BME 4931 MODELS, MUSLCES, & MOVEMENT

EGN 4931 (cross-listed with EGN 6938)

Class Periods: Tuesday (Period 4: 10:40-11:30 AM) and Thursday (Period 4-5: 10:40-12:35 PM)
Location: BLK 415
Academic Term: Fall 2024

Instructor:

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352-294-8803
Office Hours: TBD

Course Description

Musculoskeletal biomechanics will be introduced through discussion of physics-based models. Physics-based (or biomechanical models) will be described in the context of locomotion (walking, running), muscle physiology, force generation, as well as complex analyses of healthy and pathological movement. Experimental methods to support model development and validation, such as motion capture, electromyography, medical imaging, and force sensors, will also be discussed.

Course Pre-Requisites / Co-Requisites

There are no required pre-requisites or co-requisites. However, an understanding of calculus, differential equations, statics, and basic coding skills will be useful.

Course Objectives

By the end of this course, students should be able to do the following:

- **Models**: Describe Bones & Joints Using Physics
  - Describe the musculoskeletal system using appropriate anatomical terms
  - Mathematically define position and orientation in three dimensions
  - Draw free-body diagrams and define equations of motion for linkage systems
  - Solve kinematic and kinetic problems to calculate joint angles, internal forces, and external forces

- **Muscles**: Evaluate Muscle-Tendon Function
  - Describe the biological, mechanical, and neurological aspects of how muscles produce movement
  - Mathematically model and describe muscles and tendons
  - Analyze the electrical signals used by the nervous system to generate muscle activity
  - Solve forward dynamic problems to calculate muscle forces and joint torques

- **Movement**: Apply Biomechanics Knowledge to Real-World Problems Involving Movement
  - Describe experimental and computational engineering tools that are used to study movement
  - Explain the mathematical foundations behind biomechanical engineering tools
  - Identify when to apply experimental and computational tools to solve biomechanics problems
  - Critically read and discuss the biomechanics literature

Relation to Program Outcomes (ABET):

Outcome	Coverage*
1. An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics	Medium
2. An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors	
3. An ability to communicate effectively with a range of audiences	Low
4. An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts	Low
5. An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives	
6. An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions	Medium
7. An ability to acquire and apply new knowledge as needed, using appropriate learning strategies	Medium

*Coverage is given as high, medium, or low. An empty box indicates that this outcome is not covered or assessed in the course.

Required Textbooks and Software

Title: Biomechanics of Movement: The Science of Sports, Robotics, and Rehabilitation
Author: Thomas Uchida & Scott Delp
Publisher: MIT Press
Date & Edition: 2021, 1st Ed.
ISBN: 978-0262044202
Website: https://simtk-confluence-homeworks.stanford.edu:8443/display/BMH

Opensim, an open-source musculoskeletal software program, will be used for homework assignments. This software runs on Windows and Mac computers, and is freely available at https://simtk.org/projects/opensim

Matlab or Python will be required for some assignments.

Recommended Materials

The following are useful reference texts:

Title: Biomechanics and Control of Human Movement
Author: David A. Winter
Publisher: Wiley
Date & Edition: 2009, 4th Ed.
ISBN: 978-0-470-39818-0

Title: Atlas of Human Anatomy
Author: Frank H. Netter
Publisher: Saunders Elsevier
Date & Edition: 2014, 6th Ed.
ISBN: 978-1455704187

or any other good atlas of human anatomy

Required Computer

UF student computing requirement: *https://news.it.ufl.edu/education/student-computing-requirements-for-uf/*

Course Schedule

Week 1: Introduction to Musculoskeletal Biomechanics (Chapter 1)
Week 2: Models: What is a physics-based model?
Week 3: Models: Walking (Chapter 2)
Week 4: Models: Running (Chapter 3)
Week 5: Models in Action
Week 6: Muscles: Biology & Force (Chapter 4)
Week 7: Muscles: Architecture & Dynamics (Chapter 5)
Week 8: Muscles: Musculoskeletal Geometry (Chapter 6)
Week 9: Muscle in Action
Week 10: Movement: Quantifying Movement (Chapter 7)
Week 11: Movement: Inverse Dynamics (Chapter 8)
Week 12: Movement: Muscle Force Optimization (Chapter 9)
Week 13 Movement: Muscle-Driven Simulations (Chapter 10)
Week 14: Movement in Action
Week 15: Real-World Applications & Conclusion

Important Dates

- *Thurs. 11/21 Project Presentations (in-class)*
- *Quizzes will be scheduled during Week 5, Week, 9, and Week 14*

Class: Students are expected to attend scheduled class sessions. Attending class is critical for understanding the course material, as there is no textbook. Class sessions will regularly include presentation of new material, solving sample problems, answering questions, and discussion. Students who are regularly absent from class (defined as 6 or more unexcused absences) will receive a zero for their participation grade. Excused absences must be consistent with university policies in the Graduate Catalog (https://catalog.ufl.edu/graduate/regulations) and require appropriate documentation. Additional information can be found here: https://gradcatalog.ufl.edu/graduate/regulations/

Homework: Homework assignments provide students with an opportunity to apply concepts learned in class and affirm their understanding of the course material. All assignments should be turned in electronically via the course website. Please use the following convention when naming your homework files: **LastName_HW_X.pdf** (replace "LastName" with your last name and "X" with the homework number). Assignments turned in late will not be graded, except under extreme circumstances at the discretion of the instructor. Students are encouraged to work cooperatively on assignments. However, each student must individually submit assignments consisting of his or her own work. This means that students are encouraged to discuss the solution process for problems. However, copying another student's work (or allowing a student to copy your work) will be considered a violation of the University honor code.

Quizzes: Quizzes are an opportunity for students to demonstrate their mastery of course concepts. There will be three in-class quizzes. Students are expected to be present for quizzes. Students who miss an quiz due to an illness or emergency and who provide proper documentation of the excused absence will take a make-up for full credit as soon as possible after original date.

Journal Paper Activities: The journal paper activities are an opportunity for students practice critically evaluating the literature, presenting, and leading discussion. Students will work in small groups to present two or three papers. Further details will be discussed in class and distributed on the course website.

Project: The project allows students to gain an in-depth understanding of a biomechanics topic of their choice. Further details on the project will be discussed in class and distributed on the course website.

Re-Grade Policy: If a student feels that an assignment or exam was graded incorrectly, they should return the assignment and a written description of the grading error to the instructor within 5 business days of receiving the

graded assignment. The instructor will evaluate the request and adjust the grade if an error was made. Any request for re-grading where the student has altered the assignment after it was returned to gain a grade benefit will be considered a violation of the University honor code.

Changes to the Syllabus: Occasionally, course policies may need to be changed due to unforeseen circumstances or to improve the course. The instructor reserves the right to make necessary changes. Additionally, if a student or group of students have a suggestion on how to revise the course and the instructor agrees that the revision would improve the course, the proposed change will be put to put to an anonymous vote by the entire class. If the majority of the class agrees to the change, it will become part of the syllabus.

Evaluation of Grades

Assignment	**Percentage of Final Grade**
Homework *(best 6 of 8)*	15%
Quizzes (*3 total*)	15%
Modeling Assignments (*3 total*)	15%
Journal Paper Activities (*3 total*)	15%
Project	40%
	100%

Grading Policy

Grade	***A***	***A-***	***B+***	***B***	***B-***	***C+***	***C***	***C-***	***D+***	***D***	***D-***	***E***
Percent	*93.4 - 100*	*90.0 - 93.3*	*86.7 - 89.9*	*83.4 - 86.6*	*80.0 - 83.3*	*76.7 - 79.9*	*73.4 - 76.6*	*70.0 - 73.3*	*66.7 - 69.9*	*63.4 - 66.6*	*60.0 - 63.3*	*0 - 59.9*
Grade Points	*4.00*	*3.67*	*3.33*	*3.00*	*2.67*	*2.33*	*2.00*	*1.67*	*1.33*	*1.00*	*0.67*	*0.00*

More information on UF grading policy may be found at:
https://catalog.ufl.edu/ugrad/current/regulations/info/grades.aspx

Students Requiring Accommodations
Students with disabilities who experience learning barriers and would like to request academic accommodations should connect with the disability Resource Center by visiting https://disability.ufl.edu/students/get-started/. It is important for students to share their accommodation letter with their instructor and discuss their access needs, as early as possible in the semester.

Course Evaluation
Students are expected to provide professional and respectful feedback on the quality of instruction in this course by completing course evaluations online via GatorEvals. Guidance on how to give feedback in a professional and respectful manner is available at https://gatorevals.aa.ufl.edu/students/. Students will be notified when the evaluation period opens, and can complete evaluations through the email they receive from GatorEvals, in their Canvas course menu under GatorEvals, or via https://ufl.bluera.com/ufl/. Summaries of course evaluation results are available to students at https://gatorevals.aa.ufl.edu/public-results/.

In-Class Recording
Students are allowed to record video or audio of class lectures. However, the purposes for which these recordings may be used are strictly controlled. The only allowable purposes are (1) for personal educational use, (2) in connection with a complaint to the university, or (3) as evidence in, or in preparation for, a criminal or civil proceeding. All other purposes are prohibited. Specifically, students may not publish recorded lectures without the written consent of the instructor.

A "class lecture" is an educational presentation intended to inform or teach enrolled students about a particular subject, including any instructor-led discussions that form part of the presentation, and delivered by any instructor hired or appointed by the University, or by a guest instructor, as part of a University of Florida course. A class

lecture does not include lab sessions, student presentations, clinical presentations such as patient history, academic exercises involving solely student participation, assessments (quizzes, tests, exams), field trips, private conversations between students in the class or between a student and the faculty or lecturer during a class session.

Publication without permission of the instructor is prohibited. To "publish" means to share, transmit, circulate, distribute, or provide access to a recording, regardless of format or medium, to another person (or persons), including but not limited to another student within the same class section. Additionally, a recording, or transcript of a recording, is considered published if it is posted on or uploaded to, in whole or in part, any media platform, including but not limited to social media, book, magazine, newspaper, leaflet, or third party note/tutoring services. A student who publishes a recording without written consent may be subject to a civil cause of action instituted by a person injured by the publication and/or discipline under UF Regulation 4.040 Student Honor Code and Student Conduct Code.

University Honesty Policy

UF students are bound by The Honor Pledge which states, "We, the members of the University of Florida community, pledge to hold ourselves and our peers to the highest standards of honor and integrity by abiding by the Honor Code. On all work submitted for credit by students at the University of Florida, the following pledge is either required or implied: "On my honor, I have neither given nor received unauthorized aid in doing this assignment." The Honor Code (https://sccr.dso.ufl.edu/process/student-conduct-code/) specifies a number of behaviors that are in violation of this code and the possible sanctions. Furthermore, you are obligated to report any condition that facilitates academic misconduct to appropriate personnel. If you have any questions or concerns, please consult with the instructor or TAs in this class.

Commitment to a Safe and Inclusive Learning Environment

The Herbert Wertheim College of Engineering values varied perspectives and lived experiences within our community and is committed to supporting the University's core values, including the elimination of discrimination. It is expected that every person in this class will treat one another with dignity and respect regardless of race, creed, color, religion, age, disability, sex, sexual orientation, gender identity and expression, marital status, national origin, political opinions or affiliations, genetic information, and veteran status.

If you feel like your performance in class is being impacted by discrimination or harassment of any kind, please contact your instructor or any of the following:

- Your academic advisor or Undergraduate Coordinator
- HWCOE Human Resources, 352-392-0904, student-support-hr@eng.ufl.edu
- Pam Dickrell, Associate Dean of Student Affairs, 352-392-2177, pld@ufl.edu
- Toshikazu Nishida, Associate Dean of Academic Affairs, 352-392-0943, nishida@eng.ufl.edu

Software Use

All faculty, staff, and students of the University are required and expected to obey the laws and legal agreements governing software use. Failure to do so can lead to monetary damages and/or criminal penalties for the individual violator. Because such violations are also against University policies and rules, disciplinary action will be taken as appropriate. We, the members of the University of Florida community, pledge to uphold ourselves and our peers to the highest standards of honesty and integrity.

Student Privacy

There are federal laws protecting your privacy with regards to grades earned in courses and on individual assignments. For more information, please see: https://registrar.ufl.edu/ferpa.html

Campus Resources:

Health and Wellness

U Matter, We Care:
Your well-being is important to the University of Florida. The U Matter, We Care initiative is committed to creating a culture of care on our campus by encouraging members of our community to look out for one another and to reach out for help if a member of our community is in need. If you or a friend is in distress, please contact umatter@ufl.edu so that the U Matter, We Care Team can reach out to the student in distress. A nighttime and weekend crisis counselor is available by phone at 352-392-1575. The U Matter, We Care Team can help connect students to the many other helping resources available including, but not limited to, Victim Advocates, Housing staff, and the Counseling and Wellness Center. Please remember that asking for help is a sign of strength. In case of emergency, call 9-1-1.

Counseling and Wellness Center: https://counseling.ufl.edu, and 392-1575; and the University Police Department: 392-1111 or 9-1-1 for emergencies.

Sexual Discrimination, Harassment, Assault, or Violence
If you or a friend has been subjected to sexual discrimination, sexual harassment, sexual assault, or violence contact the **Office of Title IX Compliance**, located at Yon Hall Room 427, 1908 Stadium Road, (352) 273-1094, title-ix@ufl.edu

Sexual Assault Recovery Services (SARS)
Student Health Care Center, 392-1161.

University Police Department at 392-1111 (or 9-1-1 for emergencies), or http://www.police.ufl.edu/.

Academic Resources

E-learning technical suppor*t*, 352-392-4357 (select option 2) or e-mail to Learning-support@ufl.edu. https://elearning.ufl.edu/.

Career Connections Center, Reitz Union, 392-1601. Career assistance and counseling; https://career.ufl.edu.

Library Support, http://cms.uflib.ufl.edu/ask. Various ways to receive assistance with respect to using the libraries or finding resources.

Teaching Center, Broward Hall, 392-2010 or 392-6420. General study skills and tutoring. https://teachingcenter.ufl.edu/.

Writing Studio, 302 Tigert Hall*,* 846-1138. Help brainstorming, formatting, and writing papers. https://writing.ufl.edu/writing-studio/.

Student Complaints Campus*:* https://sccr.dso.ufl.edu/policies/student-honor-code-student-conduct-code/;https://care.dso.ufl.edu.

On-Line Students Complaints*:* https://distance.ufl.edu/getting-help/; *https://distance.ufl.edu/state-authorization-status/#student-complaint*.