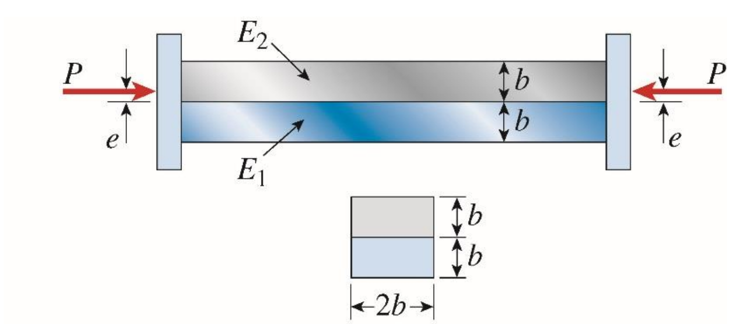
PLEASE NOTE:
Answer 3 out of the 4 problems. In case you answer the 4 problems, clearly state which 3 problems you want to be graded.

Problem 1:

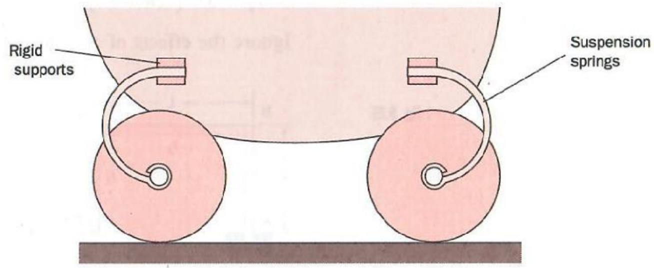
A bimetallic bar of square cross section with dimensions of 2b*2b (b=5 cm) is constructed of steel and copper at room temperature and has moduli of elasticity E1=210 GPa and E2=120 GPa, respectively (see figure). The two parts of the bar have the same cross-sectional dimensions. The bar is compressed by forces P of 300 kN acting through rigid end plates. The line of action of the loads has an eccentricity *e* (the deviation of the line of action of the load from the center of the composite bar) of such magnitude that each part of the bar is stressed uniformly in compression.

a) Determine the axial forces P_1 and P_2 in the two parts of the bar
b) Determine the eccentricity *e* of the loads
c) Assume the thermal expansion coefficients of steel and copper are $\alpha_1=12*10^{-6}$/K and $\alpha_2=16.6*10^{-6}$/K, respectively. If the whole system is heated up from room temperature (25°C) to 75 °C. The line of action of the loads can translate accordingly so the bar is still stressed uniformly in compression and the magnitude of loads P is still 300 kN. The two rigid ends can move horizontally accordingly. Determine P_1, P_2 and *e*.
d) Assume the bonding between the two metals is very strong. At 75 °C, If the bar is released from the rigid ends, qualitatively describe how the composite bar would (or would not) deform, why?



Problem 2:

A child's pram uses four semicircular springs for its suspension as shown in the figure. If the combined weight of the pram and the content in it is *W*, derive (1) an expression for the vertical movement of the centers of the wheels relative to the pram, and (2) an expression for the horizontal movement of the centers of the wheels relative to the pram. Feel free to make reasonable assumptions that best simplify your work. Please define quantities you use and assume all information you need is known.



Problem 3:

A center-cracked plate has dimensions, as defined in the figure below, of b = 38 mm and t = 6 mm, and it contains an initial half-crack length a_i = 2 mm. The stress intensity factor, K, for this crack configuration can be approximated as:

$$K = \sigma\sqrt{\pi a}$$

where σ is the far-field stress. The plate is subjected to tension-to-tension cyclic loading between constant values of minimum and maximum far-field stress, σ_{min} = 0 and σ_{max} = 100 MPa. The material properties of the plate are as follows:

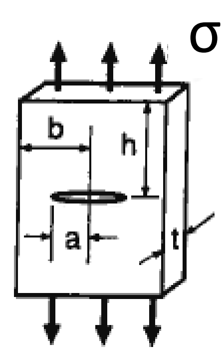
Yield stress, σ_0 = 1255 MPa

Plane strain Fracture toughness, K_{IC} = 30 MPa.m$^{1/2}$

Paris equation (for $R = \sigma_{min}/\sigma_{max} = 0$): $\frac{da}{dN}(mm/cycle) = 5.11\times10^{-10}\times\left(\Delta K(MPa\sqrt{m})\right)^{3.24}$

(a). Calculate the half-crack length at failure;

(b). Determine the number of cycles that can be applied before failure occurs.



Problem 4:

A sphere of mass m rolls from left to right along a platform with width w attached to Block A, which is fixed in space and rigid. When the roller is 2/3 L from the starting point, the platform needs to just touch Block B. The distance between the end of the platform and Block B is h. If the platform material is isotropic elastic with properties E and ν, derive an equation to determine the thickness t of the platform to make this work.