

Comprehensive Examination

Time: **180 min**

Max Marks: 90

Q1. Consider a bicycle pedal arm assembly as in figure Q1. A rider applies a static load of 1500 N at the pedal, the pedal arm has circular cross section and is machined to 25 mm diameter. Find:

- a) Maximum bending moment and torque in the pedal arm
 - b) Maximum principal stress in the pedal arm
 - c) The von Mises stress in the pedal arm
 - d) Assuming dynamic condition that the rider applied force changes from 0 to 1500 N at the pedal during each cycle, find the fatigue safety factor for 90% reliability using Gerber criteria (Given $S_{ut} = 500 \text{ MPa}$)
- Clearly state all assumptions made. [4x4=16]

Q2. A 02 series single row deep groove ball bearing having bore diameter 60 mm is used for a work cycle with 1000 rpm for one third of the time, at 2000 rpm for another one third of the time and at 4000 rpm for the rest of the time. Assuming higher side of light shock load condition for the applied load having a combination of 3 kN as axial and 3.5 kN as radial load, find the expected life of the bearing in hours [14]

Q3. A cone clutch has asbestos as friction liner and outer diameter of friction liner 250 mm. The coefficient of friction is 0.25 while the maximum pressure intensity is limited to 0.25 MPa. Design the clutch for transmitting 25 kW at 600 rpm, assuming semi cone angle 12.5° and uniform wear consideration. Find

- a) Inner diameter of friction lining
- b) Face width of friction lining
- c) Axial force required to engage the clutch [3x5=15]

Q4. A journal bearing has bore diameter of 50 mm and length 80 mm. The bearing pressure is limited to 6 MPa and rotates at 1000 rpm. The ratio of journal diameter to clearance is 1000. The oil used in the bearing has a viscosity of 0.015 kg/m-s at the designated operating temperature of 75°C , while the room temperature is 25°C . Find:

- a) The amount of heat to be removed through artificial cooling (in watt)
- b) Required coolant oil circulation if the specific heat of the oil is $1900 \text{ J/kg}^\circ\text{C}$ and the difference in inlet and outlet of oil temperature is 25°C

The bearing casing is exposed to still air and has a heat transfer area of $25 \times 10^3 \text{ mm}^2$ [10+5=15]

Q5. Refer Figure Q5, the required leg size of the weld needs to be found under von Mises stress criteria. The 500 mm long square hollow bar of steel $150 \times 150 \text{ mm}^2$ in dimension supports a concentrated end load of 25 kN as a cantilever beam. The electrode recommended is AWS E60XX and factor of safety 2. [12]

Q6. The following data is given for a concentric helical compression spring to be designed having squared and ground ends, subjected to an axial load of 500N

	Mean coil diameter (mm)	Wire diameter (mm)	Total number of coils	Free length (mm)
Inner coil	30	4.064	10	70
Outer coil	40	4.877	12	80

Find spring rate, deflection and loads shared by each of the springs. Given $G = 84 \text{ GPa}$. [6x3=18]

--Figure(s) overleaf--

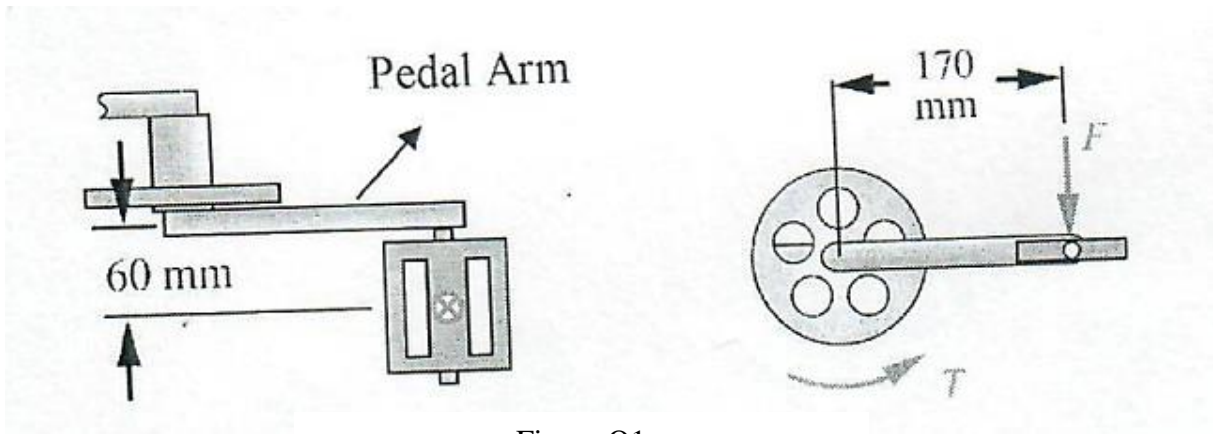


Figure Q1

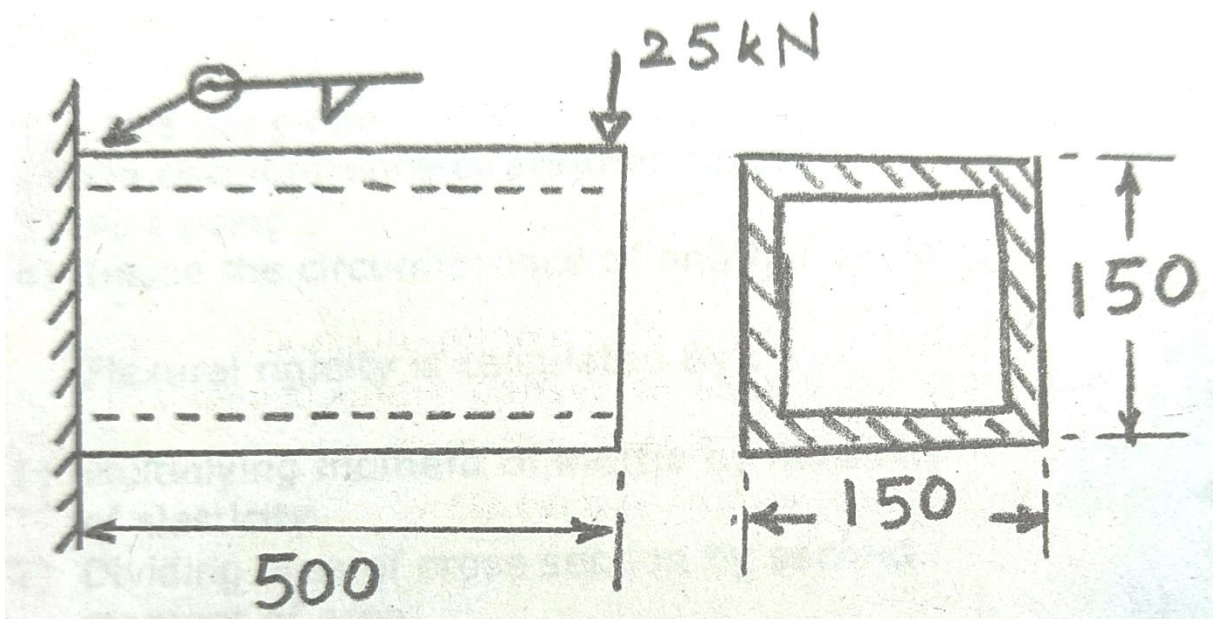


Figure Q5