Problem 1 (10 points). A non-planar dislocation loop is shown in the diagram below. All of the dislocation segments are parallel or perpendicular to the coordinate axes shown. The segment labeled L-A is a positive edge dislocation.

(a) Determine the character of the segments C-D, D-E, E-F and F-G.

(b) Assuming that all of the screw dislocation segments are locked and are not free to move, determine which of the dislocation segments will move in response to a positive shear stress, $\sigma_{xy}$. Indicate the direction of motion of those segments that will move in response to this shear stress.

Problem 2 (10 points). A pure right handed screw dislocation is shown in a crystal in the diagram below. The dislocation is made to glide, first in plane 1, next in plane 2, then in plane 3 and finally in plane 4, such that the dislocation returns to the initial position. Describe what happens to the shape of the crystal when the dislocation traverses that path 100 times. The dislocation can take such a path by cross-slipping from one crystallographic plane to another.
**Problem 3.** Three circular glide dislocation loops lying on a close packed plane in an FCC crystal are shown in the figure below. The Burgers vectors of the loops, which are of the type $a/2<110>$, are indicated by the double ended arrows (the precise Burgers vector depends on the choice of tangent vector). The magnitudes of the Burgers vectors of the loops are assumed to be the same. If the loops expand by glide, they can combine with each other to produce the heavy grey dislocation structure shown. Determine the character (sense vector, Burgers vector, half plane, etc) of each of the dislocation segments AO, BO and CO.

**Problem 4.** The definition of dislocation density is the total dislocation length ($\text{m}$)/the sample volume ($\text{m}^3$). It is not easy to measure the total length of dislocations because they are always curved. An alternative way to measure the dislocation density is ‘the line intercept method’. The dislocation density of the line intercept method is given by

$$\rho_d = \frac{N}{L \cdot t},$$

where $\rho_d$ is the dislocation density, $N$ is the number of intercept points between the random straight line and dislocation line, $L$ is the total line length of random straight lines and $t$ is the sample thickness. As an example, there is one random straight line and the intercept points on that line in the figure below.

(a) Draw 5 more random straight lines across the image (from the one side to the opposite side) and count the total number of intercept points. Then, calculate the dislocation density assuming the thickness of sample is 100 nm. (The random lines should not be too close to each other. Ignore the screw dislocation direction in figure.)
(b) Obtain the mean spacing between dislocations.

(c) Apply a shear strain pulse, 0.01 for 0.1 millisecond (assume that this is a plastic shear strain). Obtain the average dislocation velocity under this condition. The magnitude of Burgers vector is 0.22 nm. Assume that dislocation density does not change during the application of shear strain pulse and that all the dislocations are on the same slip plane to which the pulse is applied.