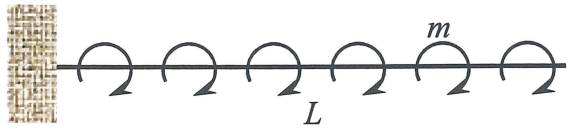
Tentamen
SOLID MECHANICS (NASM)
October 30 2008, 9–12 h

Question 1 A thin plate of thickness h with elastic constants k and μ is loaded by in-plane principal stresses σ_1 and σ_2. Assuming plane stress in the direction perpendicular to the plate, determine how much the plate thins down as a function of the stress state.

Question 2 A cantilever of length L and bending stiffness EI is subjected to a distributed *moment* per unit of length, m.

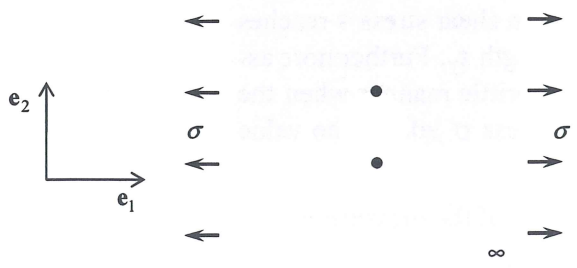


a. Determine the distribution of the bending moment M in the beam

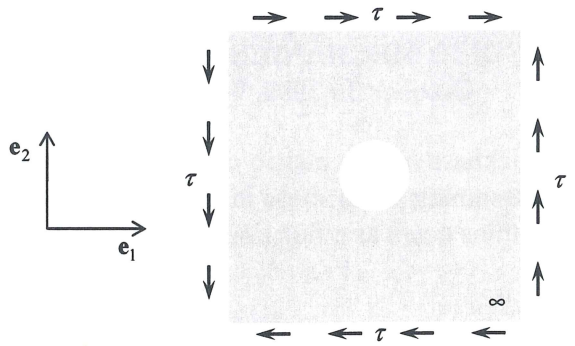
b. Compute the end displacement

c. Compare the result with the 'vergeet-me-nietjes' in Fig. 3.6 and explain the connection

Question 3 An infinitely large plate of an isotropic elastic material contains a circular hole. It is known that when the plate is subjected to remote uniaxial tension there is a stress concentration of a factor 3 at the two locations indicated by the dots in the following figure, i.e. at these points $\sigma_{11} = 3\sigma$.



a. What is the value of the stress concentration factor under remote compression and where are the locations of the highest stress?

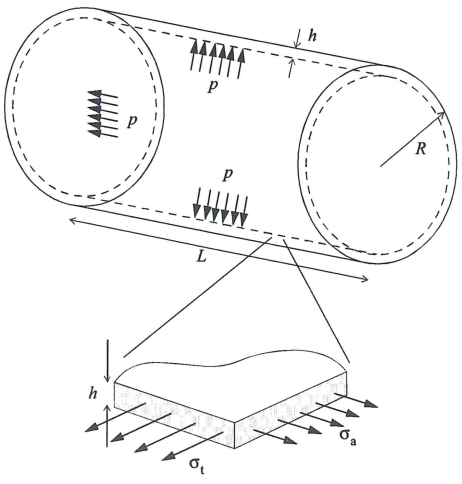


b. Determine the location of the highest principal stresses when the plate is subjected to a remote shear stress τ. What is the value of the stress concentration factor (defined as the ratio between highest principal stress and τ)?

Question 4 Consider again the pressurized cylinder of Exer. 2.10, where the stress state inside the wall is characterized by a uniform axial stress σ_a and a tangential stress σ_t given by

$$\sigma_t = 2\sigma_a = \frac{pR}{h}.$$

For the design of vessels etc. for safety and reliability, both the initiation of plastic deformation and brittle fracture are regarded as failure. Therefore, it is important to be able to calculate the maximum pressure as a function of the material's failure properties. Imagine the rather realistic scenario that the polycrystalline structure of the metal is not known; hence, one cannot perform a crystal plasticity calculation (and often one does not even want to do so). A first estimate, however, can be made by assuming that plasticity starts when the maximum shear stress τ reaches the material specific yield strength τ_y. Furthermore assume that fracture takes in a brittle manner when the maximum principal tensile stress σ attains the value σ_b.



a. Express σ and τ in terms of the pressure p.

b. When does failure take place by fracture?

c. Generally brittle fracture is a more catastrophic event than plasticity, so that the occurance of yield is considered to be favorable. What is the necessary value of the yield strength in order that yield occurs prior to fracture?