Problem 1: A simple, two-element truss whose elements are made of the same material support a vertical load $P$. The length $L$ of the horizontal bar is fixed but the angle $\theta$ (and length $AC$) can be changed by adjusting the location of support $A$. The allowable stress in the bars are the same in tension and compression. When the angle is reduced, bar $AC$ becomes shorter but its cross-sectional area increases (due to the axial forces increasing). Thus, the weight of the structure depends upon the angle $\theta$. Determine $\theta$ so that the structure has minimum weight without exceeding the allowable stresses in the bars. To simplify, you may ignore the self-weight of the bars (due to $P$ being so large).

Problem 2: A hollow circular steel column is designed to support the axial load, $P = 85$ k. The modulus of elasticity of the column is $E = 30,000$ ksi. The dimensions of the column are: $L = 8.0$ ft and $d = 7.5$ in. If the allowable compressive stress is 7000 psi and the allowable shortening of the column is 0.02 in, what is the minimum wall thickness, $t_{\text{min}}$?

Problem 3: The horizontal rigid beam ABCD is supported by vertical bars BE and CF and is loaded by axial forces $P_1 = 400$ kN and $P_2 = 360$ kN acting at A and D, respectively. Bars BE and CF are made of steel ($E = 200$ GPa) and has cross sectional areas of $A_{BE} = 11,100$ mm$^2$ and $A_{CF} = 9,280$ mm$^2$. Determine the vertical displacements $\delta_A$ and $\delta_D$ of points A and D, respectively.
**Problem 4:** As shown to the right, a circular element is designed for use as a primarily axial acting element to carry load $P$. The element is only 0.5 m long ($L$) and has a diameter of 30 mm ($d_1$). To improve the performance of the axial element, an outer ring element of length 0.3 m ($c$) is securely bonded to the rod such that slippage between the two is not possible. The original rod (AB) is made of acrylic ($E_1 = 3.1$ GPa) and the outer sleeve is made of polyamide ($E_2 = 2.5$ GPa).

a. Determine the elongation of the axial element when a $P = 12$ kN load is applied.

b. If the sleeve is extended for the full length of the original axial element, now what is the elongation?

c. In contrast, if the sleeve is eliminated, what is the element’s elongation?

**Problem 5:** A bar is constructed with fixed supports as shown to the right. The fixed supports are completely rigid and cannot move. The bar has cross-sectional area $A_f$ on segment AC and $2A_f$ on segment CD.

a. Derive an analytical expression for the reactions at A and D (namely, $R_A$ and $R_D$).

b. Determine the displacements at $\delta_B$ and $\delta_C$ under load $P$.

c. Draw a diagram in which the abscissa is the distance from the left hand support (A) to any point in the bar and the ordinate is the horizontal displacement $\delta$ at the given point along the length. Plot the displacement-axial location graph.

**Problem 6:** A large sculpture with a weight of 750 lb is designed by a famous architect for public display. To display her outdoor piece, the heavy sculpture is supported by three wires: two steel wires ($E_s = 30 \times 10^6$ psi) and one aluminum. The wires are equidistant from one another with the aluminum wire in the middle. The diameters of the wires are 1/8 in. In the sculpture location, the temperature is expected to go through significant variation due to winter/summer season cycles. As such, you are required to do a thermal analysis on the static structure as designed. What temperature increase $\Delta T$ induces the aluminum wire to carry no load? Assume the thermal expansion coefficient of the steel and aluminum is $6.5 \times 10^{-6}/^\circ$F and $12 \times 10^{-6}/^\circ$F.