Lecture 12

Fundamental Concepts in Structural Plasticity

Problem 12-1: **Stress yield condition**

Consider the plane stress yield condition in the principal coordinate system σ_1, σ_2

a) Calculate the maximum difference $\|\sigma\|$ between the Von-Mises and Tresca yield condition

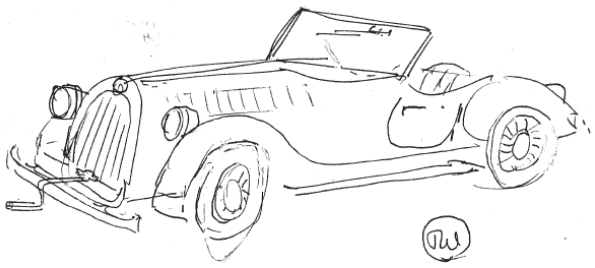
b) Show the locations on the plane stress graph where the maximum difference occurs

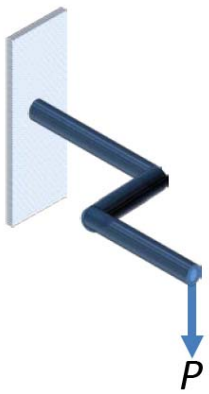
Problem 12-2:

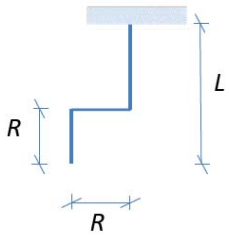
In the early twenties, passenger cars did not have electric starters. The driver had to use a crank to start the engine. The crank is a solid rod of radius r and the geometry of the crank is shown below. Define the equivalent stress by $\overline{\sigma} = \sqrt{\sigma^3 + 3\tau^2}$ where σ sigma is the stress produced by bending and τ is the shear stress due to torsion.

a) Find the relationship between the maximum equivalent stress in the crank and the magnitude of the crank load P. (Use the principle of superposition)

b) Derive a formula for the elastic deflection under the load P in the direction of the load P.







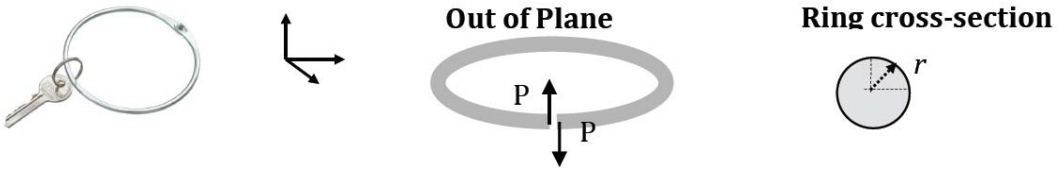
Problem 12-3:

Consider a thin-walled tube of radius r, thickness t and length L. The tube is fully clamped on one end and free on the other. It is twisted at the free end by an axial torque T.

(a) Derive an expression between torsional moment and the relative end rotation.

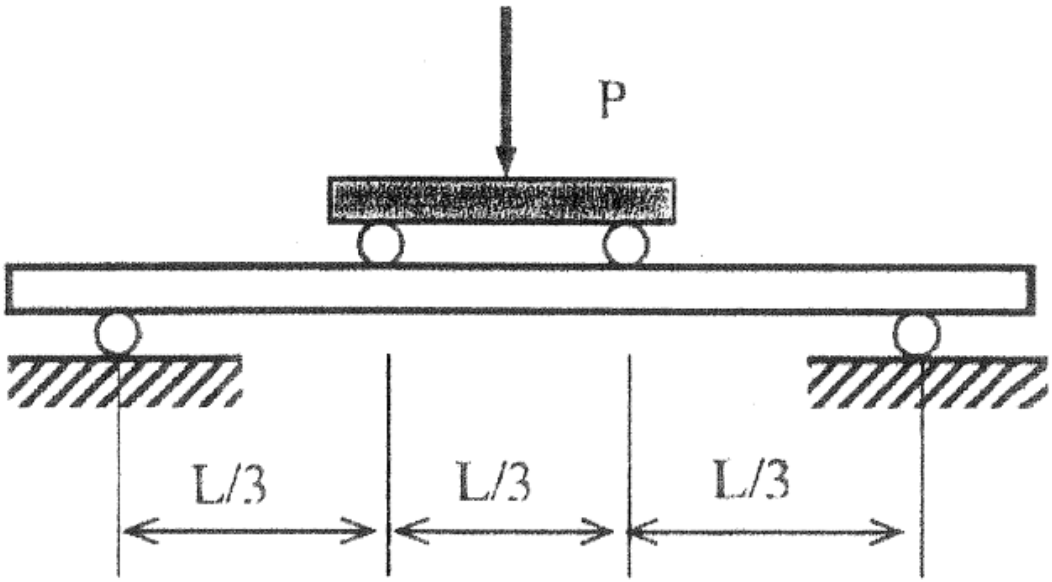
(b) Assuming L/R=10 and R/t=10, give the expression for the critical torque that will cause the tube stress to reach yield in shear.

Problem 12-4: Consider the following key ring problem



a) Derive the out of plane displacement where the force is applied.
b) Determine the magnitude and distribution of the bending stress and the shear stress along the ring.
c) Find the location of the maximum equivalent plastic strain.
d) Determine the critical opening force for which first yield would occur. Consider the plane stress

Problem 12-5: Plasticity



Consider the four –point bending of a beam of length L. The beam is loaded by two rollers parted by a distance of L/3. The material of the beam is rigid, perfectly plastic. Determine the load capacity of the beam under two different end conditions.

a) Write an expression for fully plastic bending moment of a beam of rectangular cross-section $b \times h$.
b) Ends of the beam are simply supported
c) Ends of the beam are clamped

2.080J / 1.573J Structural Mechanics
Fall 2013