Indian Institute of Technology Kanpur
Department of Aerospace Engineering

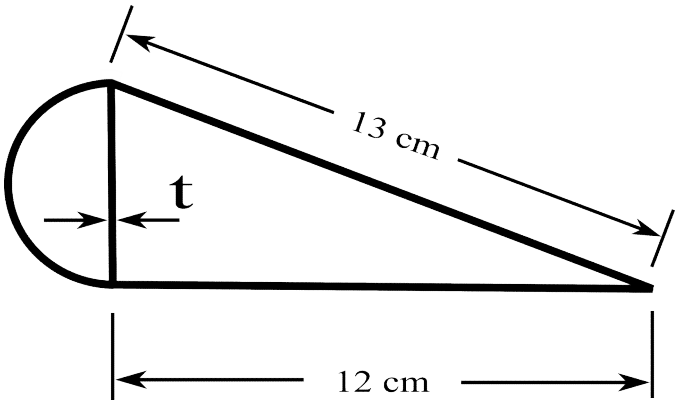
AEROSPACE STRUCTURES I (AE 333)

Quiz - 2, 2024-25/1 Semester Venue: L7

Duration: 40 minutes | Tuesday - Oct 29, 2024 | Max mark: 10

Attempt all parts. Show all steps clearly.

1. Consider a thin-walled, homogeneous aluminum wing structure with a uniform cross-section, as shown in the sketch provided. The structure includes curved sections forming a semi-circular shape. There is no significant warping constraints. Given the shear modulus G = 25 GPa:
   (a) Calculate the shear flows over the surface of the cross-sections for a constant torque M_t. **(4)**
   (b) If applied torque, torque M_t = 1000 Nm, calculate the shear flow distribution over the surface of the central spar and draw a sketch to indicate the direction of shear flow. **(2)**
   (c) Now, if the uniform thickness, t = 1 mm, Calculate the twist per unit length of the section. **(2)**
   (d) Using all the above results, calculate the St. Venant constant for uniform torsion for this cross-section. **(2)**



Formula Basket:

$$M_t = GJ\frac{d\theta}{dz} \qquad q_{s,0} = -\frac{\oint q_b ds}{\oint ds} \qquad \frac{\partial q}{\partial s} + t\frac{\partial \sigma_z}{\partial z} = 0 \qquad \frac{d\theta_i}{dz} = \frac{1}{2G_0\hat{A}_i}\oint_{\partial C_i}\frac{q}{t}ds$$

$$q_b = -\left(\frac{S_x I_{xx} - S_y I_{xy}}{I_{xx}I_{yy} - I_{xy}^2}\right)\int_0^s txds - \left(\frac{S_y I_{yy} - S_x I_{xy}}{I_{xx}I_{yy} - I_{xy}^2}\right)\int_0^s tyds \qquad M_t = 2\sum q_i \hat{A}_t$$

$$S_y = \frac{\partial M_x}{\partial z} \qquad q_2 - q_1 = -\left[\frac{\left(\frac{\partial M_y}{\partial z}\right)I_{xx} - \left(\frac{\partial M_x}{\partial z}\right)I_{xy}}{I_{xx}I_{yy} - I_{xy}^2}\right]B_r x_r - \left[\frac{\left(\frac{\partial M_x}{\partial z}\right)I_{yy} - \left(\frac{\partial M_y}{\partial z}\right)I_{xy}}{I_{xx}I_{yy} - I_{xy}^2}\right]B_r y_r$$