

Course: ME 5223 - Materials in Design

Course objective:

The course will stress selection of materials to fulfill specific design and functional requirements, to guard against progressive and/or catastrophic failure, and to meet design-manufacturing requirements.

The course aims to provide the theoretical and science background for selection of materials used in engineered products and to provide practical guidelines for material selection in the design context. Similar considerations apply for process selection.

Since polymeric materials have come into extensive engineering use in machines and consumer products, discussion of design principles applicable to polymers (and rubbers) will be an integral part of this course.

The first part of the course will stress materials selection. The second part of the course will focus on polymeric materials and design with polymers. The final part of the course will focus on design against failure

Course content:

Part 1

- i. Review of required background in mechanics, engineering design and materials, and a review of principal considerations in materials selection.
- ii. Principles and rational basis for materials selection (Quantitative principles).
- iii. Materials selection without shape. Selection of material and choice of shape(s).
- iv. Material and process selection practice.

Part 2

- i. Introduction to polymers, polymer structure and properties.
- ii. Elastomers and rubbers, and geometric design of elastomeric structures for mechanical property control.
- iii. Visco-elasticity and creep, and composite materials. Thermo-mechanical treatment of polymers in polymer processing.
- iv. Elastic and pseudo-elastic design. Designing for stiffness and designing for strength.

Part 3

- i. Review of materials science, structure and properties of polymers, metals and ceramics with emphasis on mechanical properties.
- ii. Defect theory, strength of crystalline materials, phase diagrams, theory of microstructure and micro structural design. Dispersion hardened materials. Thermal treatment principles.
- iii. Fracture toughness, fatigue and fatigue failures. Materials selection for yield-based design, resistance to fatigue and fracture, creep, oxidation and corrosion.
- iv. Materials of current technology, consumer products and engineered commodities. Electrical, electronic, magnetic and optical materials. Fine, precision mechanical devices; sensors and transducers. Introduction to sensors and integrated sensors.
- v. Interaction between advances in materials, manufacturing technology and technological opportunities.

Course expectation:

For this senior elective, expected background includes prior completion of a course each in materials science, deformable body mechanics, and mechanical design. It is recommended that you review material from these courses as needed.

This course will:

- a. Emphasize product engineering concepts, trace them to their **design principles** and property requirements, examine the role that process design plays in generating and controlling properties and, thus, the role that materials and their mechanical/thermal treatments play in engineering design.
- b. Emphasize synthesis in engineering practice by stressing **product and process design**.

Course credit of 4 hours will require 6 and 8 hours/week of reading, review and work beyond class discussions.

Grading:

There will be one mid-term examination during the semester (for 30% of the course grade) and one two-hour final exam (for 40% of the course grade). Both examinations will be 'closed book'. Formulae needed for problems will be included in the exam paper as appropriate.

University/Institute of Technology policies on use of electronic devices during examinations apply (No Laptops, cell phones, PDAs, etc.) You are encouraged to acquire an inexpensive scientific calculator for use in the examinations.

Home Assignments:

There will be about 10 home assignments through the semester (for 30% of the course grade). Home assignment schedule will depend on course topic progression. No fixed assignment schedule should be expected. Typically home assignments are due 1 week after posting.

Late home assignments will not be accepted. When unavoidable, you will need to obtain instructor's permission for late submission. This should be requested only under exceptional circumstances. The same policy holds for mid-term and final examinations.

Lecture attendance is encouraged as is class room participation, raising discussion issues and participating in them. The course will only use your university e-mail address.

Classroom Matters :

It is expected that during classroom lecture and discussion sessions, your cell phone, laptop, PDA and other electronic/recording devices will be turned off to preclude distracting other students in the class.

Course Texts: **Materials Selection in Mechanical Design**, Michael F. Ashby, Elsevier (Butterworth-Heinemann), 3rd Edition, 2005. **Full Text Electronic Resource - Walter Library**

Plastics Engineering, R. J. Crawford, Elsevier, 3rd Edition, 1998. **Full Text Electronic Resource - Walter Library**

Library Reserve:

The following books have been placed on library reserve for your use during the semester:

1. **Principles of Polymer Engineering: N. G. McCrum, C. P. Buckley and C. B. Bucknall**, Oxford Science Publications, 2nd Edition, 1997
2. **"Materials: Engineering, Science, Processing and Design"**, M. F. Ashby, H. Shercliff, and D. Cebon, Elsevier, 2007

Useful full-Text Online Books in the Walter Library

[Materials Selection in Mechanical Design, M. F. Ashby, 3rd Edition](#)

[Plastics Engineering by R. J. Crawford \(3rd Edition\)](#)

[Plastics Microstructure and Engineering Applications by Mills \(2nd Edition\)](#)

[Roark's Formula's for Stress and Strain \(7th Edition\)](#)

[Mechanics of Materials Vol. 1 - An Introduction to the Mechanics of Elastic and Plastic Deformation of Solids and Structural Materials \(3rd Edition\)](#)

[Mechanics of Materials, Volume 2 - The Mechanics of Elastic and Plastic Deformation of Solids and Structural Materials \(3rd Edition\)](#)

[Military Handbook - MIL-HDBK-5H: Metallic Materials and Elements for Aerospace Vehicle Structures](#)

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For the two books on Polymers (by Crawford and Mills) listed above, Select Area : Plastics & Rubber