Assignment #1

Material and Manufacturing Processes (446.305A) Fall 2014, Prof. Ahn, Sung-Hoon
Out: September 22, 2014 / Due: 6PM, September 29, 2014 (Bldg. 301, Room 1405)

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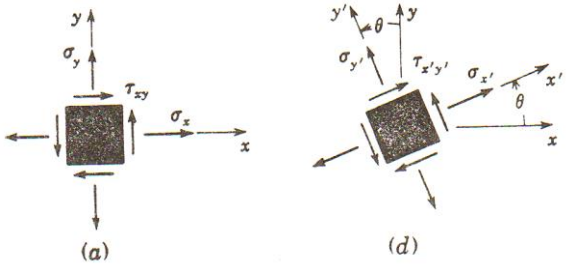
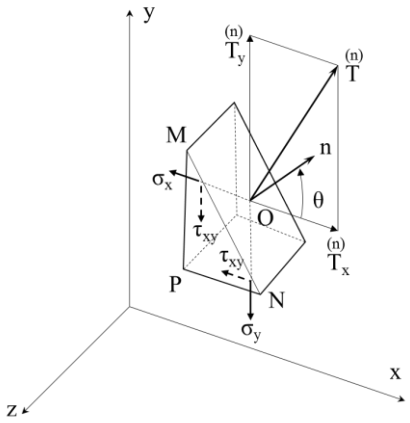
1. We have observed that once ultimate tensile strength is reached, the specimen begins to neck and thus deformation is no longer uniform. Show that the true strain at the onset of necking (ε) is numerically equal to the strain-hardening exponent, n, expressed in true stress-true strain curve equation $\sigma = K\varepsilon^n$.

2. When *x'y'* plane makes an arbitrary angle θ with the *x* axis of *xy* plane, show stress components in *x'y'* plane, $\sigma_{x'}$, $\sigma_{y'}$, and $\tau_{xy'}$, could be expressed in terms of σ_x, σ_y, τ_{xy} and θ like as following. Use force equilibrium of given triangular components.

$$\sigma_{x'} = \sigma_x \cos^2\theta + \sigma_y \sin^2\theta + 2\tau_{xy}\sin\theta\cos\theta$$
$$\tau_{x'y'} = (\sigma_y - \sigma_x)\sin\theta\cos\theta + \tau_{xy}(\cos^2\theta - \sin^2\theta)$$
$$\sigma_{y'} = \sigma_x \sin^2\theta + \sigma_y \cos^2\theta - 2\tau_{xy}\sin\theta\cos\theta$$



Rotation of coordinates (by angle θ)



Stress vector and stress components acting on faces of a small wedge, cut from the big body, which is in a state of plane stress in the *xy* plane

3. A strip of metal is originally 2.5 m long. It is stretched in three steps: first to a length of 2.75 m, then to 3.0 m, and finally to 4.0 m. Show that the total true strain is the sum of the true strains in each step, that is, that the strains are additive. Show that, using engineering strains, the strain for each step cannot be added to obtain the total strain.

4. In a disk test performed on a specimen 30 mm in diameter and 5 mm thick, the specimen fractures at a stress of 500 MPa. What was the load on the disk at fracture?

5. An aluminum alloy yields at a stress of 50 MPa in uniaxial tension. If this material is subjected to the stresses $\sigma_1 = 25$ MPa, $\sigma_2 = 15$ MPa, and $\sigma_3 = -26$ MPa, will it yield? Explain.

6. A cable is made of four parallel strands of different materials, all behaving according to the equation $\sigma = K\varepsilon^n$, where $n = 0.3$. The materials, strength coefficients and cross sections are as follows:

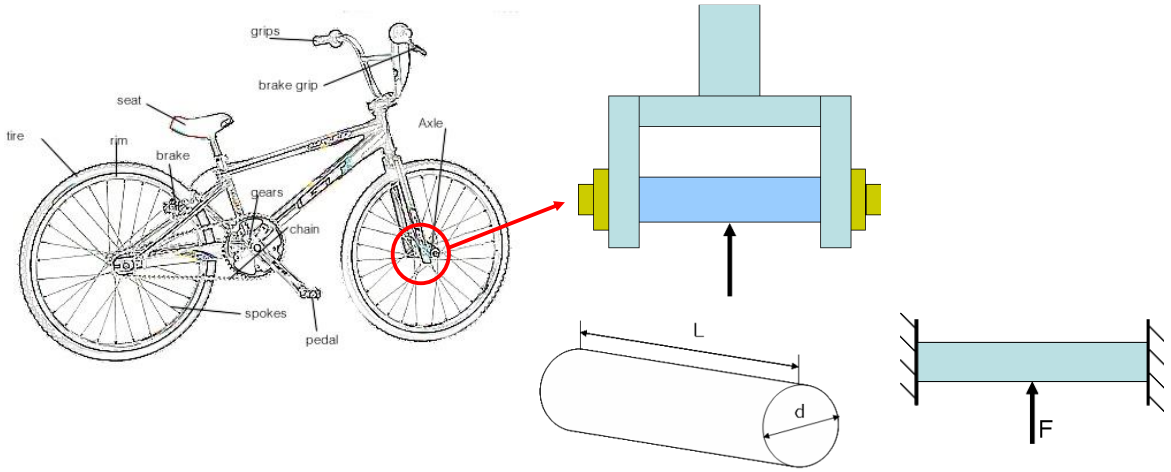
Material A: $K = 500$ MPa, $A_0 = 8$ mm^2
Material B: $K = 450$ MPa, $A_0 = 2.5$ mm^2
Material C: $K = 300$ MPa, $A_0 = 5$ mm^2
Material D: $K = 760$ MPa, $A_0 = 2$ mm^2

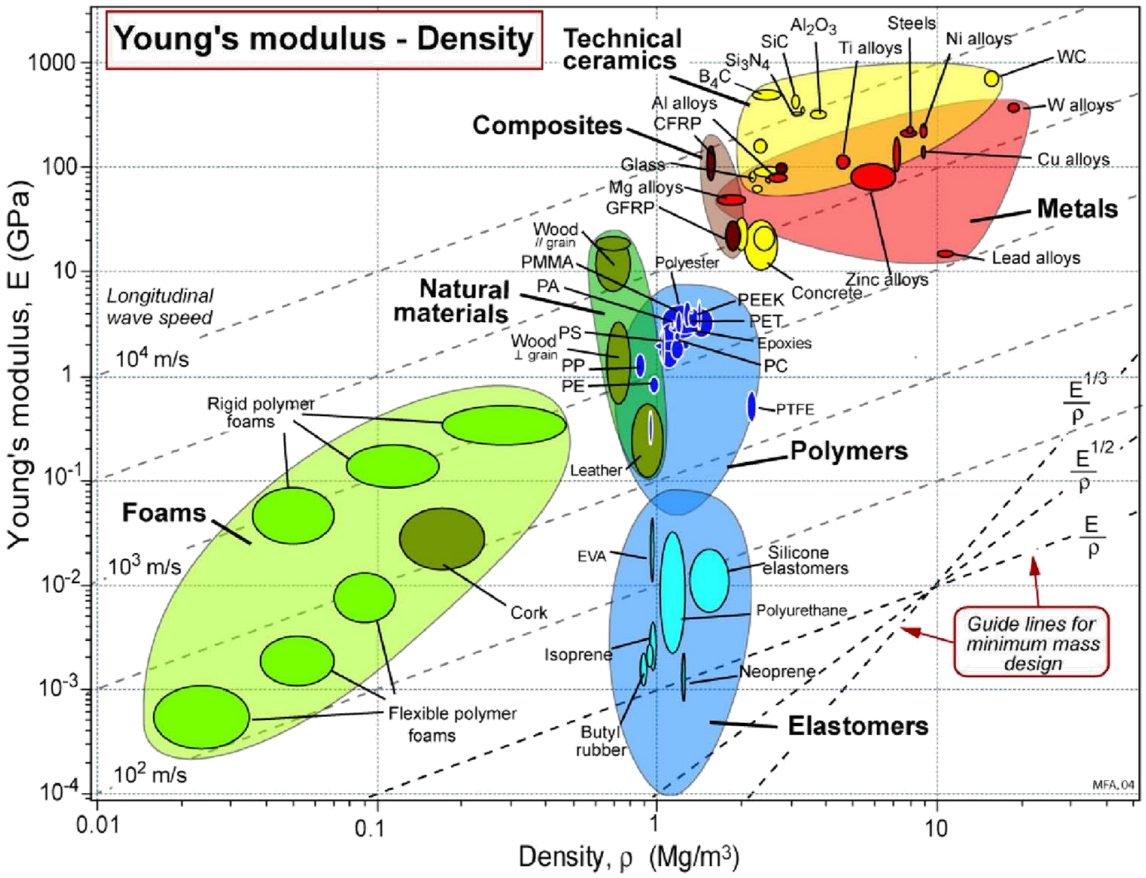
Calculate the maximum tensile load that this cable can withstand prior to necking.

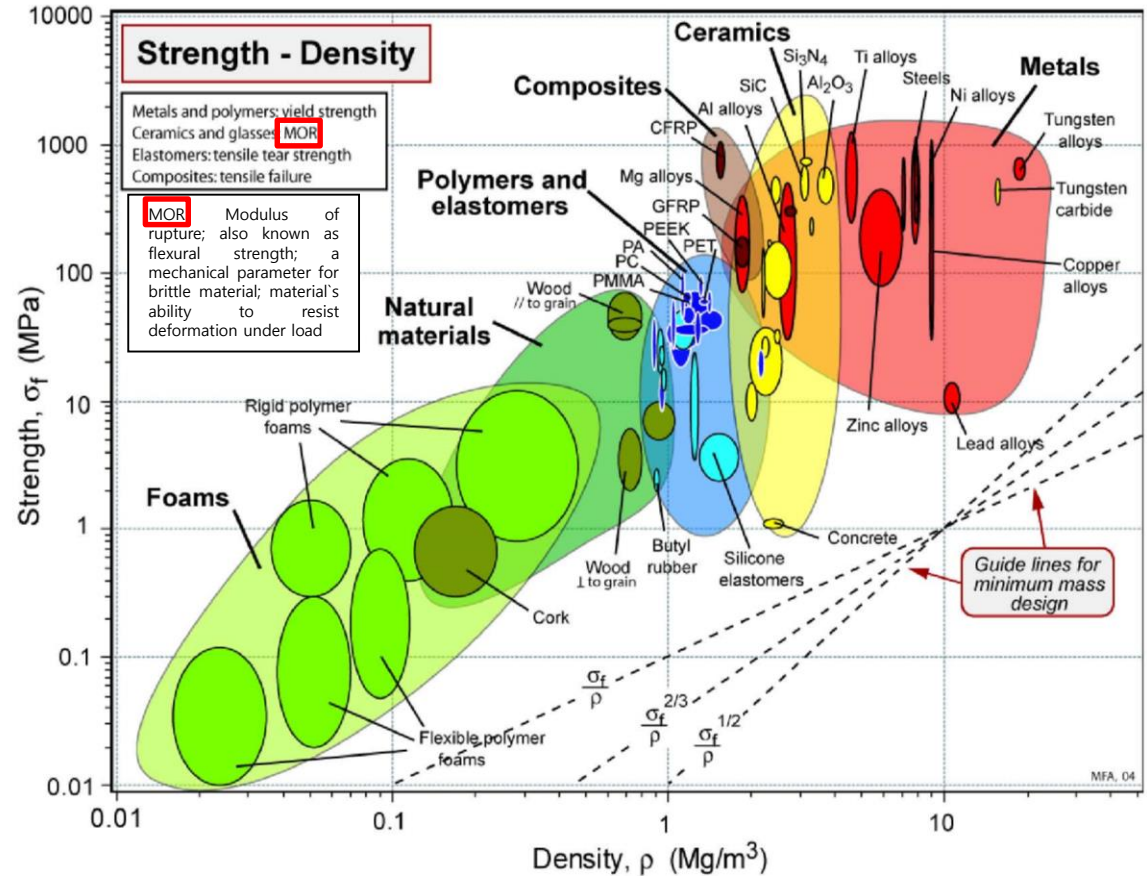
7. A material has a strength coefficient $K = 689{,}475.73$ kPa. Assuming that a tensile-test specimen made from this material begins to neck at a true strain of 0.17, show that the ultimate tensile strength of this material is 430,564.07 kPa.

8. An axle of a bike is loaded and supported as shown in the figures. Considering that the maximum stress and deflection of the axle are within tolerable limits($\sigma_{max} < \sigma_Y$, $\delta_{max} < \delta_{lim}$), select materials which minimize the mass of the axle using following Ashby chart or Material Database. (http://www.matweb.com/)
Constraints :

a. F and L are constants.
b. Structure has uniform density.
c. No torque is applied to the axle.
d. Ignore aspects which are not mentioned above.
(e.g. vibration, cost, heat, etc.)




Young's modulus - Density
Technical ceramics
Composites
Natural materials
Polymers
Foams
Elastomers
Metals
Longitudinal wave speed
10^4 m/s
10^3 m/s
10^2 m/s
Young's modulus, E (GPa)
Density, ρ (Mg/m3)
Guide lines for minimum mass design
MFA, 04


Strength - Density
Metals and polymers: yield strength
Ceramics and glasses: MOR
Elastomers: tensile tear strength
Composites: tensile failure
MOR Modulus of rupture; also known as flexural strength; a mechanical parameter for brittle material; material's ability to resist deformation under load
Ceramics
Composites
Polymers and elastomers
Natural materials
Foams
Metals
Strength, σf (MPa)
Density, ρ (Mg/m3)
Guide lines for minimum mass design
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