**IET 307: Materials Science**

HW 6 (based on chapter 11), Due by 11.55 PM, October 10’Th, 2010

100 points

1. Explain in depth the four categories of steels, namely low, medium and high carbon steels and stainless steel concentrating on its composition, properties and typical applications. (10 points)

* Low Carbon Steel: contain less than about 25 wt%C and are unresponsive to heat treatments intended to form martensite; strengthening is accomplished by cold work. The alloys are relatively soft and weak but have outstanding ductility and toughness. They are also machinable, weldable and are the least expensive to make. Typical applications include automobile body components, structural shapes, and sheets.
* Medium Carbon Steel: carbon concentrations of about 0.25 and .60 wt%. They may be heat treated by austenitizing, quenching, and then tempering to improve their mechanical properties. They are most often used in the tempered condition. They are stronger than low carbon steels, but at a sacrifice of ductility and toughness. Applications include railway wheels and tracks, gears, crankshafts, and other machine parts and high-strength structural components calling for a combination of high strength, wear resistance, and toughness.
* High Carbon Steel: have carbon contents between .60 and 1.4 wt% are the hardest, strongest, and least ductile of the carbon steels. They are almost always used in a hardened and tempered condition. This causes them to be wear resistant and capable of holding a sharp cutting edge. The tool and die steels are high carbon alloys, usually containing chromium, vanadium, tungsten, and molybdenum. They are used in cutting tools and dies for forming and shaping materials, as well as in knives, razors, hacksaw blades, springs, and high strength wire.
* Stainless Steel: highly resistant to corrosion in a variety of environments. Their predominant alloying element is chromium. They are divided into 3 classes, and they have a wide range of mechanical properties combined with excellent resistance to corrosion which makes them very versatile in their applicability.

2. What is Cast Iron? What are the various types of Cast Iron? Explain each one of them in detail. (10 points)

Cast Iron: class of ferrous alloys with carbon contents above 2.14 wt% carbon

The different types of cast irons are gray cast irons, nodular iron, white cast iron, malleable iron, and compacted graphite iron.

3. What is Precipitation hardening? By what methods are they accomplished? Explain the methods. (10 points)

Precipitation Hardening: the process in which extremely small uniformly dispersed particles of a second phase within the original phase matrix; it must be accomplished by phase transformations that are induced by the appropriate heat treatments.

The methods that are used are solution heat treatment and precipitation heat treatment.

4. Write a detailed study of titanium and its alloys. (10 points)

Titanium has a relatively low density, a high melting point, and an elastic modulus of 107 GPa. It is extremely strong; room temperature strengths as high as 1400 GPa are attainable, yielding remarkable specific strengths. The major limitation of titanium is its chemical reactivity with other materials at elevated temperatures.

5. What are the five main casting methods for metals? Explain each one of them. How would you cast an engine block? (10 points)

* Sand: sand is used as the mold material. A two piece mold is formed by packing sand around a pattern that has the shape of the intended casting.
* Die: liquid metal is forced into a mold under pressure and at relatively high velocity, and allowed to solidify with the pressure maintained. A two piece permanent steel mold or die is employed; when clamped together, the two pieces form the desired shape. When solidification is complete, the die pieces are opened and the cast piece is ejected.
* Investment: pattern is made from wax or plastic that has a low melting temperature. Slurry is poured around the pattern, which sets up to form a solid mold or investment; plaster of paris is usually used. The mold is then heated, so that the pattern melts and is burned out, leaving the mold cavity that has the desired shape.
* Lost Foam: foam that can be formed by compressing polystyrene beads into the desired shape and then bonding them together by heating. As the molten metal is poured into the mold, it replaces the pattern which vaporizes. Upon solidification, the metal assumes the shape of the mold.
* Continuous: the refined molten metal is cast directly into a continuous strand that may have either a rectangular or circular cross section. Solidification occurs in a water cooled die having the desired cross sectional geometry.

You would cast an engine block with sand casting.

6. From the following list of applications, select the **most appropriate** metals and their alloys that suit them and cite at least one reason for your choice. Applications – (a) Engine block, (b) electric cable, (c) automobile body, (d) watch strap, (e) kitchen knife, (f) thermocouple, (g) hip transplant, (h) beverage can, (i) jet aircraft landing gear bearing, (j) dental restoration ; Metals – magnesium, aluminum, stainless steel, platinum, copper, gray cast iron, titanium, silver, carbon steels (10 points)

7. What is the Jominy end-quench test? Explain with a schematic (10 points)

All factors that may influence the depth to which a piece hardens are maintained constant.

8. Discuss whether it would be advisable to hot work or cold work the following metals and alloys on the basis of melting temperature, oxidation resistance, yield strength, and degree of brittleness: aluminum alloys, magnesium alloys, titanium alloys, copper alloys and tungsten (10 points)

9. Cite advantages and disadvantages of forming metals by extrusion as opposed to rolling (10 points).

* Rolling is the most widely used deformation process. It consists of passing a piece of metal between two rolls; a reduction in thickness results from compressive stresses exerted by the rolls. Cold rolling may be used in the production of sheet, strip, and foil with high quality surface finish. Circular shapes as well as I-beams and railroad rails are fabricated using grooved rolls.
* Extrusion is when a bar of metal is forced through a die orifice by a compressive force that is applied to a ram. The extruded piece that emerges has the desired shape and a reduced cross sectional area. Extrusion products include rods and tubing that have rather complicated cross sectional geometries; seamless tubing may also be extruded.

10. What is a shape memory alloy? Explain. What kind of metals are called shape memory alloys? (10 points)

Shape Memory Alloy: polymorphic, it may have 2 crystal structures, and the shape memory effect involves phase transitions between them

Nickel-titanium alloys and some copper base alloys are shape memory alloys.