Biodynamics

EGM 4590 Section 237H
Class Periods: MWF Period 4 (10:40 am – 11:30 am)
Location: LAR 0239
Academic Term: Spring 2026

Instructor:
Kerry E. Costello, Ph.D.
k.costello@ufl.edu [Note: All course-related contact should be via Canvas, not email]
(352) 392-0800
Office Hours: Mondays Periods 5-6 (11:45 am – 1:40 pm) or by appointment, WERT 482

Teaching Assistant/Peer Mentor/Supervised Teaching Student:
Please contact through the Canvas website; office hours and locations posted on Canvas

- Emma Patterson
- Emily Palmer

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. (3 Credit Hours)

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 both 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, and interpret the results in the context of model assumptions and limitations. (*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 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, may be used for some assignments and the final project. 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 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

Required Computer
Recommended Computer Specifications: https://it.ufl.edu/get-help/student-computer-recommendations/
HWCOE Computer Requirements: https://www.eng.ufl.edu/students/advising/fall-semester-checklist/computer-requirements/

Course Schedule
The following schedule outlines the planned sequence of topics for the course. Specific assignment due dates, mini-project details, engagement activities, and any guest lectures will be communicated and maintained on Canvas. Students are responsible for checking Canvas regularly for the most up-to-date information. Exam dates listed below are fixed and will not change.

Week 1: Introduction to Biodynamics
Week 2: Biodynamics: From Data to Predictions
Week 3: Introduction to Rigid-Body Kinematics & Dynamics
Week 4: Multi-Body Kinematics
Week 5: 3D Biodynamics
Week 6: Hands-on Musculoskeletal Modeling
Week 7: Key Concepts for Dynamics
Week 8: Inverse Dynamics: Core Mechanics
Week 9: Inverse Dynamics: Forces & Muscles
Week 10: SPRING BREAK
Week 11: Forward Dynamics: Concepts & Comparison
Week 12: Putting It All Together: From Models to Meaning
Week 13: Applied Biodynamics: Course Projects
Week 14: Project Presentations
Week 15: Advanced Topics & Extensions in Biodynamics

Important Dates
02/23/2026 Exam 1 (in class)
04/01/2026 Exam 2 (in class/take-home)

Evaluation of Grades

Assignment	**Percentage of Final Grade**
Homework Sets	10%
Mini-Projects (2 @ 5% each)	10%
Exam 1	25%
Exam 2	25%
Engagement & Participation	5%
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

Academic Policies & Resources
To support consistent and accessible communication of university-wide student resources, instructors must include this link to academic policies and campus resources: https://go.ufl.edu/syllabuspolicies. Instructor-specific guidelines for courses must accommodate these policies.

Commitment to a Positive 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.

If you feel like your performance in class is being impacted, 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

COURSE-SPECIFIC POLICIES & EXPECTATIONS

Class Expectations
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, Matlab, or 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.

All submitted work must be your own**.** Collaborative discussion in small groups (3-5 students) is allowed, but you must be able to solve problems independently to succeed on exams. 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. A student-created reference sheet may be used during all exams. The sheet must be *handwritten (no photocopies or printouts), include your full name printed at the top, and be no larger than two sides of an 8.5" x 11" piece of paper*. You may include **anything you find helpful**, such as formulas, worked examples, reminders, or encouraging notes to yourself. Some students find it helpful to add material to the same reference sheet throughout the semester, but you may also create a new reference sheet for each exam if you prefer. Reference sheets must be submitted with your exams and will be returned to you when your graded exams are returned. If you are caught cheating, you will receive a zero on the exam and be subject to academic dishonesty policies.

Makeup policy: No makeup exams are allowed except for rare instances with documentation and pre-approval by the instructor per University policy. Click here to read the university attendance policies: https://catalog.ufl.edu/UGRD/academic-regulations/attendance-policies/

Engagement & Participation

Engagement credit is based on active participation in course activities that support learning beyond homework and exams. Examples may include completing brief post-lecture reflections or surveys, providing peer feedback on projects, and participating in in-class activities. Specific engagement opportunities and requirements will be communicated on Canvas.

Course Project

In lieu of a final exam, students will complete a final course project using the appropriate biomechanical modeling tools, which may include OpenSim musculoskeletal modeling software, Matlab, or Python. The purpose of the project is to apply 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 Canvas.

Use of Generative AI Tools

Generative AI tools (e.g., NavigatorAI, ChatGPT, Gemini, Copilot) may be permitted for certain assignments when explicitly allowed by the instructor. When AI use is allowed, students are responsible for verifying correctness and must follow assignment-specific guidelines. Students may be required to turn in the prompt(s) used and AI output(s) with their submission. Use of AI is prohibited on exams and on any assignment sections explicitly marked as "No AI." Further details will be provided on Canvas and in individual assignment instructions.

Re-grade Policy

All graded work is evaluated using detailed rubrics to ensure fair and consistent grading. Students are encouraged to review feedback carefully upon receiving their grades.

If you believe a *grading error* has occurred (e.g., a point was missed or added incorrectly), you may submit a written regrade request via a Canvas message to the instructor **within 1 week** of receiving your graded assignment. Your request should include the original graded work and a clear explanation of the specific grading error you believe was made.

Please note that ***regrade requests are intended to address objective grading mistakes***, not to challenge subjective assessments or rubric criteria. The instructor will review all requests and adjust grades only if a grading *error* is confirmed.

Altering any graded work after it has been returned to request a higher grade is considered a violation of the University honor code and will be dealt with accordingly.