

MASSACHUSETTS INSTITUTE OF TECHNOLOGY  
DEPARTMENT OF MATERIALS SCIENCE AND ENGINEERING  
CAMBRIDGE, MASSACHUSETTS 02139

3.22 MECHANICAL PROPERTIES OF MATERIALS  
PROBLEM SET 6

Due in 8 days from its assigned date

Reading

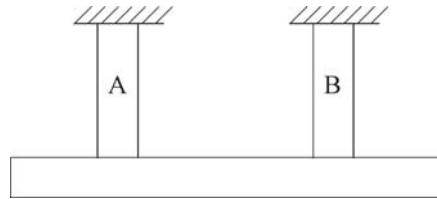
Hertzberg, *Deformation and Fracture Mechanics of Engineering Materials* (John Wiley & Sons, Inc.)

Chapter I, sections 3 – 6.

Ashby, M.F., *Mechanical Behaviour of Materials* (Course Notes). Section 6.

Dowling, *Mechanical Behavior of Materials* (Prentice Hall) Chapter 7, sections 1,2,4.

1. (Hertzberg 1.11) A platform is suspended by two parallel rods, as shown in the sketch, with each rod being 1.28 cm in diameter. Rod A is manufactured from 4340 steel [ $Q + T$  (650°C)] ( $E = 210$  GPa,  $\sigma_y = 885$  MPa); rod B is made from 7075-T6 aluminum alloy ( $E = 70$  GPa,  $\sigma_y = 505$  MPa).
  - a. What uniform load can be applied to the platform before yielding can occur?
  - b. Which rod will yield first?  
(*Hint*: Both rods experience the same elastic strain)



2. (Hertzberg 1.27) A 40 cm diameter pipe is used to carry a pressure of 20 MPa without yielding. The alloy choices are Al 2024-T3 ( $\sigma_y = 345$  MPa,  $\rho = 2.7$  g/cm<sup>3</sup>, cost = \$2/Kg) and 1015 steel ( $\sigma_y = 315$  MPa,  $\rho = 7.9$  g/cm<sup>3</sup>, cost = \$0.5/Kg). With a safety factor of unity, compute
  - a. the lightest, and
  - b. the cheapest pipe per unit length, based on the two possible alloy choices.
3. (Hertzberg 1.30) A 7178-T6 aluminum alloy ( $\sigma_y = 540$  MPa) is to be used to make a thin-walled cylindrical pressure vessel. If the diameter is 40 cm, what wall thickness is required to ensure that a pressure of 50 MPa will result in a maximum stress no greater than 50% of the alloy's yield strength?

4. Consider a metallic material with a yield strength  $\sigma_y = 250$  MPa subjected at all points to the stress state

$$\sigma_{ij} = \begin{bmatrix} 100 & 150 & 5 \\ 150 & 100 & 10 \\ 5 & 10 & 100 \end{bmatrix} \text{MPa} .$$

Determine if yielding occurs using the Tresca and Von Mises yield criteria. Discuss the significance of the two yield criteria relative to each other.

5. A cylindrical steel pressure vessel ( $\sigma_y = 320$  MPa) has a diameter of 10 cm and a thickness of 1 mm.
- What pressure is required to produce yielding in the wall of the vessel?
  - What is the equivalent plastic strain increment in terms of the increment of normal plastic strain in the hoop direction?