

**COURSE SYLLABUS**  
**BME 599 ~ Modeling & Simulation**  
**of Human Movement**  
**Spring 2019**

**Course Section:** 012  
**Meeting Time and Place:** 11:10AM – 12:25PM | TR | AP 308  
**Course Credit Hours:** 3

---

**FACULTY CONTACT**  
**INFORMATION**

Jeff Reinbolt  
Office hours: 1:00PM - 3:00PM W  
Office: DO 207  
Phone: 865.974.5308  
Email: [reinbolt@utk.edu](mailto:reinbolt@utk.edu)

**TEACHING ASSISTANT CONTACT** Not applicable  
**INFORMATION**

---

**1. COURSE DESCRIPTION.** Special Topic in Biomedical Engineering (1-3)

*Repeatability: May be repeated. Maximum 12 hours.*  
*Registration permission: consent of instructor.*

The goal of this course is to teach you how to develop dynamic models, analyses, and simulations of the human musculoskeletal system for different types of movement. Learning will be achieved through a series of lectures, journal article presentations, laboratory exercises, and a course project.

This course is modeled after the undergraduate course ME 382 "Modeling and Simulation of Human Movement" that we have developed along with Dr. Scott Delp at Stanford University. Variations of this course are also taught at the University of Florida, the University of Texas at Austin, the University of Wisconsin, Wake Forest University/Virginia Tech, North Carolina State University, and Rice University. The instructors from each of these courses (including the present course here) have agreed to share all course materials in order to create a world-class instructional opportunity. Consequently, you will be benefiting from extensive work done by instructors at six institutions while taking this course

**2. COURSE OBJECTIVES.** The objectives of this course are to teach you: to develop complex three-dimensional musculoskeletal models; to analyze musculoskeletal models; to create simulations of musculoskeletal motion; and to apply biomechanics principles to "real-world" clinical and biomechanical research.

3. **TEXTS/MATERIALS/RESOURCES FOR THE COURSE.** Course Reader (available online)

**Suggested reference books:**

*Biomechanics of the Musculo-skeletal System*, 3rd edition, B. M. Nigg and W. Herzog, John Wiley & Sons, 2007. ISBN: 978-0470017678

*Basic Orthopaedic Biomechanics and Mechanobiology*, 3rd Edition. V. C. Mow and R. Huiskes, Lippincott Williams & Wilkins, 2004. ISBN: 978-0781739337

*Human Anatomy and Physiology*, 2nd Edition. A. P. Spence and E. B. Mason, Benjamin/Cummings, 1983. ISBN: 978-0314876935

Online resources: <http://rrg.utk.edu/resources/BME599>

4. **INFORMATION LITERACY/TECHNOLOGICAL RESOURCES.** Online@UT

5. **TEACHING APPROACH.**

**Methods of Instruction.** To learn fundamental concepts of modeling and simulation of movement, we will use lectures activities and student research papers/presentations, assignments and simulation exercises, and office hours.

**Lectures.** We will cover all of the material in the *Course Reader* handout and more. I do not anticipate the class time being a one-way communication without your participation. To learn, you will need to think and respond to questions and ask your own questions for clarification.

**Class Collaboration and Peer-to-Peer Teaching.** You are encouraged to become part of a study group early on in the course, as this will greatly facilitate your ability to learn from one another as well as to complete the homework assignments and simulation exercises.

**Assignments.** No solutions will be provided to assignments. You are encouraged to work together to figure out the *solution process*. However, each student must write out his or her own work, and direct copying of another student's solutions will be considered a violation of the University Honor Statement.

**Role of the Student.** The role of the student is that of a learner, a collaborator, and a team member. You should be disciplined and motivated to follow the course schedule and complete assignments. If you have questions, it will be your responsibility to meet during office hours to receive additional assistance. You will be required to play an active role in identifying your learning issues and needs.

**Role of the Instructor.** The role of the instructor is that of a tutor, a mentor, and a resource. I should effectively organize, plan, and teach the curriculum. If you need additional assistance, I will provide support and encouragement to address your learning needs.

**Classroom Expectations.** To maintain a high-quality learning environment, the following standards will be followed:

- Professional courtesy and respect for others
- You are responsible for your own work
- You should show up on-time and be prepared for lectures
- Cell phones, iPods, audio players, and other devices will *not* be used
- Laptop computers will *not* be used in class, except for simulation assignments
- Disruptive behavior will *not* take place
- The University Honor Statement will *not* be violated

## 6. COURSE REQUIREMENTS, ASSESSMENT, AND EVALUATION METHODS.

**Attendance Policy.** Attendance is not required except to present your assigned journal articles and to present your final project. However, it will be extremely difficult to pass the course unless you regularly attend lectures.

**Tardiness Policy.** Arriving late (or leaving early) is disruptive and does not meet the Class Expectations standards nor suggestions for How to be Successful in this Class. Since difficult days will arise during the semester, you will be permitted the occasional late arrival. If tardiness becomes a problem, I will meet with you individually to discuss your issues and possible consequences.

**Journal Article Reviews.** Each student will choose, or be assigned, journal articles to review and present to the class. This exercise will help students internalize the material covered. See the *Journal Article Review* handouts for additional details.

**Simulation Labs.** Simulation lab assignments will involve mathematical modeling of each component of the musculoskeletal system. Each lab will grow in complexity to build your musculoskeletal modeling capabilities. While you are encouraged to work together on lab assignments, copying of assignments is not permitted. After figuring out with others how to complete the assignment, each student must work individually to create and run his or her own computer code.

You will be required to perform all laboratory assignments on your own personal computer. OpenSim is freely available at <https://simtk.org/home/opensim>. If MATLAB is required, the University of Tennessee has a system-wide license agreement with the MathWorks that makes MATLAB free to all students. Go to <http://oit.utk.edu/matlab/> for additional information on obtaining the software. See the *Simulation Labs* handout for additional details.

**Course Project/Presentation.** A final course project will be required involving modeling and simulation of the human musculoskeletal system. Students will need to setup a meeting with the instructor to discuss a suitable final course

project. The project will be an excellent opportunity to apply what you have learned to a real-life problem. Each student will give a final project presentation during the last week of class. The presentations will be done in the environment of a “mini-conference”, since the ability to explain and present a project is an important skill for any future position you will hold. See the *Course Project* handout for additional details.

**Late Assignment Policy.** Late assignments will not generally be accepted. Since difficult weeks will arise during the semester, each student will be permitted one (1) late assignment (*applicable only to the simulations labs*) turned in not more than one week after the original due date. Hardship cases will be considered on an individual basis and only if the instructor was notified before the due date.

**Grading System.** The final course grade,  $g$ , will be calculated based on the following percentages:

| Assessment                   | Percentage |  |
|------------------------------|------------|--|
| Simulation Labs ( $s$ )      | 50%        | $g(x) = \frac{(0.50s + 0.15a + 0.25r + 0.10p)}{(0.50 + 0.15 + 0.25 + 0.10)}$ |
| Article Reviews ( $a$ )      | 15%        |  |
| Project Report ( $r$ )       | 25%        |  |
| Project Presentation ( $p$ ) | 10%        |  |

You will earn your own final course grade based on the percentages above. I am simply the individual who does the calculations. If you are afraid that you are not performing well enough during the semester, come see me to get back on track.

**Grading Scale.** Assessed grades will use the following divisions that are linearly related to the University’s quality point scale:

| Grade | Quality Points ( $x$ ) | Percentage ( $10x+50$ ) |
|-------|------------------------|-------------------------|
| A     | 4.0                    | $90\% \leq g$           |
| A-    | 3.7                    | $87 \leq g < 90\%$      |
| B+    | 3.3                    | $83 \leq g < 87\%$      |
| B     | 3.0                    | $80 \leq g < 83\%$      |
| B-    | 2.7                    | $77 \leq g < 80\%$      |
| C+    | 2.3                    | $73 \leq g < 77\%$      |
| C     | 2.0                    | $70 \leq g < 73\%$      |
| C-    | 1.7                    | $67 \leq g < 70\%$      |
| D+    | 1.3                    | $63 \leq g < 67\%$      |
| D     | 1.0                    | $60 \leq g < 63\%$      |
| D-    | 0.7                    | $57 \leq g < 60\%$      |
| F     | 0.0                    | $g < 57\%$              |

**Honor Statement Policy.** See the University Policies section below.

**7. COURSE OUTLINE/ASSIGNMENT/UNITS OF INSTRUCTION.** See the *Lecture Schedule* handout for a day-by-day outline of the following general topics we will cover:

- Introduction to Movement Biomechanics
- OpenSim Overview
- Inverse Kinematics Analysis
- Inverse Dynamics Analysis
- Forward Dynamics Simulations
- Patient-Specific Modeling
- Muscle Model Evaluation
- Musculoskeletal Geometry
- Systems-Level Modeling

See the *Journal Article Review*, *Simulation Labs*, and *Course Project* handouts for details on how to complete assignments. The instructor will announce specific due dates in lecture. Plan your time carefully!

**8. HOW TO BE SUCCESSFUL IN THIS CLASS.** In addition to fully completing the assignments, general guidelines for improving your performance are as follows:

- Attend every class and be on time
- Bring documents from *Course Reader* handout, printouts of web documents, notebook, pen/pencil, and laptop to class
- Take notes and go over them before the next class
- Read the assigned documents before each class.
- Take advantage of office hours for extra help whenever you need it!
- Use the documents from *Course Reader* handout and course website!
- Ask questions! Participate in discussions!
- Do your own work!

**9. COURSE FEEDBACK.** In addition to formative feedback opportunities during office hours or via email, you have the opportunity to provide general anonymous feedback and you may complete a *Feedback Form* online at any time:

<http://rrg.utk.edu/resources/BME599/feedback.html>

## **10. UNIVERSITY POLICIES.**

***Freedom to Learn.*** The responsibility to secure and to respect general conditions conducive to the freedom to learn is shared by all members of the academic community. The university welcomes and honors people of all races, creeds, cultures, and sexual orientations, and values intellectual curiosity, pursuit of knowledge, and academic freedom and integrity.

**Academic Integrity.** The Honor Statement as printed in *Hilltopics* encourages each student to make a personal commitment to academic integrity:

*"An essential feature of the University of Tennessee is a commitment to maintaining an atmosphere of intellectual integrity and academic honesty. As a student of the University, I pledge that I will neither knowingly give nor receive any inappropriate assistance in academic work, thus affirming my own personal commitment to honor and integrity."*

All students admitted to the University of Tennessee have signed and dated a pledge acknowledging their affirmation of academic honesty committing themselves to be honest in all academic work and understanding that failure to comply with this commitment will result in disciplinary action.

**Plagiarism.** Students are also responsible for any acts of plagiarism that uses the intellectual property of someone else without giving proper credit. Plagiarism is a serious offense, subject to disciplinary action that may include failure in a course and/or dismissal from the university.

**11. STUDENTS WITH DISABILITIES POLICY.** Any student who feels s/he may need an accommodation based on the impact of a disability should contact the instructor privately to discuss their specific needs. Students with documented disabilities should contact the Office of Disability Services for assistance with appropriate accommodations at (865) 974-6087 or [ods@tennessee.edu](mailto:ods@tennessee.edu).

**12. IMPORTANT DATES IN THE ACADEMIC CALENDAR SPRING 2019.**

|                                     |                   |
|-------------------------------------|-------------------|
| Last Day to Add Classes             | January 18, 2019  |
| Last Day to Drop Course without "W" | January 18, 2019  |
| MLK Holiday (no classes)            | January 21, 2019  |
| Spring Break (no classes)           | March 18-22, 2019 |
| Last Day to Drop Course with "W"    | April 3, 2019     |
| Spring Recess (no classes)          | April 19, 2019    |
| Last Day of Classes                 | April 26, 2019    |

**13. SYLLABUS CHANGES.** I reserve and likely will exercise the right to revise, alter, and/or amend this syllabus as necessary. You will be notified of any such changes. You should check the course web site on a regular basis for up-to-date course information.