1. Please answer the following short questions in detail.

(a) What is flexural stress in a beam? How does flexural stress relate to bending moment and area moment of inertia of the beam? How does it vary across the cross section of a beam? Make a sketch and explain. (10%)

(b) How does shear stress vary across the cross section of a solid circular rod under torsion? Make a sketch and explain. (5%)

(c) What is a strain rosette? How does it work? (5%)

(d) Using a typical stress-strain plot, illustrate elastic and plastic behaviors. (5%)

2. A stepped rod is made up of three uniform elements as shown. The rod exactly fits between rigid walls (A and D) when no external forces are applied, and the ends of the rod are welded to the rigid walls.

(a) Determine the displacements, u_B and u_C of the two joints B and C in terms of three stiffness coefficients of the rods, when the external loads P_B and P_C are applied. (10%)

(b) Determine the internal force in each of the three elements. (10%)

(c) Determine the reaction forces P_A and P_D at the fixed ends A and D. (5%)
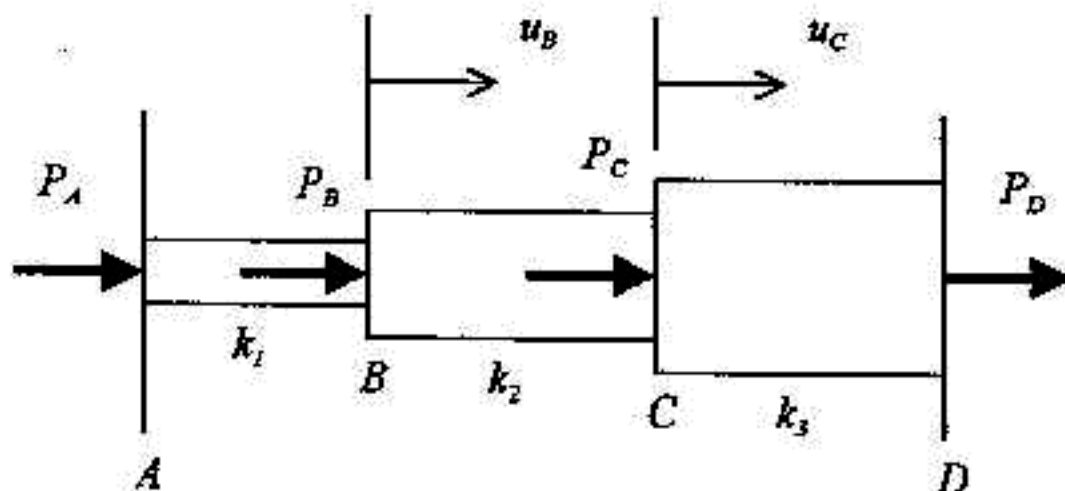
3. For the plane-stress state of an element shown below, do the following:

(a) Draw Mohr's circle. (5%)

(b) Determine the stresses on all faces of an element that is rotated 30° counter-clockwise from the orientation of the stress element shown. (10%)

(c) Determine the orientation of the principal planes; determine the principal stresses. (5%)

(d) Determine the orientation of the planes of maximum shear stress; determine the value of the maximum shear stress. (5%)
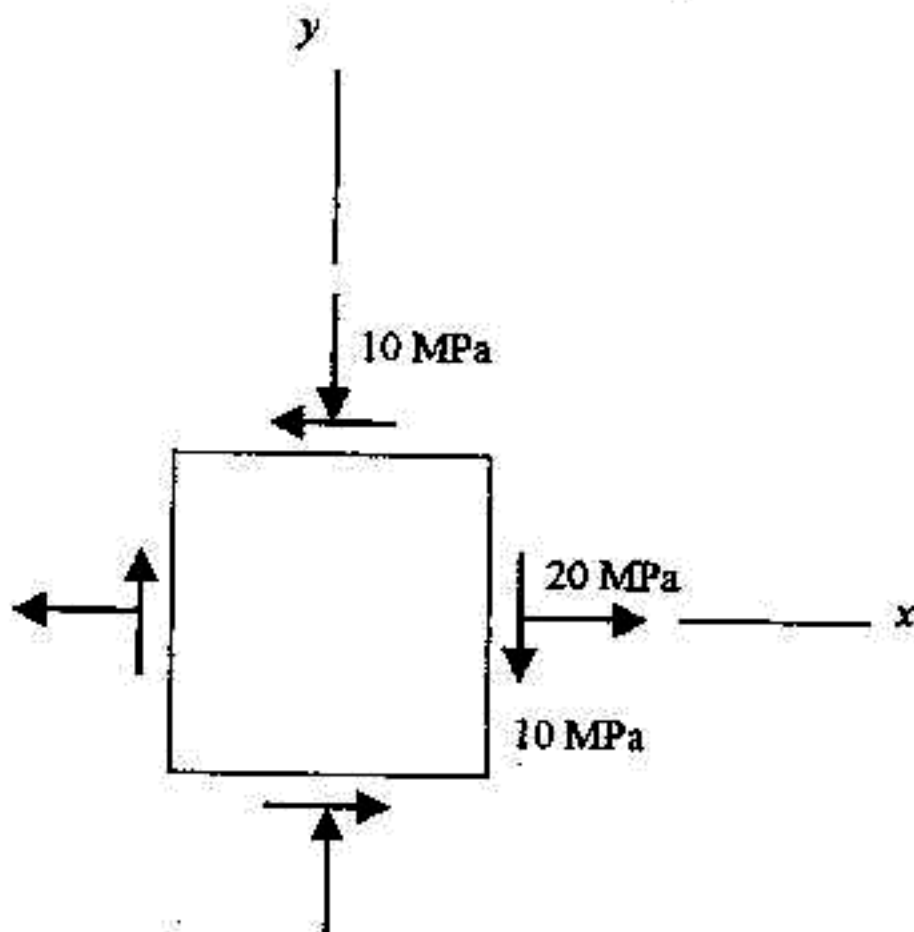
4. The proposed cantilever beam below is subjected to a concentrated load P at distance a from end A.

(a) Use the second-order integration method to determine the reactions at A and C and the deflection curves $v_a(x)$ and $v_b(x)$ for the segments of the beam to the left of load P and to the right of load P, respectively. (15%)

(b) Letting $a = L/3$. Sketch the shear diagram, $V(x)$, and the moment diagram, $M(x)$. (10%)