1. Determine the vertical displacement of joint $C$ of steel truss as shown in Fig. 1 by **the principle of virtual work**. Due to radiant heating, member $AB$ is subjected to an increase in temperature of $\Delta T = +45^\circ C$, and member $CD$ has been fabricated 4 mm too long. The cross section area of each member is $A = 300\ \text{mm}^2$, the thermal expansion coefficient is $\alpha_{st} = 12\times10^{-6}/^\circ C$, and Young's modulus is $E_{st} = 200\ \text{GPa}$. (20%)

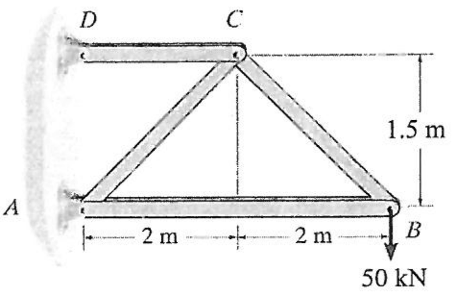


**Fig. 1**

2. The two bars, as shown in Fig. 2(a), are made of polystyrene, which has the stress-strain diagram as shown in Fig. 2(b). If the cross-sectional area of bar $AB$ is 1.5 in$^2$ and $BC$ is 4 in$^2$, determine the largest force $P$ that can be supported before any member ruptures. Assume that buckling does not occur. (20%)

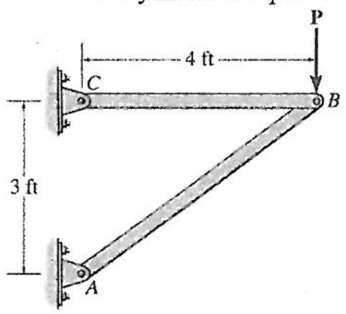


**Fig. 2(a)**

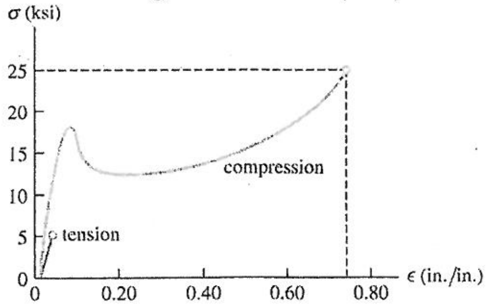


**Fig. 2(b)**

3. There are three **thin-walled** members with cross sections as shown in Fig. 3.
(a) Please schematically plot the locations of their shear centers. (6%)
(b) Please determine the exact location of the shear center for the member shown in Fig. 3(c). (9%)

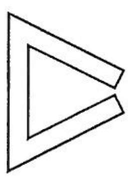

**Fig. 3(a)**

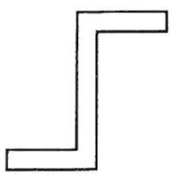

**Fig. 3(b)**

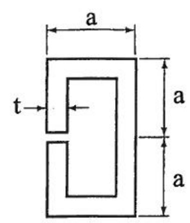


**Fig. 3(c)**

4. The isotropic solid shaft shown in Fig. 4 has a radius of $R$, Young's modulus of $E$, and shear modulus of $G$. The solid shaft is subjected to a torque of $\boldsymbol{T}$, a moment of $\boldsymbol{M}$, and an axial loading of $\boldsymbol{P}$. The cross-section $a$-$a$ is far away from the loads.
   (a) Identify the position on the cross-section $a$-$a$, called point $A$, where the maximum stress occurs. (3%)
   (b) Draw the corresponding stress state at point $A$. (4%)
   (c) Describe how to measure the strains at point $A$ induced by the loadings. (3%)
   (d) Using the maximum-normal-stress theory, determine the maximum allowable principal stress in terms of $R$, $T$, $M$, and $P$. (10%)

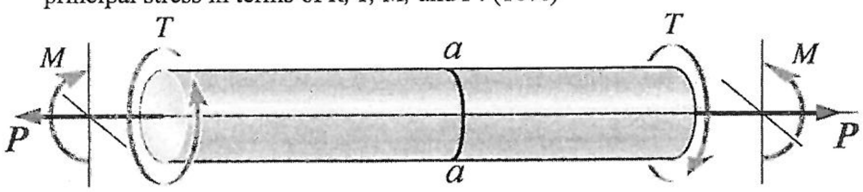


**Fig. 4**

5. The following beams have a moment of inertia of $I = 65\times10^{-6}\,\text{m}^4$ and a Young's modulus of $E = 200$ GPa .
   (a) Determine the displacement at $C$ of the beam (Fig. 5(a)) by the method of **discontinuity functions**. (10%)
   (b) Determine the displacement at $C$ of the beam (Fig. 5(b)) by the **integration method**. (9%)
   (c) Based on the above solutions, determine the reactions at $A$ and $B$ of the beam (Fig. 5(c)) by the **superposition method**. (6%)

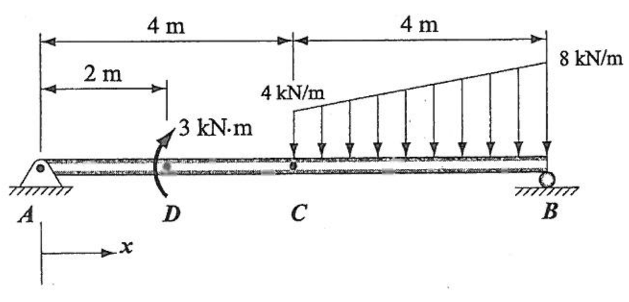


**Fig. 5(a)**

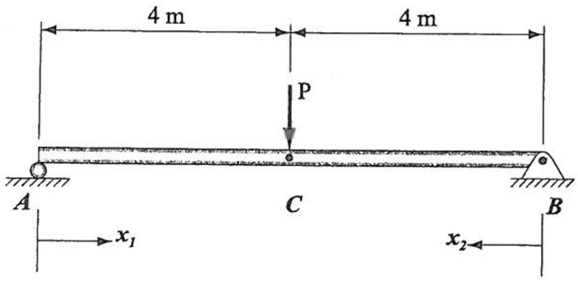


Fig. 5(b)

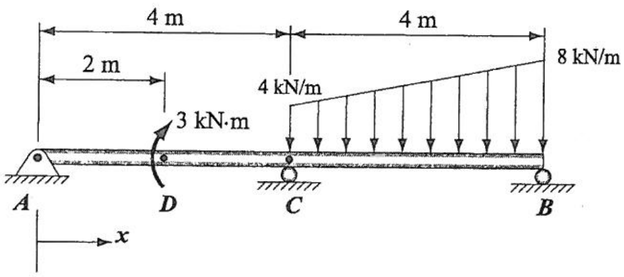


Fig. 5(c)