MCEN 4228/5228: Materials and Devices in Medicine

A. COURSE OBJECTIVES:

The main objective of this multidisciplinary course is to provide students with a broad survey of biomaterials and their use in medical devices for restoring or replacing the functions of injured, diseased, or aged human tissues and organs. Biomedical materials are rarely used per se, but always integrated into medical devices or implants. Wound dressings, vascular stents, artificial joints, dental implants, heart valves, intraocular lens are just a few examples from a very long list of medical devices in which biomaterials are engaged. The clinical success of such medical devices strongly depends on the properties of biomaterials used. The course is oriented towards biomaterials engineering, testing and applications in medical devices for surgery, implant and regenerative medicine. The focus is placed on design principles for medical materials. The topics to be covered include: biomaterials evolution in the medical device industry, a broad introduction to the materials used in medicine and their chemical, physical, and biological properties, different properties of synthetic and biological materials, materials interaction with the human body, basic mechanisms of wound healing, biocompatibility issues, testing methods and techniques in accordance with standards and relevant regulations, biofunctionalities required for specific applications, as well as the state-of-the-art approaches for the development of new regenerative materials targeting cellular mechanisms. By the end of the course, students should be able to identify material problems related to human medical health, understand the selection of replacement materials, design materials for use in particular medical applications, and choose proper analysis and testing methods for these materials.

B. BASIC INFORMATION

Course instructor: Prof. Wei Tan
Contact information: ECOT 516, Phone: (303)492-0239, Email: wtan@colorado.edu
Class hours & locations: 12 to 12:50pm, Mon, Wed & Fri
Office hours: By **appointment ONLY** on Wednesdays, 2-6pm; may sit in a conf room
TA: Adrienne Scott. Email: Adrienne.Scott@Colorado.EDU, Office hours: 3:30 – 6pm.
Location: Idea Forge in the DIDL (Drop In Design Lab)
Grader: Parnaz Boodagh. Email: Parnaz.Boodagh@Colorado.EDU
Prerequisite courses: Materials Science and College chemistry or biology
Web Page: D2L site: learn.colorado.edu

C. GRADING:

Midterm exam I: (Oct. 26)	20%
Midterm exam II: (Dec. 7)	20%
In-class group presentation on Biodesign*:	10%
Homework (HWA and HWB):	15%
Quizzes (Reading quizzes and in-class quizzes)[%]:	10%
Final paper[†]: (Due: 10am, Dec. 14, Wednesday)[†]	20%
Workshop/discussion and class participation*:	5%

* Extra credit opportunity. *Presentation*: For extra credit percentage points, consider taking your presentation to the next level, you may present case studies in a creative way during lecture, or improve your presentation by adding further in-depth information that supports the chapter you are reading or adding interviews that are related to your topic. In order to qualify for the extra credit, you must prepare a high quality 5 min presentation of all your findings and deliver it to our class during lecture. *Class Participation*: There will always be

opportunities for you to participate during class. Be sure to complete the in-class assignments. Being an active and proactive student is crucial. Continuously showing leadership and critical thinking in these assignments will be rewarded with extra credits. *If showing graduate-level presentation or graduate-level understanding during class participation,* u*ndergraduate students will get extra credit points.*

† Graduate students: SBIR/STTR research proposal

Undergraduate students: Biodesign review paper. 10 bonus points for undergraduates who submit SBIR/STTR research proposal.

% Reading quizzes: Questions related to learning goals of each chapter. Open-book; work on-line and graded online. Allow two attempts. Passing the quiz needs 80% or above accuracy, which will result in full score or 100 on the quiz. If not passing the quiz (70% or below), your score will be the percentage of correct answers (e.g. 70). You are allowed to skip ONE assignment. In other words, the quiz with your lowest score won't count towards the final grade for quizzes.

For reading quizzes and homework assignments, students are required to work individually on all assignments. No late turn-in except rare cases with convincing evidence present.

D. TEXTBOOK & SUGGESTED REFERENCE:

TEXTBOOK:

(Required) *Introduction to Biomaterials: Basic Theory with Engineering Applications*
Authors: C. Mauli Agrawal, et al. Publisher: Cambridge University Press
ISNB: 9780521116909

(Optional) *Biodesign : The Process of Innovating Medical Technologies*, **2nd Edition**
Authors: Paul G. Yock, et al. Publisher: Cambridge University Press
ISNB: 9781107087354

Suggested References: (some available online through CU library)

Lisa A. Pruitt, Ayyana M. Chakravartula. Mechanics of Biomaterials: Fundamental Principles for Implant Design Cambridge University Press, Oct 20, 2011

Temenoff JS and Mikos AG. Biomaterials: The intersection of biology and material science, Pearson, 2008

Park JB and Lakes RS: Biomaterials an Introduction (3rd Edition). Springer, 2007

Black J: Biological Performance of Materials: Fundamentals of Biocompatibility

Ratner BD, Hoffman AS, Schoen FJ, Lemons JE: Biomaterials Science: An Introduction to Materials in Medicine. Academic Press, New York, 2004.

E. COURSE SYLLABUS:

1. **Clinical applications, governmental regulation and industrial standards**
   Week 1 (8/22-8/26)
   Reading assignment: Chapter 14 and supplementary materials

2. **Introduction to Biomaterials**
   Week 2 (8/29-9/2)
   Reading assignment: Chapter 1

3. **Basic properties of materials**
   Week 3 (9/5-9/9)
   Reading assignment: Chapter 2

4. **Biological systems**

Week 4 (9/12-9/16)
Reading assignment: Chapter 3 (Partially, 3.1-3.6) and supplemental materials on Acute, chronic and long-term host response to biomaterials (related to wound healing)

5. Characterization of biomaterials
Week 5 (9/19-9/23)
Reading assignment: Chapter 4

6. Metals: structure and properties
Week 6 (9/26-9/30)
Reading assignment: Chapter 5

7. Polymers
Week 7 (10/3-10/7)
Reading assignment: Chapter 6

8. Ceramics
Week 8 (10/10-10/14)
Reading assignment: Chapter 7

9. Natural biomaterials
Week 9 (10/17-10/21)
Reading assignment: Chapter 8

10. Review and Midterm1
Week 10 (10/24-10/28)
Review on Monday (10/24)
Midterm1

11. Surface modification
Week 11 (10/31-11/4)
Reading assignment: Chapter 9

12. Sterilization of biomedical implants
Week 12 (11/7-11/11)
Reading assignment: Chapter 10

13. Cell-biomaterial interactions AND Drug delivery systems
Week 13 (11/14-11/18)
Reading assignment: Chapter 11/12 (Selected sections)

14. Drug delivery systems AND Tissue engineering
Week 14 (11/28-12/2)
Reading assignment: Chapter 12/13 (Selected sections)

15. Review and Midterm2
Week 15 (12/5-12/9)
Review on Monday (12/5)
Midterm 2

F. COURSE POLICY

Any incident of academic dishonesty will lead to an automatic F grade for the course. Exchange of helpful suggestions is ok, but using another student's work (or allowing another student to use your work) is not ok. Description of academic integrity and climate is attached. Special issues: if you qualify for accommodations because of a disability, please submit to the instructors a letter from Disability Services in a timely manner so that your needs may be addressed. For details, visit this Web site:www.Colorado.EDU/disabilityservices. Some students may have serious religious obligations which may conflict with academic requirements such as scheduled exams. The full text of the policy regarding this conflict can be read on the web at http://www.colorado.edu/policies/fac_relig.html. In addition, the University has recently adopted a student Honor Code, which is described at http://www.colorado.edu/policies/honor.html

Academic Integrity

You will be asked to complete individual homework assignments in this course. Though you may work in groups to discuss and solve problems, it is expected that you will abide by the University of Colorado at Boulder honor code at all times. Therefore, you may not plagiarize a problem set or allow another student to plagiarize your answers to a problem set. Examples of plagiarism include: copying from a solution manual, copying from Internet sites, copying from previous academic year homework sets, and copying directly from classmates. If you have any doubt that you are using sanctioned materials to assist with your homework solution, please ask your current instructor/professor. On assignments that require you to use supplemental materials, it is also essential that you properly document the sources of information you use.

Any instances of dishonesty on homework or tests will result in a minimum sanction for your first violation of the honor code of a zero score and an entry in your department file. Additional sanctions will be imposed by the ME Department for subsequent violations, possibly including expulsion from the ME program. You may contest any accusation according the campus honor code system.

University of Colorado at Boulder Honor Code Policy:

All students of the University of Colorado at Boulder are responsible for knowing and adhering to the academic integrity policy of this institution. Violations of this policy may include: cheating, plagiarism, aid of academic dishonesty, fabrication, lying, bribery, and threatening behavior. All incidents of academic misconduct shall be reported to the Honor Code Council (honor@colorado.edu; 303-725-2273). Students who are found to be in violation of the academic integrity policy will be subject to both academic sanctions from the faculty member and non-academic sanctions (including but not limited to university probation, suspension, or expulsion). Other information on the Honor Code can be found at http://www.colorado.edu/policies/honor.html and at http://www.colorado.edu/academics/honorcode/

Academic Climate

In Class Expectations:

It is our expectation that each of you will be respectful to your fellow classmates and instructors at all times. In an effort to create a professional atmosphere within the classroom, it is requested that you:

- Arrive to class on time
- Turn off your cell phone
- Limit use of your laptop computer to class purposes
- Put away newspapers and magazines
- Refrain from having disruptive conversations during class
- Remain for the whole class, or if you must leave early do so without disrupting others
- Display professional courtesy and respect in all interactions related to this class

Compliance with these expectations will assist us with the creation of a learning community and a high quality educational experience. The University of Colorado Classroom behavior policy will compliment the outlined classroom expectations.

University of Colorado Classroom Behavior Policy:

Students and faculty each have responsibility for maintaining an appropriate learning environment. Those who fail to adhere to such behavioral standards may be subject to discipline. Professional courtesy and sensitivity are especially important with respect to individuals and topics dealing with differences of race, culture, religion, politics, sexual orientation, gender, gender variance, and nationalities. Class rosters are provided to the instructor with the student's legal name. I will gladly honor your request to address you by an alternate name or gender pronoun. Please advise me of this preference early in the semester so that I may make appropriate changes to my records. See polices at

http://www.colorado.edu/policies/classbehavior.html and at
http://www.colorado.edu/studentaffairs/judicialaffairs/code.html#student_code

Out of Class Expectations:

Though many of the above stated policies address academic climate within the classroom, these policies should also be upheld outside of the classroom. As a member of the ME community you are expected to consistently demonstrate integrity and honor through your everyday actions. Furthermore, faculty and staff members are very willing to assist with your academic and personal needs. However, multiple professional obligations make it necessary for us to schedule our availability. Suggestions specific to interactions with faculty and staff include:

- Respect posted office hours. Plan your weekly schedule to align with scheduled office hours
- Avoid disrupting ongoing meetings within faculty and staff offices. Please wait until the meeting concludes before seeking assistance. Respect faculty and staff policies regarding use of email and note that staff and faculty are not expected to respond to email outside of business hours. Send emails to faculty and staff using a professional format. Tips for a professional email include:
    - Always fill in the subject line with a topic that indicates the reason for your email to your reader.
    - Respectfully address the individual to whom you are sending the email (e.g., Dear Professor Smith).
    - Avoid email, chat room or text message abbreviations.
    - Be brief and polite.
    - Add a signature block with appropriate contact information.
    - Reply to emails with the previously sent message. This will allow your reader to quickly recall the questions and previous conversation.