Type A: Exam instructions

Make sure that you are taking the correct Type Midterm Exam. You can find the Type in the exam instructions document by looking up your Student ID number.

Date and time: The exam will be 50 minutes long, from 2:05 pm to 2:55 pm, and you will have an additional 10 minutes to scan and submit your exam to Gradescope. Make sure your document is submitted before 3:05 pm. Late exams will not be accepted. If you are having technical issues submitting your exam, please contact me and the GSIs as soon as possible.

During the exam: Please take the exam in a quiet space with reliable internet access so you can submit your exam. You may not share a room with anyone else taking the exam. The GSI and I will be on zoom in case you have any questions. Logging into zoom will not be required during the exam.

Materials that can be used during the exam: You will only be allowed to use a calculator and two sheets (front and back) of notes. You may NOT use any internet resources during the exam, except zoom. All the problems in this exam is protected and cannot be uploaded or distributed to third party websites.

Submission: Please scan your submission clearly and ensure all text is legible to Gradescope. You can use a third-party scanning app (for example, CamScanner) that produces a PDF file. You cannot submit raw pictures. Here is a nice google doc that explains how to make a PDF: https://t.co/s8B8qIiJ84?ssr=true. It is your responsibility that your submission is legible and easy to understand. Please double and triple check your submitted PDF that everything is legible and all pages of your exam are included.

On your first page, please write down your Exam Type along with your name and student ID. When working on the exam, make sure to start every problem on a new page and clearly label Problem 1, Problem 2, part a) and part b). In Gradescope, submit your PDF to the corresponding Midterm Type Assignment and select the pages of your work that corresponds to the problem numbers.

Honor code: Please write out this statement on the first page of your exam submission:

"I pledge my honor that all my exam work was done entirely by myself, with no help from others; I did not communicate with anybody during the exam; I did not share information with others during the exam; I did not use any materials beyond a calculator and two sheets of notes during the exam."

Things to note: Make sure to provide units when necessary. Show all work. Good luck!

Problem 1 (8pts)

A sample is subjected to a uniaxial tensile loading. Its load-displacement relation is shown in the figure. The original cross-sectional area is $A_0 = 100\ \text{mm}^2$ and the gage length is $L_0 = 100\ \text{mm}$. Assume that the volume of the sample is unchanged throughout the whole loading process and that the proportional limit and elastic limit coincide at point A.

Determine the following material properties (Use engineering stress and strain):

(a). Proportional limits of stress and strain, σ_{pl}, ϵ_{pl}

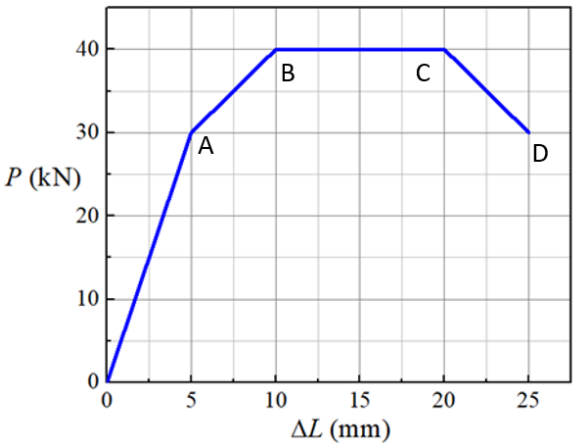
(b). Modulus of elasticity, E

(c). Modulus of resilience, u_r

(d). Modulus of toughness, u_t

(e). Maximum elastic strain energy of the sample, U

(f). Total energy stored in the sample at failure, U_f



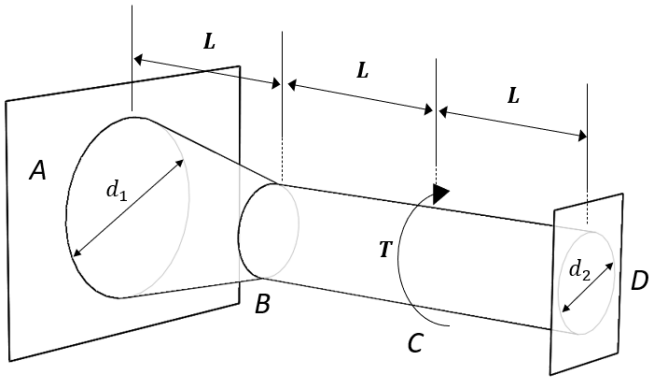
Problem 2 (10pts)

As is shown in the figure, a brass shaft is confined by the fixed supports at A and D. Segment AB has a tapered shape and segment BD has a cylindrical shape. A torque $T = 1000\ \mathrm{N \cdot m}$ is applied at C. There is an equal distance $L = 1\mathrm{m}$ between AB, BC, and CD. The diameter at A is $d_1 = 1\ \mathrm{m}$ and the diameter at D is $d_2 = 0.5\ \mathrm{m}$. The shear modulus of brass is $G_{\mathrm{br}} = 39\ \mathrm{GPa}$.

(a). Calculate the polar moment of inertias of cross-sectional areas (about the center) at A and D.

(b). Determine the reaction torque magnitudes at A and D.

(c). Calculate the magnitude of rotation angle of the cross section at B (with respect to A).



Problem 3 (10pts)

The structure in the diagram contains three rods joined by a pin at A. The rods are supported by pins at B, C and D. **Only** the rod AB is subjected to a temperature change of ΔT. All the rods have the same length L, same Young's modulus E, same cross-sectional area A, and same thermal expansion coefficient α.

(a). Prove that the relation between the changes in length δ_{AB} and δ_{AC} is

$$\boldsymbol{2\delta_{AB} = \delta_{AC}}$$

Assume the angle between rod AC and AD negligibly changes. *Hint: you can directly assume symmetry and the relation can be derived purely geometrically.*

(b). Find the magnitude of internal axial force in the member AB with respect to $\alpha, \Delta T, E, A$ and L.

(c). Find δ_{AB} with respect to $\alpha, \Delta T$ and L.

(d). Given the yield stress σ_y of AB, determine the temperature at which AB will yield.