth milling cutters both disc and end mill type cutters.

Gear hobs : Design of rake profile, lead, straight and helical gears, diameter and length of hobs, pre–shave, pre–grinding, semi topping, full topping hobs, carbide tipped hobs.

Gear shaper cutters : Disc type and shank type cutters, details and angles, pre–shave, pre–grinding, semi topping cutters.

References :

1. Fundamentals of Metal Machining and Machine Tools (*G. Boothroyd*) Tata McGraw Hill, 1975
2. ASM Handbook, Vol 6: Machining Printed in USA, 1999
3. Metal Cutting and Machine Tools by (*Juneja and Shekho*) Wiley
4. Exp. Methods in Metal Cutting (*V.C. Venkatesh*) PHI, 1982
5. Metal Cutting Theory & Practice (*Sen and Bhattacharya*) New Central Book Agency, 1969
6. The Machining of Metals Inc. 1969 (*Aarmarego and R.H. Brown*) Prentice Hall Inc. 1969
7. Metal Cutting and Tool Design (*Arshinov*)
8. Typical Examples and Problems in Metal Cutting (*N. Nefedov, K.Osipov*) Mir Publishers 1987
9. Production Technology HMT Handbook, TMH
10. Metal Cutting Principles (*Shaw, Milton*) Oxford Uni. Press 2004



Material Technology

T.E. Sem.V [PROD.]

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SYLLABUS

1. Structure of Materials

Solidification and structure of metals

- Formation of solids from liquids of pure metals and alloys, ingot defects and their remedies.
- Single crystal and polycrystalline structure. Classification of crystal system, crystal structure, unit cell, co-ordination number, atomic packing factor, crystallographic notations.

Crystal imperfection

- Definition, classification, Point defects : vacancy, interstitial, impurity atoms, their formation and effects. Dislocations : Edge and screw dislocations, their significance. Surface defects : Grain boundary, sub-angle grain boundary, stacking fault, and their significance.
- Dislocation generation at Frank Reed sources. Edge Screw Dislocation interactions.

Deformation

- Mechanisms of deformation, Critical resolved shear stress. Slips systems of FCC, BCC, HCP metals.
- Elastic deformation & Plastic deformation and their significance.
- Deformation in Single and Polycrystalline materials. Strain Hardening and its significance. Strain Hardening and it significance

2. Ferrous Materials

- Classification of Steels : Plain Carbon Steels, High Strength Low Alloy Steels, Tool Steels, Stainless Steels, Maraging Steels, Creep Resistant Steels and Steels for Low Temperature Applications. ISI Designations.
- Classification of Cast Irons : Gray, Malleable, Nodular, Meehanite and other Alloy Cast Irons. ISI Designations
- Engineering & other Applications of Ferrous Materials: Construction, Automobile, Marine, Aerospace, Electrical, Electronics & Telecom Engineering, Chemical & General Engineering

3. Heat Treatment of Steels

- Iron–Iron Carbide diagram–Steel and Cast Iron portions of Iron–Iron Carbide diagram, applications of Lever Rules. Formation of Ferrite, Austenite, Pearlite and Ledeburite.
- TTT and CCT diagrams and their industrial significance. Formation of Bainite and Martensite.
- Basic Heat Treating Processes: Annealing, Normalizing, Hardening, Tempering, Aus–tempering, Mar–tempering and Maraging.
- Basic Surface Hardening Processes: Carburizings, Nitriding, Cyaniding, Flame Hardening and Induction Hardening.

4. Non Ferrous materials, Alloys & Theory of alloying

Basic Treatment Only

- Important non ferrous materials like Aluminum, Brass, Copper Nickel, Chromium, Tin, Zinc – Their properties and applications.
- Phase diagrams and their importance. Eutectic, Eutectoid, Peritectic and Solid Solution type of alloys. Intermediate alloys.
- Important alloys of aluminum, copper, titanium, Brass, Berillium, nickel, tin and zinc with applications.

5. Non metallic Materials

Ceramics

- Definition, Comparative Study of Structure and Properties of Engineering Ceramics with reference to Metallic Materials, Toughening Mechanisms in Ceramics.
- Applications of Engineering Ceramics: Glass and Glass–Ceramics, Aluminum Oxide, Silicon Carbide, Silicon Nitride, Titanium Carbide, Titanium Nitride, Zirconia, and Refractories.

Polymers

- Definition; Types and classification, Comparative Study of Structure and Properties of Polymers with reference to other Materials.
- Important characteristics, properties and Applications of Polymers, Polyethylene, PP, ABS, Polyamides (Nylon), polycarbonates, PPS, Poly acetal, Polyesters, acrylics, Silicons, PEK and PEEK Epoxies, Phenolics & Polyurethones

6. Structured Formulations

Composites

- Definition; Classification; Particle–reinforced Composites and Fibre–reinforced Composites; Rule of Mixtures; Sandwich structures.
- Applications of Composites: GFRP composites (PMC), Al₂O₃ in Al–alloy (MMC), and Carbon Fibre in Carbon (CMC).
Fundamental understanding only

Nano–structured Materials

- Definition and Introduction to Nano–Technology. Unique features of Nano–structured Materials.
- Classification of Nano–structured Materials: Nano–crystalline Materials; Carbon Nanotubes; Dendrimers; Nano–intermediates & Nano–composites
(Fundamental understanding only).

Powder Metallurgy

- Powder manufacturing and powder compaction, Sintering, Slip Casting,
- Applications and limitations of Powder Metallurgy.

Reference :

1. Mechanical Metallurgy (*G.E.Dieter*)
2. Engineering Physical Metallurgy (*Y.Lakhtin*)
3. Metallurgy for Engineers (*E.C. Rollason*)
4. Introduction to Engineering Materials (*B.K.Agrawal*)
5. Engineering Metallurgy Part I & II (*R.A. Higgins*)
6. Material Science (*S.L. Kakani & A. Kakani*)
7. Material Technology (*S.B. Barve*)
8. Materials Science and Engineering (*V. Raghavan*)
9. Engineering Materials (*C.P.Sharma*)
10. The Science & Engineering of Materials (*D.R. Askeland & P.P. Phule*)
11. An Introduction to Materials Engineering (*Brian S. Mitchell*)
12. Science for Chemical and Materials

