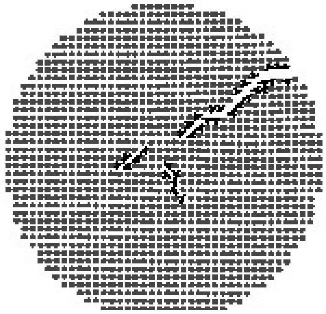


ME 4733: Deformation and Fracture of Engineering Materials

Spring 2002

Problem Set 3

Problems are due at the beginning of the class, Friday, February 15. If you turn in the solutions at the Wednesday's class (2/13), you can get 2 extra points. No credit for homework turn in after or during Friday's class.

1) Hertzberg, 3.6 (a little different)
From the work of Andrade and Roscoe, *Proc. Phys. Soc., London*, **49**, 152(1937), the following data were taken relating to the deformation of cadmium single crystals.

A (mm^2)	Force (g)	λ	ϕ
0.172	53.2	80	10.1
0.1835	21.8	54.2	38.7
0.181	24.5	30.5	61.4
0.185	35.2	35.2	70.6
0.191	37.2	23.3	72.3
0.181	41.0	20.1	75.4
0.179	46.0	11.8	78.2

where

ϕ = angle between loading axis and normal to slip plane
λ = angle between loading axis and slip direction
F = force acting on crystal when yielding begins

(a) What is the meaning of "*Proc. Phys. Soc., London*, **49**, 152(1937)"? Find the title for this paper from the library. Briefly describe the procedure to get the data.
(b) What are the probable slip systems?
(c) Calculate the resolved shear τ_{RSS} and normal σ_n stresses acting on the slip plane when yielding begins.
(d) From your calculations, does τ_{RSS} and σ_n control yielding? Explain how?
(e) Plot on graph paper the Schmid factor versus the normal stress acting on the rod.

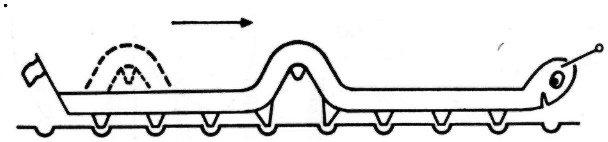
2) Hertzberg, 3.20

A cylindrical single crystal rod of Zirconium is loaded in compression normal to one of its prism planes.

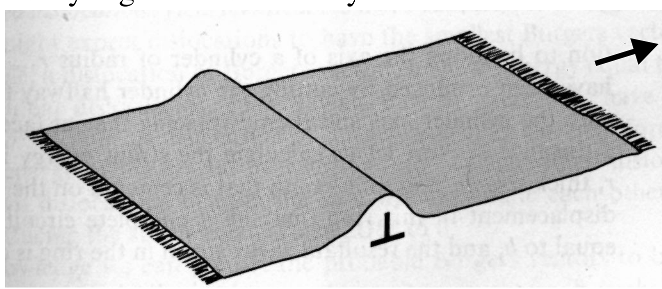
(a) What load is necessary to deform the metal if the crystal diameter is 1.2cm and the yield strength is 400kPa

(b) Speculate as to whether this load would change if the direction of the loading were reserved.

3) The concept of dislocation explains that ductile crystalline materials can slip at much lower stress level. Explain the similarities of this material behavior with the following behaviors:
(a) A caterpillar walks over stepping-stones by passing a dislocation between itself and the periodic substrate.



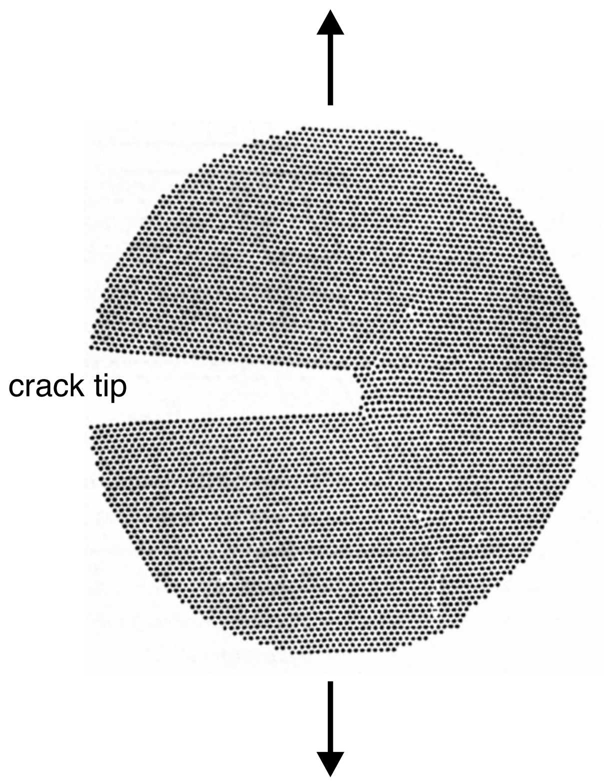
(b) How to move a heavy rug ahead effectively?



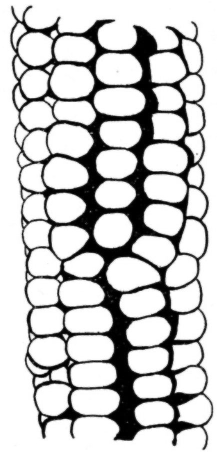
(c) Give another example that has a similar dislocation behavior.

4) Using a 2-diemsional atomic model I simulated the crack-tip atomic behaviors. A two-dimensional atomic model is an idealized model assuming no out-of-paper movements for all the atoms considered. There are inter-atomic bonds between atoms (solid circles in the following figure).

Dislocation emissions from the crack tip can be easily observed. In the following figure, locate the dislocations inside the 2D atom lattice surrounding the crack tip. Also show the movement directions for those dislocations.



5) Edge dislocation is introduced by wedge an extra half plane of atoms into the lattice. There is nothing mysterious about the appearance of edge dislocations as static pattern. Here are two pictures show the pattern defects similar to edge dislocations. Try to find another similar pattern as edge dislocation.



(a) A dislocation pattern in a corn-cob

(b) The strips on zebra has dislocation-like pattern