MIDTERM EXAM

MMAE 530 Advanced Mechanics of Solids
October 13, 2011
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Problem 1. (35 pts) An engineer in an aerospace company is designing a rotor blade and wants to have estimates of the maximum stress and deformation in the blade. The engineer approaches you for help because of your expertise in stress analysis. The problem is simplified to the following idealized situation so that you can make a back of the envelope calculation. The blade is idealized to be a bar attached to the axis of rotation and rotating at N revolutions per second. Assume the bar is of constant cross-sectional area, A, and density, ρ.

(a) Find the maximum stress and location.

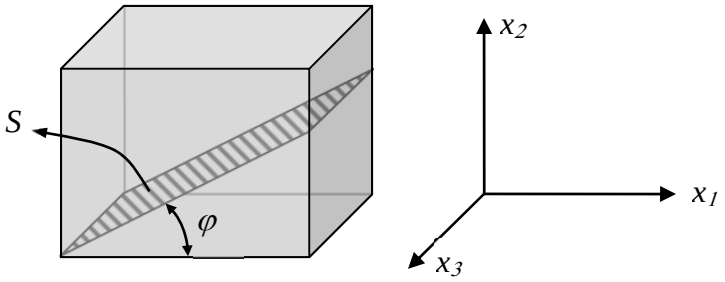
(b) What is the maximum displacement in the blade and its location?
(Hint: Formulate this as a 1-D problem)

Problem 2. (35pts) Shown in the figure below is a solid body subjected to a 2-D stress state (plane stress), i.e., $\sigma_{i3} = 0,\ i = 1,2,3$. Let φ be the angle between the surface S and the x_1 axis. Without using the Mohr's circle and 2D transformation formulas (i.e., treat the problem as a full 3D problem),

(a) (15 pts) Find the traction on plane S in terms of stress components σ_{11}, σ_{22} and σ_{12}.

(b) (15 pts) Find the normal and shear stresses on this plane.

(c) (10 pts) If the plane is traction free, find the relation between σ_{11} and σ_{22}.



Problem 3. (30 pts) Consider an infinitesimal deformation of a body in which the following infinitesimal strain components are zero: $\varepsilon_{13} = \varepsilon_{23} = \varepsilon_{33} = 0$. Such problems are called plane strain problems. In the plane formed by the first base vector $\underline{e}_1$ and the second base vector $\underline{e}_2$, we know normal strains along *0º*, *45º*, and *90º* directions where the angles are measured counterclockwise from the direction of $\underline{e}_1$. The normal strains are given as ε_0, ε_{45} and ε_{90}.

(a) Find all components of the infinitesimal strain tensor

(b) Find principal strains

(c) Find the corresponding principal directions for the following case: $\varepsilon_{45} = (\varepsilon_0 + \varepsilon_{90})/2$

Good Luck,