Department of Bioengineering

BIOE 4120 section 001 - Orthopaedic Engineering and Pathology
Critical Thinking Seminar (CT²)
3 credits (3,0) - Syllabus - Fall 2015

CLASS MEETING
TIMES: Tuesday and Thursday 2:00 - 3:15 PM
LOCATION: Rhodes Annex 201

Instructor: Melinda Harman, PhD
Asst. Professor of Bioengineering
E-mail: harman2@clemson.edu
Office: Rhodes 201-2
Office Hours: Tues 3:15-4:30 PM, Thurs 12:30-1:30 PM
(Rhodes 201): / or by appointment

Teaching Assistant: Xinyue (Lucy) Lu
PhD graduate student
xinyuel@g.clemson.edu
Rhodes 311 (3rd row near window)
Office Hours: Wed 10:30-11:30am
(Rhodes 201): / or by appointment

DESCRIPTION
Interdisciplinary study of clinical orthopaedic cases (bone growth, bone remodeling, osteoarthritis, implant fixation, and joint replacements); biomechanical, biomaterials, tribology, and clinical diagnosis of failed implants (total joint replacements, fracture fixation, and spinal instrumentation); basic concepts of orthopaedic pathology for engineers.

Furthermore, this is a Critical Thinking Seminar (CT²) that is designed to actively engage you in thinking deeply about various issues related to medical technology in orthopaedics. Critical thinking requires a foundation based on your learning the content provided in this course while developing the ability to think clearly and rationally. Critical thinking will be discussed throughout the semester and you will be assigned readings and exercises to help develop your skills. Thus, you must come to class prepared for these discussions. CT² seminars are part of Clemson’s Quality Enhancement Plan, as presented at this web link (http://www.clemson.edu/assessment/thinks2/).

PREREQUISITES: BIOE 302 (Biomaterials), BIOE 320 (Biomechanics)
CONCURRENT ENROLLMENT: BIOSC 315 (Functional Human Anatomy)

COURSE LEARNING OUTCOMES
1. To identify the anatomical and functional requirements of the musculoskeletal system and the effect of pathology on implant design and selection (3-a)
2. To apply and select biomaterials and biomechanics failure analysis methods to problems related to failure of orthopaedic implants (3-e)
3. To develop an engineering diagnosis to assess the failure of a clinical orthopaedic device (3-a)

ABET STUDENT OUTCOMES:
3a: an ability to apply knowledge of mathematics, science and engineering to engineering problems
3e: an ability to identify, formulate and solve engineering problems

CT² CRITICAL THINKING OUTCOMES:
1. Evaluate key assumptions and uncertainties about medical device innovation from medical case studies
2. Interpret evidence of medical device successes and failures based on clinical outcomes
3. Communicate effective risk/benefit arguments for medical device innovation from the perspective of various stake-holders (e.g. patient, industry, society)
COURSE LEARNING OUTCOMES MAP

Engineering Orthopaedic Devices, Clinical Cases & Failure

Fracture Fixation Hardware  
Joint Repairs & Replacements  
Clinical Applications  
Failure Analysis & Wear

Fractures & Healing  
Joint Pathology  
Biomechanics  
Contact Stress & Tribology

Musculoskeletal Tissues  
Synovial Joints  
Orthopaedic Biomaterials  
Mechanical Properties

CLASS MATERIAL
1) Lecture notes taken in class, lecture presentations posted on Blackboard
2) Other pertinent materials distributed in class, including websites, journal articles, and industry news articles.
3) Exams will consist of materials posted on BlackBoard, in-class lecture notes, homework materials, assigned reading materials, and other provided information.

Other Textbooks and Journals (available online or through Cooper Library):


Text available in the stacks at Cooper Library (RD686.J65 1996)

ASSIGNMENTS AND HOMEWORK

Homework (HW): 6 assigned problem sets based on material covered in class and provided on BlackBoard. Homework assignments are due at the beginning of class on the date given as the due date for that assignment. Late homework assignments will not be accepted - no exceptions. Homework assignments received after the due date will not receive any credit (i.e. you will receive a 0 grade for that assignment). You are welcome to turn in homework assignments prior to the due date. Please note that all homework assignments, unless otherwise designated, are to be submitted in hard copy form. Electronic submissions, unless specifically requested, will not be accepted.

Guided Reading (Ortho-Bowl): 6 assigned articles or book chapters
Guided reading is meant to build your foundation of knowledge. Assigned materials will be posted on BlackBoard. In-class discussion of the materials (Ortho-Bowl) will occur the following week. In-class participation is expected and will be used to determine extra credit awarded at the time of final grades. Students who are not in attendance, for any reason, will not be eligible for Ortho-Bowl extra credit points awarded the day(s) they were absent.

Orthopaedic Implant Failure Analysis Case Report
Clemson University undergraduate students gain knowledge of core competencies. Evidence of gained knowledge is demonstrated through effective oral and written communication.

This course includes one formal assignment meant to target core competencies. You will be assigned an implant failure case and will conduct a literature review and device failure assessment, with the entire study and conclusions presented in written form. There will be a required critical thinking component in this assignment. Completed case reports (HW #7 CR) are due Nov. 19 at the beginning of class.

Exams: Three in-class exams are scheduled during the semester (Sept. 22, Oct. 22, Nov. 24). Exams will include all material covered since the previous exam. However, overlap of some concepts is inevitable as we progress through course materials. A comprehensive in-class Final Exam is scheduled for Thurs Dec. 10 (8:00-10:30 AM).

Any assigned coursework that is missed due to an unexcused absence will not receive any credit (i.e. you will receive a 0 grade for that assignment). If you have a planned absence for a valid reason that coincides with a homework due date or scheduled exam, notify the instructor prior to the absence. The homework is due before the absence. No make-up exams will be provided for missed in-class exams. The % weight of the exam on the final grade will be added to the weight of the final exam. Any extensions of deadlines must be requested more than 24 hours before the assignment is due and will only be granted for a valid, written medical or university excuse (see Attendance note in Class Policies written below).

Critical Thinking Assignments
Critical thinking is the “intellectually disciplined process of actively and skillfully conceptualizing, applying, analyzing, synthesizing, and/or evaluating information gathered from, or generated by, observation, experience, reflection, reasoning, or communication, as a guide to belief and action. In its exemplary form, it is based on universal intellectual values that transcend subject matter divisions: clarity, accuracy, precision, consistency, relevance, sound evidence, good reasons, depth, breadth, and fairness” (National Council for Excellence in Critical Thinking, 1987). More simply, critical thinking is a self-aware process of thinking in a clear and systematic way in order to gain a deeper understanding. To do so it requires engaging in metacognition, which means reflecting on your own thinking and recognizing your own biases, assumptions, and considering how you create knowledge. Critical thinking does not come naturally to most people; therefore, you must practice critical thinking – which is one of the goals of this course.

- California Critical Thinking Skills Test (CCTST): This is the premier critical thinking test that has been used across the U.S. as a discipline-neutral measure of reasoning. It has been designed to permit test-takers to demonstrate the critical thinking skills required to succeed in educational or workplace settings
where solving problems and making decisions by forming reasoned judgments are important. The test items range in difficulty and complexity, typically taking 45 minutes to complete. You are required to complete this exam twice, once at the beginning of the semester (CT² pre-test) and once at the end (CT² post-test). You will not be graded based on your performance on this test, however you will receive participation points for completing the exam both times. The CCTST has been included so that Clemson University can collect data on the effectiveness of this course and other CT² seminars.

- Complete the CT² pre-test and CT² post-test outside of class time using the following link
  - Go to testing website http://www.insightassessment.com
  - Click on the Test Taker button in the upper right hand corner
  - BIOE 4120 User ID: f5bi412a
  - password: clemson2015
  - Note: You must have the most recent version of Java on your computer. Check it at www.java.com

- Three in-class assignments (pass/fail) & discussion involving the CT² Critical Thinking Outcomes. One assignment will be a meta-assignment in which you are required to reflect on the thinking process you used to successfully complete the Failure Analysis Case Report (described above)

- Each exam will include at least one question specifically tailored to assess your Critical Thinking skills

**COURSE MARKING SCHEME** - This course is a graded course.

- **Homework (HW #1-HW #6)**
  - 25%
- **Failure analysis case report (CR #7)**
  - 10%
- **Exams (n=3 @15%)**
  - 45%
- **Final Exam**
  - 20%

A - 90-100%; B - 80-89%; C - 70-79%; D - 60-69%; F - <60%

**CLASS POLICIES**

1. **Office hours:** This course builds on your previous bioengineering coursework and the content increases in complexity throughout the semester. Therefore, it is important for you to use the course learning outcomes map to structure your learning and make efforts to grasp relationships between presented concepts. I encourage you to digest course materials outside of class. Office hours will be held in Rhodes 201 where you can meet with the TA or instructor during office hours or by appointment to discuss lecture notes, in-class example problems, homework problems, etc.

2. **Attendance:** All students are required to attend the first scheduled day of classes. Students who cannot attend the first class are responsible for contacting the instructor to indicate their intent to remain in that class. If a student does not attend the first class meeting or contact the instructor by the second meeting or the last day to add, whichever comes first, the instructor has the option of dropping the student from the roll. Students must not assume that instructors are obligated to drop them from the roll if they fail to attend the first few days of class.

3. **Attendance:** Students are expected to attend all classes. Attendance will be recorded periodically and always on Ortho-Bowl days. If classes must be missed for extra-curricular activities, illness, or other valid reasons (as defined in the Academic Regulations section of the Clemson University Student Handbook), the instructor must be informed prior to absence with written documentation from the appropriate authorized official. Students are encouraged to use the “Notification of Absence” form under the “student” tab in BlackBoard. In cases of medical or family emergencies, or any special circumstances, the instructor must be informed as soon as possible upon return. Unexcused absences may detrimentally influence borderline grades.

4. **Waiting for Instructor:** If the instructor or TA does not come to class within the first 15 minutes of the scheduled beginning of class, students are authorized to leave and the class should be considered canceled for that period.

5. There is no required textbook for the course; homework, quizzes and exams will be composed based on material covered in class and resource material provided through Blackboard.

6. **Any questions pertaining to grading or requests for re-consideration of grading must be made in writing within 1 week of when the exam / assignment is returned in class.**

7. This class will function in airplane takeoff mode (No laptops, iPhones, BlackBerries, etc.)

**ACADEMIC INTEGRITY (CU official statement on Academic Integrity):** “As members of the Clemson University community, we have inherited Thomas Green Clemson’s vision of this institution as a “high seminary of learning.” Fundamental to this vision is a mutual commitment to truthfulness, honor, and responsibility, without which we cannot earn the trust and respect of others. Furthermore, we recognize that academic dishonesty detracts from the value of a Clemson degree. Therefore, we
shall not tolerate lying, cheating, or stealing in any form. In instances where academic standards may have been compromised, Clemson University has a responsibility to respond appropriately to charges of violations of academic integrity.”

The College of Engineering & Science Honor Code (http://www.clemson.edu/ces/students/honor-code.html) has been in effect since 1994. Cheating and plagiarism have no place in a respected academic institution; such activities will not be tolerated and will be reported to the BIOE department for further disciplinary action. Homework, quizzes, and final exams are to be an individual effort unless specified by the instructor. If the honor pledge is not stated and signed at the end of each Exam and Project, the instructor will not provide a grade.

Honor Pledge:
1) I have neither given nor received aid for this (examination, homework).
2) We have neither given nor received aid for this team project. The work has been equally divided among team members. (Provide acknowledgment to contributors - clinicians, graduate students, professors, etc.)

DISABILITY ACCESS POLICY: Students with disabilities should request accommodations by making an appointment with Dr. Margaret Camp, Director of Disability Services, to discuss specific needs within the first month of classes. Students should present a Faculty Accommodation Letter from Student Disability Services when they meet with instructors. Student Disability Services is located in Suite 239 Academic Success Building (656-6848; sds-l@clemson.edu ). Please be aware that accommodations are not retroactive and new Faculty Accommodation Letters must be presented each semester.

TITLE IX SEXUAL HARRASSMENT STATEMENT: Clemson University is committed to a policy of equal opportunity for all persons and does not discriminate on the basis of race, color, religion, sex, sexual orientation, gender, pregnancy, national origin, age, disability, veteran’s status, genetic information or protected activity (e.g., opposition to prohibited discrimination or participation in the complaint process, etc.) in employment, educational programs and activities, admissions and financial aid. This includes a prohibition against sexual harassment and sexual violence as mandated by the Title IX of the Education Amendments of 1972. This policy is located at http://www.clemson.edu/campus-life/campus-services/access/title-ix/index.html. Mr. Jerry Knighton is the Clemson University Title IX Coordinator and he may be reached at knightl@clemson.edu or 864-656-3181.

COPYRIGHT: Some materials in this course are copyrighted. These materials are intended for use only by students registered and enrolled in this course and only for instructional activities associated with and for the duration of the course. They may not be retained in another medium or disseminated further. They are provided in compliance with the provisions of the Teach Act. Students are reminded to refer to the Use of Copyrighted Materials and “Fair Use Guidelines” policy on the Clemson University website for additional information: http://www.lib.clemson.edu/copyright/.

A FEW FINAL CAVEATS:
1) Students may vary in their competency levels on the course learning outcomes, and they can expect to achieve these outcomes only if they honor all course policies, attend classes regularly, complete all assigned work in good faith and on time, and meet all other course expectations of them as students.
2) The schedule, policies, procedures, and assignments in this course are subject to change in the event of extenuating circumstances, by mutual agreement, and/or to ensure better student learning.

IMPORTANT DATES – FALL SEMESTER 2015

Aug 19, W Classes begin
Aug 25, Tu Last day to register or add a class
Sep 1, Tu Last day to drop a class or withdraw from the University without a W grade
Sep 8, Tu Last day to apply for December graduation
Oct 9, F Last day for instructors to issue midterm evaluations
Oct 12-13, M-Tu Fall break
Oct 27, Tu Last day to drop a class or withdraw from the University without final grades
Nov 2, M Registration for spring and summer terms begins
Nov 25-27, W-F Thanksgiving holidays
Dec 3-4, Th-F Classes meet; exams permitted in labs only
Dec 7-11, M-F Examinations
Dec 14, M 9:00 a.m.–Deadline to submit candidate grades
Dec 16, W 9:00 a.m.–Deadline to submit other grades
Dec 17, Th Graduation
<table>
<thead>
<tr>
<th>Date</th>
<th>Reading Assignments</th>
<th>HW and Exam Assignments</th>
<th>Items DUE</th>
<th>Topics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aug 20</td>
<td>Intro Article</td>
<td>CT² pre-test</td>
<td></td>
<td>Introduction - Impact on Industry</td>
</tr>
<tr>
<td>Aug 25</td>
<td>Reading #1</td>
<td>HW #1</td>
<td>CT² pre-test</td>
<td>Musculoskeletal Tissues</td>
</tr>
<tr>
<td>Aug 27</td>
<td></td>
<td></td>
<td></td>
<td>Review Statics, Beams &amp; Bending</td>
</tr>
<tr>
<td>Sept 1</td>
<td></td>
<td>HW #2</td>
<td>Ortho-Bowl #1</td>
<td>Orthopaedic Biomaterials</td>
</tr>
<tr>
<td>Sept 3</td>
<td></td>
<td></td>
<td></td>
<td>Mechanical properties of musculoskeletal tissues</td>
</tr>
<tr>
<td>Sept 8</td>
<td>Reading #2</td>
<td>CR #7 case report</td>
<td>HW #1</td>
<td>Synovial Joints &amp; Joint Biomechanics</td>
</tr>
<tr>
<td>Sept 10</td>
<td></td>
<td></td>
<td></td>
<td>Bone &amp; Joint Pathology</td>
</tr>
<tr>
<td>Sept 15</td>
<td>Reading #3</td>
<td>HW #3</td>
<td>Ortho-Bowl #2</td>
<td>Examination of Orthopaedic Tissues</td>
</tr>
<tr>
<td>Sept 17</td>
<td></td>
<td></td>
<td></td>
<td>CT² exercise – assumptions/uncertainties</td>
</tr>
<tr>
<td>Sept 22</td>
<td>EXAM 1</td>
<td></td>
<td></td>
<td>Failure Analysis -Intro to Implant Retrieval</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Contact stress – Hertz theory</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Tribology &amp; Wear – Stribeck curve, Archard's law</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>FE modeling</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Bone &amp; Joint Pathology</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Fractures &amp; Healing</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Fracture fixation</td>
</tr>
<tr>
<td>Sept 24</td>
<td></td>
<td></td>
<td></td>
<td>Failure Analysis –Wear &amp; Biological reactions</td>
</tr>
<tr>
<td>Sept 29</td>
<td>Reading #4</td>
<td>HW #4</td>
<td>Ortho- Bowl #3</td>
<td>Fracture Analysis &amp; Fatigue – Goodman diagram, critical flaws</td>
</tr>
<tr>
<td>Oct 1</td>
<td></td>
<td></td>
<td></td>
<td>Principles of TKR Engineering &amp; Design</td>
</tr>
<tr>
<td>Oct 8</td>
<td>Guest lecture</td>
<td></td>
<td>HW #3</td>
<td>Principles of THR Engineering &amp; Design</td>
</tr>
<tr>
<td>Oct 13</td>
<td>no class</td>
<td>no class</td>
<td>no class</td>
<td>Clinical Applications &amp; Case Reports</td>
</tr>
<tr>
<td>Oct 15</td>
<td></td>
<td></td>
<td>HW #4</td>
<td>CT² exercise – evidence of success/failure</td>
</tr>
<tr>
<td>Oct 20</td>
<td>Reading #5</td>
<td>HW #5</td>
<td>Ortho- Bowl #4</td>
<td>6120 Team Project Presentations</td>
</tr>
<tr>
<td>Oct 22</td>
<td></td>
<td></td>
<td>EXAM 2</td>
<td>Final Review</td>
</tr>
<tr>
<td>Oct 27</td>
<td></td>
<td>HW #6</td>
<td>Ortho- Bowl #5</td>
<td></td>
</tr>
<tr>
<td>Oct 29</td>
<td>Reading #6</td>
<td>CT² post-test</td>
<td>HW #5</td>
<td></td>
</tr>
<tr>
<td>Nov 3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nov 5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nov 10</td>
<td>Reading #6</td>
<td>CT² post-test</td>
<td>HW #6</td>
<td></td>
</tr>
<tr>
<td>Nov 12</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nov 17</td>
<td></td>
<td></td>
<td>CR #7 due</td>
<td></td>
</tr>
<tr>
<td>Nov 19</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nov 24</td>
<td>EXAM 3</td>
<td></td>
<td>EXAM 3</td>
<td></td>
</tr>
<tr>
<td>Nov 26</td>
<td>no class</td>
<td>no class</td>
<td>no class</td>
<td></td>
</tr>
<tr>
<td>Dec 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dec 3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dec 10</td>
<td>8-10:30am</td>
<td>Comprehensive Final Exam</td>
<td>Comprehensive Final Exam</td>
<td></td>
</tr>
</tbody>
</table>