Solid & Structural Mechanics

Qualifying Exam
Department of Mechanical Engineering

January 2020

Closed book
One-page note

In order to receive full credit, you must show all work
A calculator is permitted

Answer all questions
All questions have equal weight

TIME: 3.0 hrs

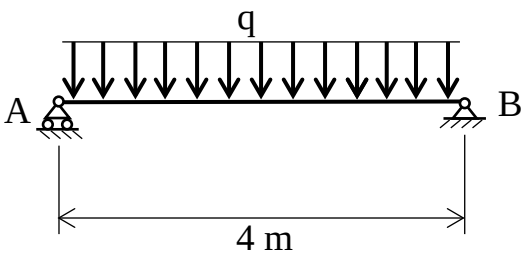
Prepared by: Profs. Sara Roccabianca, Lik C. Lee & Patrick Kwon

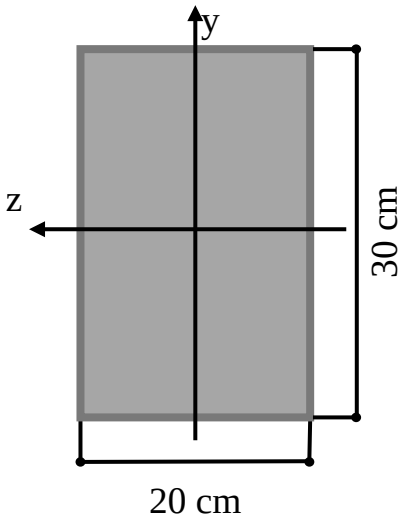
1. Estimate the maximum value of the distributed load q (expressed in N/m) for the beam shown in Figure, given that:

a. a prismatic beam with a constant rectangular cross section of 20 cm x 30 cm (see Figure);

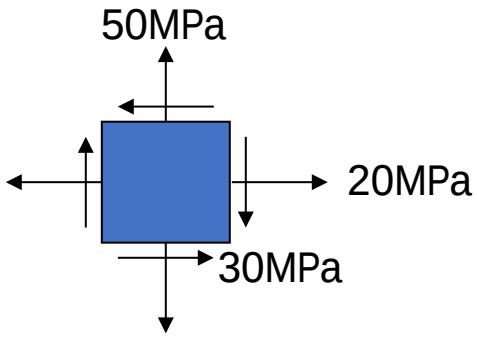
b. the ultimate compression/tension strength for the beam of $\sigma^u = 100\ MPa$ and the ultimate shear strength of $\tau^u = 10\ MPa$; and

c. the beam with a factor of safety of 2.5.





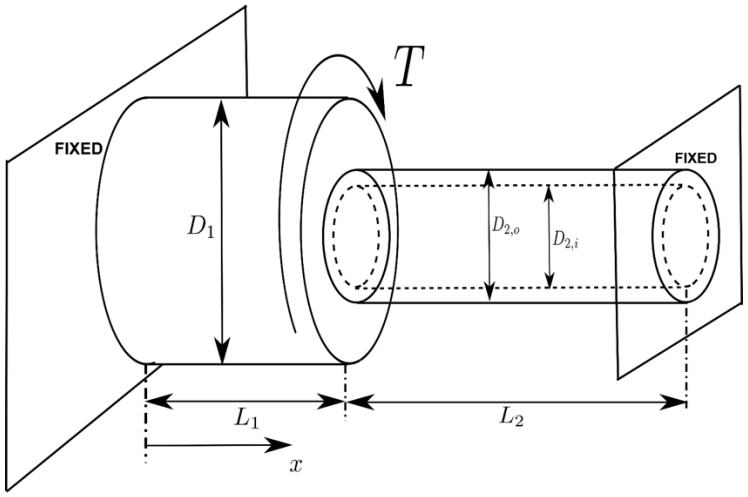
2. Using the Mohr's circle technique, for the stress state in the Figure ($\tau = 30MPa$), determine
   a. The principal stresses and the angle for the principal plane.
   b. The maximum shear and angle of the maximum shear plane



3.The above figure shows a composite shaft consisting of:

(1) a solid section $0 \leq x \leq L_1$ with diameter D_1 and shear modulus G_1,
(2) a hollow section $L_1 < x \leq L_2$ with inner diameter $D_{2,i}$, outer diameter $D_{2,o}$ and shear modulus G_2.

Given that the solid and hollow sections are fixed together without any slip, find the value of torque T imposed at $x = L_1$ that produces a maximum shear stress of τ at $x = L$, where $L < L_1$. Express T as a function of $\tau, L_1, L_2, D_1, D_{2,i}, D_{2,o}, G_1, G_2$. What is the lowest value of shear stress at $x = L$?



4. The structure is made with the solid cross-section with the dimension of 50mm and 100mm. (a) Determine the reaction forces and moment at the base. (b) Determine the stresses at the base located A. Please do not ignore any small stress.