MSE C113/ME C124
Mechanical Behavior of Engineering Materials
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October 6, 2005

Midterm Exam No. 1

1. Consider the following statement: "A single dislocation in an infinitely large crystal would have infinite elastic energy." (25 points)

   (a) Give the equation on which the statement is apparently based, defining all terms.

   (b) Is the statement true? Give a brief, qualitative rationale for your answer.

   (c) In a real crystal containing, say, 1×10^7 dislocations/cm^2 the total elastic energy is finite. Explain why. If you were asked to estimate the magnitude of this energy, explain how you would proceed.

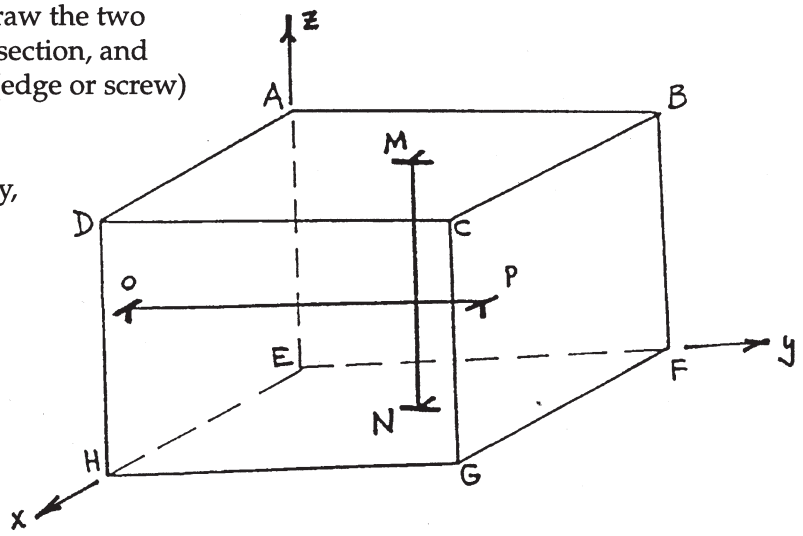
2. The sketch below shows a cube of crystal containing two dislocations. (30)

   (a) Sketch the slip planes of the two dislocations and identify each plane by the index letters at the corners of a plane to which they are parallel, for example ABCD.

   (b) Show how dislocation OP moves when each of the following shear stresses is applied (as a couple), and sketch these stresses on a crystal cube in each case:
   (i) τ_{zy}
   (ii) τ_{zx}
   (iii) τ_{xy}

   (c) If the dislocation moves under one or more of the stresses in (b), assume it intersects with MN. Draw the two dislocations after intersection, and indicate the character (edge or screw) of the resulting jogs.

   (d) Do the jogs in (c), if any, affect motion of the dislocations on which they are located? Give a brief explanation.



3. At temperatures somewhat above room temperature, crystals of the ionic alkali halide KCl are quite plastic. Assume you are conducting mechanical tests on this material.

(25 points)

(a) Sketch a typical curve for *engineering stress* vs. *engineering strain* which could be observed in such a test. Show on the curve where the following features are defined or located:

(i) Ultimate tensile strength;
(ii) Uniform elongation;
(iii) Young's modulus;
(iv) 0.2% offset yield strength.

(b) Assume now that such a crystal is loaded with the following stresses:
$\sigma_x = 40$ MPa, $\sigma_y = -20$ MPa, $\tau_{xy} = 11$ MPa.

Draw the Mohr's circle for this loading, determine the principal stresses, and find the orientation of the principal stresses relative to σ_x, σ_y.

4. Choose the right answer and give a one-sentence explanation of your choice. (1 point for the answer; 3 points for the sentence)

(20)

a) When screw dislocations are intersected, jogs are formed; these jogs strongly impede, weakly impede, do not impede, reverse, assist subsequent dislocation motion at low temperatures.

b) The force on a dislocation is always, never, 2/3 of the time, sometimes, 1/4 of the time in the direction of the Burgers vector.

c) The von Mises criterion for yielding is based on maximum tensile stress, hydrostatic stress, deviatoric stress, fracture stress, invariant stress, maximum shear stress, necking stress.

d) The critical resolved shear stress for yielding is strongly, inversely, weakly, proportionately, not dependent on the orientation of the single crystal studied.

e) Principal stresses are the stresses (at a particular orientation) for which the shear stress is larger than, equal to, proportional to, smaller than, zero relative to the tensile stress.