MECE-4381-01, Experimental Orthopaedic Biomechanics
Fall 2017

Lectures: Room ENGR 1.242 two times a week on MW, 12:15 pm – 1:30 pm


Prerequisites: MECE 2304 and MECE 3450 (or MATH 3349)

Professor: Dumitru Caruntu, PhD, PE, Phone: (956) 665-2079, Email: dumitru.caruntu@utrgv.edu

Office: SCIE 3.124 Office hours: M 5:00 pm – 6:30 pm

Course Description: This course includes experimental, numerical and theoretical orthopaedic biomechanics and covers loads and motion in the musculoskeletal system, tissue mechanics, structural analysis, bone-implant systems, total hip replacements, total knee replacements, articulating surfaces, introduction to and utilization of a synchronized experimental biomechanics system consisting of a Motion Analysis System, Force Plates, and EMG system, computational packages in orthopaedic biomechanics, and computer aided design of implants. Labs for investigating muscle activity, ground reaction forces, and kinematic data for tasks such as walking, squatting, and running are included in the course.

Learning Objectives/Outcomes for the Course: 1. Introduce engineering models of musculoskeletal systems. 2. Develop skills to perform static analysis and dynamic analysis of musculoskeletal systems. 3. Develop skills for using biomechanics instrumentation, Motion Analysis System, Force Plates, and electromyography (EMG), to determine 3D kinematics and kinetics.

Conduct of the Course: There will be a great deal of hands on and observed problem solving in the class. Regular attendance is necessary to be successful in the class. There are reading assignments, homework and computer projects, announced quizzes and pop quizzes, two midterm exams and a final examination.

Grading Policies: Reports and Presentations, and Computer Projects: 30%; Quizzes 20%; Exams 30%; Final Exam 20%

Grading Scale: A: 90 or higher  B: 80-89.99%  C: 70-79.99%  D: 60-69.99%  F: Below 59.99%

Examination Policy: All exams and quizzes are closed book and closed notes. Make-up exam(s) will not be given except for legitimate and unusual circumstances. Prompt notification and appropriate documentation will be required. The exams are strictly individual with no assistance to be given or received.

Scholastic Integrity: As members of a community dedicated to Honesty, Integrity and Respect, students are reminded that those who engage in scholastic dishonesty are subject to disciplinary penalties, including the possibility of failure in the course and expulsion from the University. Scholastic dishonesty includes but is not limited to: cheating, plagiarism, and collusion; submission for credit of any work or materials that are attributable in whole or in part to another person; taking an examination for another person; any act designed to give unfair advantage to a student; or the attempt to commit such acts. Since scholastic dishonesty harms the individual, all students and the integrity of the University, policies on scholastic dishonesty will be strictly enforced (Board of Regents Rules and Regulations and UTRGV Academic Integrity Guidelines). All scholastic dishonesty incidents will be reported to the Dean of Students.

Reports and Presentations, and Computer Projects Policy: Both Reports and Computer Projects must be submitted in ASME format (hard copy and electronic format required). Presentations must be in Power Point format (electronic submission required).

Attendance: Attendance will be taken every time the class meets. Any student arriving to class 5 minutes after the class has started will not be allowed in class. Students will be allowed a maximum of 5 absences for the whole semester for classes meeting three times a week, 3 absences for classes meeting twice a week, and 2 absences for classes meeting once a week. Five points will be deducted from the total (100%) for each absence exceeding the maximum allowable unless documentation justifying that absence is provided. Students are not permitted to leave the classroom during lectures and exams except for extreme emergencies.

Mandatory Course Evaluation Period: Students are required to complete an ONLINE evaluation of this course, accessed through your UTRGV account (http://my.utrgv.edu); you will be contacted through email with further instructions. Students who complete their evaluations will have priority access to their grades. Online evaluations will be available: Fall 2017 (full semester)... Nov. 15 – Dec. 6

Syllabus*:

<table>
<thead>
<tr>
<th>Days</th>
<th>Subjects</th>
<th>Reading Assignments</th>
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<tbody>
<tr>
<td>W</td>
<td>Aug 30</td>
<td>Hip, Knee, and Spine. Damage and Repair. 1.6 - 9</td>
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<tr>
<td>M</td>
<td>Sep 4</td>
<td>Labor Day Holiday</td>
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*BARTEL, DAVY, AND KEAVENY: Chapter 1: The Musculoskeletal System
Chapter 2: Loads and Motion in the Musculoskeletal System

W  Sep  6  Basic Concepts. Static Analysis. Musculoskeletal Dynamics  2.1 - 3
M  Sep  11 Joint Stability.  2.4 - 6

Chapter 3: Tissue Mechanics I: Bone

W  Sep  13 Composition. Composite Material. Elastic Anisotropy.  3.1 – 4
M  Sep  18 Cortical Bone. Trabecular Bone. Hierarchical Analysis. Anisotropy  3.5 – 8
W  Sep  20 Biomechanics of Bone Adaptation  3.9 - 11

Chapter 4: Tissue Mechanics II: Soft Tissue

M  Sep  25 Tendon. Ligament. Articular Cartilage. Intervertebral Disc.  4.1 – 3
W  Sep  27 Muscle. Viscoelasticity.  4.4 - 7

WINTER:

Chapter 2: Kinematics

W  Oct  4 Angles, velocity and acceleration from smoothed data.  2.6 - 8……Quiz #1

Chapter 3: Anthropometry

M  Oct  9 Density, mass, inertial properties. Measurements. Muscles  3.1 – 4

Chapter 4: Kinetics: Forces and Moments of Force

W  Oct 11 …………………………………………………………………………………………………Exam #1
M  Oct 16 Models, equations, force transducers, force plates  4.1 – 3
W  Oct 18 Bone-on-bone forces on dynamics conditions  4.4 – 5
M  Oct 23 Biomechanics laboratory – Motion Analysis System

Chapter 5: Mechanical Work, Energy, and Power

W  Oct 25 Efficiency, movement, energy storage, internal and external work  5.1 – 4
M  Oct 30 Power balances at joints and within segments  5.5 – 6

Chapter 6: Synthesis of Human Movement – Forward Solutions

W  Nov  1 Mathematical formulation, system energy, external forces and torques  6.1 – 4……Quiz #2
M  Nov  6 Biomechanics laboratory - Forward Dynamics Matlab
W  Nov  8 …………………………………………………………………………………………………Exam #2
M  Nov 13 Designation of joints, example  6.5 - 7

Chapter 7: 3D Kinematics and Kinetics

W  Nov 15 Axes, anatomical axes, angular velocities and accelerations  7.1 – 3
M  Nov 20 Reaction forces  7.4 – 5

Chapter 8: Muscle Mechanics

W  Nov 22 Force-length, force-velocity, modeling.  8.1 - 3
M  Nov 27 Biomechanics laboratory – Force Plates and EMG

Chapter 9: Kinesiological Electromyography

W  Nov 29 Electromyography, muscle contraction, recording, processing.  9.1 - 3……Quiz #3
M  Dec  4 Relationship between electromyogram and biomechanical variables  9.4
W  Dec  6 Review
W  Dec 13 …………………………………………………………………………………………….10:15 pm – 12:00 pm ….FINAL EXAM

* Subject to revision

STUDENTS WITH DISABILITIES: Students with a documented disability (physical, psychological, learning, or other disability which affects academic performance) who would like to receive academic accommodations should contact Student Accessibility Services (SAS) as soon as possible to schedule an appointment to initiate services. Accommodations can be arranged through SAS at any time, but are not retroactive. Students who suffer a broken bone, severe injury or undergo surgery during the semester are eligible for temporary services. Brownsville Campus: Student Accessibility Services is located in Cortez Hall Room 129 and can be contacted by phone at (956) 882-7374 (Voice) or via email at ability@utrgv.edu. Edinburg Campus:
Student Accessibility Services is located in 108 University Center and can be contacted by phone at (956) 665-7005 (Voice), (956) 665-3840 (Fax), or via email at ability@utrgv.edu.

**SEXUAL HARASSMENT, DISCRIMINATION, and VIOLENCE:** In accordance with UT System regulations, your instructor is a “Responsible Employee” for reporting purposes under Title IX regulations and so must report any instance, occurring during a student’s time in college, of sexual assault, stalking, dating violence, domestic violence, or sexual harassment about which she/he becomes aware during this course through writing, discussion, or personal disclosure. More information can be found at www.utrgv.edu/equity, including confidential resources available on campus. The faculty and staff of UTRGV actively strive to provide a learning, working, and living environment that promotes personal integrity, civility, and mutual respect that is free from sexual misconduct and discrimination.

**Course Drops:** According to UTRGV policy, students may drop any class without penalty earning a grade of DR until the official drop date. Following that date, students must be assigned a letter grade and can no longer drop the class. Students considering dropping the class should be aware of the “3-peat rule” and the “6-drop” rule so they can recognize how dropped classes may affect their academic success. The 6-drop rule refers to Texas law that dictates that undergraduate students may not drop more than six courses during their undergraduate career. Courses dropped at other Texas public higher education institutions will count toward the six-course drop limit. The 3-peat rule refers to additional fees charged to students who take the same class for the third time.

**ABET:** You should be aware that there is a national board (the Accreditation Board for Engineering and Technology (ABET)) that accredits engineering programs. The University of Texas Rio Grande Valley, Mechanical Engineering degree program is ABET-accredited. It is important to you that the engineering program from which you graduate is ABET-accredited because that is one of the requirements in the process of obtaining a Professional Engineering (PE) license. ABET wants to be sure that graduates of its accredited programs meet 11 educational objectives.

**Course Outcomes:** Upon completion of this course, students shall demonstrate that they are able to:

1. Define a musculoskeletal problem, identify components and state the engineering problem (Q,E,P,PP)
2. Calculate static forces for different biomechanical human postures (Q,E,P)
3. Model mathematically tissue structures such as bones, ligaments and tendons (Q,E, P,PP)
4. Collect experimental human biomechanics data such as displacements, ground reaction forces, muscles activity (Q,E,P,PP)
5. Calculate knee joint internal forces in ligaments, cartilage and muscles using experimental data and modeling (Q,E, P,PP)
6. Determine stress in bony structures (Q,E,P)
7. Calculate stress in bones with fracture fixation devices (Q,E,P)
8. Analyze total replacements, knee and hip, designs (Q,E,P)
9. Model and calculate contact stress analysis of articulating surfaces (Q,E,P)
10. Use engineering software for analysis (P,PP)