

GOVT. POLYTECHNIC BALANGIR

Department of Mechanical Engineering

LESSON PLAN: 2024-25

Name of the Faculty: *A. N. Biswal*

Subject: DESIGN OF MACHINE ELEMENTS (Th. 2)

Program: Diploma in Mechanical Engineering

Semester: 5th

Total Contact Hours: 60

Total Marks: 100

Assessment: Progressive –20, End Term – 80

Credits: 4

COURSE OBJECTIVES:

At the end of the course the students will be able to

1. Understanding the behaviours of material and their uses.
2. Understanding the design of various fastening elements and their industrial uses.
3. Understanding the different failures of design elements.
4. Understanding the change of design to accomplish the different field of applications.
5. Design shafts, keys, couplings required for power transmits Design closed coil helical spring

Unit I – Introduction (Design of Machine Elements) (Total Classes: 12)				
Class No.	Topic	Subtopic	Teaching Aids/Activities	Course Objective
1	Introduction to Machine Design	Meaning of machine design, its purpose in engineering; classification into adaptive, developmental, and creative design	Real-life product demo, chalkboard explanation	CO1
2	Design Materials	Types of engineering materials: metals, polymers, ceramics, composites; criteria for selection	Samples of materials, classification chart	CO1
3	Material Properties	Explanation of physical and mechanical properties: strength, ductility, hardness, resilience, etc.	Posters showing property curves, real object demos	CO1
4	Stress Terms	Definitions and comparison of stresses: working stress, yield stress, ultimate stress, factor of safety	Numerical problems, visual stress models	CO1
5	Stress-Strain Curve (MS)	Complete stress-strain diagram of mild steel: elastic limit, yield point, ultimate strength, breaking point	Stress-strain chart, projected graph animation	CO1
6	Stress-Strain Curve (CI)	Stress-strain behaviour of cast iron compared to mild steel, brittle vs. ductile failure	Side-by-side graph comparison, material test videos	CO1
7	Modes of Failure	Elastic deformation, yielding, brittle fracture, fatigue, creep	Animated clips showing failure, failure part models	CO3
8	Types of Loading	Static, dynamic, impact, fluctuating loads and their effects on failure modes	Diagrams showing loading conditions, simple load experiment	CO3
9	Design Considerations	Factors affecting design: load conditions, service life, manufacturability, aesthetics, cost	Industrial case examples (gear/shaft design discussion)	CO4
10	Selection of Materials	Factors for material selection: strength, corrosion resistance, cost, availability, etc.	Group discussion on selecting material for a fan blade or bike frame	CO4

11	Machine Design Procedure	General steps: problem identification, need analysis, synthesis, modeling, analysis, optimization, testing	Flowchart of design process, simplified real-world example	CO4
12	Revision and Assessment	Recap of full unit through Q&A, MCQ quiz, and discussion on real-world applications	Quiz activity, group discussion, design-thinking recap	CO1, CO3, CO4

Unit II – Design of Fastening Elements (Total Classes: 12)				
Class No.	Topic	Subtopic	Teaching Aids/Activities	Course Objective
13	Introduction to Joints	Definition and need of joints in machine design; classification: permanent (welded/riveted) and temporary (bolted/pinned)	Chart of joint types, physical demo of bolted vs welded joint	CO2
14	Welded Joints	Types: butt, lap, fillet, corner, edge joints; symbols as per BIS	Welding symbol charts, welded metal samples	CO2
15	Advantages of Welded Joints	Over riveted and bolted joints: better appearance, lighter, less stress concentration, ease of fabrication	Comparison table, classroom discussion	CO2
16	Design of Welded Joint	Concepts of direct and eccentric loading; calculating throat thickness, weld length, moment arm; weld sizing	Numerical example using diagram on board	CO2
17	Riveted Joints & Rivets	Types of riveted joints (lap, butt, single/double); rivet heads (snap, pan, countersunk); applications	Sample riveted plates, rivet head models	CO2
18	Failure of Riveted Joints	Modes: tearing of plate, shearing of rivet, crushing of rivet; failure paths in chain/zig-zag joints	Diagrams and failure models (paper rivet experiment)	CO2
19	Strength & Efficiency	Strength of joint based on weakest failure mode; joint efficiency = (strength of joint / strength of solid plate) × 100	Board derivation, example with numerical data	CO2
20	Riveted Joint Design	Design principles for pressure vessels: diameter & pitch of rivet, plate thickness, margin; BIS standards	Solve a design problem using a vessel diagram	CO2
21	Numerical: Welded Joint	Solve numerical problems on eccentric loading in welded joints; calculate throat thickness, size of weld	Numerical worksheet, step-by-step problem solving	CO2
22	Numerical: Riveted Joint	Numerical problems on riveted joints: strength calculation, efficiency, pitch, margin, failure check	Practice problems, group activity with peer checking	CO2
23	Revision & Application	Summary of all types of fastening elements; real-world examples like bridges, boilers, automotive frames	Case studies, joint design analysis from engineering field	CO2
24	Class Test/Assignment	Conduct assessment with design-based and numerical questions on welded and riveted joints	Test paper, viva discussion, reinforcement activity	CO2

Design of Shafts and Keys (Total Classes = 12)				
Class No.	Topic	Subtopic (with elaboration)	Teaching Aids/Activities	Course Objective
25	Design of shafts and keys	Functions of shafts in mechanical systems, e.g., transmitting torque, supporting rotating parts, etc.	Real examples of shafts from lab or machines, photos, videos	CO5
26	Materials for shafts	Discuss commonly used shaft materials like mild steel, alloy steel, carbon steel. Compare their mechanical properties and cost.	Chart showing properties of shaft materials	CO5
27	Design of shafts (strength)	Design of solid and hollow shafts using shear stress and combined bending and tension stress equations.	Whiteboard derivations, sample problems, problem-solving worksheet	CO5

28	Design of shafts (rigidity)	Angle of twist, torsional deflection, modulus of rigidity, and related formulas. Conditions for rigidity-based design.	Torsion shaft setup demonstration or simulation	CO5
29	Standard shaft sizes	Introduce IS standards related to standard diameters and tolerances of shafts.	IS code sample or PDF, shaft catalogues	CO5
30	Keys: function and types	Purpose of keys, types like sunk, saddle, tangent, splines. Materials used for different key types.	Display of various keys, actual samples from workshop	CO5
31	Failure and keyway effect	Shear and crushing failure of keys, weakening of shaft due to keyway, stress concentration issues.	Failure charts, shaft-key assemblies, animations of failure modes	CO5
32	Design of sunk key (theory)	Design for strength using shear and crushing failure theories. Assumptions in design.	Formula derivation and example calculation	CO5
33	Design using empirical formula	Empirical relation for key length: $l = (1.5 \text{ to } 2)d$; application for fast key sizing in industry.	Design chart, empirical formula tables, practice sheet	CO5
34	IS specification of keys	Standard dimensions, designation of keys: parallel key, gib-head key, taper key. Reading specifications from IS code.	IS chart and catalog, measuring tools demonstration	CO5
35	Numerical on shaft design	Solved problems involving shaft design based on strength and rigidity. Power transmission at given RPM.	Whiteboard calculations, assignments	CO5
36	Numerical on key design	Solved examples on design of rectangular sunk key for given shaft torque. Verification against failure criteria.	Worksheets, group activity on numerical problems	CO5

Unit5: Design of Coupling (Total Classes: 12)

Class No.	Topic	Subtopic (with elaboration)	Teaching Aids/Activities	Course Objective
37	Design of Shaft Coupling	Introduction to shaft couplings. Their necessity in transmitting power between shafts, maintaining alignment, and absorbing shocks and vibrations.	Physical demo of couplings, machine animations	CO5
38	Requirements of good coupling	Discuss functional, mechanical, and economic requirements — alignment, ease of assembly/disassembly, maintenance, cost, and strength.	Chalkboard discussion, posters showing good vs. bad coupling examples	CO5
39	Types of Coupling	Rigid (sleeve, clamp, flange) and flexible (Oldham, universal joint, etc.) couplings. Compare their applications and suitability.	Real samples, models or cut-sections of different coupling types	CO5
40	Sleeve/Muff Coupling: intro & construction	Constructional features, operation principle. Application in aligned shafts. Load transfer via key.	Cross-sectional diagrams, exploded view animation	CO5
41	Design of Sleeve/Muff Coupling	Design procedure: Torque transmission, sleeve dimensions, key dimensions, and materials.	Step-by-step design derivation on board, real-case example	CO5
42	Clamp Coupling: intro & construction	Construction and function of clamp or split-muff coupling. Bolted connection for easy assembly and disassembly.	Physical coupling sample, lab videos	CO5
43	Design of Clamp Coupling	Design calculations involving bolts, sleeve, key, and shaft. Consideration of crushing and shear stresses.	Example problems, simplified bolt design exercise	CO5
44	Numerical on Coupling Design – 1	Solve a numerical on muff coupling for given power, RPM, and material properties. Design sleeve and key.	Worksheet with a solved example	CO5

45	Numerical on Coupling Design – 2	Solve a numerical on clamp coupling — including bolt design and torque transmission. Evaluate safety against failure.	Assignment for students, collaborative peer-solving session	CO5
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Design of a Closed Coil Helical Spring (Total Classes: 12)				
Class No.	Topic	Subtopic	Teaching Aids/Activities	Course Objective
49	Design a closed coil helical spring	Introduction to spring design, types and importance of springs in mechanical systems	Physical models of various springs, charts showing applications	CO5
50	Materials used for helical spring	Discuss spring materials like high-carbon steel, stainless steel, and their selection criteria	Sample material swatches, comparison table of properties	CO5
51	Standard size spring wire (SWG)	Explain Standard Wire Gauge (SWG), use charts to relate SWG to wire diameter	SWG chart, real spring wire samples	CO5
52	Terms used in compression spring	Define free length, solid length, pitch, spring index, coil diameter etc.	Chart showing spring terminology, labelled diagrams	CO5
53	Stress in helical spring	Torsional shear stress, direct shear stress, Wahl's factor for stress correction	Formula derivation on board, numerical example demonstration	CO5
54	Deflection of helical spring	Deflection formula derivation and factors affecting deflection	Graph of deflection vs. load, animation showing spring compression	CO5
55	Deflection of helical spring (Contd.)	Solve numerical problems on deflection using given parameters	Practice worksheet, calculator-based session	CO5
56	Surge in spring	Explain surge phenomenon, resonance in springs, ways to reduce surge	Video demonstration of spring vibration, example of dampers	CO5
57	Design procedure summary	Combine stress and deflection formulas into design methodology	Step-by-step design flowchart, board explanation	CO5
58	Numerical Problem – I	Solve a design problem involving given load, number of coils, material etc.	Problem solving with board and group participation	CO5
59	Numerical Problem – II	Solve another practical design problem (variation in spring index or material)	Group worksheet, discussion of alternate solutions	CO5
60	Revision and Class Test	Recap of spring design concepts, brief quiz or class test	Question paper handout, oral quiz round	CO5

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24.08.24

Signature of the Faculty

SPD
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Signature of the HOD