# LOK JAGRUTI UNIVERSITY (LJU)

# INSTITUTE OF ENGINEERING AND TECHNOLOGY

## Department of Mechanical Engineering

## Bachelor of Engineering (B.E.) – Semester – IV

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|---|---|
| **Course Code:** | **017103402** |
| **Course Name:** | **Design of Machine Elements** |
| **Category of Course:** | Professional Core Course (PCC) |
| **Prerequisite Course:** | Engineering Mechanics (017102291), Strength of Materials (017103391) |

| Teaching Scheme | | | | |
|---|---|---|---|---|
| **Lecture (L)** | **Tutorial (T)** | **Practical (P)** | **Credit** | **Total Hours** |
| **4** | **1** | **2** | **6** | **60** |

**Syllabus**

| Unit No. | Topic | Prerequisite Topic | Successive Topic | Teaching Hours |
|---|---|---|---|---|
| **01** | **Introduction to Machine Design** | | | **4 (7%)** |
| | 1.1 Introduction about Machine Design and Design procedure | --- | --- | |
| | 1.2 Standardization | --- | --- | |
| | 1.3 Selection of preferred sizes | --- | --- | |
| | 1.4 Aesthetic and Ergonomic considerations in Design, Manufacturing considerations in Design | --- | --- | |
| | 1.5. Selection of Manufacturing method in Design | --- | --- | |
| **02** | **Design Against Static Load** | | | **6 (10%)** |
| | 2.1 Concepts of stresses and Strain, Combinations of Axial, Shear, Torsional and Bending loads | Types of loads, Gradual, sudden, Impact and shock loading (017103391-Unit-1.1) | --- | |
| | 2.2 Theories of Failures, (Maximum Principal stress, Maximum-Shear stress, Distortion energy, Maximum strain theory and Maximum Strain Energy theory) | Stress and types of stress, Strain and types of strain (017103391-Unit-1.2) | --- | |
| | 2.3 Selection and Use of theories of failures | --- | --- | |
| | 2.4 Factor of safety and Selection of Factor of Safety | --- | --- | |
| **03** | **Design Against Eccentric Load** | | | **5 (8%)** |
| | 3.1 Hertz contact Stress theory, Coulomb-Mohr Theory, Bearing stress and Crushing stress | Stress and types of stress, Strain and types of strain (017103391-Unit-1.2) | --- | |
| | 3.2 Application problems: eccentric loading (Direct and Bending Stresses) | Moment of a force, Principle of moments, Couples, Equivalent couples (017102291-Unit-3.1) | --- | |
| **04** | **Shafts** | | | **8 (13%)** |
| | 4.1. Introduction of Shaft, Material Used for Shafts, Types of Shafts | --- | --- | |
| | 4.2 Stresses in Shafts, Maximum Permissible Working Stresses for Transmission Shafts. | | | |
| | 4.3 Design of shaft (Solid and Hollow circular)- (When Shafts Subjected to Twisting Moment Only, Shafts Subjected to Bending Moment Only, Shafts Subjected to Combined Twisting Moment and Bending Moment) | Concept of shear force and bending moment (017103391 -Unit-4.1), Derivation of equation of torsion (017103391 -Unit-9.1) | --- | |
| | 4.4 Design of shaft subjected to Fluctuating Loads | --- | --- | |
| | 4.5 Design of shaft for rigidity | --- | --- | |
| **05** | **Keys and Couplings** | | | **7 (12%)** |
| | 5.1 Introduction and Types of Keys (Sunk Keys. Saddle Keys, Tangent Keys, Kennedy Key, Round Keys, Splines) | --- | --- | |
| | 5.2 Design of a Sunk Key | Concept of shear force and bending moment (017103391 -Unit-4.1), Derivation of equation of torsion (017103391 -Unit-9.1) | --- | |
| | 5.3 Effect of Keyways | --- | --- | |
| | 5.4 Introduction and Types of Shaft Couplings, Requirements of a Good Shaft Coupling. | --- | --- | |
| | 5.5 Design of Coupling: Sleeve or Muff Coupling, Clamp or Compression Coupling, Flange Coupling (Protected and Unprotected Type Coupling), Bush-pin Flexible Coupling | --- | --- | |
| **06** | **Power Screws** | | | **7 (12%)** |
| | 6.1 Introduction of Power Screws, Forms of Threads and Multiple Threaded Screws | Derivation of equation of torsion (017103391 -Unit-9.1) | --- | |
| | 6.2 Terminology of Power Screw | --- | --- | |
| | 6.3 Torque Requirement of Lifting Load and Lowering Load by Square Threaded Screws | Friction and its applications, Types of friction (017102291 -Unit-7.1) | --- | |
| | 6.4 Efficiency of Square Threaded Screw and Condition for | --- | --- | |

| | | | | |
|---|---|---|---|---|
| | Maximum Efficiency | | | |
| | 6.5 Overhauling and Self-locking Screws, Efficiency of Self-Locking Screws | --- | --- | |
| **07** | **Design of Power Screws** | | | **8 (13%)** |
| | 7.1 Trapezoidal and Acme Threads and Collar Friction Torque | --- | --- | |
| | 7.2 Overall Efficiency and Concept of coefficient of Friction at the thread surface | --- | --- | |
| | 7.3 Design of Screw and Nut | Theories of Failures (0171034021-Unit-2.2) | --- | |
| **08** | **Lever** | | | **5 (8%)** |
| | 8.1 Introduction of lever and it's Types, Basic Design of Lever | Types of load, supports and beams (017102291-Unit-6.1) | --- | |
| | 8.2 Design analysis of levers (Bell crank, lever loaded safety valve, Rocker arm) | Moment of a force, Principle of moments, Couples, Equivalent couples (017102291-Unit-3.1) | --- | |
| **09** | **Riveted Joint** | | | **6 (10%)** |
| | 9.1 Introduction of Riveted joints, rivet materials | --- | --- | |
| | 9.2 Types of rivet joints (Lap and butt joint) and Terminology of Riveted Joints | --- | --- | |
| | 9.3 Types of failure, strength and efficiency of joint (Shearing, Tearing, Crushing), Efficiency of Riveted Joints | Stress and types of stress, Strain and types of strain (017103391-Unit-1.2) | --- | |
| | 9.4 Introduction of Longitudinal and circumferential lap joint for boiler | --- | --- | |
| | 9.5 Eccentrically loaded riveted joint (Derivation and Problems) | Moment of a force, Principle of moments, Couples, Equivalent couples (017102291-Unit-3.1) | --- | |
| | 9.6 Caulking and Fullering | --- | --- | |
| **10** | **Limit, Fit and Tolerance** | | | **4 (7%)** |
| | 10.1 Interchangeability | --- | --- | |
| | 10.2 Important Terms Used in Limit System. | --- | --- | |
| | 10.3 Fits and Types of Fits | --- | --- | |
| | 10.4 Basis of Limit System | --- | --- | |

**Major Components/ Equipment**

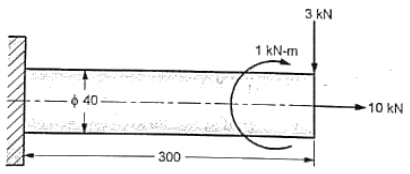
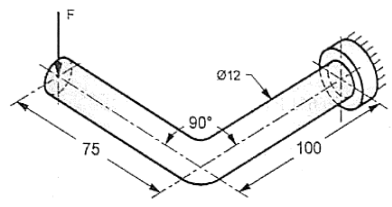
| Sr. No. | Component/Equipment |
|---|---|
| 1. | Hollow and Solid Shaft |
| 2. | Sunk Key, Woodruff Key, Spline Key, Square Key, Rectangle Key |
| 3. | Rigid and Flexible Coupling |
| 4. | Power Screw |
| 5. | Bell crank, Lever loaded safety valve, Rocker arm |
| 6. | Model of Rivet |

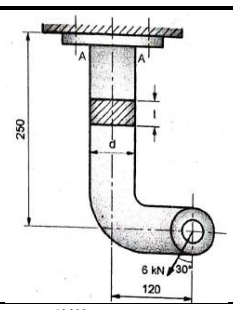
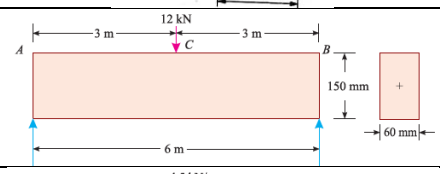
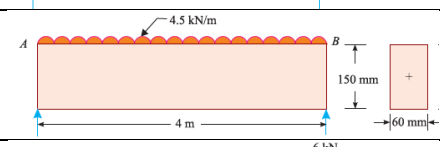
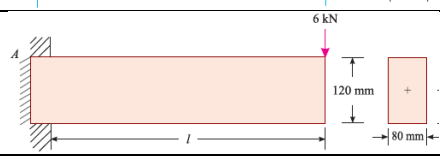
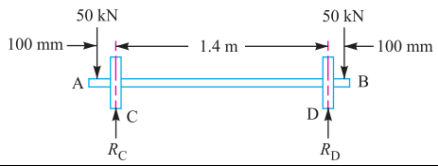
| Sr. No. | Practical Title | Link to Theory Syllabus |
|---|---|---|
| **1** | Analysis of structural member and verification of results for different theory of failure. | Unit-2 |
| **2** | Analysis of structural member and verification of results for different theory of failure. | Unit-2 |
| **3** | Analysis of eccentric load member and verification of results through manual calculation. | Unit-3 |
| **4** | Structural analysis of simply supported beam and verification of results through manual calculation. | Unit-4 |
| **5** | Structural analysis of simply supported beam and verification of results through manual calculation. | Unit-4 |
| **6** | Structural analysis of cantilever beam and verification of results through manual calculation. | Unit-4 |
| **7** | Structural analysis of fixed beam and verification of results through manual calculation | Unit-4 |
| **8** | Structural analysis of shaft under bending and verification of results through manual calculation. | Unit-4 |
| **9** | Structural analysis of shaft under torsion and verification of results through manual calculation. | Unit-4 |
| **10** | Structural analysis of shaft under combined loading and verification of results through manual calculation. | Unit-4 |

| Proposed Theory + Practical Evaluation Scheme by Academicians<br>(% Weightage Category Wise and it's Marks Distribution) | | | | | |
|---|---|---|---|---|---|
| **L:** | **4** | **T:** | **1** | **P:** | **2** |
| **Note: In Theory Group, Total 4 Test (T1+T2+T3+T4) will be conducted for each subject.<br>Each Test will be of 25 Marks.<br>Each Test Syllabus Weightage: Range should be 20% - 30%** | | | | | |
| **Group (Theory or Practical)** | **Group (Theory or Practical) Credit** | **Total Subject Credit** | **Category** | **% Weightage** | **Marks Weightage** |
| Theory | **5** | **6** | MCQ | 25% | 30 |
| Theory | | | Theory Descriptive | 0% | 00 |
| Theory | | | Formulas and Derivation | 17% | 20 |
| Theory | | | Numerical | 42% | 50 |
| **Expected Theory %** | **84%** | | **Calculated Theory %** | **84%** | **100** |
| Practical | **1** | | Individual Project | 10% | 60 |
| Practical | | | Group Project | 0% | 0 |
| Practical | | | Internal Practical Evaluation (IPE) | 6% | 40 |
| Practical | | | Viva | 0% | 0 |
| Practical | | | Seminar | 0% | 0 |
| **Expected Practical %** | **16%** | | **Calculated Practical %** | **16%** | **100** |
| **Overall %** | **100%** | | | **100%** | **200** |

| **Course Outcome** | |
|---|---|
| | *Upon completion of the course students will be able to* |
| 1 | Analyze stresses induced in components subjected to static load and eccentric load. |
| 2 | Design different dimensions of shaft, keys and couplings. |
| 3 | Evaluate dimensions of power screw to find torque required to raise & lower load and screw efficiency. |
| 4 | Compute design calculations in design of levers and riveted joints and understand terminology of limits, fits and tolerance. |
| **Suggested Reference Books** | |
| 1 | A text book of Machine Design by R S Khurmi, eurasia publishing house (pvt.) Ltd. |
| 2 | Machine Design an Introduction by R L Norton, Mcgraw-Hill Higher Education |
| 3 | Machine Design Databook by V B Bhandari, Tata mcgraw-Hill Education |
| 4 | Fundamentals of Machine Component Design by R C Juvinall, John wiley and sons, inc |
| 5 | Machine Design: Fundamentals and Applications, by P C Gope, PHI Learning Pvt. Ltd |
| 6 | Machine Design by R.K.Jain, Khanna publishers |
| 7 | Machine Design by TVS Murthy and N.Shanmugam, Anuradha |
| 8 | Machine Design by Pandya and Shah, Charotar Publishing House Pvt. Limited |
| 9 | Design of Machine Elements by Shigley, Mcgraw-Hill Higher Education |

| **List of Open Source Software/Learning website** | |
|---|---|
| 1 | http://nptel.ac.in |
| 2 | https://www.machinedesignonline.com |
| 3 | https://www.coursera.org |
| 4 | https://www.edx.org |
| 5 | https://in.linkedin.com |

| | **Practical Project/Hands on Project** | | |
|---|---|---|---|
| **Sr. No.** | **Project List** | | **Linked with Unit** |
| **1** | A steel bar of 40 mm diameter and 300 mm length is subjected to a torque of 1 kN-m and two other loads, as shown in figure. If the ultimate tensile strength and yield strength of the bar material are 450 N/mm2 and 250 N/mm2 respectively, determine factor of safety using: (i) the maximum principal stress theory, (ii) the maximum shear stress theory, and (iii) the distortion energy theory. |  | Unit-2 |
| **2** | Figure shows L shaped lever subjected to a load F. Diameter of lever is uniform throughout and is 12 mm. The material of the lever is 20C8 for which ultimate tensile strength and yield strength are 435 N/mm2 and 246 N/mm2 respectively. If the factor of safety based on yield strength is 1.5, find the maximum load F the lever can take safely using (i) the maximum shear stress theory and (ii) the distortion energy theory. |  | Unit-2 |

| | | | |
|---|---|---|---|
| **3** | Figure Shows a hanger with rectangular cross-section.The force P acting on the hanger is 6 KN and acts 30 degree to the vertical as shonw. If the permissible stress in the hanger material is 60 Mpa, determine the size of cross-section.assume d=2t |  | Unit-3 |
| **4** | A rectangular beam 60 mm wide and 150 mm deep is simply supported over a span of 6 m. If the beam is subjected to central point load of 12 kN, find the maximum bending stress induced in the beam section. |  | Unit-4 |
| **5** | A rectangular beam 60 mm wide and 150 mm deep is simply supported over a span of 4 metres. If the beam is subjected to a uniformly distributed load of 4.5 kN/m, find the maximum bending stress induced in the beam. |  | Unit-4 |
| **6** | A cantilever beam is rectrangular in section having 80 mm width and 120 mm depth. If the cantilever is subjected to a point load of 6 kN at the free end and the bending stress is not to exceed 40 MPa, find the span of the cantilever beam. |  | Unit-4 |
| **7** | An encastre beam AB 4 m long is subjected to uniformly distributed load of 3 kN/m over the entire length. Determine the values of maximum negative and positive bending moments. Also calculate the maximum deflection of the beam. Take flexural rigidity of the beam as 10 MN-m$^2$. | ---- | Unit-4 |
| **8** | A pair of wheels of a railway wagon carries a load of 50 kN on each axle box, acting at a distance of 100 mm outside the wheel base. The gauge of the rails is 1.4 m. Find the diameter of the axle between the wheels, if the stress is not to exceed 100 MPa. |  | Unit-4 |
| **9** | A line shaft rotating at 200 r.p.m. is to transmit 20 kW. The shaft may be assumed to be made of mild steel with an allowable shear stress of 42 MPa. Determine the diameter of the shaft, neglecting the bending moment on the shaft. | ---- | Unit-4 |
| **10** | A solid circular shaft is subjected to a bending moment of 3000 N-m and a torque of 10 000 N-m. The shaft is made of 45 C 8 steel having ultimate tensile stress of 700 MPa and an ultimate shear stress of 500 MPa. Assuming a factor of safety as 6, determine the diameter of the shaft. | ---- | Unit-4 |