

Department of Materials Science and Engineering
Massachusetts Institute of Technology
3.14 Physical Metallurgy – Fall 2003

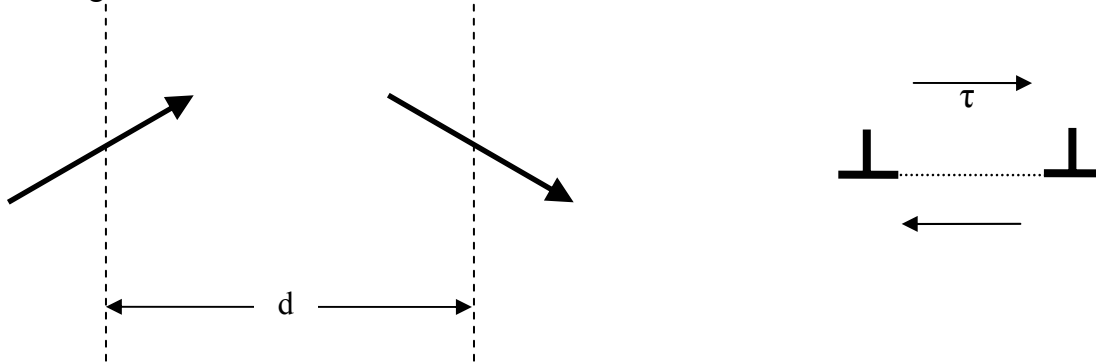
Quiz #1 Solutions

September 24, 2003

The Rules: 30 minutes, no calculators, props or crutches of any kind. Complete both problems with answers of the highest quality.

Problem #1:

On your homework, you considered the forces associated with the splitting of a full dislocation into two partials separated by a stacking fault. The partial dislocations are the dashed lines, with the Burger's vectors shown as arrows:



Imagine now that you apply a shear stress to such a split dislocation, as shown above at the right.

Part A: Briefly describe what would happen on loading and unloading if the leading partial (the one at the right) were pinned in place (due to, e.g., the presence of an obstacle). **(2 pts)**

The trailing partial moves to the right and the stacking fault between them shrinks. The repulsion between the dislocations as they pile up is strong, however. When the load is removed, the trailing partial moves back to its original position.

Part B: Briefly describe what would happen on loading and unloading if the trailing partial (the one at the left) were pinned in place. **(2 pts)** Is this case symmetric to the one in Part A? Why or why not? **(1 pt)**

The leading partial will move to the right on application of the load creating a larger stacking fault. The distance it moves will be related to energy of broadening the stacking fault. After the load is removed, the leading partial will return to its equilibrium spacing.

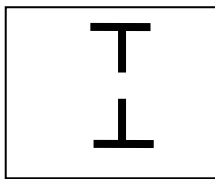
The two cases are not symmetric: the repulsive forces (edge-edge interactions) are not equal to the attractive forces (screw-screw interactions and stacking fault energy). The leading partial in part b will move further than the trailing partial in part a due to this imbalance.

Problem #2:

An edge dislocation dipole looks like this:



Part A: Give a simple physical reason why this configuration is of lower energy than other competing configurations like these: **(2.5 pts)**



It may help to draw a picture or two...

Due to the shape of the stress field around a dislocation, the configuration shown will allow the most overlap of stress fields and cancel out the stresses. The dipole in the box on the left will have the large compressive stresses overlapping, causing an energetic nightmare. The dipole in the box on the right is spaced too far apart to allow for any benefits of stress field cancellation.

Part B: Despite being of opposite sign, these edge dislocations do not annihilate. Explain why not. **(1 pt)**

They are on different slip planes, and can't leave their slip planes in order to annihilate.

Part C: Explain why this dipole is unstable if the dislocations are screw-type instead of edge-type. **(1.5 pts)**

Screw dislocations do not have a unique slip plane, therefore they can annihilate each other.