Machine Design - 1

Consider a countershaft with two V-belt pulleys shown below. Pulley ***A*** receives power from a motor through a belt, and the power is transmitted through the shaft and delivered to the belt on pulley ***B***. The belt tensions on the two pulleys are shown in the diagram. All the dimensions are in mm.

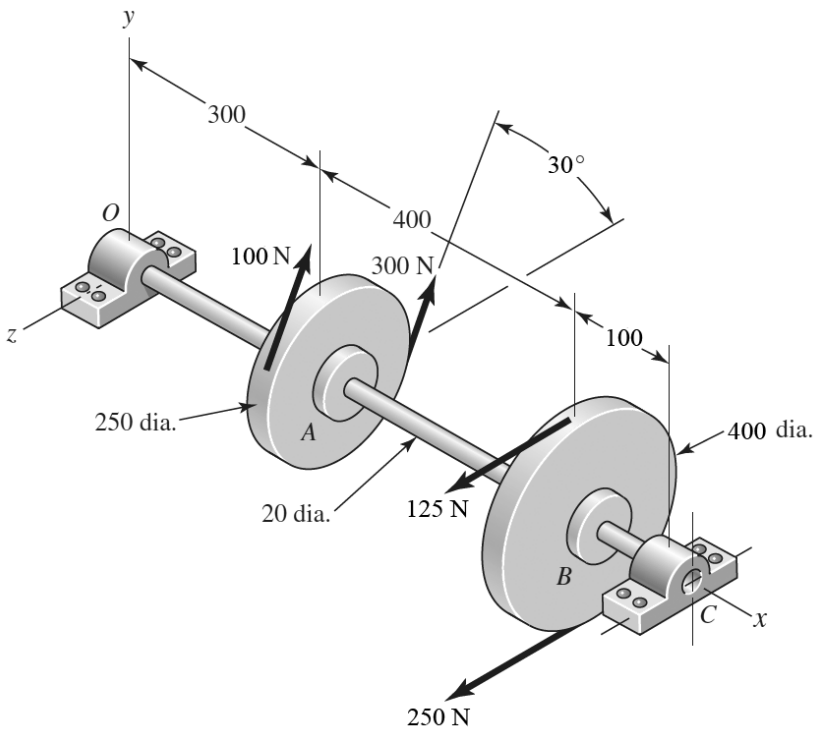
(a) Determine the bearing reaction forces at location *O* and *C*. Assume the bearings act as simple supports. **(15 points)**

(b) Assume transverse shear stress is negligible. Determine the critical axial location (*i.e.* the axial location with highest stresses) and calculate the corresponding bending stress and shear stress due to torsion. **(25 points)**

(c) At the critical axial location, determine the location of the critical stress element by considering the circular cross section of the shaft. Draw the corresponding stress element and indicate nonzero stresses. **(25 points)**

(d) Determine the principal normal stresses and maximum shear stress for the critical stress element. **(20 points)**

(e) By using Distortion Energy failure theory, determine the factor of safety of the shaft. Assume the shaft is made of AISI 1020 CD (cold-drawn) steel (ultimate tensile strength = 470 MPa, yield strength = 390 MPa). **(20 points)**



Useful formulas:

For circular cross sections,

$$I = \frac{\pi d^4}{64} \qquad \text{and} \qquad J = \frac{\pi d^4}{32} .$$

von Mises stress

$$\sigma' = \left[\frac{(\sigma_1 - \sigma_2)^2 + (\sigma_2 - \sigma_3)^2 + (\sigma_3 - \sigma_1)^2}{2} \right]^{1/2}$$