Donald P. Shiley School of Engineering
EGR 221 Materials Science
Assignment 8, Fall 2015

NOTE: various graphs, some from your textbook, have been included at the end of this assignment. They may or may not be useful. If you do use them in your work, be sure to copy them into your homework – mark on them appropriately, and **cite** them (eg. "Figure 8-11 in the textbook").

1. Briefly cite the differences between recovery and recrystallization processes.
2. Explain the differences in grain structure for a metal that has been cold worked and one that has been cold worked and then recrystallized.
3. (a) What is the driving force for recrystallization?
   (b) What is the driving force for grain growth?
4. You are a design engineer responsible for determining appropriate degree of cold working of copper that best meets the following design criteria:

Criteria	**Importance**
Minimum yield strength of 40kpsi	Very important
Minimum ductility of 10%EL	Very important
Final thickness of 0.250 +/- 0.010 inch	Very important

   Fully annealed copper has a yield strength of about 20kpsi and ductility of 30%EL. What range cold working (%CW) would produce acceptable properties? What range of pre-cold worked thicknesses would be acceptable?
5. You are a design engineer responsible for selecting a material that best meets the following design criteria:

Criteria	**Importance**
Minimum yield strength of 18kpsi	Very important
Carry electrical current with minimal heating (therefore, good conduction)	Important

   Your lead engineer is recommending you consider either brass or commercially pure copper. Select a material (if it's an alloy, describe its composition, if you decide on cold working, describe degree of cold working) and briefly justify (explain) your decision.
6. Define the following: phase, system, component, homogeneous, equilibrium , free energy.
7. Consider the NaCl- H_2O phase diagram.
   a) The solidification temperature is decreased when NaCl (salt) is added to pure H_2O (water). What composition of this liquid solution (saltwater, aka, brine) results in the lowest solidification temperature? What is that temperature?
   b) If you add 3 pounds of salt (NaCl) to 7 pounds of water (H_2O) at +20°C and stir for a few minutes so that equilibrium is reached, the overall composition will be 30% NaCl and 70% H_2O. At +20°C, this will result in a nearly saturated single solution of brine. What is the composition of the brine (hint, this is a very simple question to answer – no tricks).

c) If you add 5 pounds of salt (NaCl) to 5 pounds of water (H_2O) at +20°C and stir for a few minutes so that equilibrium is reached, the result will be a two phase system composed of liquid (brine, aka, saltwater) and solid (NaCl). What is the composition of the brine (how much H_2O and how much NaCl)? What is the composition of the solid (hint, this is a very simple question to answer – no tricks – hint #2, the answer is *the composition of the solid is 100% NaCl*).

d) If you have a mixture of 5 pounds NaCl and 5 pounds H_2O at +20°C at equilibrium, and then completely separated the liquid (brine) from the solid (NaCl), how much would the liquid weigh? How much would the solid weigh?

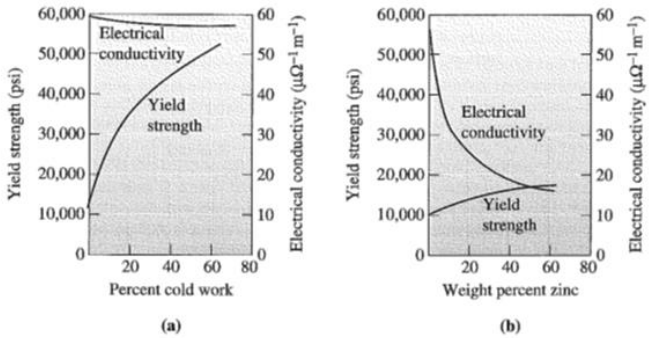

Figure 8-11 A comparison of strengthening copper by (a) cold working and (b) alloying with zinc. Note that cold working produces greater strengthening, yet has little effect on electrical conductivity.

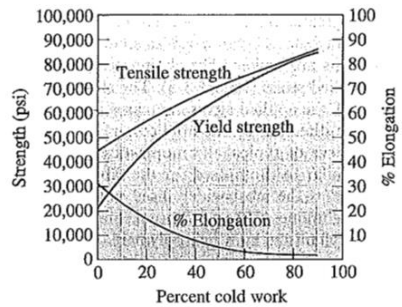

Figure 8-6 The effect of cold work on the mechanical properties of copper.