Course Syllabus

Course Information

Course Number/Section: BMEN 6V87 – Biomaterials and Medical Devices
Term: Spring 2013
Days &Times: Class meets in SLC 2.302 on Tuesdays and Thursdays, 9:00 AM – 10:15 AM

Instructor Information

Professor: Danieli Rodrigues
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Office hours: Tuesdays and Thursdays: 12:00 PM – 1:00 PM

Suggested Textbook

Biomaterials Science: An introduction to materials in Medicine. Buddy D. Ratner et al. 2012, 3rd edition (textbook is not required for this class).

Websites

Course Materials (updated syllabus, solutions, and handouts) will be available on eLearning.utdallas.edu.

Prerequisites/Corequisites

CHEM1311, CHEM1312, MATH 2414, MATH 2415, BMEN 2310 (MECH 2310), or equivalent coursework.

Course Description

Introduction to the field of biomaterials used in the design of medical devices, and to augment or replace soft and hard tissues. Discussion of bulk properties, applications, and *in vivo* behavior of different classes of natural and synthetic biomaterials. Analysis of biological response and biocompatibility, degradation and failure processes of implantable biomaterials/devices. Overview of regulatory compliance and performance requirements for commercialization of biomaterials and medical devices.

Course Learning Objectives and Outcomes:

Introduce the field of biomaterials in medicine and their use in specific implant designs focusing on: material and implant requirements, structure-property relationships for synthetic and biological materials, and static and dynamics properties of biomaterials.

The primary objectives of the course are:

- Understand biology and physiology, and apply math, science and engineering to solve the problems at the interface of engineering and biology;
- Knowledge of contemporary issues;
- Evaluate design considerations, experimental techniques and data interpretation;
- Understand professional and ethical responsibility;
- Use techniques, skills and tools necessary for engineering practice.

Course Content Outline and Tentative Schedule:

1. Course Overview and Introduction

01/15

1.1. Introduction to biomaterials science: a multidisciplinary endeavor
1.2. Brief history of biomaterials: surgeon-era to engineered biomaterials
1.3. Today's biomaterials applications: overview of types of implantable biomaterials and devices

2. Properties of Biomaterials: Physics and General Concepts

01/17, 01/22, 01/24

2.1. Bonding, interatomic, intermolecular, surface interactions
2.2. Introduction to bulk properties: microstructure, strength, deformation, thermal and optical properties
2.3. Physics of surfaces:
- *role of water: hydrophilic and hydrophobic interactions*
- *electrostatic and dynamic interactions*
- *specific and non-specific interactions*

2.4. Characterization of Biomaterials:
- *surface analysis techniques: overview of principles and methods*

3. Classes of Materials Used in Medicine

01/29, 01/31

3.1. Metallic biomaterials:
- *atomic structure*
- *microstructure*
- *fabrication and processing effects*
- *surface structure and modification: oxide films*
- *examples of metallic alloys used in implantable devices: Ti, stainless steel, CoCr, CoCrMo*

02/05

3.2. Ceramic biomaterials:
- *oxides: thin film and bulk*
- *characteristics and processing*
- *strengthening mechanisms*
- *examples of implantable ceramics: natural and synthetic hydroxyapatite, calcium phosphate and alumina*

02/07, 02/12, 02/14, 02/19

3.3. Polymeric biomaterials:
- *basic principles: molecular and chemical structure, molecular weight and polydispersity*
- *physical behavior*
- *synthesis: addition, free-radical, condensation polymerization*
- *examples of biopolymers and applications: polyurethane, polyethylene, polystyrene, poly(ethylene) oxide, fluorinated (PTFE), acrylics (PMMA), silicones*
- *degradable and resorbable biopolymers*
- *applications of smart polymers as biomaterials*

02/21

3.4. Hydrogels:
- *structure and synthesis*
- *examples of biomedical hydrogels: acrylic, PVA, PEG, degradable, smart hydrogels*

02/26

3.5. Composite materials:

- *reinforcing composites: carbon, polymer, ceramics, glasses and nanofillers*
- *fabrication*
- *mechanical and physical properties*
- *current applications*

02/28

3.6. Biological materials:

- *structure and properties*
- *hard tissues: tooth and bone*
- *soft tissues: skin, blood vessel, tendon*

03/05 - Midterm

4. Physical and Mechanical Properties of Biomaterials

03/07, 03/19, 03/21, 03/26

4.1. Static properties: tensile, compressive, flexural, torsional
4.2. Dynamic properties: viscoelasticity-creek, dynamic modulus
4.3. Fracture toughness, material toughness
4.4. Fatigue endurance
4.5. Implant and biomaterial performance requirements
4.6. Overview of finite element analysis in biomechanics

5. Biomaterials Degradation in the Biological Environment

03/28, 04/02, 04/04

5.1. Fatigue failure
5.2. Mechanisms of metallic corrosion
5.3. Wear and fretting
5.4. Polymer degradation
5.5. Ceramic degradation
5.6. Biomaterial calcification

6. Biocompatibility

04/09, 04/11, 04/16

6.1. Biomaterials surface properties

- *protein adsorption, surface tension*
- *cells and surfaces in vitro*

6.2. Tissue-material interface

- *cell/tissue-biomaterials interaction*
- *biological responses to biomaterials*
- *inflammation, wound healing, and the foreign-body response*
- *systemic toxicity and hypersensitivity*

6.3. Biofilms, biomaterials and device-related infections

7. Selected Applications of Biomaterials

04/18, 04/23

7.1. Orthopedics applications: upper extremities, lower extremities and spine
7.2. Dental implantation
7.3. Tissue engineering scaffolds

7.4. Bone tissue engineering

8. Special Considerations for Implants, Devices and Biomaterials

04/25
8.1. Regulatory compliance
8.2. Commercialization: what it takes to get a product to the market
8.3. Legal aspects of biomaterials, clinical trials and case studies in regulations

04/30, 05/02 – Graduate students' projects presentations

04/07 – **Final exam:** 8:00am-10:45, SLC 2.302.

Grading Policy

Midterm: 30%
Final: 30%
Homework: 10%
Proposal, report and oral presentation: 30%

Grade	**100-95**	**94-90**	**89-87**	**86-83**	**82-80**	**79-77**	**76-73**	**72-70**	**69-60**	**<60**
	A	**A-**	**B+**	**B**	**B-**	**C+**	**C**	**C-**	**D**	**F**

Course Assessment

- One midterm and one final exam will be given. The final will cover topics discussed after the midterm plus selected chapters, as determined by the instructor.
- Homework will be assigned more or less in a biweekly basis.
- Device design problem study: students are expected to turn in a project proposal after the first month of classes describing the device/biomaterial to be investigated. A two-page long progress report will be due mid-March, and a final report will be due by the end of the semester. Presentations will occur during the last week of classes. A tentative schedule for reports and presentations is given below:
    - Project proposal: 02/21
    - Progress report: 03/28
    - Presentations: 04/30 and 05/02

Device design problem study: The goal of this activity is to identify current problems associated with medical device designs. Students will be separated in teams and will select a specific problem of interest with a medical device design. Each team will give an oral and written presentation of the selected device at the end of the semester defining the design problem and proposing alternative materials/design/processing that could potentially mitigate the risks or "solve the problem" associated with the selected device. Extensive literature review, as well as a proposal, will be required prior to the presentation of the project. Design, development, performance requirements and regulatory aspects will be addressed for each device selected and will have a separate section in the report.

UT Dallas Syllabus Policies and Procedures

The information contained in the following link constitutes the University's policies and procedures segment of the course syllabus. Please go to http://go.utdallas.edu/syllabus-policies for these policies.

The descriptions and timelines contained in this syllabus are subject to change at the discretion of the Professor.