1. The state of stress at a point in two Cartesian systems is **(20 marks)**

$$\sigma_{ij} = \begin{pmatrix} 5 & a & -a \\ a & 0 & b \\ -a & b & 0 \end{pmatrix} \quad , \quad \sigma_{ij} = \begin{pmatrix} c & 0 & 0 \\ 0 & 2 & 0 \\ 0 & 0 & d \end{pmatrix}$$

where a, b, c, d, are constants

If the magnitude of the maximum shearing stress at this point is 5.5 MPa

(a) Determine the principal stresses at this point

(b) Also find a and b (you need not solve for them, just give the equation that yields their solution)

2. A solid is subject to the deformation field **(10 marks)**

$$x_1^* = x_1 + \phi x_2 \; ; \quad x_2^* = x_2 + \psi x_1 \; ; \quad x_3^* = x_3$$

where ϕ, ψ are functions of time. Determine the limit(s) on $\phi\psi$ for the deformation field to represent the deformation of a real material.

3. Consider a bar of uniform cross-section suspended vertically by **fixing** the **centroid** of the upper base, as shown. Thus, an arbitrary line element at the centroid of the upper base has **zero rotation**. Obtain the stresses, strains, and displacements. (Hint: Assume a suitable distribution of stresses σ_{ij} such that all but one stress components are zero, and the non-zero stress varies only with the x_3 coordinate, the variation being linear. Check that your stress distribution satisfies boundary condition, equilibrium, compatibility. Then, use this distribution to obtain strains and hence displacements). **(20 marks)**