Biodynamics

EGM4590

Class Periods: MWF, Period 4, 10:40 – 11:30 AM
Location: WEIM 1094
Academic Term: Spring 2023

Instructor:
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(352) 294-0435
WERT 461
Office Hours: MW Period 5 (11:45 – 12:35) or by appointment

Course Description

Dynamic analysis of the human musculoskeletal system. Includes development of lumped mass, planar rigid-body and 3D rigid-body models of human movement. Also includes calculation of internal forces in muscles and joints and analysis of muscle function using dynamics principles and musculoskeletal geometry.

Course Pre-Requisites / Co-Requisites

EGM 3400 / EGM 3401 or instructor permission

Course Objectives

The goal of EGM 4590 is to teach you how to apply engineering dynamics to problems involving human musculoskeletal function. The course is designed to build on concepts learned in undergraduate dynamics. Emphasis is placed on the relationship between engineering mechanics and human body structure, with special emphasis on static and dynamic analysis of how muscles, ligaments, and bones interact during typical activities (e.g., walking, jumping, reaching, etc.).

By the end of this course, you should be able to do the following:
- Develop multi-body dynamical models of the human musculoskeletal system possessing appropriate complexity for the problem at hand. (*Biomechanical Modeling*)
- Calculate internal forces in muscles, joints, and bones during movement using basic principles of engineering mechanics by hand and using software such as OpenSim, Matlab, and/or Python. (*Biomechanical Calculations*)
- Analyze the mechanical function of the human body and individual muscles using dynamics principles, musculoskeletal geometry, and software. (*Biomechanical Analyses)*
- Answer such questions as: how should muscles be coordinated to produce a reaching motion? how do joint contact forces change due to muscle contraction? what is the best way to perform a soccer kicking motion? etc. (*Biomechanical Problems*)

Materials and Supply Fees

None

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	High
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	Medium
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	
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	Medium
6. An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions	
7. An ability to acquire and apply new knowledge as needed, using appropriate learning strategies	

*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

Textbooks: None.

Software:
- OpenSim, an open-source musculoskeletal software program, will be used for assignments. This software runs on both Windows and Mac computers, and is freely available at https://simtk.org/projects/opensim
- Matlab or Python may be required for some assignments and the final project.

  Note that for some lectures, you will need to bring your laptop to class to work on Opensim models and analyses.

Recommended Materials
The following are useful references:

- OpenSim Support (https://simtk-confluence.stanford.edu:8443/display/OpenSim/OpenSim+Documentation)
  Note in particular the "User's Guide" and the "Examples and Tutorials" links.

- Title: Dynamics of Particles and Rigid Bodies: A Systematic Approach
  Author: Anil V. Rao
  Publisher: Cambridge University
  Date & Edition: 2006
  ISBN: 9780521187909
  or any other good dynamics textbook

- Title: Biomechanics of Movement: The Science of Sport, Robotics, and Rehabilitation
  Author: Thomas Uchida & Scott Delp
  Publisher: MIT Press
  Date & Edition: 2021, 1st Ed.
  ISBN: 9780262044202
  Online Resources: https://simtk-confluence-homeworks.stanford.edu:8443/display/BMH

- Title: Atlas of Human Anatomy
  Author: Frank H. Netter
  Publisher: Saunders Elsevier
  Date & Edition: Any edition.
  ISBN: 9780323393225 (for 7th edition)
  or any other good atlas of human anatomy

Course Schedule

Below is a tentative course schedule subject to change. A more detailed and up-to-date schedule, including suggested readings, assignment and exam due dates, etc. is posted on the course website.

Week	Date	Topic
1	1/09 – 1/13	Introduction to Biodynamics
2	1/16 – 1/20	Biodynamics: From Data to Predictions
3	1/23 – 1/27	Introduction to Rigid-Body Kinematics and Dynamics
4	1/30 – 2/03	Multi-Body Kinematics and 3D Rotations
5	2/06 – 2/10	Angular Velocity and Acceleration
6	2/13 – 2/17	Hands-on Musculoskeletal Modeling: Kinematics
7	2/20 – 2/24	Key Concepts for Dynamics
8	2/27 – 3/03	Forward Dynamics
9	3/06 – 3/10	Inverse Dynamics
10	3/13 – 3/17	SPRING BREAK
11	3/20 – 3/24	Hands-on Musculoskeletal Modeling: Dynamics
12	3/27 – 3/31	Muscle Force Estimation and Optimization
13	4/03 – 4/07	Muscle Models
14	4/10 – 4/14	Advanced Musculoskeletal Modeling
15	4/17 – 4/21	Work on Course Project
16	4/24 – 4/26	Course Project Presentations

Attendance Policy, Class Expectations, and Make-Up Policy

CLASS: Regular attendance and participation in class is expected and encouraged as there is no textbook. You are responsible for all information disseminated during lectures. Disseminated information includes concepts explained by the instructor verbally, on the whiteboard, and in OpenSim and Matlab/Python programs, as well as any course logistics communicated by the instructor.

HOMEWORK: Homework assignments provide students an opportunity to apply concepts learned in class and affirm their understanding of the course material. Some homework assignments may require you to use Matlab or Python. Your well-commented code and associated answers must be turned in along with any written work. Students are encouraged to work together to understand the concepts in each homework; however, submitted assignments should reflect your own work. Assignments that are obviously copied will receive no credit and be subject to academic dishonesty policies. Homework will be graded on a scale of 0 to 3 based on completeness and correctness. The lowest homework grade will be dropped. *Submission Policy:* Homework assignments will typically be due one week after assigned (refer to course website for most up-to-date deadlines). All assignments should be turned in electronically via the course website as a single PDF document. You must use the following convention when naming your submission: LastName_HW_X.pdf (replace "LastName" with your last name and "X" with the assignment number). *Makeup and Late Policy*: There will be no make-up homework assignments. Since difficult weeks will arise during the semester, students will be allowed to turn in two homework assignments up to 48 hours late (two days). The instructor need not be notified ahead of time. No other late homework assignments will be accepted.

MINI-PROJECTS: The mini-projects provide students a deeper opportunity to study dynamical systems in a biological context and to analyze complex biomechanical problems. Students are encouraged to work together to understand the concepts in each mini-project, however, submitted assignments should reflect your own work. Assignments that are obviously copied will receive no credit and be subject to academic dishonesty policies. *Submission policy:* All submissions should be turned in electronically via the course website by the posted deadline (refer to course website for most up-to-date deadlines). You must use the following convention when naming your submission: LastName_MiniProject_X.pdf (replace "LastName" with your last name and "X" with the assignment number). *Makeup and Late policy:* There will be no make-up mini-projects. Late mini-projects will be subject to a strict deduction policy as follows: 10% per each 12 hours past the deadline, with a maximum of 40% deduction after

48 hours (two days). Mini-projects submitted beyond two days late will receive no credit unless a prior arrangement was made with the instructor.

EXAMS: Exams are an opportunity for students to demonstrate their mastery of course concepts. There will be two cumulative exams given during the semester. Exams will be given in-class and may also include a take-home portion. Students will be permitted to use one 8.5 x 11-inch handwritten sheet of notes (front and back) for the in-class exams. All notes must be turned in with the exam. If you are caught cheating, you will receive a zero on the exam and be subject to academic dishonest policies. _Makeup policy:_ No makeup exams are allowed except for rare instances with documentation and pre-approval by the instructor per University policy.

COURSE PROJECT: In lieu of a final exam, you will be required to complete a final course project using the OpenSim musculoskeletal modeling software. The purpose of the project is to provide students an opportunity to apply the concepts learned throughout the semester to analyze a complex real-world problem in human movement. Further details on the project will be discussed in class and distributed on the course website.

RE-GRADE POLICY: All grading appeals must be received in writing within 1 week after the assignment is graded and/or returned. If a student feels than an assignment, quiz, or exam was graded incorrectly, they should return the assignment and a written description of the grading error within 1 week 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.

Requirements for class attendance and make-up exams, assignments, and other work in this course are consistent with university policies. Click here to read the university attendance policies:
https://catalog.ufl.edu/UGRD/academic-regulations/attendance-policies/

Evaluation of Grades

Assignment	Percentage of Final Grade
Homework Sets	10%
Mini-Projects (3 @ 5% each)	15%
Exam 1	25%
Exam 2	25%
Course Project	25%
	100%

Grading Policy

Percent	Grade	Grade Points
93.4 - 100	A	4.00
90.0 - 93.3	A-	3.67
86.7 - 89.9	B+	3.33
83.4 - 86.6	B	3.00
80.0 - 83.3	B-	2.67
76.7 - 79.9	C+	2.33
73.4 - 76.6	C	2.00
70.0 - 73.3	C-	1.67
66.7 - 69.9	D+	1.33
63.4 - 66.6	D	1.00
60.0 - 63.3	D-	0.67
0 - 59.9	E	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 broad diversity within our community and is committed to individual and group empowerment, inclusion, and the elimination of discrimination. It is expected that every

person in this class will treat one another with dignity and respect regardless of gender, sexuality, disability, age, socioeconomic status, ethnicity, race, and culture.

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 Graduate Program Coordinator
• Jennifer Nappo, Director of Human Resources, 352-392-0904, jpennacc@ufl.edu
• Curtis Taylor, Associate Dean of Student Affairs, 352-392-2177, taylor@eng.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://lss.at.ufl.edu/help.shtml.

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/state-authorization-status/#student-complaint*.