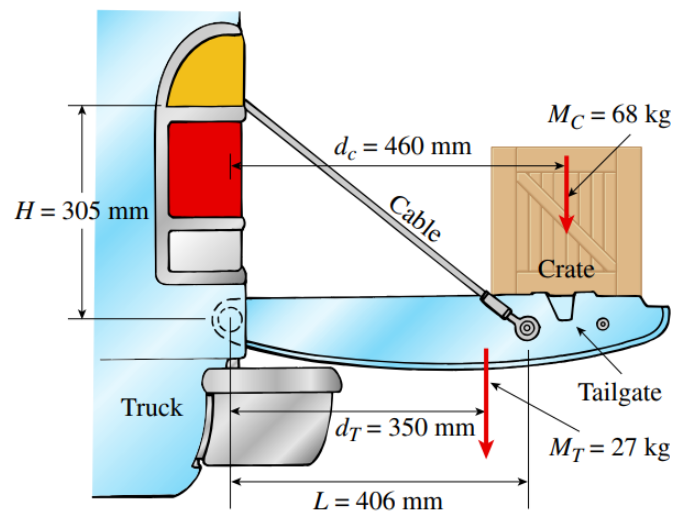Submission: Please submit the scanned/typed document to Canvas.

Question 1: (Review of statics)

A pickup truck tailgate supports a crate whose mass is $M_C = 68$ kg, as shown in the figure. The mass of the tailgate is $M_T = 27$ kg and is supported by two cables (only one is shown in the figure). Use dimensions shown in the figure and find the tensile force T in each cable. ($g = 9.81 \, m/s^2$)

Question 2: (Mechanical Properties of Materials)

2.1 Following Question 1, the cable cross-sectional area is $A_e = 11 \text{ mm}^2$. What is the normal stress σ in each cable? If each cable elongates $\delta = 0.25 \text{ mm}$ due to the weight of both the crate and the tailgate, what is the Young's modulus of the cable? If Poisson's ratio of the cable is 0.3, what is the shear modulus of the cable?

2.2 Please explain the differences between engineering stress and true stress. Under what circumstances would these differences be most significant?

Question 3: (Tension, Compression and Shear)

Consider a straight bar having the width $b = 10.0$ mm, the thickness $h = 2.00$ mm, and the leng`th $l = 200$ mm, which is made by a material exhibiting the stress-strain relationship as shown in the following figure. (i) Calculate the elongation of the bar when a tensile load $P = 2.00$ kN acts on the bar. (ii) Calculate the elongation of the bar after removing the load from the bar.
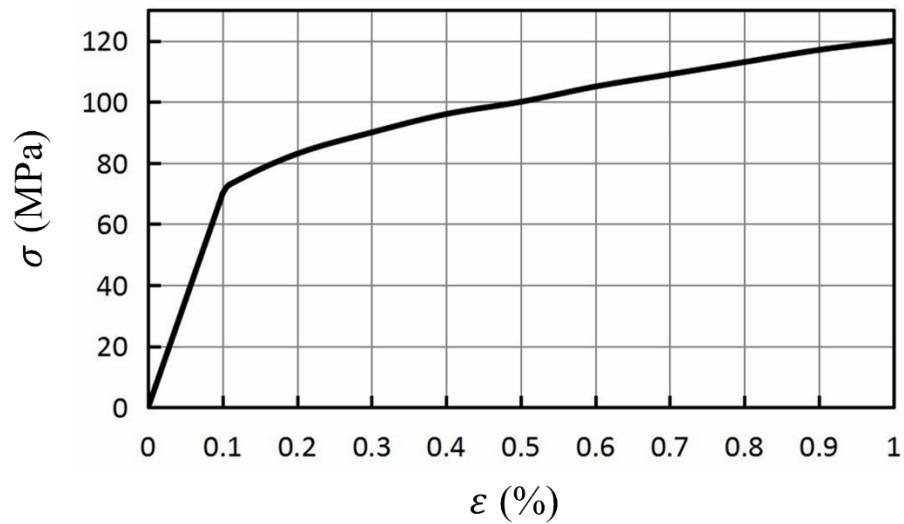
Question 4: (Axial loads and axial deformations)

4.1 A vertical steel bar ABC is pin-supported at its upper end and loaded by a force P_1 at the lower end. A horizontal beam BDE is pinned at the vertical bar at joint B and supported at point D. The beam carries a load P_2 at end E. If P_1=10kN, P_2=25 kN (disregard the weights), determine the vertical displacement at point C.
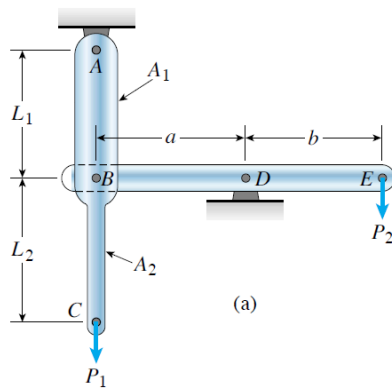
Parameters:

upper part:
L_1 = 500 mm, cross-sectional area
A_1 = 160 mm²,

lower part:
L_2 = 750 mm, cross-sectional area
A_2 = 100 mm².
E_{steel} = 200 GPa, a = 700 mm, b = 625 mm

4.2 A symmetrical framework consisting of three pin-connected bars is loaded by a force P. The angle between the inclined bars and the horizontal is $\alpha = 45°$. The axial strain in the middle bar is measured as 0.2%. Determine the tensile stress in the outer bars if they are constructed of stainless steel with Young's modulus $E = 210\ \text{GPa}$.
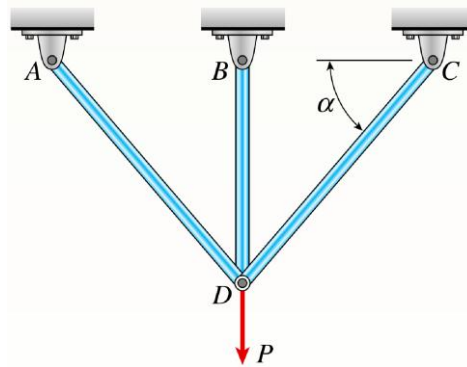
4.3 A straight prismatic circular bar AD has diameter d and length L in its undeformed state. Its left end is fixed. A uniformly distributed axial force, p per unit length, is applied on segment AB, a concentrated force, P_c, cross-section C, and a concentrated force, P_D, on the right end D. The bar undergoes linear elastic deformation with a homogeneous Young's modulus, E. The original lengths of segments AB and BC are L_{AB} and L_{BC}, respectively.

(i) Describe the stress/strain states in the bar as piecewise functions of x.

(ii) Calculate the elongations of segments AB, BC, CD, and the total elongation of bar AD.
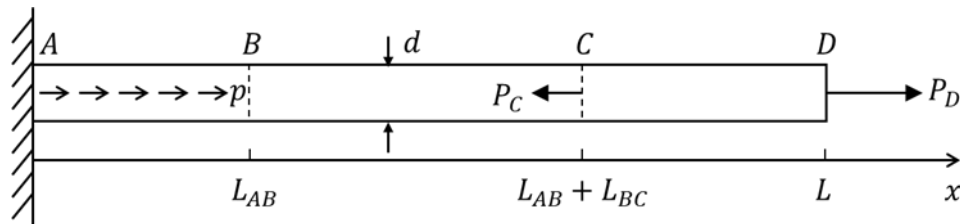
Question 5: (Statically Indeterminate Problems)

A bimetallic bar (or composite bar) of square cross section with dimensions $2b \times 2b$ is constructed of two different metals having moduli of elasticity E_1 and E_2 (see figure, $E_2 > E_1$). The two parts of the bar have the same cross-sectional dimensions. The bar is compressed by forces P acting through rigid end plates. The line of action of the loads has an eccentricity e of such magnitude that each part of the bar is stressed uniformly in compression.

(i) Determine the axial forces P_1 and P_2 in the two parts of the bar.

(ii) Determine the stresses σ_1 and σ_2 in the two parts of the bar.

(iii) Determine the eccentricity e of the loads.