Dr. M. Medraj Mech. Eng. Dept. - Concordia University

MECH 221 - Materials Science

LECTURES: Wed and Fri H-531 from 10:15 to 11:30 am

Instructor: Dr. Mamoun Medraj, P.Eng
e-mail: mmedraj@encs.concordia.ca
Dept. of Mech. & Ind. Eng., Room, EV 12.185

Office Hours: Wednesdays 2:30 to 4:00 pm.


Handouts: Available at http://users.encs.concordia.ca/~mmedraj/mech221.html

Midterm Exam: Friday October 20th, 2017

The midterm exam is optional. Students who write the midterm exam, however, will get the higher mark of the final exam plus the midterm or the final exam alone.

- Assignments will not be collected but the questions will be used as the basis for the In-Tutorial Assignment Problems.
- Also, some of the assignment problems and tutorials questions (or similar ones) will be asked in the exams. The solutions will be discussed in the tutorial sessions.

The In-Tutorial Assignment Problems will take place every second tutorial. The first one will be on Monday Sep. 18th or Friday Sep. 22nd.

MECH 221 - Materials Science

What is Material?

- Oils, gases, pharmaceuticals
- Iron, copper, polymers, cement:

- Material can be put into certain geometric shape
- The product has some

- Old materials: metals, wood, ceramics, skins, natural fibers, (papyrus)
- New materials:

- TAs:
  - Rahele Nikonam
e-mail: rahele_nikonam@ymail.com
  - Dulani Kodippili
e-mail: dulanipankaja@gmail.com

- Assignments will not be collected but the questions will be used as the basis for the In-Tutorial Assignment Problems.
- Also, some of the assignment problems and tutorials questions (or similar ones) will be asked in the exams. The solutions will be discussed in the tutorial sessions.

The In-Tutorial Assignment Problems will take place every second tutorial. The first one will be on Monday Sep. 18th or Friday Sep. 22nd.

Midterm Exam: Friday October 20th, 2017

The midterm exam is optional. Students who write the midterm exam, however, will get the higher mark of the final exam plus the midterm or the final exam alone.
Introduction: Historical Perspective

- Civilization strongly linked with materials
  Stone age, iron age, bronze age ... nuclear age, information age

- Sumerians: ceramics
- Egyptians: lime
- Anatolians: Iron (12th century BC)
- The earliest known Bronze is from what is now Iran and Iraq

Introduction

Technological advances have been materials driven:

- Transportation; engines, airframes, auto bodies
- Space exploration; shuttle tiles, high temp alloys
- Energy; solar power, batteries
- Communications; semiconductors

• Military uses ⇒ Commercial uses

What is Materials Science?

- Relationships between structure and .......... of materials

What is Materials Engineering?

- Structure-property correlations
- Design the structure of a material to impart some desired properties

Property: Response of a material to an external effect, such as

- Mechanical
- ..........
- ..........
- ..........

Properties are independent of material .................
General Course Outline:

- Structure
  - Atomic
  - Molecular
  - Microscopic

Properties

Atomic processing

Why study Materials Science?

(1) Important to understand capabilities and limitations of materials:

- The following are just a few examples of catastrophic failure caused by a lack of fundamental understanding of materials, their properties, and failure modes.

Examples of Catastrophic Failure

- **Liberty ships (WWII)**
- **D-B-T in BCC Fe (metal)**
- **Challenger (1986)**
- **failure of an O-ring seal (polymer)**
Examples of Catastrophic Failure

- **Hyatt Regency (KC)** walkway collapse (1981)
  - Overstressed steel support rods (underdesigned)

- **Alaska MD-80 crash** (1999)
  - Excessive wear on stabilizer jack screw

- **Tacoma Narrows Bridge Collapse** (1940)
  - Poor design – …………

- **de Havilland Comet** (first commercial jet) (1954 – 55)
  - Metal fatigue, aggravated by high stresses around rivet holes near window openings

- **United DC-10 crash** (Sioux City, IA) (1989)
  - Inclusion and cracking in primary #2 engine turbine blade

Examples of Catastrophic Failure

Why Study Materials Science?

(2) An understanding of Materials Science helps us to design better components, parts, devices, etc.

- How do you make something stronger or lighter?
- How do elements come together to form alloys?
- Why do some materials have vastly different properties than others?

(3) It is interesting and helps to make you a more informed person

Classes of Materials

There are 3 major classes:

1. **Metals**
   - Pure metallic elements or combination of metallic elements (alloys)
   - Large number de-localized electrons (conduct electricity)

2. **Ceramics**
   - Molecules based on bonding between metallic and non-metallic elements (including oxides, nitrides, carbides)
   - Typically insulating and refractory

3. **Polymers**
   - Many are organic compounds
   - Chemically based on C, H, other non-metals
   - Large molecular structures
**Sub-Classes of Materials**

**Semiconductors** (ceramics)
- Intermediate electrical properties

**Composites** (all three classes)
- Combinations

**Bio Materials** (all three classes)
- Materials compatible with body tissue

---

**Introduction**

**MATERIALS SELECTION**

Selection of the correct/appropriate or best material for the job.

Short List:
(a) Availability ?
(b) Properties ?
(c) ...... ? (Usually determining factor).

- In many cases a more suitable material is available but at an increased cost, e.g.
  - Car bodywork/exhausts
    - “mild” steel, rusts,
    - stainless steel, lasts much longer

- Cost not big problem in defence, sport, medicine.

---

**Trends in Materials Use**

- Materials ......

**Materials Design:**
- design of new materials to meet new requirements.
- design of new materials with a unique set of properties.
- design can include the development of a new or better processes for manufacturing of new or existing materials.

Next time: Chemistry Review