Take Home Exam02D.2: Force on a Dislocation and Energy

Assigned: Friday 02/25/2022

Due (as pdf by email) 03/02/2022 (Wednesday)

You may submit your answers in one of two ways:

(i) •For typed answers: as a .docx file (as is) or converted into a pdf file. (DO NOT SEND GOOGLE DOC)

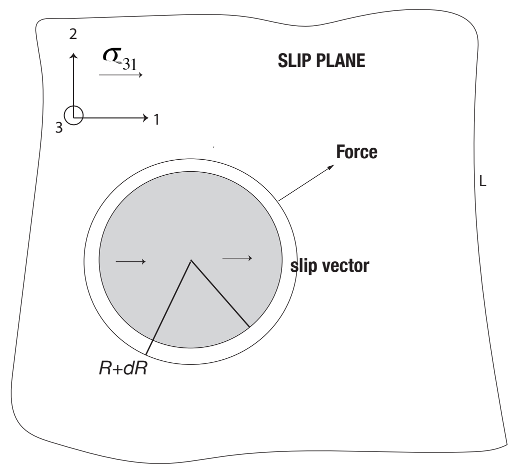
•For handwritten answers: Please scan as images, and group together into one pdf file. Or you may hand them manually to my office (ECME-212)

(ii) Please send your submission via email starting with HWExam02D1 in the subject line.

HW 02D2.1

The following equation related the radius of curvature of a dislocation loop to the applied stress. G and b have the usual meaning

$$\sigma = \frac{Gb}{2R} \qquad \text{(D2.3)}$$



Consider a circular dislocation loop which is held open by an applied stress σ to a radius R, where the applied stress exerts a outward force on the dislocation line equal to σb per unit length of the dislocation This force is perpendicular to the line of the dislocation, that is an outward force on the loop.

Now apply the virtual work principle We perturb the circle to extend it slightly; in this way the applied stress does a small amount of work equal to the total force on the circle multiplied by the expansion of the circle (dR).

This work is now stored as the increased energy of the dislocation because it is now of slightly greater total length.

HW 02D2.2

Stress is defined by two vectors, one is the vector normal to the plane to which the force is applied, and the second is the direction of the force. For example, σ_{31} is the applied to the plane normal along (003) in the direction [100].

A dislocation is also defined by two vectors: (i) the slip vector which is a constant everywhere for the dislocation, and (ii) the line vector which meanders with the shape of the dislocation line.

In simple language (fifty words or less) explain

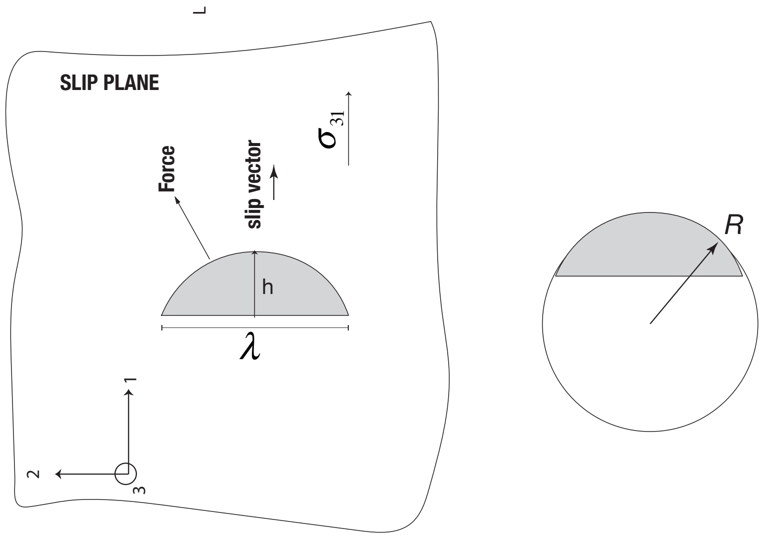
(i) why the at least a (nonzero) component of the slip vector must be parallel to the vector associated with the direction of the force in the stress tensor? and

(ii) why the force exerted on the dislocation is always normal to the line vector of the dislocation.

HW 02D2.3

A segment of a dislocation is pinned between two particles (or points) that are spaced by λ. The dislocation segment bows out in a circular shape when a stress is applied (while remaining pinned at the particles).

- You are asked to develop an equation the relates the applied stress, σ, to the distance the dislocation moves away from the line joining the particles, shown as "h" in the figure below.
- Show that the stress reaches a maximum value when $h = R$.



Hint: use the method and the result in problem HW 02D2.1 to address this problem. It is simply a matter of geometry. Also note that the force on the dislocation segment is the same as it would be for the full circle of radius R shown on the right.