BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI
FIRST SEMESTER 2023-2024
ME F211/ MF F211 MECHANICS OF SOLIDS
Comprehensive Examination (Regular) (Closed Book)

Duration: 1 hr **PART- A** Total marks: 30

Q1. The 60-mm-diameter shaft shown in fig. Q1 is made of 6061-T6 aluminum having an allowable shear stress of 80MPa. Determine ***[10M]***

a) the maximum allowable torque **T**.
b) the internal torques in shaft AB and Shaft BC.
c) the corresponding angle of twist of disk *A* relative to disk *C*. Take G=26 GPa

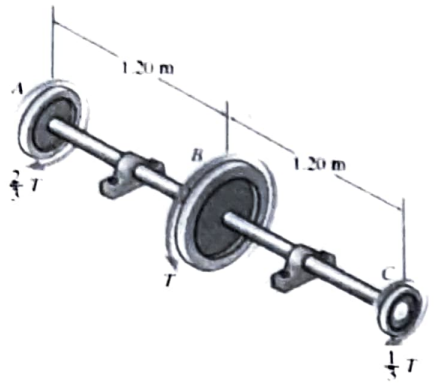

Fig.Q1

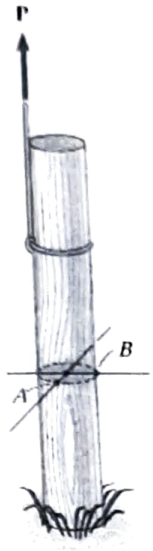

Fig.Q2

Q2. The cylindrical post, having a diameter of 40 mm, is being pulled from the ground using a sling of negligible thickness (Fig.Q2). If the rope is subjected to a vertical force of $P = 500N$, determine the normal stress at points *A* and *B*. Show the results on a volume element located at each of these points. ***[10M]***

Q3. A rectangular plate in *biaxial stress* (see Fig.Q3) is subjected to normal stresses $\sigma_x = 67\ MPa\ (Tension)$ and $\sigma_y = -23\ MPa\ (Compression)$. The plate has dimension $400mm \times 550mm \times 20mm$ and is made of steel with $E=200MPa$ and Poisson's ratio $\vartheta = 0.30$.

a) Determine the maximum in-plane shear strain γ_{max} in the plate.
b) Determine the change Δt in the thickness of the plate.
c) Determine the change ΔV in the volume of the plate ***[10M]***

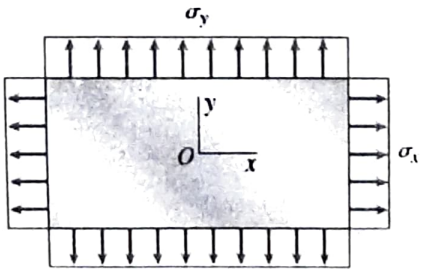

Fig.Q3

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Duration:2 hrs **PART- B** Total marks: 50

Q1. The hoisting arrangement for lifting a large pipe is shown in the Fig.Q1. The spreader is of rectangular cross-section (width=50mm, Height=80mm). Its length is 3 m and its modulus of elasticity is 200 GPa. Based upon a factor of safety of 2 with respect to Euler buckling of the spreader, what is the maximum weight of pipe that can be lifted? (Assume pinned conditions at the ends of the spreader.) **[15M]**

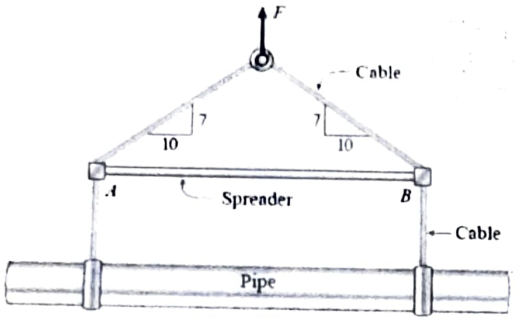

Fig.Q1

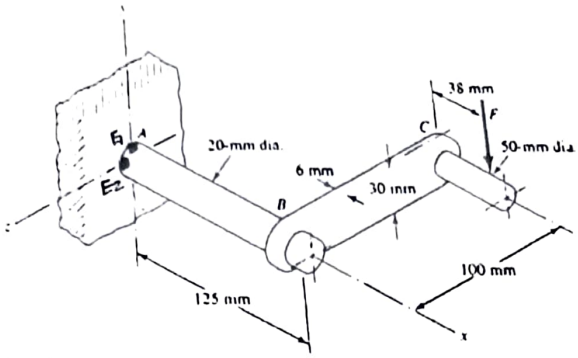

Fig.Q2

Q2. ***Fig.Q2*** shows a crank loaded by a force ***F= 2 k N*** that causes twisting and bending of a ***20mm*** diameter shaft fixed to a support at the origin of a reference system. In actuality, the support may be an inertia that we wish to rotate, but for the purpose of stress analysis consider this as a static problem. **[20M]**

a) Draw ***Free body diagram of the shaft AB and compute support Reactions at A.***

b) Consider two **elements** ***E_1 and E_2***, both of which are on the outer surface of the shaft at end A. Element ***E_1 is on y-axis*** *and* ***Element E_2 is on the Z-axis***. Calculate all the ***stress components that act upon this elements E_1 and E_2.***

c) ***Show the stresses on*** elements ***E_1 and E_2*** on properly oriented 2D element.

d) Determine the ***maximum normal stress, minimum normal stress and shear stress at*** element ***E_1.***

Q3. The beam *ABC* shown in the figure has flexural rigidity ***$EI = 4.0\ MN{\cdot}m^2$***. When the loads are applied to the beam, the support at *B* settles vertically downward through a distance of ***6.0 mm***. Using singularity function, **[15M]**

a) Obtain the ***deflection equation.***

b) Calculate Support ***Reactions at A and B***

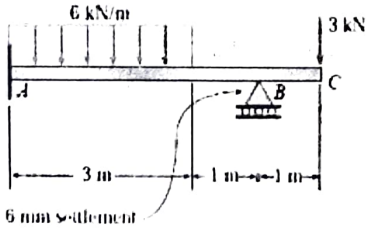

Fig.Q3