MS 730 - In class exam #2 – closed book, closed notes. Show all your work and make sure your units work out correctly.

1. Consider a straight dislocation interacting with spherical precipitates of radius, r, and average spacing L. Gp and Gm are the shear modulus of the precipitate and the matrix respectively. The Burgers vector of the precipitate and matrix are bp and bm. The interfacial energy of the precipitate is and the anti-phase boundary energy is APBE for an ordered precipitate.
   1. How does the energy of the dislocation change as it passes through the precipitate if Gp = Gm and the Burgers vectors are different. Give an algebraic answer and a schematic answer. Make sure your schematic indicates the distances properly.
   2. How does the energy of the dislocation change if bp = bm and the shear moduli are different. Give and algebraic and schematic answer. Make sure your schematic indicates the distances properly.
   3. ***Derive*** expressions for the increase in resolved shear stress for part a and part b.
   4. Which will have a bigger effect; a precipitate with a 10% increase in modulus or a 10% increase in Burgers vector and how much bigger with that effect be?
2. Consider a system with 10 nm diameter ordered precipitates with APBE = 0.1 J/m2 and a precipitate-matrix surface energy of 0.05 J/m2 occupying 30% of the volume. The Burgers vector of the matrix and the precipitate is 0.255 nm and the shear modulus the matrix and the precipitate is 26.1 GPa.
   1. What is the approximate equilibrium spacing of perfect dislocations in the ordered crystal? Is this larger or smaller than the precipitate?
   2. Estimate the increase in *flow* stress from the combination of order and chemical hardening based on the straight dislocation derivation.
   3. If the excess solute has been all precipitated out, the volume fraction of precipitate will remain constant. However, the particles will coarsen to minimize their surface energy. This results in an increase in both radius and spacing. At what radius will the stress from particle looping be less than the stress from particle cutting? Give an algebraic answer first and then evaluate the expression making sure your units are correct.
3. Assume the theoretical shear stress of the matrix of a system with impenetrable precipitates is G/30.
   1. If the precipitate volume fraction is 30% and the precipitate radius is 100b, at what shear strain will the back stress from geometrically necessary dislocations be equal to the theoretical shear stress? You may assume the lattice friction stress is negligibly small.
   2. What is the average dislocation spacing at this strain? Does your answer take the volume of precipitates into account?