MSE 1030: Materials Selection
Syllabus for 2021 Fall

Instructor: Dr. Yingjie Wu (Office: Room 4-226; Email: yingjie.wu@scupi.cn)

Lecture: Tuesday, 1:50 pm - 4:25 pm, Room 3-102
Office Hours: Tuesday, 9:15 am – 11:55 am, Room 4-226
TA: Guodong Niu (Email: 2018223010033@stu.scu.edu.cn)
Prerequisites: ENGR 0022, MEMS 1028

Course Description:

This course teaches the essential methodology for materials selection in mechanical design processes, including: (i) design process and consideration, (ii) criteria for materials and their shape selection, and (iii) design case study. Mechanical components have mass; they carry loads; they conduct heat and electricity; they are exposed to wear and to corrosive environments; they are made of one or more materials; they have shape; and they must be manufactured. This course provides knowledge on how these activities are related.

Course Objectives:

The goals of this course are 1) to develop advanced understanding on the basic concepts and methodology of materials selection in mechanical design; 2) to advance better understanding on mechanical properties (i.e., fracture, fatigue, creep, deep drawability, etc.) of different materials; 3) to make materials information readily available to designers during the design process; 4) to achieve or improve on a specified product performance or eliminate a material or service failure; and 5) to solve processing difficulties and/or take advantage of new processing techniques, reduce material and/or production costs and rationalize on materials stockholding, anticipate or exploit a change in the availability of a material.

Applicable ABET Outcomes:

1. An ability to apply knowledge of mathematics, science, and engineering
2. An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
3. An ability to function on multi-disciplinary teams
4. An ability to identify, formulate, and solve engineering problems
5. An understanding of professional and ethical responsibility
6. An ability to communicate effectively
7. An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice

Required Resources:

There is no required textbook for this course. Useful supporting materials are listed as follows:
1. Ashby, M. F. *Materials Selection in Mechanical Design*, 4th ed. Burlington: Elsevier, 2011. Print.
2. Farag, M. M. *Materials and Process Selection for Engineering Design*, 3rd ed. Boca Raton: CRC Press, 2013, Print.
3. Ashby, M. F., Hugh Shercliff, and David Cebon. *Materials: Engineering, Science, Processing and Design*, 4th ed. Kidlington, Oxford, United Kingdom: Butterworth-Heinemann, 2019. Print.
4. Raman, A. *Materials Selection and Applications in Mechanical Engineering*. New York: Industrial Press, 2007. Print.
5. Dieter, G. E. *Mechanical Metallurgy*, 3rd ed. New York: McGraw-Hill, 1986. Print.
6. Meyers, M. A., and Krishan Kumar Chawla. *Mechanical Metallurgy: Principles and Applications*. Englewood Cliffs, N.J: Prentice-Hall, 1984. Print.
7. Smith, W. F. *Structure and Properties of Engineering Alloys*, 2nd ed. New York: McGraw-Hill, 1993. Print.

Course Content (tentative):

1. The Design Process
2. Initial Selection based on Mechanical Properties
2.1 Steps in Materials Selection
- *Mechanical properties and measurement*
- *Fundamentals of fracture*
- *Indices*
- *Selection charts*
- *Ranking*
- *Examples*

2.2 Stiffness and Strength of Composite Materials
- *Properties of fibers*
- *Stiffness of composites containing uniaxially aligned fibers*
- *Stiffness of composites containing discontinuous fibers*
- *Fracture of composites*

2.3 Materials and the Environment
- *Lifecycle of materials*
- *Energy consumption over material lifetime*
- *Eco-attributes and selection*

3. Complex Issues including Material Lifetime and Reliability
3.1 Fracture and Reliability
- *Fracture toughness and toughening*
- *Reliability of brittle materials*
- *Reliability of ductile materials*

3.2 Fatigue

S-N curve
Empirical relationships between fatigue lifetime and basic material properties
Fatigue of polymers

3.3 Corrosion Resistance

Definition of electrochemical corrosion
Anode and cathode reactions
Electrode Potentials and the galvanic series
Cathodic and anodic protection
High temperature oxidation

3.4 Creep and Stress Rupture

Lifetime prediction
Creep in single, two-phase systems and ceramics
Creep resistance

Grading Policies:

Requirements	**Corresponding Percentages**
Assignments (5)	25%
Design Projects (2)	20%
Individual Presentation	10%
Mid-Term Exam	20%
Final Exam	20%
Participation	5%

Grading Scale:

100% ≥ A ≥ 90%; 90% > A− ≥ 85%; 85% > B+ ≥ 80%; 80% > B ≥ 76%; 76% > B− ≥ 73%; 73% > C+ ≥ 70%; 70% > C ≥ 66%; 66% > C− ≥ 63%; 63% > D ≥ 60%; 60% > F.

Homework:

There will be about five homework assignments that will be submitted on Blackboard either as Word document or as pdf before the start of the class (1:50 pm) on the due day. If you are unable to attend a class, you may attach a note to your homework and submit it in advance. ***If homework is submitted late, you would lose 10% per day. You may receive no credit if homework is not submitted within a week from the due day.***

Design Projects:

The materials selection design projects are 2 longer assignments throughout the semester in which you will be asked to give suggestions for materials for a certain problem. For these projects, you will be able to use the CES EduPack software to select. The projects will be submitted on Blackboard either as Word document or as pdf. The document needs to be submitted to Blackboard ***before the start of the class (1:50 pm) on the due day***.

Design projects must include all steps of the Ashby process, they must include figures of the Ashby plots used for the project as well as values for all materials under consideration. The

final selection of the materials needs to be documented and supported not only by the materials database but also common materials engineering understanding.

Individual Presentation:
Each student of the class needs to give a 5 min presentation that includes a 1-page handout during the semester. Handouts and slides need to be submitted to Blackboard the evening (11:59 pm) before class as a zip or rar file. Timing, presentation, style, content, and handouts will be considered for the grade. The topic can be chosen by each student (first come first serve basis) and needs to be relevant to "Materials Selection" (from research internship, coop, work, or interesting other topic) or an accident that involved failing material. If an accident is chosen as topic, 1 slide needs to be about ethical implications.

Exams:
If no final exam is given (based on students' approval), the exams are not cumulative. An equation sheet might be permitted (information about this will be given a week before the exam). The students need to be present during the exam. In case of an emergency (doctors notice), a make-up exam might be given. The only allowed things during the exams are pens, ruler, water, potentially calculator. Paper and the equation sheet will be provided.

A student found ***cheating***, ***attempting to cheat***, having an ***unauthorized device/tool*** during the exam ***independent of the reason*** will receive a zero on the exam.

Participation:
Participation through presence but also answering questions, asking questions, contributing to activities is very important to improve active learning for each student. Therefore, your participation will be graded during each lecture starting with the second week.