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MAE420/520 Course Syllabus

Dynamics of Human Movement

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INSTRUCTOR INFORMATION

Name	Office Phone	Email	Office Location
Katherine Saul, PhD	919-515-1273	ksaul@ncsu.edu	EB3 3162

Office Hours

Tuesday 2-3 in person and Wednesday 10-11 on zoom or by scheduled appointment. **DE students can use Monday 6-7 on Zoom by prior appointment only.** See Zoom link in Moodle.

Preferred Method of Communication

My preferred mode of communication is 1) general questions in the Student Help Forum on Moodle or 2) individual questions by email (ksaul@ncsu.edu). If you use email, please put MAE 420/520 in the subject heading.

Response Time

I will typically respond to emails and phone calls within 24 hours during the week. For Sunday due dates, please email prior to 5pm Friday for guaranteed response. If you contact me by phone, please leave a voicemail.

Announcements

I will post any announcements in the announcement area of our Moodle classroom. All announcements will be sent to your NCSU email account.

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COURSE INFORMATION

Course Website: https://wolfware.ncsu.edu/courses/my-wolfware/
Course Credit Hours: 3

Meeting Time and Tool Used

Tuesday/Thursday 10:15AM - 11:30AM in 2213 Engineering Building 3
Join me during our class time for lecture. Meetings during our class time will be recorded and posted for review on Moodle for distance and in person students.

Prerequisites/Corequisites

Undergraduate dynamics (MAE 208) with a grade of C or better (or equivalent for graduate students)

General Education Program (GEP) Information

none

GEP Category Fulfilled

none

GEP Corequisites

none

COURSE OVERVIEW

Catalog Description

Topics in movement biomechanics and computational analyses of movement, including muscle physiology and mechanics, advanced muscle modeling, neural control of muscle and motor control theories, and dynamic simulation and optimization. Discussion of fundamental research underpinnings and clinical and sports applications.

Structure

- This course delivers learning materials, activities, and assignments, through **Moodle**, a secure and easy-to-use online learning platform.
- The course has **asynchronous** and **synchronous** learning content and assessments. Synchronous lectures are also recorded and can be watched asynchronously. Asynchronous lectures should be watched within 24 hours.
- The course is organized into 5 Modules, or topic areas, that each has supportive material, practice activities to develop your skills, and homeworks to apply your skills to new and fun systems in a more practical way. All deadlines and expectations are outlined in more detail below.

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LEARNING OUTCOMES

Upon completion of this course, students will be able to:

1. Describe the biological, mechanical, and neurological aspects of how muscles produce movement
2. Identify the engineering tools that are used to study movement, explain their function, and analyze data
3. Create and solve engineering models of human movement analytically and computationally
4. Synthesize existing literature on a chosen topic area and propose new research to fill an existing gap.

See Course Map for all Module level learning outcomes.

COURSE MATERIALS

Required Textbook and/or Software

Moodle: http://wolfware.ncsu.edu

Optional Materials

Uchida T.K. and Delp, S.L., Biomechanics of Movement: The Science of Sports, Robotics, and Rehabilitation. Readings from the textbook align with the lecture material and example problems, and the textbook is a resource for additional practice problems and explanations beyond that provided in class.

Course handouts

There will be a course handout associated with each class. The course handout will be available in Wolfware/Moodle. It is each student's responsibility to download/print out the handout before coming to lecture. Handouts will include important class information and will have drawings and problem statements associated with example problems to be worked in class – you will be at a disadvantage in class without the handout.

Exams

There will be two (2) midterm tests. These tests will be timed, using the resources designated in class, including equation sheets provided by the instructor. You should document your process. This should include:

- Sketching the system and the givens.
- Remember BREAD (body, reactions, external forces, axes, dimensions) when drawing free body diagrams.
- State what you are solving for.
- State your assumptions.
- Solve completely and box your answer.
- Document your units

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Homework Assignments

There are analytical and modeling assignments due periodically throughout the semester and the bulk of the content in this course. They will involve computational aspects, literature review, analytical derivations, and synthesis. Detailed descriptions are available below. These require substantial time investment. Do not wait to begin. Late completion will not be accepted.

Research project

The course project will be completed as student teams, due according to the dates on the syllabus. No late submissions will be accepted. Further details regarding the project are below and templates will be provided in a separate document. Students will be required to perform a literature review and design an experimental method. Final report and presentation will be required.

GRADING

Grading Policy

- 20%: **Research Project:** Research and experimental design project culminating in research proposal and/or video. Scoring rubric is found in the Moodle assignment for each part. See assignment handout for detailed information. Feedback will be provided within about two weeks of each due date.
- 50%: **HW Assignments.** Analysis and modeling assignments. Scoring rubric is found in the Moodle assignment for each part. See assignment overview below for detailed information. Each project is equally weighted. Feedback will be provided within about two weeks.
- 30%: **Midterm Exams:** 2 exams throughout the course. Multiple choice, short answer, and numerical problem solving. The exams will be graded with a rubric for potential partial credit. Feedback will be provided within about two weeks.

Grading Scale

This course uses this grading scale with no rounding:

A+	A	A-	B+	B	B-	C+	C	C-	D+	D	D-
>97	93	90	87	83	80	77	73	70	67	63	60

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COURSE SCHEDULE

Week	Date	Topic	Reading	SUNDAY Due Dates
1	T, 8/2	**Module 1: Locomotion and Simple models** 1 Introduction	Srinivasan	
	Th, 8/22	2 Principles of locomotion	Kuo, McMahon	8/25: Orientation
2	T, 8/27	3 Simple Models	Hutchinson 1	
	Th, 8/29	**Module 2: MSK mechanics/modeling** 4 Muscle structure and biology	Ortho, Llewellyn	8/28 Census Day 9/1: HW1
3	T, 9/3	5 Muscle mechanics		
	Th, 9/5	6 Muscle architecture	Zajac, Hill	
4	T, 9/10	7 History of muscle models	Huxley, Bassett	
	Th, 9/12	8 Musculoskeletal geometry	Arnold	9/15: topic, HW2
5	T, 9/17	Wellness Day		
	Th, 9/19	**Module 3: Other tissues and adaptation** 9 Neuromuscular structures - KEEN		
6	T, 9/24	10 Musculoskeletal tissues	Loboa	
	Th, 9/26	11 Adaptation		
7	T, 10/1	Review		9/29: HW3
	Th, 10/3	**Exam 1**		
8	T, 10/8	**Module 4: Experimental methods** 12 Principles of research design		
	Th, 10/10	13 Anatomy and imaging	Handsfield, Holzbaur	
9	T, 10/15	FALL BREAK- HOLIDAY		
	Th, 10/17	14 MSK modeling - NIH	Delp 2007, Hutchinson 2	**DROP DEADLINE**
10	T, 10/22	15 Motion capture		
	Th, 10/24	16 Inverse kinematics - SWE		10/27: Outline
11	T, 10/29	17 Inverse dynamics		
	Th, 10/31	18 Joint work and power	Sasaki	11/3: HW4
12	T, 11/5	**Module 5: Control and analysis** 19 Motor control strategies	Ting, Batista	
	Th, 11/7	20 Neural interfaces		
13	T, 11/12	21 Forward dynamics and optimization	Ashby	
	Th, 11/14	22 Analysis	Goldberg, Hernandez	11/17: HW5
14	T, 11/19	Review		
	Th, 11/21	**Exam 2**		
15	T, 11/26	23 Applications	Liu, Steele, Damiano, Lloyd, Sheets	
	Th, 11/28	THANKSGIVING HOLIDAY		
16	T, 12/3	**Final reports/projects, in class share**		Project due: 12/2
Finals		**No final exam**		

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Assignment types

HW#: type	Topic
HW1: Analytic, literature review	Principles of locomotion Tuned track and simple models
HW2: Analytic, programming, data analysis, simulation	Excitation of skeletal muscle Muscle structure and biology Muscle architecture Musculoskeletal geometry
HW3: Analytic, literature review, data analysis	Cont. from above Neuromuscular structures Musculoskeletal tissues Muscle adaptation
HW4: Programming, data analysis, simulation, literature review	Anatomy and Imaging Musculoskeletal modeling Joint biomechanics Motion capture techniques Inverse kinematics Inverse dynamics
HW5: Analytic, simulation	Muscle and joint work and power Motor control strategies Forward dynamics Optimization and control

Note: Assignments are of the following formats:

- Analytic: typical problem set with hand derivations or solutions
- Programming: implementation of analytic solutions or models (typically performed in Matlab)
  Data analysis: use of real data (motion capture, force data) from published papers or data collection
- Simulation: musculoskeletal model building and dynamic simulation of movement, using OpenSim, an opensource research-grade simulation software package
- Literature review: use of primary sources from the academic literature to justify conclusions, or obtain data for model implementation

FINAL PROJECT

The project will give you an opportunity to deepen your knowledge in an area of biomechanics that interests you. Through this assignment, you will access the scientific literature so you can see for yourself the results of biomechanics research. The project will help hone your critical reading and writing skills and give you team project experience. You may work in groups of 3-4 people.

MAE 420:

- **Aim 1. Topic.** Rationale: An early project checkpoint will ensure that your topics are properly scoped. Hypothesis: Students will be able to identify a fascinating application of biomechanics.
- **Aim 2. Script or storyboard.** Rationale: It is important to ensure that teams are finding adequate relevant literature for review and have a plan for their video. Hypothesis: Video plans will include interesting applications and technical content that reflects class content.

- **Aim 3. Video.** Rationale: Practice conveying biomechanics concepts in an engaging way that can serve as an advertisement for how exciting and applicable the field is. Hypothesis: Each team will be successful developing a technically accurate and engaging video on an important biomechanics topic

MAE520:

- **Aim 1. Topic.** Rationale: An early project checkpoint will ensure that your aims are properly scoped. Hypothesis: Students will be able to identify a fascinating application of biomechanics.
- **Aim 2. Literature summary.** Rationale: It is important to ensure that teams are finding adequate relevant literature for review. Hypothesis: At least 5 primary articles will be available in the literature regarding your topic.
- **Aim 3. Project proposal.** Rationale: Practice preparing a formal scientific proposal is valuable to learning how to integrate literature sources and hone your ability to design a research study. Hypothesis: Each team will be successful identifying a significant and innovative study design to answer an important biomechanics question.

SYLLABUS MODIFICATION STATEMENT

The schedule is the anticipated plan for the semester. **Please note the due dates now!** We will stick as closely to this schedule and plan as possible. Dates, topics, and assignments are subject to change to meet educational requirements or accommodate unexpected events during the semester. Any changes will be clearly communicated in synchronous lecture, by Moodle announcements, and/or an updated syllabus. Be sure you are subscribed to and receiving Moodle announcements as this will be an important mode of communication.

TECHNOLOGY REQUIREMENTS

Hardware

NC State's Online and Distance Education provides technology requirements and recommendations for computer hardware.

Software

- Moodle and Wolfware
  - Moodle Accessibility Statement
  - Moodle Privacy Policy
  - NC State Privacy Policy
- Adobe Reader (for reading PDF files)
  - Accessibility Statement
  - Adobe Privacy Policy
- Zoom:
  - Zoom Accessibility Statement
  - Zoom Privacy Policy
- Panopto
  - Accessibility Features
  - Privacy Policy
- G Suite
  - Accessibility Statement
  - Privacy Policy
- Office 365
  - Accessibility Statement
  - Privacy Policy
- Headsets with microphone
- Matlab
  - Matlab accessibility Statement
  - Matlab privacy policy
- OpenSim

Minimum Computer and Digital Literacy Skills

- Obtain regular access to a reliable internet connection
- Proficient typing and word processing skills (MS Word, text editors, Google Docs)
- Ability to use online communication tools, such as email (create, send, receive, reply, print, send/receive attachments), discussion boards (read, search, post, reply, follow threads), chats, and messengers.
- Download and upload attachments
- Knowledge of copy/paste and use of spell check
- Use computer networks to locate and store files or data
- Understanding of Excel and Matlab for mathematical analysis and plotting
- Internet skills and ability to perform online research using various search engines and library databases. Visit Distance Learning Services at NC State Libraries for more information.

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NETIQUETTE

Netiquette is the term used to describe guidelines for respectful online communication. Students should be aware that their behavior impacts other people, even online. I hope that we will all strive to develop a positive and supportive environment and will all be courteous to peers and instructors.

- Follow the same standards of behavior that you subscribe to offline. Be respectful to your peers and the instructor. Keep in mind that all online communication is documented and therefore permanent.
- Consider your surroundings for synchronous Zoom sessions. Please participate as much as possible as though you were in person. Lectures will be recorded.
- Use proper grammar and professional language in discussion forums or email messages to instructors or classmates.
- Ensure you are responding to forums by the due date to leave time for peers to comment on your response. Feel free to offer help to your peers in the Student Help Forum as well.

COURSE POLICIES

Attendance and Late Assignments

For attendance and excused absence policies, see NC State's Attendance Policy: https://policies.ncsu.edu/regulation/reg-02-20-03-attendance-regulations/ and the Withdrawal Process: https://studentservices.ncsu.edu/your-classes/withdrawal/process/ Excuses for unanticipated absences must be reported to the instructor no more than one week after the return to class.

Late homework will only be accepted with a valid excused absence. Makeup exams will be permitted only with a valid excused absence. See the above referenced policy. Advanced notice of an absence is required when possible to facilitate scheduling of a makeup exam.

Incomplete Grades

If an extended deadline is not authorized by the instructor or department, an unfinished incomplete grade will automatically change to an F after either (a) the end of the next regular semester in which the student is enrolled (not including summer sessions), or (b) the end of 12 months if the student is not enrolled, whichever is shorter. Incompletes that change to F will count as an attempted course on transcripts. The burden of fulfilling an incomplete grade is the responsibility of the student. The university policy on incomplete grades is located at http://policies.ncsu.edu/regulation/reg-02-50-3.

UNIVERSITY POLICIES

Academic Integrity and Honesty

Students are required to comply with the university policy on academic integrity found in the Code of Student Conduct. Therefore, students are required to uphold the university pledge of honor and exercise honesty in completing any assignment.

Please refer to the Academic Integrity web page for a detailed explanation of the University's policies on academic integrity and some of the common understandings related to those policies.

Privacy and Policies, Regulations, and Rules

Students may be required to disclose personally identifiable information to other students in the course, via electronic tools like email or web-postings, where relevant to the course. Examples include online discussions of class topics and posting of student coursework. All students are expected to respect the privacy of each other by not sharing or using such information outside the course. Students are responsible for reviewing the NC State University PRR's which pertains to their course rights and responsibilities:

- > Equal Opportunity and Non-Discrimination Policy Statement and additional references
- > Code of Student Conduct
- > Grades and Grade Point Average
- > Credit-Only Courses
- > Audits

Students with Disabilities

Reasonable accommodations will be made for students with verifiable disabilities. In order to take advantage of available accommodations, students must register with the Disability Resource Office at Holmes Hall, Suite 304,Campus Box 7509, 919-515-7653 . For more information on NC State's policy on working with students with disabilities, please see the Academic Accommodations for Students with Disabilities Regulation (REG02.20.01)

Trans-Inclusive Statement

In an effort to affirm and respect the identities of transgender students in the classroom and beyond, please contact me if you wish to be referred to using a name and/or pronouns other than what is listed in the student directory.

Basic Needs Security

Any student who faces challenges securing their food or housing or has other severe adverse experiences and believes this may affect their performance in the course is encouraged to notify the professor if you are comfortable in doing so. Alternatively, you can contact the Division of Academic and Student Affairs to learn more about the Pack Essentials program https://dasa.ncsu.edu/pack-essentials/

COURSE EVALUATIONS

ClassEval is the end-of-semester survey for students to evaluate instruction of all university classes. The current survey is administered online and includes 12 closed-ended questions and 3 open-ended questions. Deans, department heads, and instructors may add a limited number of their own questions to these 15 common-core questions. Each semester students' responses are compiled into a ClassEval report for every instructor and class. Instructors use the evaluations to improve instruction and include them in their promotion and tenure dossiers, while department heads use them in annual reviews. The reports are included in instructors' personnel files and are considered confidential. Online class evaluations will be available for students to complete during the last two weeks of the semester for full semester courses and the last week of shorter sessions. Students will receive an email directing them to a website to complete class evaluations. These become unavailable at 8am on the first day of finals.

- > Contact ClassEval Help Desk: classeval@ncsu.edu
- > ClassEval website
- > More information about ClassEval