BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI

ME G641: THEORY OF ELASTICITY & PLASTICITY

FIRST SEMESTER 2016-2017

Comprehensive Examination (**OPEN BOOK**)

Max Marks: 40 Duration: 3 Hours 7th December, 2016 (2PM - 5PM)

Q1. Show that if all the components of stress (i.e. σ_x, σ_y, σ_z, τ_{xy}, τ_{yz}, τ_{xy}) are equal to one other, the state of stress is uniaxial. **[3M]**

Q2. A ship propeller of 60 kN weight is carried by a shaft (σ_{yield} = 280 MPa) of 22 cm diameter and overhangs the supporting bracket by 44 cm as shown in FigQ2. The propeller receives 2985 kW at a speed of 300 rpm.

If the propeller thrust is 148 kN, determine **(a)** the stress components (i.e. σ_x and τ_{xy}) at point *A* (see FigQ2) and show them on a 2D element. Point *A* is located on outer surface at the vertical diameter. **(b)** the principal stresses and maximum shear stress at point *A* **(c)** the factor of safety based on maximum shear stress criterion for point *A*. Neglect the inertia forces. **[4M]**

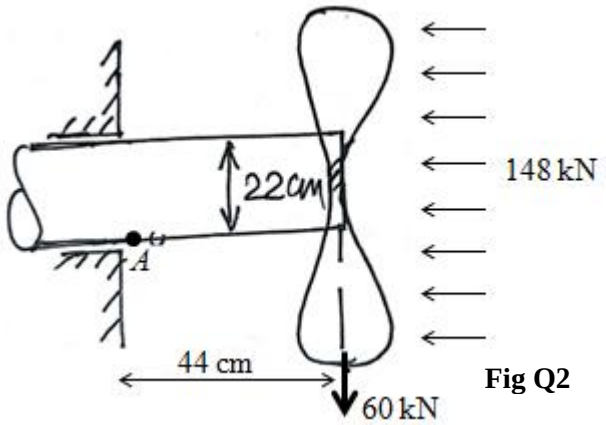

Fig Q2

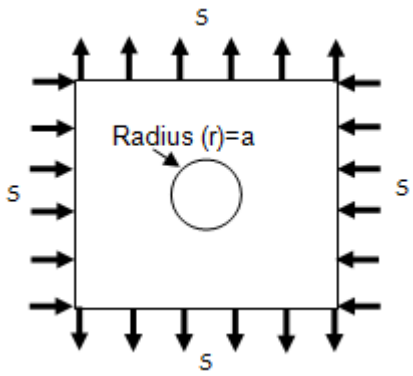

Fig Q3

Q3. Determine the stress concentration factor for the plate as shown in FigQ3. Find the expression for strain components (i.e. ε_r, ε_θ, $\gamma_{r\theta}$) at $r = a$. Mark the corresponding point(s) in diagram. (Note: Specify each and every equation used and its reference in the text book) **[5M]**

Q4. The stress components at a point in a plate are σ_{xx} = 80 MPa, σ_{yy} = 60 MPa, σ_{zz} = τ_{xy} = 20 MPa, τ_{zx} = 40 MPa, and τ_{yz} = 10 MPa. Determine **(a)** the principal stresses (σ_1, σ_2, and σ_3) and maximum shearing stress **(b)** the normal and tangential stress components on a plane normal to the vector (i + 2j + k). **[4M]**

Q5. A steel rotor disc which is part of a turbine assembly has a uniform thickness of 40 mm. The disc has an outer diameter of 600 mm and a central hole of 100 mm diameter. If there are 200 blades each of mass 0.153 kg pitched evenly around the periphery of the disc at an effective radius of 320 mm, determine the rotational speed at which yielding of the disc first occurs according to the maximum shear stress criterion of elastic failure. For steel E = 200 GPa, υ = 0.3, ρ = 7470 kg/m^3 and the yield stress in simple tension σ_{yield} = 500 MPa. **[5M]**

Q6. The diameter of a circle which is scribed on a plate is 25 cm. After the circle is scribed, the plate is subjected to the following state of stress σ_{xx} = 25 MPa, σ_{yy} = 8 MPa and τ_{xy} = 10 MPa; and the circle is deformed into an ellipse. If E = 200 GPa and υ = 0.3, find the length of the major and minor axes. **[3M]**

Q7. Consider a thick tube $a < r < b$, fixed at $r = a$ and free at $r = b$. Along the free outer surface, the tube is subjected to uniform shear which forms a couple M as shown in Fig Q7. State the boundary conditions. Determine the stress and strain field inside the cylinder. Use the stress function $\varphi = A\theta$. **[4M]**

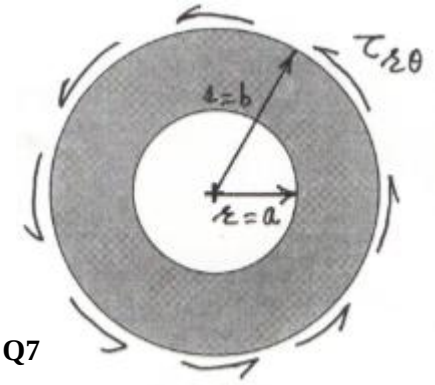

Fig Q7

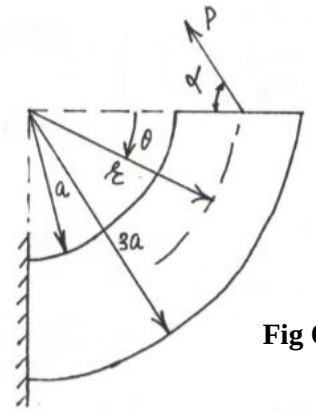

Fig Q8

Q8. A curved cantilever beam of inner radius a and outer radius $3a$ is subjected to end loadings as shown in FigQ8. State the assumed Airy's stress functions, write down the strong and weak boundary conditions separately for the problem and compute the stress components σ_r, σ_θ, & $\tau_{r\theta}$. **[6M]**

Q9. In a forward extrusion process, a mild steel billet of 300 mm diameter and 500 mm length is extruded to 15 mm diameter rods at a speed of 0.25 m/s. The billet is heated to 980°C. Where strain rate sensitivity parameters are C = 135 MPa and m = 0.15. The coefficient of friction at the billet/container interface is 0.15. Calculate **(a)** the extrusion ratio and percent reduction **(b)** the number of 4 m rods to be produced, if 16% of billet length is to be discarded due to the dead zone effect **(c)** The ideal pressure and the pressure at the start of plastic deformation **(d)** the required extrusion force. **[3M]**

Q10. Estimate the maximum force required for extruding a cylindrical Aluminum billet of 45 mm diameter and 90 mm length to a final diameter of 10 mm. The average tensile yield stress for Aluminum is 182 MPa. What percent of the total power input will be lost in friction at the start of the operation? **[3M]**