

GUJARAT TECHNOLOGICAL UNIVERSITY
BE-7 SEMESTER – OLD PAPER – S22 TO S26 – QUESTION BANK
Subject Name & Code: Design of Machine Elements - 3171917

Chapter 1: Design Considerations

Repeated Questions:

1. Standardization / Preferred Numbers:

- **Q.** Find out the numbers of the R5 basic series from 1 to 10. **(SUMMER 2023, 4 Marks)**
- **Q.** It is required to standardize eleven shafts from 100 to 1000 mm diameter. Specify their diameters. **(SUMMER 2022, 3 Marks)**
- **Q.** It is required to standardize load-carrying capacities of dumpers... developing seven models... Specify their load carrying capacities. **(SUMMER 2024, 4 Marks)**

Other Important Questions:

1. Manufacturing Considerations:

- **Q.** Explain the manufacturing considerations to take into account while designing the assemblies. **(WINTER 2024, 4 Marks)**

2. Tolerances:

- **Q.** What is unilateral and bilateral tolerance? **(WINTER 2023, 3 Marks)**
- **Q.** What is tolerance? Explain various terms used in specifying the tolerance for a given dimension. **(SUMMER 2026, 3 Marks)**
- **Q.** A journal of nominal diameter 79 mm rotates in a bearing. The upper and lower deviations in hole diameter are +0.05 mm and +0.00 mm respectively, while those for the shaft are -0.03 mm and -0.07 mm. Calculate: (i) Extreme diameters for hole and shaft, (ii) Tolerances for hole and shaft, and (iii) maximum and minimum clearance. **(WINTER 2025)**
- **Q.** The tolerances for a shaft and bearing are H8/g7. If the nominal size of the shaft is 50 mm, determine the limits of dimensions of shaft and bearing. What is the type of the fit? **(SUMMER 2026, 4 Marks)**

3. Ergonomics:

- **Q.** Explain in detail aesthetic and ergonomic consideration in design. **(WINTER 2023, 7 Marks)**

4. Standards:

- **Q.** Explain different types of Standards used in Machine Design. **(WINTER 2022, 3 Marks)**
- **Q.** What is standardization? Enlist its advantages. **(WINTER 2025)**

Chapter 2: Design of Coupling

Repeated Questions:

1. Coupling Function & Types:

- Q. What do you mean by coupling? Give its applications. (SUMMER 2025, 3 Marks)
- Q. Discuss the function of a coupling. Give at least three practical applications of it. (SUMMER 2023, 4 Marks)
- Q. Explain the function of coupling. How it is differ from clutch? (WINTER 2024, 4 Marks)

2. Flexible Coupling:

- Q. What are the advantages and disadvantages of bushed-pin flexible coupling? (SUMMER 2024, 3 Marks)
- Q. Explain flexible coupling and what are its applications? (SUMMER 2023, 3 Marks)

3. Rigid Flange Coupling (Protected vs. Unprotected):

- Q. Differentiate between... Protected and unprotected flange coupling. (SUMMER 2022, 3 Marks)
- Q. What is the difference between protected and unprotected rigid flange couplings? (SUMMER 2025, 3 Marks)

4. Design of Muff Coupling (Numerical):

- Q. Design muff coupling to connect two steel shaft transmitting 40 kW at 350 rpm... (WINTER 2023, 7 Marks; WINTER 2025)

Other Important Questions:

1. Design of Muff Coupling (Numerical):

- Q. Design a muff coupling to connect two steel shafts transmitting 25 kW power at 360 rpm... (SUMMER 2024, 7 Marks)

2. Design of Flange Coupling (Numerical):

- Q. Design and draw a protective type of cast iron flange coupling for a steel shaft transmitting 15 kW at 200 r.p.m.... (SUMMER 2022, 7 Marks)
- Q. The shaft and the flange of a marine engine are to be designed for flange coupling... Find: 1. diameter of shaft; 2. diameter of bolts; 3. thickness of flange; and 4. diameter of flange. (SUMMER 2023, 7 Marks)
- Q. A rigid coupling is used to transmit 20 KW power at 720 rpm... Determine the diameter of the bolts. (SUMMER 2025, 7 Marks)
- Q. Explain the design of Protected type Rigid Flange Coupling. (SUMMER 2026, 7 Marks)

3. Design of Bushed-Pin Flexible Coupling (Numerical):

- Q. Design a bushed pin-type flexible coupling for transmission of 30 kW from a motor to a centrifugal pump shaft, at 1,440 rpm. The following data is given: Diameter of motor shaft = 36 mm; Diameter of pump shaft = 30 mm; Allowable bearing pressure in rubber bush = 0.5 MPa; Allowable stress in pins = 50 MPa. (SUMMER 2026, 7 Marks)

4. Power Capacity of Coupling (Numerical):

- Q. Calculate the power transmitting capacity of the rigid coupling having following specifications... (WINTER 2024, 7 Marks)

Chapter 3: Spring

Repeated Questions:

1. Spring Terminology:

- **Q.** Define the following terms: (i) Solid length (ii) Free Length (iii) Spring Index (iv) Wahl's stress factor (v) Surge in spring (vi) Spring rate (vii) Pitch. **(SUMMER 2023, 7 Marks)**
- **Q.** Explain following term regarding spring 1. Solid Length 2. Free Length 3. Spring index 4. Spring stiffness. **(WINTER 2023, 4 Marks)**

2. Curvature Effect (Wahl's Factor):

- **Q.** What is the curvature effect in a helical spring? How does it vary with spring index? **(SUMMER 2024, 3 Marks; WINTER 2022, 3 Marks; SUMMER 2026, 4 Marks)**

3. Leaf Springs (Nipping):

- **Q.** What is nipping in a leaf spring? Discuss its role. **(SUMMER 2022, 3 Marks; SUMMER 2026, 3 Marks)**

4. Design of Helical Compression Spring (Numerical):

- **Q.** A helical compression spring is made of music wire. The spring has to support a load of 150 N... **(WINTER 2022, 7 Marks; SUMMER 2026, 7 Marks)**

Other Important Questions:

1. Design of Helical Compression Spring (Numerical):

- **Q.** A safety valve of 60 mm diameter is to blow off at a pressure of 1.2 N/mm². Design a suitable compression spring... Calculate: 1. Diameter of the spring wire, 2. Mean coil diameter, 3. Number of active turns, and 4. Pitch of the coil. **(SUMMER 2023, 7 Marks)**
- **Q.** It is required to design a helical compression spring subjected to a force of 500 N... Design the spring and calculate: (i) Wire diameter; (ii) Mean coil diameter; (iii) Number of active coils; (iv) Total number of coils; (v) Free length of the spring; (vi) Pitch of the coils. **(SUMMER 2024, 7 Marks)**
- **Q.** A mechanism used in printing machinery consists of a tension spring... Determine: 1. the initial torsional shear stress in the wire; 2. spring rate; and 3. the force to cause the body of the spring to its yield strength. **(SUMMER 2022, 7 Marks)**
- **Q.** A helical spring is made from a wire of 6 mm diameter and has an outside diameter of 75 mm. If the permissible shear stress is 350 MPa and the modulus of rigidity is 84 kN/mm², find the axial load which the spring can carry and the deflection per active turn. **(WINTER 2025)**

2. Concentric Springs (Numerical):

- **Q.** A concentric spring consists of two helical compression springs one inside the other... Calculate: (i) The stiffness... (ii) The stiffness... (iii) The compression of each spring. (iv) The force transmitted... (v) The maximum torsional shear stress... **(SUMMER 2024, 7 Marks)**
- **Q.** A concentric spring consist of two helical compression springs having the same free length... Calculate: (i) the maximum force transmitted by each spring, (ii) the maximum torsional shear stress induced in each spring. **(WINTER 2024, 7 Marks)**

3. Leaf Springs:

- **Q.** Explain applications of multi-leaf springs and the objectives of nipping of leaf springs. **(WINTER 2024, 3 Marks)**
- **Q.** Derive the expression for determining the stress and deflection in full length and graduated leaves. **(WINTER 2022, 4 Marks)**

4. Spring Classification & Special Types:

- **Q.** Explain classification of spring. **(SUMMER 2025, 3 Marks)**

- **Q.** Explain the Belleville spring? And its application. **(WINTER 2023, 3 Marks)**
- **Q.** Compare a helical compression spring with a helical tension spring. **(WINTER 2025, 3 Marks)**
- **Q.** What is Buckling of Compression Spring? Explain one method of avoiding the tendency of a compression spring to buckle. **(SUMMER 2026, 4 Marks)**

5. Design Procedure:

- **Q.** Write the design procedure of helical spring. **(SUMMER 2025, 7 Marks)**

Chapter 4: Gears and Gear Drives

Repeated Questions:

None identified in the latest (Winter 2025 and Summer 2026) papers.

Other Important Questions:

1. Gear Drives & Spur Gear Theory:

- **Q.** Describe advantages and disadvantages of Gear Drives. **(WINTER 2025, 4 Marks)**
- **Q.** Describe the design procedure of a spur gear. **(WINTER 2025, 7 Marks)**
- **Q.** Derive the expression of Lewis form factor in Gear design. How does it vary with number of teeth on gear? **(SUMMER 2026, 3 Marks)**

2. Spur Gear (Numerical):

- **Q.** A pair of spur gears consists of a 24 teeth pinion, rotating at 1000 rpm and transmitting power to a 48 teeth gear. The module is 6 mm, while the face width is 60 mm. Both gears are made of steel with an ultimate tensile strength of 450 N/mm². They are heat treated to a surface hardness of 250 BHN. Assume that velocity factor accounts for the dynamic load. Calculate (i) beam strength; (ii) wear strength; and (iii) the rated power that the gears can transmit, if service factor and the factor of safety are 1.5 and 2, respectively. **(SUMMER 2026, 7 Marks)**

3. Helical Gears (Numerical):

- **Q.** A pair of helical gears are to transmit 15 kW. The teeth are 20° stub in diametral plane and have a helix angle of 45°. The pinion runs at 10000 r.p.m. and has 80 mm pitch diameter. The gear has 320 mm pitch diameter. If the gears are made of cast steel having allowable static strength of 100 MPa; determine a suitable module and face width from static strength considerations and check the gears for wear, given $\sigma_{es} = 618$ MPa. **(WINTER 2025, 7 Marks)**
- **Q.** A pair of helical gears transmits 5 kW. The following are its details: Teeth on pinion, $Z_p = 25$; Teeth on gear, $Z_g = 50$; Normal module, $m_n = 4$ mm; Helix angle $\Phi = 20^\circ$; Normal pressure angle, $\alpha_n = 20^\circ$. Determine P_t , P_a , and P_r components of tooth load and draw the force analysis diagram. The pinion runs at 1,200 rpm. **(SUMMER 2026, 7 Marks)**

4. Worm Gears:

- **Q.** Formulate the efficiency of worm gearing. **(WINTER 2025, 4 Marks)**
- **Q.** Derive the expression for efficiency of worm wheel drive. **(SUMMER 2026, 4 Marks)**
- **Q.** Why dissimilar materials are used for worm and worm wheel? Explain the designation 4/29/10.6/2.5/50 used for the pair of worm and worm gear. **(WINTER 2025, 4 Marks)**

5. Bevel Gears:

- **Q.** Explain spiral bevel gears with Spiral Gear Terminology. **(SUMMER 2026, 3 Marks)**

Chapter 5: Pressure Vessels

Repeated Questions:

None identified in the latest (Winter 2025 and Summer 2026) papers.

Other Important Questions:

1. Pre-stressing & Failure of Pressure Vessels:

- **Q.** What is pre-stressing? Why is it required in pressure vessels? **(WINTER 2025, 4 Marks)**
- **Q.** Explain the causes of failure in pressure vessels? **(SUMMER 2026, 3 Marks)**

2. Thick Cylinders – Derivations:

- **Q.** Derive the Lamé's equation for thick cylindrical shell. **(WINTER 2025, 7 Marks)**
- **Q.** Derive and Explain the Clavarino's and Birnie's equations for Pressure vessels Design. **(SUMMER 2026, 4 Marks)**

3. Compound Cylinders (Numerical):

- **Q.** A high pressure cylinder consists of an inner cylinder of inner and outer diameters of 200 and 300 mm respectively. It is jacketed by an outer cylinder with an outside diameter of 400 mm. The difference between the outer diameter of the inner cylinder and the inner diameter of the jacket before assembly is 0.25 mm ($E = 207 \text{ kN/mm}^2$). Calculate the shrinkage pressure and the maximum tensile stress induced in any of the cylinders. **(SUMMER 2026, 7 Marks)**

Chapter 6: Bearings (Rolling and Sliding Contact)

Repeated Questions:

None identified in the latest (Winter 2025 and Summer 2026) papers.

Other Important Questions:

1. Rolling Contact Bearings – Theory:

- **Q.** Classify rolling contact bearings. **(WINTER 2025, 3 Marks)**
- **Q.** Define the following terms in the context of rolling contact bearing: (i) basic static load rating, (ii) static equivalent load, (iii) rating life, (iv) minimum life. **(WINTER 2025, 4 Marks)**
- **Q.** Derive the expression of Striebeck's Equation for Load distribution on balls in a Rolling Bearing. **(SUMMER 2026, 3 Marks)**

2. Rolling Contact Bearings (Numerical):

- **Q.** A single-row deep groove ball bearing has a dynamic load capacity of 45000 N and operates on the following work cycle: (i) Radial load of 6000 N at 800 rpm for 35% of the time. (ii) Radial load of 11000 N at 600 rpm for 45% of the time. (iii) Radial load of 8000 N at 500 rpm for the remaining 20% of the time. Calculate the equivalent load for the complete work cycle and the expected life of the bearing in hours. **(WINTER 2025)**
- **Q.** If the designation of a bearing is 6308, give its complete specification from the SKF catalogue and determine its life at 20,000 N dynamic load. If the bearing rotates at 720 rpm, what are its life in hours? **(SUMMER 2026)**

3. Sliding Contact Bearings:

- **Q.** Define the following terms in the context of a sliding contact bearing: (i) Thick film lubrication, (ii) Thin film lubrication, (iii) Hydrostatic lubrication bearing. **(WINTER 2025, 3 Marks)**
- **Q.** Describe a detailed design procedure of a sliding contact bearing. **(WINTER 2025, 7 Marks)**
- **Q.** On a hydro-static thrust bearing, the axial thrust load is 400 kN, while the shaft rotates at 800 rpm. If the diameter of the shaft is 400 mm and the diameter of the recess is 320 mm, film thickness is 0.10 mm, viscosity of lubricant is 150 SUS, and specific gravity is 0.86, calculate the supply pressure and flow requirements. **(SUMMER 2026)**

Chapter 7: Wire Ropes and Crane Hooks

Repeated Questions:

None identified in the latest (Winter 2025 and Summer 2026) papers.

Other Important Questions:

1. Wire Ropes:

- **Q.** What do you understand by 6x37 rope? Describe it with a sketch. **(WINTER 2025, 3 Marks)**
- **Q.** Give the classification of wire ropes and explain its construction with neat sketches. **(WINTER 2025, 3 Marks)**
- **Q.** Fatigue life of a 6x37 wire rope of nominal diameter 12 mm is to be achieved to 2×10^5 bends. Tensile stress designation of wire is a 1960. How much load can be lifted through a sheave diameter 480 mm, through the arrangement shown in the Fig. [Diagram/Table given – refer to the original question paper of Summer 2026] **(SUMMER 2026, 4 Marks)**

2. Crane Hooks:

- **Q.** Write the detailed design procedure of the crane hook. **(WINTER 2025, 7 Marks)**
- **Q.** Explain the different cross section being used for hook design. **(SUMMER 2026, 3 Marks)**

Chapter 8: Valves and Valve Gear Mechanism

Repeated Questions:

None identified in the latest (Winter 2025 and Summer 2026) papers.

Other Important Questions:

1. Valve Gear Mechanism:

- **Q.** Enlist components of valve gear mechanism. **(WINTER 2025)**
- **Q.** Explain the valve gear mechanism with a neat sketch. **(WINTER 2025, 3 Marks)**

2. Design of Valves (Numerical):

- **Q.** Design an exhaust valve for a horizontal diesel engine using the following data: Cylinder bore = 150 mm; Length of stroke = 275 mm; Engine speed = 500 rpm; Maximum gas pressure = 3.5 MPa; Seat angle = 45° . Calculate: (i) diameter of the valve port; (ii) diameter of the valve head; (iii) thickness of the valve head; (iv) diameter of the valve stem; and (v) maximum lift of the valve. **(SUMMER 2026, 7 Marks)**

Chapter 9: Machine Tool Gear Box Design

Repeated Questions:

None identified in the latest (Winter 2025 and Summer 2026) papers.

Other Important Questions:

1. Gear Box Design – Theory:

- **Q.** Explain the range ratio in gear box design. **(WINTER 2025)**
- **Q.** Explain Constant Loss of Economic Cutting Speed and Constant Loss of Productivity in the Whole rpm Range of gear box design. **(SUMMER 2026, 3 Marks)**
- **Q.** What are the fundamental principles or mechanical regulation? Describe the principle of stepped speed regulation as applied to machine tools. **(SUMMER 2026, 4 Marks)**

2. Gear Box Design (Numerical / Layout):

- **Q.** Explain the design procedure of an 8-speed gearbox for machine tool application with suitable assumptions. **(WINTER 2025, 7 Marks)**
- **Q.** Draw the structural diagrams and gear box layout of the structural formula: $2(1) 2(2) 2(4)$. **(WINTER 2025, 4 Marks)**
- **Q.** Design a gear box of a machine tool (turret) having 9 spindle speeds ranging from 90 to 1800 rpm. The gear box should be a compact one. Also (a) Represent the speeds graphically. (b) Draw the structural diagram. (c) Show the layout of the gear box. (d) Find out the numbers of teeth on various gears. **(SUMMER 2026, 7 Marks)**
