Final exam will be **CLOSED BOOK, CLOSED NOTES, NO CALCULATOR.**

All problems will be multiple choice (or true/false). These may be of similar form to those on the midterms, or they may similar to non-multiple choice midterm exam questions. For example, there may be a phase diagram question asking “what is the composition of alpha at 200 degrees C?” – with multiple choice answers. All questions will be similar in nature to mid-term exam questions – but the answers will all be multiple choice.

Determine planes and directions in cubic systems given the Miller indices, and visa versa

Understand how and why the following can affect strength: impurities (solid solutions), precipitates, grain boundary/grain size

Understand what causes dislocations to move, what inhibits them from moving, and what direction they move in a crystal (slip systems).

Understand the following mechanical properties and be able to determine them from a stress-strain curve: yield strength, tensile strength, toughness, ductility, Young’s modulus.

Understand the following mechanical properties and the testing used to determine them: hardness, Poisson’s ratio.

Be able to read phase diagrams and determine compositions of phases and determine how much of each phase is present given overall composition and temperature – and visa versa. This includes determining amounts of pearlite and proeutectoid ferrite (primary alpha) or proeutectoid cementite that may be present based on overall composition of plain carbon steel.

Understand the following microstructures in steel (how are they created, what are their morphologies, relative hardness/strength, toughness/ductility): austenite, pearlite, bainite, martensite, spheroidite, tempered martensite. Need be able to use a Time-Temperature-Transformation diagram (TTT diagram, a.k.a. isothermal diagram) to determine which of the above microstructures would be formed based off a given cooling history.

Understand the difference between hardening mechanisms of steel (such as formation of martensite) and precipitation heat treating of certain alloys (such as aluminum alloys).

Understand the microstructural differences between thermosetting and thermoplastic polymers (linear/branched vs. crosslinked/networked). Understand the general effect that temperature and strain rate have on strength, ductility and stiffness.

Understand the following types of corrosion well enough to explain how they are damaging and how they may be prevented: uniform attack, galvanic corrosion, crevice corrosion, pitting.

*(more on next page)*
**Additional Terminology:**

crystal
substitutional solid solution
interstitial solid solution
non-steady state diffusion (transient)
steady state diffusion
phase
free energy
equilibrium
metastable
composition

eutectic reaction (hint: “easily melted.” Definition: a reaction that upon cooling a liquid transforms isothermally into two solid phases).
eutectoid reaction (hint: like eutectic, but different – “oid” means “like”, an android is human-like. Definition: a reaction that upon cooling one solid transforms isothermally into two new/different solid phases).
elastic deformation
plastic deformation
isotropic (“iso” means same – same properties in all directions)
anisotropic (“aniso” means not the same – properties are direction dependent)

HINT: there will be questions on determining material properties using stress-strain curves, and there will be phase diagram questions.

PHASE DIAGRAMS: you MUST be sure to understand the difference between the following types of questions:

*What is the composition of a phase?* The answer will always be expressed as a percentage of each element. For example, the answer could be alpha is composed of 16% Zn and 84% Cu

*How much of each phase is present (what is the weight/mass fraction of each phase)?* The answer would be something like: 30wt% alpha, 70wt% beta.

*Be sure to understand the difference between “microstructure” and phase.*

Microstructure terms include proeutectic alpha (aka primary alpha), eutectic structure, eutectoid structure, pearlite, bainite, spheroidite, tempered martensite, martensite (martensite is also a phase). Phases are what is shown on phase diagrams (α, β, Fe₃C, etc.). You should be able to answer questions similar to those on the last exam.

I highly recommend that once you think you understand these things, that you test your knowledge by doing the Chapter 9 practice problems listed on the course web page, then check your answers against the solutions posted.