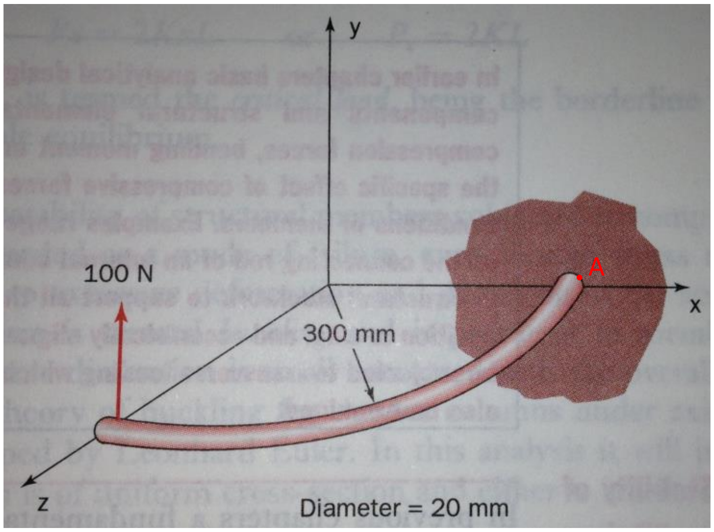
PLEASE NOTE: Answer 3 out of the 4 problems. In case you answer the 4 problems, clearly state which 3 problems you want to be graded.

Problem 1

A circular section rod has a diameter of 20 mm and the shape of a quadrant of a circle of radius 300 mm, as shown in the figure. The Young's modulus of the material is 208 GPa and the shear modulus is 80 GPa. If a vertical force of 100 N is applied at the free end, determine

(1) The deflection of the free end in the direction of the force; and
(2) The stress state at point A which is on the surface of the rod, in the x-y plane, and has a *y*-coordinate of $5\sqrt{2}$ mm.

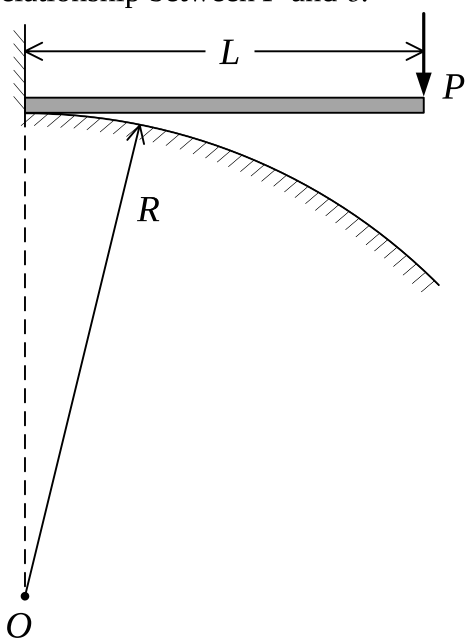


Problem 2

A cantilever beam of length L is clamped at its left end, as shown below. The beam is initially straight, horizontal, and stress free. Underneath the beam there is a cylindrical rigid surface of radius R. The top of the cylindrical surface is initially in contact with the left end of the beam. A vertical force, P, is applied to the right end of the beam, causing a deflection of δ at the right end. The beam has a rectangular cross-section of width b and height h, and is made of an elastic material with a Young's modulus of E and a Poisson's ratio of ν. Assume R>>L.

(a). Qualitatively describe the deformation behaviors of the beam when P is increased from zero to infinity.

(b). Derive a quantitative relationship between P and δ.

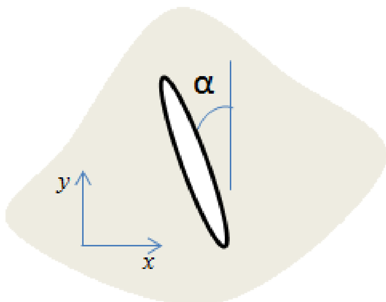


Problem 3

Consider one loading to produce normal stresses on the x-direction of σ_x = 80 MPa and σ_y = -30 MPa in a brittle material. An additional shear stress is applied. This shear stress **increases until a crack is observed to form** at an angle of α = 20° (see figure below).

a) Find shear stress τ_{xy} at which cracking occurs.

b) If this material were loaded in uniaxial tension at what critical stress would fracture occur?



Problem 4

Consider the cylindrical structure shown made of a rod of *Material A* perfectly adhered to a shell of *Material B*. Both materials are perfectly plastic *Material A* has modulus E_A and cross sectional area A_A and *Material B* has modulus E_B and cross sectional area A_B. The structure has length L_o.

A. What is the weight *W* required to deform this structure to the strain ε^*, as shown on the Figure?

B. What is the length of the structure after *W* is removed?

C. What are the residual stresses in *Material A* and *Material B* after *W* is removed?