1. (5%) In order to have uniform tension or compression in a prismatic bar, the axial force must act through the centroid of the cross-sectional area, why?

2. (10%) A circular steel rod of length $L=50$ m and diameter $d=10$ mm hangs in a mine shaft and holds a weight $W=1.0$ kN at its lower end (Fig. 2). (a) Calculate the maximum tensile stress in the rod. (b) Calculate the elongation of the rod (Young’s modulus of steel $E=200$ GPa, the weight density of steel $\gamma=77.0$ kN/m$^3$).

![Fig. 2](image)

![Fig. 3](image)

![Fig. 4](image)

3. (5 %) A material is loaded to a state $A$ (stress $\sigma_A=700$ MPa, strain $\varepsilon_A=0.1$), the load is then removed. Calculate the permanent strain after the material is unloaded. (The stress-strain diagram of this material is shown in Fig. 3 and the Young’s modulus $E=200$ GPa).

4. (15%) A solid circular bar $ABCD$ with fixed supports at ends $A$ and $D$ is acted upon by two equal and oppositely directed torques $T_0$, as shown in Fig. 4. The torques are applied at points $B$ and $C$, each of which is located at distance $x$ ($0 \leq x \leq L/2$) from one end of the bar. (a) For what distance $x$ will the angle of twist at points $B$ and $C$ be a maximum? (b) What is the corresponding angle of twist $\phi_{max}$?

5. (15%) The cantilever beam $AB$ ($L=500$ mm) shown in Fig. 5-1 is subjected to a concentrated load $P$ at the midpoint and a counterclockwise couple of moment $M_1=PL/4$ at the free end. The beam is fabricated by welding together two steel plates, the cross section is shown in Fig. 5-2. If the allowable load for each weld is 400 kN/m in the longitudinal direction, what is the maximum allowable load $P$?

![Fig. 5](image)
6. (10%) Using Fig. 6 as an example states what the method of superposition is and how it is applied to solve for the redundant loadings of statically indeterminate problem. Please set redundant in two different ways.

7. (20%) Determine the equation of the elastic curve, using discontinuity function, for the cantilevered beam shown in Fig. 7. EI is constant.

8. (20%) The 45° strain rosette is mounted near the tooth of the wrench. The following readings are obtained for each gage: \( \varepsilon_a = 800(10^{-6}) \), \( \varepsilon_b = 520(10^{-6}) \), and \( \varepsilon_c = -450(10^{-6}) \). Determine the in-plane principal strains.