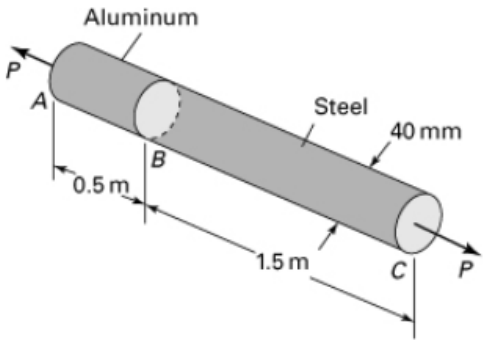
Homework 3

(due Tuesday, Jan 28)

1) A $12\text{-}mm$-diameter specimen is subjected to tensile loading. The increase in length resulting from a load of $9\ kN$ is $0.025\ mm$ for an original length L_0 of $75\ mm$. Report the true and conventional (i.e., engineering or nominal) strains and stresses? Also determine the modulus of elasticity.

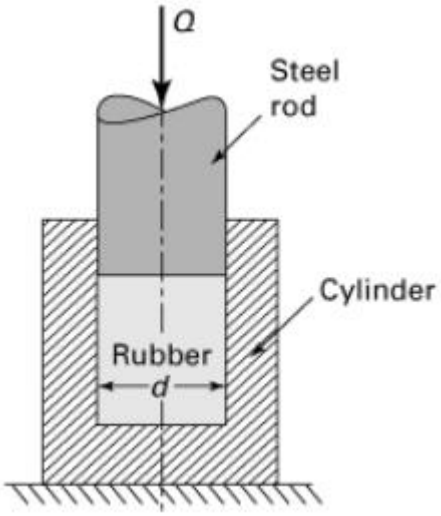
2) A $40\text{-}mm$-diameter bar ABC is composed of an aluminum part AB and a steel part BC. After axial force P is applied, a strain gage attached to the steel measures normal strain at the longitudinal direction as $\varepsilon_s = 600\ \mu$. Determine (a) the magnitude of the applied force P and (b) the total elongation of the bar if each material behaves elastically. Take $E_a = 70\ GPa$ and $E_s = 210\ GPa$.



3) A typical vibration isolation device consists of rubber cylinder of diameter d compressed inside of a steel cylinder by a force Q applied to a steel rod. Do the following:

   a. Find, in terms of d, Q, and Poisson's ratio ν for the rubber, an expression for the lateral pressure p between the rubber and the steel cylinder.
   b. Determine the value of the lateral pressure p between the rubber and the steel cylinder for $d = 50\ mm$, $\nu = 0.3$, and $Q = 5\ kN$.

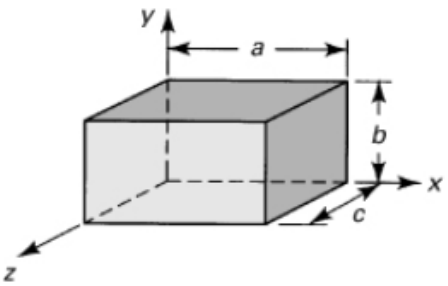
   Assumptions:
   1) Friction between the rubber and steel can be neglected.
   2) The steel cylinder and rod are both rigid.



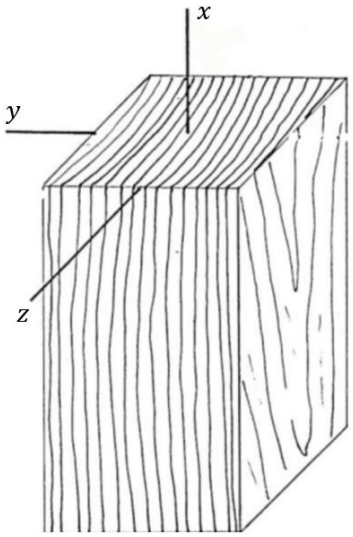
4) For a given steel, $E = 200\ GPa$ and $G = 80\ GPa$. If the state of strain at a point within this material is given as shown, determine the corresponding components of the stress tensor.

$$\begin{bmatrix} 200 & 100 & 0 \\ 100 & 300 & 400 \\ 0 & 400 & 0 \end{bmatrix} \mu$$

5) The steel ($E = 200\ GPa$ and $\nu = 0.3$), rectangular parallelepiped has dimensions $a = 250\ mm$, $b = 200\ mm$, and $c = 150\ mm$. It is subjected to triaxial stresses $\sigma_x = -60\ MPa$, $\sigma_y = -50\ MPa$, and $\sigma_z = -40\ MPa$ acting on the x, y, and z faces, respectively. Determine (a) the changes Δa, Δb, and Δc in the dimensions of the block, and (b) the change ΔV in the volume.



6) A board cut from a birch tree has the following elastic constants (FPS, 1999) relative to orthotropic axes (x, y, z):



$$E_x = 15{,}290\ MPa \qquad E_y = 1195\ MPa \qquad E_z = 765\ MPa$$
$$G_{xy} = 1130\ MPa \qquad G_{xz} = 1040\ MPa \qquad G_{yz} = 260\ MPa$$
$$\nu_{xy} = 0.426 \qquad \nu_{xz} = 0.451 \qquad \nu_{yz} = 0.697$$

where the x, y, and z axes aligned with, perpendicular to, and tangent to the grain of the wood. At a point in the board, the components of stress are determined to be $\sigma_{xx} = 7\ MPa$, $\sigma_{yy} = 2.1\ MPa$, $\sigma_{zz} = -2.8\ MPa$, $\sigma_{xy} = 1.4\ MPa$, and $\sigma_{xz} = \sigma_{yz} = 0$.

a. Determine the orientation of the principal axes of stress.
b. Determine the strain components.
c. Determine the orientation of the principal axes of strain.