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Question Paper Code : 11665

B.E./B.Tech. DEGREE EXAMINATIONS, APRIL/MAY 2026.

Fifth Semester

Mechanical Engineering

ME3591 – DESIGN OF MACHINE ELEMENTS

(Regulations 2021)

Time : Three hours

Maximum : 100 marks

(Use of PSG Design Data Book is permitted)

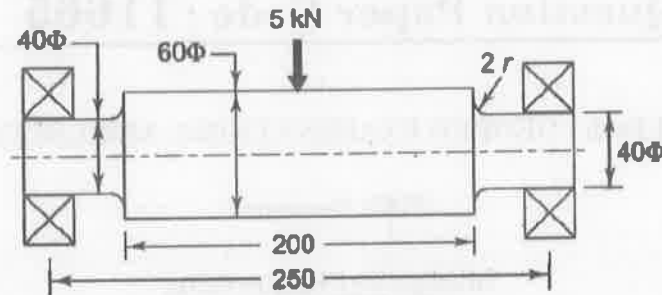
Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. List the steps involved in machine design process.
2. What is factor of safety?
3. Define stress concentration.
4. A shaft requires to be designed and manufactured with a ductile material. List out the two different methods based on which shaft design is performed.
5. What is meant critical speed of shaft?
6. What is the significance of caulking and fullering in riveted joints?
7. Differentiate between a flywheel and governor.
8. State the important advantage of 'nipping'.
9. A rolling contact bearing with number 6408 is chosen for assembly of gear box. In relation with the bearing number 6408 provide the physical meaning of the digits from right side end.
10. With a neat sketch, show the pressure distribution around the periphery of a hydrodynamic journal bearing.

PART B — (5 × 13 = 65 marks)

11. (a) A shaft carrying a load of 5 kN midway between two bearings is shown in Figure 11(a). Determine the maximum bending stress at the fillet section. Assume the shaft material is ductile.



All dimensions are in mm

Figure 11(a)

Or

- (b) A manufacturer is interested in starting a business with five different models of tractors ranging from 7.5 to 75 kW capacities. Specify power capacities of the models. There is an expansion plan to further increase the number of models from five to nine to fulfill the requirement of farmers. Specify the power capacities of the additional models.
12. (a) A transmission shaft supporting a helical gear B and an overhung bevel gear D is shown in Figure 12(a). The shaft is mounted on two bearings A and C. The pitch circle diameter of the helical gear is 450 mm and the diameter of the bevel gear at the forces is 450 mm. Power is transmitted from the helical gear to the bevel gear. The gears are keyed to the shaft. The material of the shaft is steel 45C8 ($\sigma_{ut} = 600$ and $\sigma_{yt} = 380$ MPa). The factors K_b and K_t of ASME code are 2.0 and 1.5 respectively. Determine the shaft diameter using ASME code.

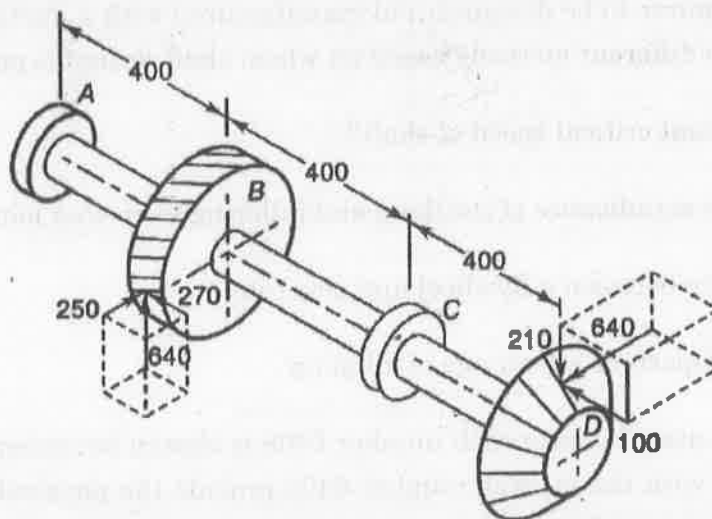


Figure 12(a)

Or

14. (a) A helical compression spring, made of circular wire, is subjected to an axial force, which varies from 2.5 kN to 3.5 kN. Over this range of force, the deflection of the spring should be approximately 5 mm. The spring index can be taken as 5. The spring has square and ground ends. The spring is made of patented and cold-drawn steel wire with ultimate tensile strength of 1050 MPa and modulus of rigidity of 81370 MPa. The permissible shear stress for the spring wire should be taken as 50% of the ultimate tensile strength. Design the spring and calculate :

- (i) wire diameter (3)
- (ii) mean coil diameter (3)
- (iii) number of active coils (3)
- (iv) total number of coils (2)
- (v) solid length of the spring (2)

Or

- (b) The torque developed by an engine is given by the following equation :

$$T = 14250 + 2200 \sin 2\theta - 1800 \cos 2\theta$$

where T is the torque in N-m and θ is the crank angle from the inner dead centre position. The resisting torque of the machine is constant throughout the work cycle. The coefficient of speed fluctuation is 0.01. The engine speed is 150 rpm. A solid circular steel disk, 50 mm thick is used as a flywheel. The mass density of steel is 7800 kg/m³. Calculate the radius of flywheel disk.

15. (a) Design a suitable ball bearing for an axial flow compressor to carry a radial load of 2.5 kN and a thrust load of 1.3 kN. The service imposes a light shock factor 1.5 and bearing will be in use for 35 hours per week for 4 years. The speed of shaft is 900 rpm and the diameter of the shaft is 45 mm. Assume $X = 0.56$ and $Y = 1.4$.

Or

(b) The following data is given for a 360° hydrodynamic bearing :

Radial load = 3.2 kN

Journal speed = 1490 rpm

Journal diameter = 50 mm

Bearing length = 50 mm

Radial clearance = 0.05 mm

Viscosity of lubricant = 25 cP

Assuming that the total heat generated in the bearing is carried by the total oil flow in the bearing, calculate

(i) coefficient of friction (3)

(ii) power lost in friction (3)

(iii) minimum oil film thickness (3)

(iv) flow requirement in liters per minute and (2)

(v) temperature rise. (2)

PART C — (1 × 15 = 15 marks)

16. (a) A transmission shaft carries a pulley midway between the two bearings. The bending moment at the pulley varies from 200 N-m to 600 N-m, as the torsional moment in the shaft varies from 70 N-m to 200 N-m. The frequencies of variation of bending and torsional moments are equal to the shaft speed. The shaft is made of FeE 400 material with Ultimate tensile strength = 540 MPa; Yield strength in tension = 400 MPa. The endurance limit of the shaft is finalized as 200 MPa. Determine the shaft diameter with a factor of safety as 2.

Or

- (b) An automotive single-plate clutch, with two pairs of friction surfaces, transmits 300 N-m torque at 1500 rpm. The inner and outer diameters of the friction disk are 170 and 270 mm respectively. The coefficient of friction is 0.35. The normal force on the friction surface is exerted by nine helical compression springs, so that the clutch is always engaged. The clutch is disengaged when the external force further compresses the springs. The spring index is 5 and the number of active coils is 6. The springs are made of patented and cold-drawn steel wires of Grade 2. ($G = 81370$ MPa). The permissible shear stress for the spring wire is 30% of the ultimate tensile strength. Design the springs and specify their dimensions.

