Banha University
Faculty of Engineering
Mechanical Engineering Department

ENGINEERING PHYSICAL METALLURGY

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Dr. Mahmoud Khedr

LECTURES

Lecturer: Dr. Mahmoud Khedr
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Office hour: Wednesday 10 - 12 pm

Class Meet

Location: Office:3 rd floor

Activities:

- Present new material
- Announce reading and homework
- Take midterms

Examinations & Evaluations

Final Exam	**60%**
Midterm Examination	**20%**
Oral Examination	**10%**
Tutorials, reports, absence	**10%**

COURSE MATERIALS

Required text:

- *Materials Science and Engineering: An Introduction*
  W.D. Callister, Jr., any edition.
- The Science and Engineering of Materials - Askeland

Complementary Material:

- *Clear Mind (think logically or whatever makes sense to you.)*
- *Curiosity (why ???)*

My requirements

- Read your textbook
- Do homework yourself

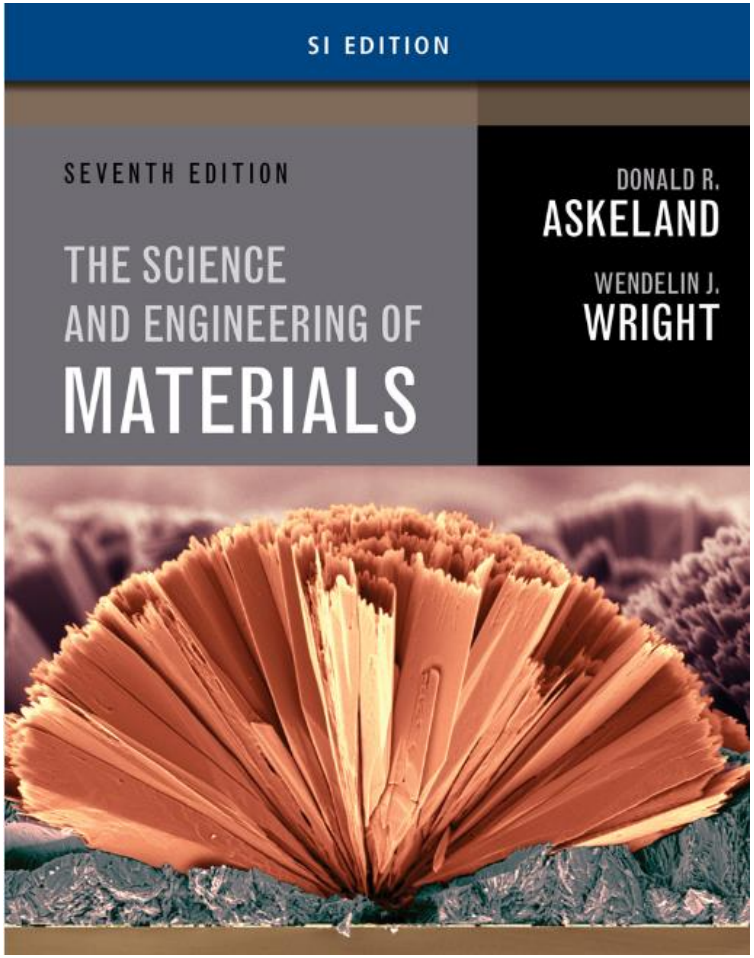
COURSE CONTENTS

1. Crystal Geometry.	2 Lectures
2. Binary Solutions	1 Lecture
3. Phase Diagrams	1 Lecture
4. Iron-Carbon System	1 Lecture
5. Single Crystal Deformation	1 Lecture
6. The Strengthening of Metals	1 Lecture
7. Heat Treatment Fundamentals	2 Lectures
8. Diffusion	1 Lecture
9. Non-Ferrous Alloys	1 Lecture

COURSE PLAN

First Semester 2016-2017(G)

Week No.	Theory	practice	Remarks
1	Introduction to engineering materials	Introduction	1. Assignments will be given at the end of each chapter(Theory) 2. Surprise quizzes will be distributed uniformly in 16 weeks (min 3)
2	Crystal structure	Assignment	
3	Binary solution	Assignment	
4	Phase diagrams	Assignment	
5	Phase diagrams	Assignment	
6	Iron-carbon phase diagram	Assignment	
7	Iron-carbon phase diagram	Assignment	
8	MID THEORY EXAM	Determination of % of Carbon	
9	Single crystal deformation	Annealing	
10	Strengthening of materials	Normalizing Processes	
11	Heat treatment fundamentals	Hardening & Tempering Processes	
12	Heat treatment fundamentals	Mechanical Properties of Heat Treated Specimens	
13	Diffusion	Case hardening	
14	Ferrous alloys non	Review	
15	Review	Oral exam	
16	FINAL THEORY EXAM		



Chapter 1

Introduction to Materials Science and Engineering

Chapter Learning Objectives

- **Understand primary concepts which define Materials Science and Engineering (MSE).**
- **Understand the role of materials science in the design process.**
- **Classify materials by properties.**
- **Classify materials by function.**

Prefixes for Fractions and Multiples

10^{-1}	deci	*d*	10	deka	*da*
10^{-2}	centi	*c*	10^{2}	hecto	*h*
10^{-3}	milli	*m*	10^{3}	kilo	*k*
10^{-6}	micro	μ	10^{6}	mega	*M*
10^{-9}	nano	*n*	10^{9}	giga	*G*
10^{-12}	pico	*p*	10^{12}	tera	*T*
10^{-15}	femto	*f*	10^{15}	peta	*P*

Roman Numerical

I II III IV V VI VII VIII IX X XI XII XIII XIV XV….

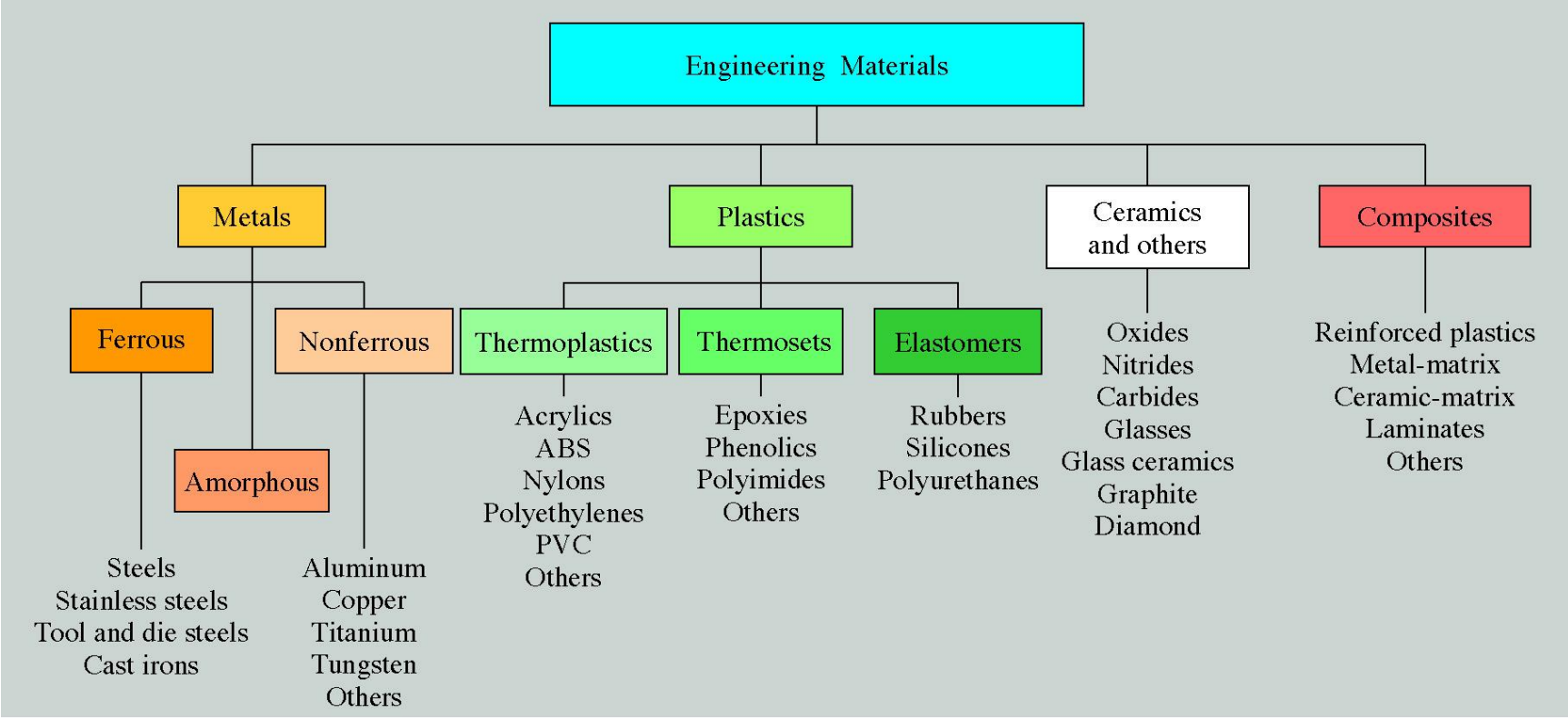
Chapter 1 - Introduction

- Materials drive our society regardless what age
  - **Stone Age**
  - **Bronze Age**
  - **Iron Age**
  - **Now?**
    - **Silicon? Nanotech? Energy?**

Introduction

CLASSIFICATIONS OF COMMON ENGINEERING MATERIALS

Engineering Materials



Further Classification

- **Metals**
  - **Ferrous**
  - **Non-ferrous**
  - **Super alloys**
- **Ceramics**
  - **Traditional ceramics**
  - **New ceramics**
  - **Glass**

Further Classification

- **Polymers**
  - **Thermoplastics**
  - **Thermosets**
  - **Elastomers**
- **Composite Materials**
  - **Metal Matrix Composites**
  - **Ceramic Matrix Composites**
  - **Polymer Matrix Composites**

Metals

- **Ferrous Metals**
  - **Cast irons**
  - **Steels**
- **Non-ferrous metals**
  - **Aluminum and its alloys**
  - **Copper and its alloys**
  - **Magnesium and its alloys**
  - **Nickel and its alloys**
  - **Titanium and its alloys**

Metals

- **Ferrous Metals**
  - Cast irons
  - Steels
- **Superalloys**
  - Iron-based
  - Nickel-based
  - Cobalt-based
- **Non-ferrous metals**
  - Aluminum and its alloys
  - Copper and its alloys
  - Magnesium and its alloys
  - Nickel and its alloys
  - Titanium and its alloys
  - Zinc and its alloys
  - Lead & Tin
  - Refractory metals
  - Precious metals

ENGINEERING MATERIALS

- **Basic Materials Groups:**

  Metals – Polymers or Plastics – Ceramics

- **Other Important Materials Groups**

  Composites – Electronic Materials – Biomaterials

(1) Metals

- A metal is an inorganic substance which composed of **one or more metallic elements** and may also contain some non-metallic elements (**non-metallic inclusions**).
- Metals also have **a crystalline structure in which the atoms are arranged in orderly manner.**
- Metals in general are **good thermal and electrical conductors**.
- Many metal are relatively **strong and ductile** at room temperature, and many maintain good strength even at high temperatures.
- Examples of metallic elements: **Iron (Fe), Copper (Cu), and Aluminium (Al).**

(1) Metals Cont.

- **Metals and alloys are commonly divided into two classes:**

1. ***Ferrous metals and alloys*; contain a large percentage of iron. Examples: Steels and Cast irons.**
2. ***Non-ferrous metals and alloys*; do not contain iron or only a relatively small amount of iron. Examples: Aluminium, Copper, Zinc, and Nickel.**

Metallic materials (stainless steel utensils for commercial kitchens). Metals posses ductility for the required processing.

(2) Polymers and Plastics

- They are materials containing of **long molecular chains** or network of low-weight elements such as carbon, hydrogen, and nitrogen.
- Most polymeric materials are **non-crystalline** but some consist of mixtures of crystalline and non-crystalline regions.
- Most polymeric materials are **poor conductors of electricity**. Some of these materials are good insulators and are used for electrical insulation applications.
- In general, they have **low densities** and relatively low softening or decomposition temperatures.

(3) Ceramic Materials

- They are inorganic materials which consists of metallic and non-metallic elements chemically bonded together.
- Ceramics can be crystalline, non-crystalline, or mixtures of both.
- Most ceramics have high hardness and high-temperature strength but tend to have mechanical brittleness.
- Most ceramics have high heat and wear resistance.
- Generally ceramics are light weight.
- Examples: Furnace linings, Tiles for the space shuttle, Spark plug coating for automotive applications.

Ceramic insulator in a spark plug. The insulator is primarily Al2O3, a compound of metal and non-metallic elements

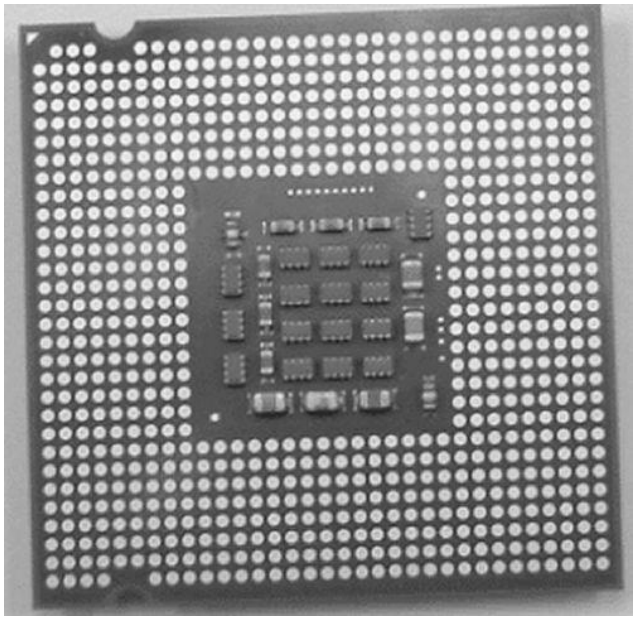
(4) COMPOSITE MATERIALS

- Composite materials are **mixtures of two or more materials.**
- Usually, **the components do not dissolve in each other** and can be physically identified by an interface between the components.
- Examples: Fibreglass, concrete, and Wood (timber).

Automobile tire is an example of the composite materials applications

(5) Electronic Materials

- Electronic materials are not a major type of material by volume but are an extremely **important type of material for advanced engineering technology.**
- The most important electronic material is **pure silicon** which is modified in various ways to change its electrical characteristics.
- Examples: Microelectronic devices have made possible such new products as communication **satellites, advanced computers, hand-held calculators, digital watches**, and welding robots.



Microprocessor, which is the central processing element of a microcomputer

(6) Biomaterials

- Biomaterials are employed in components **implanted into the human body** for replacements of diseased or damaged body parts.
- These materials **must not produce toxic substances** and must be compatible with body tissues (i.e. must not cause adverse biological reactions).
- All of the above materials - metals, ceramics, polymers, composites, and electronic materials- may be used also as biomaterials

Photograph showing mobile-bearing total knee.