2022-23

MECHANICAL ENGINEERING

DME-I

PREPARED BY
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Techno India NJR Institute of Technology

Course File

5ME4-04: DESIGN OF MACHINE ELEMENTS – I

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Syllabus

3rd Year - V Semester: B.Tech. : Mechanical Engineering

5ME4-04: DESIGN OF MACHINE ELEMENTS – I

Credit: 3 **Max. Marks: 150(IA:30, ETE:120)**

3L+0T+0P **End Term Exam: 3 Hours**

SN	Contents	Hours
1	Introduction: Objective, scope and outcome of the course.	1
2	Materials: Mechanical Properties and IS coding of various materials, Selection of material from properties and economic aspects.	3
	Manufacturing Considerations in Design: Standardization, Interchangeability, limits, fits tolerances and surface roughness, BIS codes, Design consideration for cast, forged and machined parts. Design for assembly.	4
3	Design for Strength: Modes of failure, Strength and Stiffness considerations, Allowable stresses, factor of safety, Stress concentration: causes and mitigation, fatigue failures.	4
	Design of Members subjected to direct stress: pin, cotter and keyed joints.	5
4	Design of Members in Bending: Beams, levers and laminated springs. Design for stiffness of beam: Use of maximum deflection formula for various end conditions for beam design.	7
5	Design of Members in Torsion Shaft and Keys: Design for strength, rigidity. Solid and hollow shafts. Shafts under combined loading. Sunk keys.	5
	Couplings: Design of muff coupling, flanged couplings: rigid and flexible.	3
6	Design of Threaded fasteners: Bolt of uniform strength, Preloading of bolts: Effect of initial tension and applied loads, Eccentric loading.	4
	Power screws like lead screw, screw jack.	2
	Design of members which are curved like crane hook, body of C-clamp, machine frame etc.	3
	TOTAL	41

Course Overview: Mechanical engineers are associated with the production and processing of energy and with providing the means of production, the tools of transportation, and the techniques of automation. The skill and knowledge base are extensive. Among the disciplinary bases are mechanics of solids and fluids, mass and momentum transport, manufacturing processes, and electrical and information theory. Mechanical engineering design involves all the disciplines of mechanical engineering. Therefore, this course aims to equip the mechanical engineering students with the fundamentals of these design activities and give them necessary skills to prepare complete, concise, and accurate calculation steps for machine elements. While the first part of the machine elements covering general stress analysis, failure conditions, shaft, spring, permanent and temporary joints design, screw jack, curved beam analysis.

The aim of this course is to introduce students the concepts and the use of machine elements in the design and manufacturing field. The students acquaint with the knowledge and skills in understanding failure modes, better design criterion for machine elements and the capability to design elements like screws, rivets, welded joints, shafts, springs. The students can also develop an understanding of analysis tools of these parts.

Course Outcomes:

CO. NO.	Cognitive Level	Course Outcome
1	Synthesis	Explain the fundamental scientific principles of mechanical design (stress, strain, material properties, failure theories, fatigue phenomena, fracture mechanics) and their importance and use in design analysis
2	Synthesis	Develop practical experience with the function, design and analysis of actual machine components including prediction of their life and failures
3	Synthesis	Reorganize systematic approaches to mechanical design and analysis procedures
4	Synthesis	Summarize component behaviour subjected to loads and identify the failure criteria.
5	Synthesis	Design a machine component using theories of failure.

Prerequisites:

1. Basic knowledge of Strength of material and Fluid Mechanics.
2. Concepts of Engineering mechanics, and mathematics.

Course Outcome Mapping with Program Outcome:

Course Outcome	Program Outcomes (PO's)											
CO. NO.	Domain Specific (PSO)					Domain Independent (PO)						
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1	1	1	1	-	-	-	-	1	-	-
CO2	3	2	3	2	2	-	-	-	-	1	-	1
CO3	3	2	3	2	2	-	-	-	-	1	-	1
CO4	2	1	2	1	2	-	-	-	-	1	-	-
CO5	3	2	2	1	2	-	-	-	-	-	-	-
1: Slight (Low) , 2: Moderate (Medium), 3: Substantial (High)												

Course Coverage Module Wise:

Lecture No.	Unit	Topic
1	**1**	**INTRODUCTION**
2	**2**	**INTRODUCTION TO MATERIALS:** Students will classify engineering materials and their properties.
3	2	Students will able to designate engineering materials and IS coding system of various materials.
4	2	Students will able to select the materials from properties and economic aspects
5	**2**	Students will able to know the various manufacturing considerations in design, standardization process
6	2	Students will able to know the concept of Interchangeability, limits, fits and tolerances and surface roughness
7	2	Students will able to know the design considerations for cast, forged and machined parts
8	2	Students will able to know the design for assembly concepts.
9	2	Numerical Problem Discussion based on Old RTU examination patterns.
10	**3**	**DESIGN FOR STRENGTH:** Students will able to know the modes of failure, strength and stiffness considerations
11	3	Students will able to know the allowable stress and factor of safety & Fatigue failures
12	3	Students will able to understand the key concept of stress Concentration: causes & their mitigation
13	3	Students will able to design of Pin and cotter joint
14	3	Students will able to design of Knuckle Joint
15	3	Numerical Problem Discussion based on Old RTU examination patterns.
16	**4**	**DESIGN OF MEMBERS IN BENDING**

17	4	Students will able to design of members in bending: Levers
18	4	Students will able to design of members in bending: Springs
19	4	Students will able to design for stiffness of beam: Using Deflection beam method
20	4	Students will able to design for stiffness of beam: Using Deflection beam method
21	4	Students will able to design for stiffness of beam: Using Deflection beam method, varying end conditions
22	4	Students will able to design for stiffness of beam: Using Deflection beam method, varying end conditions
23	4	Numerical Problem Discussion based on Old RTU examination patterns.
24	**5**	**DESIGN OF MEMBERS IN TORSION**
25	5	Students will able to design of shafts: design for strength and rigidity criterion
26	5	Students will able to design of shafts: Solid and hollow shafts
27	5	Students will able to design of shafts: shafts under combined loading
28	5	Students will able to design for Keys
29	5	Students will able to design for Coupling: muff coupling
30	5	Students will able to design for Coupling: flanged coupling
31	5	Students will able to design for Coupling: rigid & flexible
32	5	Numerical Problem Discussion based on Old RTU examination patterns.
33	**6**	**DESIGN OF THREADED FASTENERS**
34	6	Students will able to design of Bolts: Bolt of uniform strength
35	6	Students will able to design of Bolts: Effect of initial tension and applied loads
36	6	Students will able to design of Bolts: Eccentric loading
37	6	Students will able to design of Screw jack
38	6	Students will able to design for curved members like crane hook
39	6	Students will able to design for curved members like C clamp
40	6	Students will able to design for curved members like machine frame
41	6	Numerical Problem Discussion based on Old RTU examination patterns.

Text Books

1. A Textbook of Machine Design by R S Khurmi and J K Gupta, S Chand Publication

References

1. Bhandari, V. B., Introduction to Machine Design, Mcgraw Hill Education (India)
2. Shigley, Joseph e., Mechanical Engineering Design, Mcgraw Hill Education (India)

Assessment Methodology:

1. Conducting vica voce examination on weekly basis.
2. Practical exam in lab where students have to apply their theoretical understanding to apply numerically and correlate them analytically. (Once in a week)
3. Assignments one from each unit.
4. Midterm subjective paper where they have to solve basic questions with numerical and derivations from each unit. (Twice during the semester)
5. Final paper at the end of the semester subjective.

Teaching and Learning resources unit-wise:

Unit-1

Introduction to Engineering Materials

Video Tutorials: https://youtube.com/playlist?list=PLbMVogVj5nJTZJHsH6uLCO00I-ffGyBEm

Theory concepts: https://nptel.ac.in/courses/112/105/112105125/

Quiz: https://www.sanfoundry.com/1000-machine-design-questions-answers/

Unit-2

Design for Strength

Video Tutorials: https://youtube.com/playlist?list=PLbMVogVj5nJTZJHsH6uLCO00I-ffGyBEm

Theory concepts: https://nptel.ac.in/courses/112/105/112105125/

Quiz: https://www.sanfoundry.com/1000-machine-design-questions-answers/

Unit-3

Design of members in bending

Video Tutorials: https://youtube.com/playlist?list=PLbMVogVj5nJTZJHsH6uLCO00I-ffGyBEm

Quiz: https://www.sanfoundry.com/1000-machine-design-questions-answers/

Theory concepts: https://nptel.ac.in/courses/112/105/112105125/

Unit-4

Design of members in torsion

Video Tutorials: https://youtube.com/playlist?list=PLbMVogVj5nJTZJHsH6uLCO00I-ffGyBEm

Theory concepts: https://nptel.ac.in/courses/112/105/112105125/

Quiz: https://www.sanfoundry.com/1000-machine-design-questions-answers/

Unit-5

Design of Threaded fasteners

Video Tutorials: https://youtube.com/playlist?list=PLbMVogVj5nJTZJHsH6uLCO00I-ffGyBEm

Theory concepts: https://nptel.ac.in/courses/112/105/112105125/

Quiz: https://www.sanfoundry.com/1000-machine-design-questions-answers/

Previous Year Question Papers:

4E 4143

Roll No. _____ [Total No. of Pages : 3

4E 4143

B.Tech. IV Semester (Main/Back) Examination, May - 2018
Mechanical Engg.
4ME4 Design of Machine Elements - I
AE,ME,PI

Time : 3 Hours **Maximum Marks : 80**
Min. Passing Marks : 26

*Attempt any **five questions**, selecting **one question** from **each unit**. All Questions carry **equal** marks. Schematic diagrams must be shown wherever necessary. Any data you feel missing suitably be assumed and stated clearly. Units of quantities used/calculated must be stated clearly.*

Unit - I

1. a) Discuss the following mechanical properties of the material: **(4)**
   i) Hardness
   ii) Toughness
   iii) Creep Strength
   iv) Fatigue strength

   b) Discuss fits, types of fit and tolerance? Also discuss the shaft basis and hole basis system. **(12)**

OR

1. Write short note on followings: **(16)**
   a) Design consideration for casting.
   b) Material selection.
   c) Standardization and interchangeability.
   d) BIS designation of Plain carbon steel.

Unit - II

2. a) Why gibs are used in a cotter joint? **(4)**

   b) Describe the design procedure of a gib and cotter joint with the help of neat sketch the use of single and double gib. **(12)**

OR

2. Design a knuckle joint for a tie rod of a circular section to sustain a maximum pull of 70 kN. The ultimate tensile strength of the material of the tearing is 420 MPa. The ultimate tensile and shearing strength of the pin material are 510 MPa and 396 MPa respectively. Determine the tie rod section and pin section. Take factor of safety = 6. **(16)**

Unit - III

3. a) What is lever? Discuss the first, second and third type of levers with neat sketch. **(4)**

   b) A cranked lever has the following dimensions:

   Length of the handle = 300 mm

   Length of the lever arm = 400 mm

   Overhang of the journal = 100 mm

   If the lever is operated by a single person exerting a maximum force of 400 N at a distance of 1/3rd length of the handle from its free end, find:

   i) Diameter of the handle,

   ii) Cross-section of the lever arm, and

   iii) Diameter of the journal.

   The permissible bending stress for the lever material may be taken as 50 MPa and shear stress for shaft material as 40 MPa. **(12)**

OR

3. a) Discuss the nipping and camber in the leaf spring. **(4)**

   b) A truck spring has 12 number of leaves, two of which are full length leaves. The spring supports are 1.05 m apart and the central band is 85mm wide. The central load is to be 5.4 kN with a permissible stress of 280 MPa. Determine the thickness and width of the steel spring leaves and length of each leaf. The ratio of the total depth to the width of the spring is 3. Also determine the deflection of the spring. **(12)**

Unit - IV

4. A shaft is supported by two bearings placed 1 m apart. A 600 mm diameter pulley is mounted at a distance of 300 mm to the right of left hand bearing and this drives a pulley directly below it with the help of belt having maximum tension of 2.25 kN. Another pulley 400 mm diameter is placed 200 mm to the left of right hand bearing and is driven with the help of electric motor and belt, which is placed horizontally to the right. The angle of contact for both the pulleys is 180° and $\mu = 0.24$. Determine the suitable diameter for a solid shaft, allowing working stress of 63 MPa in tension and 42 MPa in shear for the material of shaft. Assume that the torque on one pulley is equal to that on the other pulley. **(16)**

OR

4. A shaft is supported on bearings A and B, 800 mm between centres. A 20° straight tooth spur gear having 600 mm pitch diameter, is located 200 mm to the right of the left hand bearing A, and a 700 mm diameter pulley is mounted 250 mm towards the left of bearing B. The gear is driven by a pinion with a downward tangential force while the pulley drives a horizontal belt having 180° angle of wrap. The pulley also serves as a flywheel and weighs 2000 N. The maximum belt tension is 3000 N and the tension ratio is 3 : 1. Determine the maximum bending moment and the necessary shaft diameter if the allowable shear stress of the material is 40 MPa. **(16)**

Unit - V

5. a) Discuss screw the initial stresses developed in fastening due to screwing up forces. **(4)**

   b) The cylinder head of a steam engine is subjected to a steam pressure of 0.7 N/mm^2. It is held in position by means of 12 bolts. A soft copper gasket is used to make the joint leak-proof. The effective diameter of cylinder is 300 mm. Find the size of the bolts so that the stress in the bolts is not to exceed 100 MPa. **(12)**

OR

5. A steam engine of effective diameter 300 mm is subjected to a steam pressure of 1.5 N/mm^2. The cylinder head is connected by 8 bolts having yield point 330 MPa and endurance limit at 240 MPa. The bolts are tightened with an initial preload of 1.5 times the steam load. A soft copper gasket is used to make the joint leak-proof. Assuming a factor of safety 2, find the size of bolt required. The stiffness factor for copper gasket may be taken as 0.5. **(16)**

4E4143

Roll No. _____ Total No. of Pages : 4

4E4143

B. Tech. IV-Sem. (Main) Exam; April-May 2017

Production & Industrial Engg.

4PI4A Design of Machines Elements - I

Time : 3 Hours **Maximum Marks : 80**

Min. Passing Marks : 24

Instructions to Candidates :-

*Attempt any **five questions**, selecting **one question** from **each unit**. All Questions carry **equal** marks. Schematic diagrams must be shown wherever necessary. Any data you feel missing suitably be assumed and stated clearly.*
Units of quantities used / calculated must be stated clearly.
Use of following supporting materials is permitted during examination. (Mentioned in form No: 205)

1. NIL 2. NIL

UNIT - I

1 (a) What is a machine element ? Give two examples. **4**

(b) What do you understand by mechanical properties of materials ? How these are helpful in machine design ? **12**

OR

1 (a) What is 'machine design' ? Explain the basic procedure of machine design. **8**

(b) Explain standardization, limits, fits and surface roughness for manufacturing consideration in design with neat sketch and suitable examples. **8**

UNIT - II

2 (a) What is 'Stress concentration' ? How it can be reduced in a component ?

(b) Determine the diameter of a circular rod made of ductile material wit a fatigue strength (complete stress reversal) σ_c = 265 MPa and a tensil yield strength of 350 MPa. The member is subjected to a variable axi load from $W_{min} = -300\times10^3$ N to $W_{max} = 700\times10^3$ N and has a stres concentration factor = 1.8. Use factor of safety as 2.0.

OR

2 It is required to design a cotter joint to connect two steel rods of equal diameter Each rod is subjected to an axial tensile force of 50 kN. Design the joint an specify its main dimensions.

1

UNIT - III

3 (a) What is a 'beam' ? Which type of stresses can be induced in it ? Discu the role of section modulus in beams design with two examples of differe shapes.

(b) A truck spring has 12 number of leaves, two of which are full leng leaves. The spring supports are 1.05 m and the central band is 85 m wide. The central load is to be 5.4 kN with a permissible stress of 280 MP Determine the thickness and width of the steel spring leaves. The rat of the total depth to the width of the spring is 3. Also determine t deflection of the spring.

OR

3 (a) What is a 'lever' ? Explain the principle of it and leverage. Classify t levers.

(b) A right angled bell-crank lever is to designed to raise a load of 5 kN at the short arm end. The lengths of short and long arms are 100 and 450 mm respectively. The lever and the pins are made of steel 30C8 (S_{yt} = 400 N/mm^2) and the factor of safety is 5. The permissible bearing pressure on the pin is 10 N/mm^2. The lever has rectangular cross-section and the ratio of width to thickness is 3 : 1. The length to diameter ratio of fulcrum pin is 1.25 : 1

Calculate :

(i) The diameter and the length of fulcrum pin

(ii) The shear stress in the pin

(iii) The dimensions of the boss of the lever of the fulcrum and

(iv) The dimensions of the cross-section of the lever.

Assume that the arm of bending moment on the lever expands upto the axis of the fulcrum.

8

UNIT - IV

(a) A line shaft transmits 25 kW power at 200 rpm by means of a vertical belt drive. The diameter of the belt pulley is 1 m and the pulley overhangs 150 mm beyond the centre line of the end bearing. The belt tension acts vertically downward. The tension on the tight side of the belt is 2.5 times that on slack side. The shaft is made of plain carbon steel 40C8 (S_{yt} = 380 N/mm^2) and the factor of safety is 2.5. The mass of the pulley is 25 kg. Determine the diameter of the shaft.

12

(b) What is a 'key' ? Explain the failure of key.

4

OR

(a) What is coupling ? Classify it.

4

(b) Design a muff coupling which is used to connect two steel shafts transmitting 25 kW power at 360 rpm. The shafts and key are made of plain carbon steel 30C8 (S_{yt} = S_{yc} = 400 N/mm^2). The sleeve is made of grey cast iron FG 200 (S_{ut} = 200 N/mm^2). The factor of safety for the shaft and key is 4. For the sleeve, the factor of safety is 6 based on ultimate strength.

12

UNIT - V

5 (a) Explain the concept of thread for single start and double start, relative to lead of them. Explain the terminologies used to define the threads with neat sketches. **8**

(b) What are the 'locking devices' ? Classify them and explain their working concept with neat sketches. **8**

OR

5 (a) Why uniform strength is required in bolts ? How it can be achieved ? Determine the diameter of the hole that must be drilled in a M48 belt such that the bolt becomes of uniform strength. **8**

(b) A bracket, as shown in Fig. supports a load of 30 kN. Determine the size of bolts, if the maximum allowable tensile stress is in the bolt material is 60 MPa. the distances are L_1 = 80 mm, L_2 = 250 mm and L = 500 mm. **8**

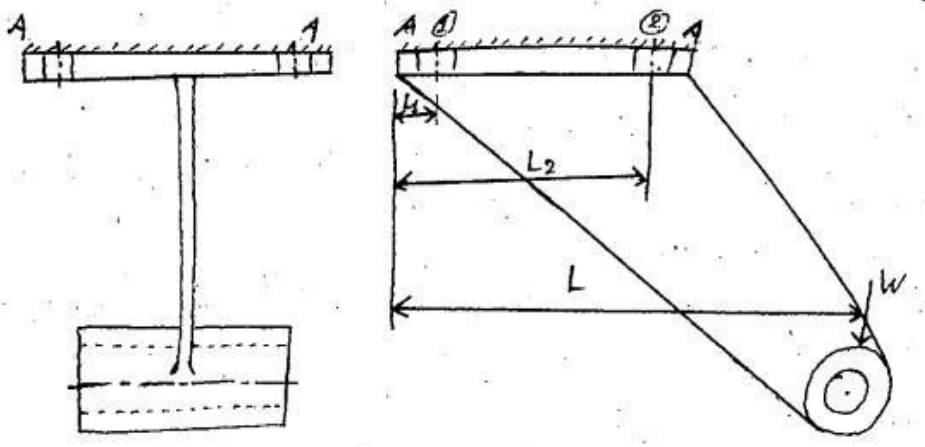

Fig. : Bracket with eccentric loading.