Syllabus APPH-6231 & BIOS-4540

Human Motor Control, 3.0 Credits

Mondays & Wednesdays, 9:30 am – 10:45 am, Engineering Science and Mechanics 202

Instructor Information

Instructor Dr. Boris I. Prilutsky	**Email** boris.prilutsky@biosci.gatech.edu	**Office Hours online** Mondays at 5:00pm – 6:00pm https://gatech.bluejeans.com/7652283212
Teaching Assistant Dr. Alex N. Klishko	**Email** aklishko3@gatech.edu	**Office Hours online** Thursday at 4:00pm – 5:00pm https://gatech.bluejeans.com/1701025525

General Information

Description

The course provides in-depth review of biomechanics and neurophysiology of human body and motion and discusses how human movements are planned, executed and corrected by the nervous system. The theoretical concepts are illustrated by practical examples from Neuroscience, Comparative Zoology, Rehabilitation, Robotics and Prosthetics.

The course consists of two parts. The first part is a series of lectures on Mechanics of Human Body and Motion, and Neurophysiological Basis of Human Motor Control. The second part of the course involves problem-based learning during which the students work on developing a neuromechanical model and computer simulations of a selected motor control problem using software AnimatLab (http://animatlab.com/) developed at Georgia State University. This part of the course gives students maximal exposure to model building and hypothesis testing. Each student keeps an electronic laboratory journal of simulation results, describing the scientific question, model used, specific simulations, including parameter values, results, analysis and interpretation.

Course Modality

This course will be taught in-person, so the students are expected to attend lectures. This is an unprecedented time. We all agree that the best way for you to learn is face-to-face. If we are required to move to an online format because of a covid outbreak, we are able to help you learn the course content remotely. Whether we meet in-person versus remotely could change depending upon health status of individuals in classroom. You have a definite stake in your personal health and the community's health.

Pre- &/or Co-Requisites

Principles of Neuroscience (NEUR 2001) or Organismal Biology (BIOS 1108 with 1108L or 1208L). In addition, students should review basics of vector and matrix algebra, calculus, mechanics and anatomy.

Course Goals and Learning Outcomes

The goal of the course is to give students a general overview of the current state of research in neural control of movement. Upon successful completion of this course, students should be able to

- Read and understand contemporary motor control literature
- Make presentations on topics of research in motor control
- Develop neuromechanical models using software AnimatLab
- Formulate novel motor control hypotheses and test them using computational experiments
- Write scientific manuscripts on a topic of motor control (graduate students).

Health

Our expectation is that everyone who is eligible will be vaccinated; vaccination significantly reduces likelihood of severe disease, including from the delta variant of SARS-CoV-2. Because the delta variant can be spread by vaccinated individuals, we also expect that everyone who is able to should wear a mask, correctly covering mouth and nose, when indoors. Both of these expectations are based on current CDC guidance. As that guidance is updated, we will communicate any new expectations.

Weekly asymptomatic surveillance testing should be part of everyone's regular routine, regardless of vaccination status. Details are here: https://health.gatech.edu/coronavirus/testing.

Course Requirements & Grading for Undergraduate Students

Assignment	Date	Percentage
Article group presentation:	Throughout the course	20%
Midterm Exam	Oct 18	40%
Group presentation on computer simulation project and model	Dec 10	40%

Description of Graded Components for undergraduate students

The article group presentation is a 10-min PowerPoint presentation with a subsequent 5-min discussion with the class. Each presentation is done by a group of 2-4 students. The students select a research article from a list provided by instructor. Each student in the group presents a separate section of the article, i.e. Background and Significance, Methods, Results, Discussion and Limitations. The group submits a copy of the PowerPoint on the day of presentation.

The exam is a written exam consisting of multiple choice and essay type questions. Students will have 1 hour and 15 min to answer ~30 questions.

The group presentation on the computer simulation project is a 10-min PowerPoint presentation with a subsequent 5-min discussion. Each presentation is done by a group of 2-4 students. Each student in the group presents a separate part of the project, i.e. Background and Significance, Goals and Hypotheses and their Justification, Simulation Model, Results, Discussion and Conclusions. The group submits a copy of the PowerPoint and a folder with their working AnimatLab model on the day of presentation, December 10, or earlier.

Course Requirements & Grading for Graduate Students

Assignment	Date	Percentage
Article group presentation:	Throughout the course	10%
Midterm Exam	Oct 18	40%
Group presentation on computer simulation project	Dec 10	10%
Report on simulation project in manuscript format and model	Dec 10	40%

Description of Graded Components

The article group presentation is a 10-min PowerPoint presentation with a subsequent 5-min discussion with the class. Each presentation is done by a group of 2-4 students. The students select a research article from a list provided by instructor. Each student in the group presents a separate section of the article, i.e. Background and Significance, Methods, Results, Discussion and Limitations. The group submits a copy of the PowerPoint on the day of presentation.

The exam is a written exam consisting of multiple choice and essay type questions. Students will have 1 hour and 15 min to answer ~30 questions.

The group presentation on the computer simulation project is a 10-min PowerPoint presentation with a subsequent 5-min discussion. Each presentation is done by a group of 2-4 students. Each student in the group presents a separate part of the project, i.e. Background and Significance, Goals and Hypotheses and their Justification, Simulation Model, Results, Discussion and Conclusions. The group submits a copy of the PowerPoint and a folder with their working AnimatLab model on the day of presentation, December 10, or earlier.

Each group of graduate students will prepare and submit a report on their simulation project in the format of a scientific manuscript. The report should have the following sections: Title, Authors, Abstract, Keywords, Introduction, Methods, Results, Discussion, Conclusions, References, Figure Legends, and Figures. The report will be submitted on the day of presentation, December 10, or earlier.

Grading Scale

Your final grade will be assigned as a letter grade according to the following scale:

A	90-100%
B	80-89%
C	70-79%
D	60-69%
F	0-59%

Course Materials

The students will receive reading material consisting of book chapters and research articles. These materials will provide additional information for the lectures.

Additional Materials/Resources

The following books may be a useful additional reading material, but are not required:

Zatsiorsky. Kinematics of Human Motion. Human Kinetics, 1998
Zatsiorsky. Kinetics of Human Motion. Human Kinetics, 2002
Zatsiorsky and Prilutsky. Biomechanics of Skeletal Muscles. Human Kinetics, 2012
Kandel, Schwartz, Jessell, Siegelbaum, Hudspeth. Principles of Neural Science (any recent edition). McGraw Hill Medical.

Course Website and Other Classroom Management Tools

All course materials will be posted on Canvas: https://canvas.gatech.edu/.

Course Expectations & Guidelines

Academic Integrity

Georgia Tech aims to cultivate a community based on trust, academic integrity, and honor. Students are expected to act according to the highest ethical standards. For information on Georgia Tech's Academic

Honor Code, please visit https://catalog.gatech.edu/policies/honor-code/ or https://catalog.gatech.edu/rules/18/.

Any student suspected of cheating or plagiarizing on a quiz, exam, or assignment will be reported to the Office of Student Integrity, who will investigate the incident and identify the appropriate penalty for violations.

Accommodations for Students with Disabilities

If you are a student with learning needs that require special accommodation, contact the Office of Disability Services at (404)894-2563 or http://disabilityservices.gatech.edu/, as soon as possible, to make an appointment to discuss your special needs and to obtain an accommodations letter. Please also e-mail me as soon as possible in order to set up a time to discuss your learning needs.

Attendance and/or Participation

If an instructor should be late in meeting the class, the students shall wait twenty minutes after the published starting time and may leave if the instructor has not arrived by that time.

Students should maintain regular attendance of the lectures and actively participate in the article and simulation project discussions if they are to attain maximum success in the pursuit of their studies.

Students should discuss planned absences with their instructors as soon as possible after the beginning of an academic term. Work missed may be made up at the discretion of the instructors.

In the event of a medical emergency or an illness that is severe enough to require medical attention, students are responsible for contacting the Office of the Vice President for Student Life and Dean of Students as soon as possible to report the medical issue or emergency, providing dated documentation from a medical professional and requesting assistance in notifying their instructors. The medical documentation will be handled confidentially within the Office of the Vice President for Student Life and Dean of Students and will inform a decision as to whether communication with instructional faculty is appropriate.

Students who are absent because of participation in a particular religious observance will be permitted to make up the work missed during their absence with no late penalty, provided the student informs the course instructor of the upcoming absence, in writing, within the first two weeks of class, and provided the student makes up the missed material within the time frame established by the course instructor.

Collaboration & Group Work

Students are expected to collaborate on group assignments (group article presentations or simulation projects). In these submitted assignments, the contribution of each group member should be clearly stated.

Extensions, Late Assignments, & Re-Scheduled/Missed Exams

If students have to attend approved Institute activities (e.g. field trips and athletic events), religious observances or career fairs and miss the exam or do not submit an assignment on time, the instructor should be notified in advance and assignment submission or exam may be rescheduled.

Student-Faculty Expectations Agreement

At Georgia Tech we believe that it is important to strive for an atmosphere of mutual respect, acknowledgement, and responsibility between faculty members and the student body. See http://www.catalog.gatech.edu/rules/22/ for an articulation of some basic expectation that you can have of me and that I have of you. In the end, simple respect for knowledge, hard work, and cordial interactions will help build the environment we seek. Therefore, I encourage you to remain committed to the ideals of Georgia Tech while in this class.

Student Use of Mobile Devices in the Classroom

Students should avoid using cell phones in the classroom. Cell phones should be in silent mode. Laptops should be used only for taking lecture notes or for simulation projects.

Additional Course Policies

Students should avoid food and drinks in the classroom.

Campus Resources for Students

In your time at Georgia Tech, you may find yourself in need of support. Below you will find some resources to support you both as a student and as a person.

Academic support

- Center for Academic Success http://success.gatech.edu
- Residence Life's Learning Assistance Program https://housing.gatech.edu/learning-assistance-program
- OMED: Educational Services (http://omed.gatech.edu/programs/academic-support)
- Communication Center (http://www.communicationcenter.gatech.edu)
- Academic advisors for your major http://advising.gatech.edu/

Personal Support

Georgia Tech Resources

- The Office of the Dean of Students: http://studentlife.gatech.edu/content/services; **404-894-6367**; Smithgall Student Services Building 2nd floor
    - You also may request assistance at https://gatech-advocate.symplicity.com/care_report/index.php/pid383662?
- Counseling Center: http://counseling.gatech.edu; **404-894-2575**; Smithgall Student Services Building 2nd floor
    - Services include short-term individual counseling, group counseling, couples counseling, testing and assessment, referral services, and crisis intervention. Their website also includes links to state and national resources.
    - *Students in crisis should call **404-894-2575** during business hours (8am-5pm, Monday through Friday) or contact the counselor on call after hours at **404-894-2204**.*
- Students' Temporary Assistance and Resources (STAR): http://studentlife.gatech.edu/content/need-help
    - Can assist with interview clothing, food, and housing needs.
- Stamps Health Services: https://health.gatech.edu; **404-894-1420**
    - Primary care, pharmacy, women's health, psychiatry, immunization and allergy, health promotion, and nutrition
- OMED: Educational Services: http://www.omed.gatech.edu
- **Women's Resource Center: http://www.womenscenter.gatech.edu; 404-385-0230**
- **LGBTQIA Resource Center: http://lgbtqia.gatech.edu/; 404-385-2679**
- **Veteran's Resource Center: http://veterans.gatech.edu/; 404-385-2067**
- **Georgia Tech Police: 404-894-2500**

Statement of Intent for Inclusivity

As a member of the Georgia Tech community, I am committed to creating a learning environment in which all of my students feel safe and included. Because we are individuals with varying needs, I am reliant on your feedback to achieve this goal. To that end, I invite you to enter into dialogue with me about the things I can stop, start, and continue doing to make my classroom an environment in which every student feels valued and can engage actively in our learning community.

Course Schedule

Date	Topic	Reading
Aug 23	Introduction	Prilutsky & Zatsiorsky. Neural control principles. In Bernstein's Construction of Movement, C6 (2021)
Aug 25	Structure and Function of Human Body	Alexander. In Handbook of Physiology. Volume II. American Physiological Society, Bethesda, Maryland, 1981. Ch 2: pp. 17-42. AnimatLab tutorials: User interface, biomechanical editor and hinge (http://animatlab.com/Getting-Started)
Aug 30	Biomechanics of Skeletal Muscle	Zatsiorsky & Prilutsky. Biomechanics of Skeletal Muscles, 2012. Ch 3: pp. 170-177, 186-193, 198-208. AnimatLab tutorials: Muscle (http://animatlab.com/Getting-Started)
Sept 1	Muscle Moment Arm, Muscle Functions and Two-joint Muscles in Human Motion	Zatsiorsky & Prilutsky. Biomechanics of Skeletal Muscles, 2012; Ch 5: pp. 269-301; Ch 6: pp. 331-350. AnimatLab tutorials: Line Charts (http://animatlab.com/Getting-Started)
Sept 6	Labor Day – No Classes	
Sept 8	Inertial Properties of Human Body	Zatsiorsky. Kinetics of Human Motion, 2002. Ch 4: pp. 265-278, 280-287.
Sept 13	Kinematics of Human Motion and Human Joints	Zatsiorsky. Kinematics of Human Motion, 1998. Ch 1: pp. 1-15, 42-49; Ch 5: pp. 283-310, 354-361.
Sept 15	Statics and Dynamics of Human Motion	Zatsiorsky. Kinetics of Human Motion, 2002. Ch 2: pp. 117-143.
Sept 20	Anatomy and Physiology of Nervous System	Kandel et al. Principles of Neural Science. Chapters 19, 20 & 22.
Sept 22	Motor Units and Electromyography	Kandel et al. Principles of Neural Science, 1991. Ch 1 & 36. Carlo De Luca. J. Applied Biomechanics, 1997, 13: 135-163.
Sept 27	Muscle Receptors and Spinal Reflexes	Kandel et al. Principles of Neural Science. 1991. Ch 37 & 38. AnimatLab tutorials: Stretch receptor, Stretch reflex and Touch receptive fields (http://animatlab.com/Getting-Started)
Sept 29	Control of Locomotion	McCrea, Rybak (2008), Brain Res Rev 57(1): 134-146. Pearson (2008), Brain Res Rev 57(1): 222-227.
Oct 4	Theories of Voluntary Motor Control	Feldman, Latash. Exp. Brain Res., 2005, 161:91-103. Kawato. Current Opinion in Neurobiology 9: 718-727, 1999.

Date	Topic	Reading
Oct 6	Brain-Computer Interfaces	Birbaumer, Cohen. J Physiol 2007, 579(Pt 3):621-636.
Oct 11	Fall Break – No Classes	
Oct 13	Computational Motor Control: Muscle and Kinematic Synergies	Bianchi et al. J Neurophysiol 79: 2155-2170, 1998. Klishko et al. J Neurophysiol 112: 1376-1391, 2014. Klishko et al., Neurophysiol 126: 493-515, 2021.
Oct 18	Midterm Exam	
Oct 20	Simulation practicum 1. Introduction to AnimatLab, body parts, body segment parameters and joints. Student article presentation	Cofer et al. J Neurosci Methods 187: 280-288, 2010.
Oct 25	Simulation practicum 2 Muscles and their parameters Student article presentation	
Oct 27	Simulation practicum 3 Models of neurons: synapses and their properties Student article presentation	
Nov 1	Simulation practicum 4 Muscle and skin receptors, basic reflexes Student article presentation	
Nov 3	Simulation practicum 5 Modeling locomotion: Central pattern generators and sensory feedback Student article presentation	
Nov 8	Simulation practicum 6 Developing computer simulations of a selected motor control problem Student article presentation	
Nov 10	Simulation practicum 7 Developing computer simulations of a selected motor control problem Student article presentation	
Nov 15	Simulation practicum 8 Developing computer simulations of a selected motor control problem. Student article presentation	
Nov 17	Simulation practicum 9 Developing computer simulations of a selected motor control problem Student article presentation	

Date	Topic	Reading
Nov 22	Simulation practicum 10 Developing computer simulations of a selected motor control problem Student article presentation	
Nov 24	Thanksgiving Break - No Classes	
Nov 29	Simulation practicum 11 Developing computer simulations of a selected motor control problem Student article presentation	
Dec 1	Simulation practicum 12 Developing computer simulations of a selected motor control problem Student article presentation	
Dec 6	Simulation practicum 13 Developing computer simulations of a selected motor control problem Student article presentation	
Dec 8	No Classes	
Dec 10 **8:00 am - 10:50 am**	Student project presentations	