MECH 573 / BIOM 573

Structure and Function of Biomaterials

Dr. McGilvray reserves the right to make changes to this syllabus at any time throughout the semester.

General Course Description (Credits: 3 (3-0-0)):

- The course will enable you to assess, analyze, and understand the design of biomaterials. We will examine classic and novel biomaterials and be exposed to the theories and applications of biomaterial development and testing.
  - We will apply the principles of material science, mathematics, and clinical sciences to gain an understanding on how biomaterials are created, tested, and eventually used in a clinical setting (including pathways through regulatory bodies, such as the U.S. Food and Drug Administration (FDA))
- Upon successful completion of this course, you will be able to:
  - Explain the essential properties of biomaterials for engineering applications,
  - Quantify the production, usage / application, and degradation of biomaterials that occur in nature,
  - Quantify the production, usage / application, and degradation of biomaterials that are ‘man-made’,
  - Compare and contrast the development of different novel biomaterials;
  - Explain qualification and testing procedures for biomaterials use for biomedical applications, including tissue engineering.
- It is my goal, that you leave this class with an advanced understanding of some of the most important structural and functional principles in mechanical and biomedical engineering with respect to natural occurring and man-made biomaterials, and as a result are a better engineer.

Class Time and Location:

- See Canvas (https://canvas.colostate.edu/)
- If applicable, Canvas will also provide login information and passwords for the class’s Zoom meeting links.

Instructor:

- Dr. Kirk C. McGilvray
  - [http://obrl.colostate.edu/members/kirk-mcgilvray/](http://obrl.colostate.edu/members/kirk-mcgilvray/)
- Email: Kirk.McGilvray@colostate.edu
- Office Hours: See Canvas (https://canvas.colostate.edu/)
Textbook:

  - Editors: William Wagner Shelly Sakiyama-Elbert Guigen Zhang Michael Yaszemski
  - This book is available hardbound or as a permanent eBook.
    - eBook ISBN: 9780128161388
    - Hardcover ISBN: 9780128161371
  - Published Date: 16th June 2020

Class Website (https://canvas.colostate.edu/)

- The Canvas portal for this class will utilize the ‘Modules’ layout, with new modules being released on a weekly basis. Each weekly module will contain technical lectures, assignments, and weekly summaries. Additionally, the Canvas site will be used for: (1) announcements, (2) assignments, (3) quizzes, (4) files, and (5) grades.
- DO NOT email through Canvas, send emails directly to Kirk.McGilvray@colostate.edu

Class Policies:

- You are responsible for your learning. Take advantage of all resources to achieve the course objectives. Be sure you have made a serious attempt at your own solutions before coming to office hours for assistance on homework.

Absence Policy:

- Arrangements may be made ahead of time for University excused absences. Please notify Dr. McGilvray prior to assuming your absence is excused.

Academic Integrity Policy:

- The Students Rights and Responsibilities (https://catalog.colostate.edu/general-catalog/policies/students-rights/) section of the University General Catalog provides general policies of conduct. Particularly important is the subsection on Academic Integrity (https://catalog.colostate.edu/general-catalog/policies/students-responsibilities/). The policies below provide additional specific guidelines on this course. Violation of Academic Integrity will result in severe and adverse penalties, including at a minimum, a loss of credit (including the possibility of negative credit) for the assignment(s) in question. If Dr. McGilvray PERCEIVES you to have violated the University’s Academic Integrity guidelines on any Exam or Project, you will be assigned an ‘F’ for the course (at a minimum) without exception.

Harassment-Free Academic Environment Policy:

- The faculty of the Mechanical Engineering department are committed to providing open and honest environments for our intellectual pursuits. Any action in a group situation (whether or not in relation to race, color, religion, sex, national orientation, age, disability, or sexual orientation) resulting in the perception of an intimidation, harassing, retaliatory, hostile or offensive environment is a violation of our education community’s obligation to provide an open, safe, conducive learning environment and will not be tolerated. Any perception of harassment will be reported to the CSU Office of Equal Opportunity which is tasked by the state of Colorado to investigate incidences of this nature.
I. Course Grading:

Any disagreement with homework (HW) or Exam grading must be settled with Dr. McGilvray within one week after the graded material is returned.

∴ Homework: 25%
∴ Exam I: 25%
∴ Exam II: 25%
∴ Final Exam (Exam III): 25%

Grading will be assigned according to the following fixed grade scale.

∴ Basic Letter Grade 90/80/70/60 Scheme
   - CSU does not accept C-, D+, D- grades.
   - Grades will not be ‘rounded’.

II. General and Homework:

○ You are responsible for everything in class (i.e., handouts, notes, assignments, etc.)
○ You may work on homework individually or in a small group (n ≤ 4) on your homework. To enhance your learning experience, I encourage you to work in groups. If you do, I recommend the following approach:
   ▪ Try to work the problems individually first, then compare your approaches and results with your group members, then work the problem together to settle on the correct approach and final answers.
   ▪ DO NOT divide the problems up within your group – every person should work every problem.
○ Homework is given to ensure that you understand and can correctly apply course material. These are the cornerstones of the educational process. Academic misconduct eliminates the educational discovery process (the “aha” moment) necessary in understanding.
○ Each student will need to submit their own HW solutions.
○ There will be on average one HW assignment a week.
   ▪ Submitted HW assignments should be original work. Copying solutions and/or answers from any source (solution manuals, internet sources, past students, course files, etc.) is plagiarism and is prohibited. Unauthorized possession or distribution of such material is also prohibited.
   ▪ Each HW problem should begin on a new page with the following info at the top:
      • 1st) Your full name, and
      • 2nd) Student sorting number (to be assigned via Canvas (https://canvas.colostate.edu/) – this will help the graders input grades and sort HWs for return).
○ Homework will be assigned and turned in weekly via Canvas (https://canvas.colostate.edu/)
   ▪ Late work will not be accepted without penalty (e.g., emailed a few minutes late -10%; a few hours late: -50%; more than a day late: -100%).
   ▪ Homework solutions will be posted via Canvas (https://canvas.colostate.edu/)
   ▪ Homework assignment grades will not be normalized to mean grades but will stand on their own. For example, a grade of 8 where the maximum score is 10 is identical to a grade of 80 where the maximum score is 100.
III. Exams

∴ Examination will be administered in either a standard (i.e., 75-minute) or a multi-day ‘take-home’ format.
  ○ Make-up exams will be given only in extreme, unanticipated, and unavoidable circumstances.
∴ At CSU the Resources for Disabled Students (RDS) provides support (including support on exams) for students with both permanent and temporary limitations and chronic illness/health conditions (physical and mental health). Limitations include, but are not limited to, mobility, hearing, seeing, and learning. Chronic illness/health conditions include, but are not limited to, depression, diabetes, epilepsy, celiac, and concussion.

I hope you have a great semester and enjoy this class. Best of luck!

Regards,
Kirk C. McGilvray, Ph.D.

If you are concerned about a student OR an employee, Tell Someone (https://supportandsafety.colostate.edu/tell-someone/) or call (970) 491-1350 to discuss concerns about any member of the CSU community.

Rams take care of Rams. Helping others, speaking up when something doesn’t feel right or when you’re worried about someone else, and reaching out are foundational values at Colorado State University. Tell Someone is a Colorado State University service where anyone can report concerns about a student or employee who may be struggling with issues such as mental health, stress management, and safety, as well as share concerns about threats of violence (against themselves or others).

Through Tell Someone, you can report anything that threatens your safety or the safety of others in the university community. Tell Someone is available to seek help for or report a concern about any CSU community member, including employees who work off campus.

Tell Someone is not designed to get people in trouble; it is designed to help students and employees who may be struggling, as well as help enhance university safety.

Tell Someone is your resource if you’re worried about a friend’s well-being. If a student or employee is disruptive, Tell Someone is the right place to turn for intervention as well as university support to help put consequences and boundaries in place.

Tell Someone is run by the Office of Support and Safety Assessment. The office is comprised of trained specialists who can identify concerns, pathways to resolution, and university resources.

Tell Someone online and phone reports are only reviewed during regular business hours. If you believe someone is at risk of immediate harm, call 911.
## Detailed Syllabus:

### Overview of Biomaterials
- Properties of Biomaterials: Naturally Occurring
  - Soft Tissues
- Animal Derived Biomaterials (e.g., silk, nacre, etc.)
- Properties of Biomaterials: Metals and Ceramics
  - Titanium Alloys (including Nitinol), Stainless Steel, and CoCr Alloys
- Biological Response to Biomaterials: Systemic
  - Introduction to Biology and Medicine
- Biological Response to Biomaterials: Organ level
  - Effect of Mechanical Forces on Tissues and Cells
- Biological Response to Biomaterials: Cellular level
  - Host Reaction to Biomaterials
- Biomaterial Development: Characterization
  - Biomaterial Testing
    - In vitro and in vivo Measurements

### Biopolymers
- Properties of Biomaterials: Polymers
  - Degradable and Resorbable Polymers
  - "Smart Polymers"
- Properties of Biomaterials: Composites
  - Hydrogels, Hydrogel-Scaffolds, Fibers, and Biotextiles
  - Textured, Porous, and Surface Modified Biomaterials

### Applications of Additive Manufacturing
- EXAM I REVIEW

### Exam II Review
- Spring Break

### Exam III
- Final Exam

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### Exam I
- Wednesday
  - 9:40-11:40AM
  - 4/19/2021
  - 4/26/2021
  - 5/3/2021
  - 5/12/2021

### Exam II
- Wednesday
  - 9:40-11:40AM
  - 5/12/2021

### Exam III
- Wednesday
  - 9:40-11:40AM
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## Summary Syllabus:

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