

Enrollment No./Seat No.:

GUJARAT TECHNOLOGICAL UNIVERSITY
Bachelor of Engineering - SEMESTER - IV EXAMINATION - WINTER 2025

Subject Code: 3141907

Date: 18-11-2025

Subject Name: Fundamentals of Machine Design

Time: 02:30 PM TO 05:00 PM

Total Marks: 70

Instructions

- 1. Attempt all questions.**
- 2. Make suitable assumptions wherever necessary.**
- 3. Figures to the right indicate full marks.**
- 4. Simple and non-programmable scientific calculators are allowed.**

	Marks
Q.1 (a) Explain the Stress–strain diagram for Ductile material and Brittle material with neat sketch.	03
(b) A cube of material is subjected to equal stresses on all three mutually perpendicular directions. Derive the expression for volumetric strain and hence define bulk modulus.	04
(c) Determine the diameter d of a circular shaft subjected to a bending moment M and a torque T , according to Maximum Normal Stress Theory of failure. Use a factor of safety N .	07
Q.2 (a) What is alloying of Material? Explain the Effect of Alloying elements and heat treatment on properties of steels.	03
(b) Design a timber beam is to carry a load of 5 kN/m over a simply supported span of 6 meters. Permissible stress in timber is 10 N/mm ² . Keep depth twice the width.	04
(c) Explain the Euler’s Column Theory formula with the assumptions.what are the Limitations of Euler’s Formula?	07

OR

(c) Calculate the diameter of a piston rod for a cylinder of 1.5 m diameter in which the greatest difference of steam pressure on the two sides of the piston may be assumed to be 0.2 N/mm ² . The rod is made of mild steel and is secured to the piston by a tapered rod and nut and to the cross-head by a cotter. Assume modulus of elasticity as 200 kN/mm ² and factor of safety as 8. The length of rod may be assumed as 3 meters.	07
Q.3 (a) What is shear strain and complimentary shear strain? Derive the relationship between shear strain and complementary shear strain using the concept of strain compatibility.	03
(b) Explain the phenomenon of Hertzian contact stress. Explain the expression for maximum contact pressure when two spheres are pressed together.	04

- (c) Two rods, made of plain carbon steel 40C8 ($S_{yt} = 380 \text{ N/mm}^2$), are to be connected by means of a cotter joint. The diameter of each rod is 50 mm and the cotter is made from a steel plate of 15 mm thickness. Calculate the dimensions of the socket end making the following assumptions: (i) the yield strength in compression is twice of the tensile yield strength; and (ii) the yield strength in shear is 50% of the tensile yield strength. The factor of safety is 6. 07

OR

- (a) Explain the Torque Requirement for Bolt tightening. 03
- (b) A screw jack has square threads 50 mm mean diameter and 10 mm pitch. The load on the jack revolves with the screw. The coefficient of friction at the screw thread is 0.05. 04
- (1) Find the tangential force required at the end of 300 mm lever to lift a load of 6000 N.
- (2) State whether the jack is self-locking. If not, find the torque which must be applied to keep the load from descending.
- (c) Design a knuckle joint for a tie rod of a circular section to sustain a maximum pull of 70 kN. The ultimate strength of the material of the rod against 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. 07

- Q.4** (a) Explain the Aesthetic and Ergonomic considerations in Mechanical System Design. 03
- (b) Derive the equation for moment of inertia of a rectangle using From First Principle of Integration. 04
- (c) A bar of steel has an ultimate tensile strength of 700 MPa, a yield point stress of 400 MPa and fully corrected endurance limit (S_e) of 220 MPa. The bar is subjected to a mean bending stress of 60 MPa and a stress amplitude of 80 MPa. Superimposed on it is a mean torsional stress and torsional stress amplitude of 70 and 35 MPa respectively. Find the factor of safety. 07

OR

- (a) Explain the concept of torsional rigidity and Lateral rigidity in design of machine shaft. 03
- (b) A standard splined connection $8 \times 36 \times 40$ is used for a gear and shaft assembly rotating at 700 rpm. The dimensions of the splines are as follows: Major diameter = 40 mm; Minor diameter = 36 mm; Number of splines = 8; The length of the gear hub is 50 mm and the normal pressure on the splines is limited to 6.5 N/mm^2 . Calculate the power that can be transmitted from the gear to the shaft. 04
- (c) A mild steel shaft transmits 20 kW at 200 r.p.m. It carries a central load of 900 N and is simply supported between the bearings 2.5 meters apart. Determine the size of the shaft, if the allowable shear stress is 42 MPa and the maximum tensile or compressive stress is not to exceed 56 MPa. What size of the shaft will be required, if it is subjected to gradually applied loads? 07

- Q.5** (a) Explain the method of determining the size of the bolt when the bracket carries an eccentric load perpendicular to the axis of the bolt. 03

- (b) What is 'self-locking' of power screw? State the applications where self-locking is essential. **04**
- (c) A triple-threaded power screw, used in a screw jack, has a nominal diameter of 50 mm and a pitch of 8 mm. The threads are square and the length of the nut is 48 mm. The screw jack is used to lift a load of 7.5 kN. The coefficient of friction at the threads is 0.12 and the collar friction is negligible. **07**
- Calculate:
- (i) the principal shear stress in the screw body; (ii) the transverse shear stresses in the screw and the nut; and (iii) the unit bearing pressure. State whether the screw is self-locking.

OR

- (a) Explain the modified Goodman diagram for bending stresses. **03**
- (b) Discuss the design procedure of a rocker arm for operating the exhaust valve. **04**
- (c) A bell crank lever is subjected to a force of 7.5 kN at the short arm end. The lengths of the short and long arms are 100 and 500 mm respectively. The arms are at right angles to each other. The lever and the pins are made of steel FeE 300 ($S_{yt} = 300 \text{ N/mm}^2$) and the factor of safety is 5. The permissible bearing pressure on the pin is 10 N/mm^2 . The lever has a rectangular cross-section and the ratio of width to thickness is 4 : 1. The length to diameter ratio of the fulcrum pin is 1.5 : 1. **07**
- Calculate: (i) the diameter and the length of the fulcrum pin (ii) the shear stress in the pin (iii) the dimensions of the boss of the lever at the fulcrum pin (iv) the dimensions of the cross section of the lever Assume that the arm of the bending moment on the lever extends up to the axis of the fulcrum.
