**Syllabus for EGRB 491: Modeling and Simulation of Human Movement**

Lecture: 3:30 - 4:45 p.m. T Th Engineering East 2221

Instructor: Carrie Peterson, Ph.D.

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Office hours: Mondays 4:00-5:00 pm or by appt, in person or Zoom

Office location: Biotech Eight Building, 737 N 5th Street, Room 440

https://vcu.zoom.us/j/2093767799

This course is designed to familiarize the student with the development, application, and analysis of biomechanical models to simulate motion. The focus of this course is the musculoskeletal system; the course introduces the components of a musculoskeletal model, illustrates how these components are integrated together, and demonstrates the value of and challenges associated with computer simulation of movement. Learning is achieved through a series of lectures, tutorials, reading, webinars, and computer simulation exercises.

Prior to taking this course students should have had previous experience with:

* Free-body diagrams and classical (Newtonian) mechanics
* Neuromuscular mechanics and physiology

Student Learning Outcomes

* Understanding of how musculoskeletal models are developed and validated
* Appropriate applications of musculoskeletal modeling and simulation
* Use optimization to solve for neuromotor controls
* Ability to generate a simulation with OpenSim software

**Textbook:** Biomechanics of Movement: The science of sports, robotics, and rehabilitation. Authors: Thomas K. Uchida and Scott L. Delp, 2021. Available at Barnes and Noble, Amazon. Hardcover $75. Kindle, $48.

Students are expected to have completed associated reading prior to class.

**Grading:**

Attendance and Participation 10%

Homework 35%

Exam 30%

Final Project 25%

The grading scale is as follows:

90-100 A

80-89 B

70-79 C

60-69 D

< 60 F

**Tentative course schedule:**

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| **Date:** | **Topics covered** | **Required Reading** | **Assessment** |
| 1/18  1/20 | Intro to Musculoskeletal Modeling and Simulation  Computer Modeling and Simulation of Human Movement | Computer Modeling and Simulation of Human Movement - Pandy |  |
| 1/25  1/27 | Basics of Kinematics  Basics of Dynamics | Supplemental |  |
| 2/1  2/3 | Basics of Models, Walking Models  Running Models | Chapter 2 - Walking  Chapter 3 - Running | Homework 1 Due 2/3 |
| 2/8  2/10 | Modeling Muscle (Biology and Force)  Modeling Muscle (Architecture and Dynamics) | Chapter 4 – Muscle Biology and Force  Chapter 5 – Muscle Architecture and Dynamics |  |
| 2/15  2/17 | Musculoskeletal Models  Inverse Kinematics | Chapter 6 – Musculoskeletal Geometry  Chapter 7 – Quantifying Movement | Homework 2 Due 2/15 |
| 2/22  2/24 | OpenSim  Inverse Dynamics | Supplemental  Chapter 8 - Inverse Dynamics | Homework 3 Due 2/24 |
| 3/1  3/3 | Muscle Force Optimization  Muscle Force Optimization continued | Chapter 9 – Muscle Force Optimization |  |
| 3/8  3/10 | Spring Break |  |  |
| 3/15  3/17 | Muscle-Driven Simulation  Muscle-Driven Simulation continued | Chapter 10 – Muscle-driven Simulation | Homework 4 Due 3/17 |
| 3/22  3/24 | Muscle-driven Walking  Intro to Final Project | Chapter 11- Muscle-driven Walking |  |
| 3/29  3/31 | Exam Review  **Exam** |  | In-Class Exam on 3/31 |
| 4/5  4/7 | Muscle-Driven Running  Final Project Discussion | Chapter 12- Muscle-driven Running |  |
| 4/12  4/14 | Moving Forward  Final Project Discussion | Chapter 13 – Moving Forward |  |
| 4/19  4/21 | Knee Joint Contact Forces  Final Project Discussion | Supplemental |  |
| 4/26  4/28 | Final Project  Final Project |  |  |
| 5/3 | Final Project |  | **Final Project Due May 10** |

## Student responsibilities (source: One VCU: Responsible Together available at: <https://together.vcu.edu/students/>)

When we return, things will look and feel different as we take necessary steps to protect the well-being of our community. Here is what is expected of you:

1. **Monitor your health** daily. Testing will occur according to protocols.
2. **Wear a face covering or mask** in common areas, including class.
3. **Apply physical distance** guidelines to all settings.
4. **Clean and disinfect** personal and shared spaces before and after use. Cleaning supplies will be available in numerous locations.
5. **Report symptoms** associated with COVID-19 to VCU Student Health Services. A call center hotline will be available later in the summer.
6. **Not sharing is caring** during this unique pandemic. Please do not share calculators, tools, lab supplies, etc.

Following rules regarding face coverings or masks, cleaning and disinfecting, and physical distancing is required. Students will receive reminders for daily health monitoring. Staff in the Dean of Students office will be notified after incidents of non-compliance. Refusal to comply with rules can include progressive disciplinary action up to and including suspension, based on the [**VCU Student Code of Conduct**](https://conduct.students.vcu.edu//student-code-of-conduct/).

**Requesting accommodations**

The university recognizes that some students who previously did not need Section 504 Academic Accommodations, and who have a qualifying condition or disability, may need support or assistance during the return to campus process. A modified approach for the temporary and more permanent need for accommodation has been developed and implemented to provide students with full access to programs and activities related to their academic majors. Because every case is different, student requests are evaluated on a case-by-case basis. Please share your need for an accommodation with the [Student Accessibility and Education Office](https://saeo.vcu.edu/), or for MCV Campus students, the [Division for Academic Success](https://das.vcu.edu/), after you have worked directly with your faculty member.

**Health and well-being**

Navigating the anticipated stressors of daily life can often be challenging enough. When unexpected stressors emerge or when we are faced with uncertainty, it can be tough to know how to cope. Try out some of these [tips and resources for health and wellness](https://students.vcu.edu/about/keep-on-being-well-at-vcu/) to see if they are a right fit for you.

**Symptoms or Diagnosis:** If an on-campus student identifies symptoms, has tested positive for COVID-19 or has come into contact with someone diagnosed with COVID-19, that student should contact [University Student Health Services](https://health.students.vcu.edu/). At that point, isolation should begin and contact tracing will be performed by Student Health Services. Symptoms will be monitored and the student should refer to a medical provider if symptoms worsen or be released from isolation after 14 days, if symptom-free.

**Nondiscrimination policy**

VCU is committed to providing a safe, equitable and inclusive environment for all its employees, patients and students. Discrimination or discriminatory harassment is not only unlawful, it is harmful to the well-being of our university community. Our university’s core values, specifically those related to diversity and inclusion, have withstood many difficult situations and trying times, and they will not falter now.

Reports of discrimination, bullying, harassment and/or stereotyping of persons of color or those impacted by COVID-19 or otherwise, will not be tolerated. Be assured that VCU will make every effort to address and prevent the occurrence of unlawful discrimination and, if necessary, take prompt and appropriate action to remedy and prevent its reoccurrence. Every member of our community is asked to:

* Become familiar with the university’s policies on [Preventing and Responding to Discrimination](https://policy.vcu.edu/universitywide-policies/policies/preventing-and-responding-to-discrimination.html) and [Duty to Report and Protection from Retaliation](https://policy.vcu.edu/universitywide-policies/policies/duty-to-report-and-protection-from-retaliation.html) in the VCU Policy Library.
* Consult with [Equity and Access Services](https://equity.vcu.edu/) or [VCU Human Resources](https://hr.vcu.edu/) for additional guidance on how to file a report of discrimination.
* Contact the [Office of Institutional Equity, Effectiveness and Success](https://inclusive.vcu.edu/) (IES) on how to address and maintain a culture of inclusion.
* Encourage individuals who may need an ADA accommodation for a known or newly acquired disability, to contact the ADA/504 Coordinator in [ADA Services](https://equity.vcu.edu/ada/).
* Bookmark and share information on university or community agencies that offer support or services, such as [VCU’s Counseling Services](https://counseling.vcu.edu/) or [Ombudsperson](https://ombudsperson.vcu.edu/).
* Explore training and educational opportunities on diversity and inclusion at [IExcel Education](https://inclusive.vcu.edu/iexcel/) and through the [Office of Institutional Equity, Effectiveness and Success](https://inclusive.vcu.edu/).
* Offer nonjudgmental support and empathy to those affected by current events and this health crisis.

I want you to know that I am grateful for your presence and input in our classrooms (whether in person or online). I appreciate and welcome you regardless of your immigration status, country of origin and/or citizenship, race, ethnicity, religious affiliation, gender/sex, gender identity, sexual orientation, age, or dis/ability. Thank you for enriching our world, sharing your vital experience, and contributing to the diversity that makes our intellectual community vibrant and evermore creative.

**Tips for Success:**

* When taking online and hybrid courses, your self-motivation and self-pacing are absolutely critical. For this course, you should plan to work about 9-12 hours per week aside from lecture time as we move through the materials. Be sure to plan your time accordingly.
* Make yourself a calendar with all of your due dates across ALL of your courses. Plan for when you will work on each one for completion in advance of the due dates.
* **Plan Ahead!!** Study as you go instead of at the last minute!

**Where to post questions**

Questions of general interest should first be posted to the discussion board (only if they have not already been answered) so that other students can benefit from the response or have an opportunity to respond to your question. Only questions of a private nature should be communicated to me through email. When sending a message to me, please *allow a minimum of 24 hours for a response*. Most of the time I will respond much faster, but sometimes meetings and running a research lab take over my schedule.

**Netiquette Guidelines**

Netiquette is a set of rules for behaving properly online. Your instructor and fellow students wish to foster a safe online learning environment. All opinions and experiences, no matter how different or controversial they may be perceived, must be respected in the tolerant spirit of academic discourse. You are encouraged to comment, question, or critique an idea but you are not to attack an individual. Working as a community of learners, we can build a polite and respectful course community. The following netiquette tips will enhance the learning experience for everyone in the course: ● Do not dominate any discussion.

● Give other students the opportunity to join in the discussion.

● Do not use offensive language. Present ideas appropriately.

● Be cautious in using Internet language. For example, do not capitalize all letters since this suggests shouting.

● Popular emoticons such as ☺ can be helpful to convey your tone but do not overdo or overuse them.

● Never make fun of someone’s ability to read or write.

● Share tips with other students.

● Keep an “open-mind” and be willing to express even your academically informed opinion.

● Think and edit before you push the “Send” button.

● Do not hesitate to ask for feedback.

● Using humor is acceptable AND ENCOURAGED (on occasion) !

**Be Proactive in Communication with Instructor**

If you find that you have any trouble keeping up with assignments or other aspects of the course, make sure you let your instructor know as early as possible. As you will find, building rapport and effective relationships are key to becoming an effective professional. Make sure that you are proactive in informing your instructor when difficulties arise during the semester so that we can help you find a solution.

**VCU Honor System**

VCU recognizes that honesty, truth, and integrity are values central to its mission to advance knowledge and student success both in the world VCU students will enter, or return to, once they have graduated and in the university community as a microcosm of that world. In a community devoted to learning, a foundation of honor must exist if that community is to thrive with respect and harmony. Therefore, all members of the university community must conduct themselves in accordance with the highest standards of academic honesty, ethics, and integrity at all times.(from <https://conduct.students.vcu.edu/vcu-honor-system/>

The B.S. program in Biomedical Engineering is accredited by the Engineering Accreditation Commission of ABET, **http://www.abet.org**

**Student Outcomes**

The student learning outcomes for this course are:

* + - 1. An ability to identify, formulate and solve complex engineering problems by applying principles of engineering, science and mathematics .
      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

**Performance Metrics for Student Outcomes**

**Student Outcome 1: An ability to identify, formulate and solve complex engineering problems by applying principles of engineering, science and mathematics**

Note: specific ABET BME program criteria for curriculum - biology, human physiology, chemistry, calculus-based physics, mathematics (through differential equations) and statistics is called out and we have to show we teach it although we do not need to specifically assess them.

Performance Metrics:

* Identify a health science problem, including those with an interaction between medically related living and non-living systems
* Propose an engineering framework to address a health science problem
* Appropriately solves the engineering problem
* Can explain the appropriate assumptions and suitability of a solution

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| --- | --- | --- | --- | --- |
| Performance Indicator | **Unsatisfactory** | **Developing** | **Satisfactory** | **Exemplary** |
| Identify a health science problem | Unable to identify a health science problem | Able to partially identify all aspects of a health science problem | Able to adequately identify all aspects of a health science problem | Able to adequately identify all aspects of a health science problem and what are related problems |
| Propose an engineering framework to address a health science problem | Unable to identify engineering principles appropriate to apply | Identifies some engineering principles appropriate to apply but does not propose an appropriate engineering framework | Proposes a completely appropriate engineering framework to address the problem | Proposes alternate engineering frameworks to address the problem, and chooses and justifies one to continue |
| Appropriately solves the engineering problem | Cannot identify steps needed to solve the problem using engineering and science principles | Appropriately identifies steps needed to solve the problem using engineering and science principles but does not solve the problem correctly | Appropriately solves the problem using engineering and science principles | Appropriately solves the problem and validates the solution |
| Can explain the appropriate assumptions and suitability of a solution | Unable to identify the appropriate assumptions | Can identify at least one appropriate assumption made | Can identify all appropriate assumptions and can begin to understand the suitability of the solution | Can identify the appropriate assumptions and can explain the suitability of a solution |

Students should be at the Satisfactory level or higher.

**Student Outcome 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**

Note: this should be at least in some courses for biomedical problems.

Performance Metrics:

* Researches relevant knowledge and constraints
* Synthesizes and creates engineering diagrams of a plausible design within the context of the appropriate constraint and risk factors
* Analyzes engineering systems
* Creates a working prototype

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| --- | --- | --- | --- | --- |
| Performance Indicator | **Unsatisfactory** | **Developing** | **Satisfactory** | **Exemplary** |
| Researches relevant knowledge and  constraints | Does not do any research | Does some research | Adequately researches directly relevant issues including constraints | Researches all directly relevant topics and further possibilities |
| Synthesizes and creates engineering diagrams… | Creates incomplete/incorrect engineering diagram | Creates an adequate conceptual diagram | Creates sufficient engineering design diagrams within constraints of system, components and/or processes as appropriate | Creates parsimonious design from alternatives |
| Analyzes engineering systems | Cannot identify methods of analysis | Can identify methods of analysis but cannot execute correctly | Sufficiently executes methods of analysis | Uses multiple methods of analysis |
| Creates a working prototype | Cannot create a prototype with any working functions | Creates a prototype with some working subcomponents | Creates a working prototype and tests | Iterates design, implement and test |

Students should be at the Satisfactory level or higher.

**Campus emergency information**

What to know and do to be prepared for emergencies at VCU:

* Sign up to receive [VCU text messaging alerts](http://alert.vcu.edu/signup/index.php). Keep your information up-to-date. Within the classroom, the professor will keep his or her phone on to receive any emergency transmissions.
* Know the safe evacuation route from each of your classrooms. Emergency evacuation routes are posted in on-campus classrooms.
* Listen for and follow instructions from VCU or other designated authorities. Within the classroom, follow your professor's instructions.
* Know where to go for [additional emergency information](http://www.vcu.edu/alert).
* Know the emergency phone number for the VCU Police (828-1234).
* Report suspicious activities and objects.
* Keep your permanent address and emergency contact information current in eServices.

## **Class registration required for attendance**

Students may attend only those classes for which they have registered. Faculty may not add students to class rosters or Blackboard. Therefore, if students are attending a class for which they have not registered, they must stop attending.

## **Honor System: upholding academic integrity**

The VCU Honor System policy describes the responsibilities of students, faculty and administration in upholding academic integrity, while at the same time respecting the rights of individuals to the due process offered by administrative hearings and appeals. According to this policy, "Members of the academic community are required to conduct themselves in accordance with the highest standards of academic honesty, ethics and integrity at all times." In addition, “To support a commitment to the Honor System, all members of the VCU community are required to:

* Adhere to the Honor System policy and its procedures;
* Report any suspicion or knowledge of possible violations of the Honor System;
* Answer truthfully when called upon to do so regarding Honor System matters;
* Maintain appropriate confidentiality regarding related to Honor System matters."

More information can be found at in the [VCU policy library](http://www.policy.vcu.edu/).

## **Important dates**

You can view important dates for the semester in the [academic calendar](http://academiccalendars.vcu.edu/).

## **Managing stress**

Students may experience situations or challenges that can interfere with learning and interpersonal functioning including stress, anxiety, depression, alcohol and/or other drug use, concern for a friend or family member, loss, sleep difficulties, feeling hopeless or relationship problems. There are numerous campus resources available to students including University Counseling Services (804-828-6200 MPC Campus, 804-828-3964 MCV Campus), University Student Health Services (MPC 804 828-8828, MCV Campus 804 828-9220) and the Wellness Resource Center (804-828-9355). 24 hour emergency mental health support is available by calling 828-1234 and asking to speak to the on-call therapist or utilizing the National Suicide Prevention Lifeline (1-800-784-2433).

**Mandatory responsibility of faculty members to report incidents of sexual misconduct**It is important for students to know that all faculty members are mandated reporters of any incidents of sexual misconduct/violence (e.g., sexual assault, sexual exploitation and partner or relationship violence). This means that faculty cannot keep information about sexual misconduct/violence confidential if you share that information with them and they must report this information immediately to the university's Title IX Coordinator. In addition, department chairs, deans, and other unit administrators are required to report incidents of sex or gender-based discrimination to the university's Title IX Coordinator. Once a report is made, you will receive important information on your reporting options, on campus and off campus resources and remedial measures such as no-contact directives, residence modifications, and academic modifications. If you would prefer to speak with someone confidentially for support and to discuss your options for reporting, contact:

## VCU's Wellness Resource Center 804.828.9355 | myoptions@vcu.edu | thewell.vcu.edu

## Greater Richmond Regional Hotline (Community program) 804.612.6126 | 24-hour hotline

## VCU’s Counseling Services 804-828-6200

## For more information on how to help, please [click here](http://www.thewell.vcu.edu/sexual-violence/how-to-help-others/). The Policy on Sexual Misconduct/Violence and Sex/Gender Discrimination, can be found in the [VCU policy library](http://www.policy.vcu.edu/sites/default/files/Sexual%20Misconduct%20Violence%20and%20Sex%20Gender%20Discrimination.pdf). For more information about the University's Title IX process, please visit [equity.vcu.edu](http://equity.vcu.edu/).

## **Military short-term training or deployment**

If military students receive orders for short-term training or for deployment/mobilization, they should inform and present their orders to Military Student Services and to their professor(s). For further information on policies and procedures contact Military Student Services at 828-5993 or access the corresponding policies.

## **Student conduct in the classroom**

According to the [Faculty Guide to Student Conduct in Instructional Settings](https://policy.vcu.edu/sites/default/files/Faculty%20Guide%20to%20Student%20Conduct%20in%20Instructional%20Settings.pdf), "The university is a community of learners. Students, as well as faculty, have a responsibility for creating and maintaining an environment that supports effective instruction. In order for faculty members (including graduate teaching assistants) to provide and students to receive effective instruction in classrooms, laboratories, studios, online courses, and other learning areas, the university expects students to conduct themselves in an orderly and cooperative manner." Among other things, cell phones should be turned off while in the classroom. The Student Code of Conduct also prohibits the possession of or carrying of any weapon. For more information see <http://register.dls.virginia.gov/details.aspx?id=3436>.

## **Student email policy**

Email is considered an official method for communication at VCU because it delivers information in a convenient, timely, cost-effective, and environmentally aware manner. Students are expected to check their official VCU email on a frequent and consistent basis in order to remain informed of university-related communications. The university recommends checking email daily. Students are responsible for the consequences of not reading, in a timely fashion, university-related communications sent to their official VCU student email account. This policy ensures that all students have access to this important form of communication. It ensures students can be reached through a standardized channel by faculty and other staff of the university as needed. Mail sent to the VCU email address may include notification of university-related actions, including disciplinary action. Please read the policy in its entirety at the [VCU Policy Library](http://www.policy.vcu.edu/sites/default/files/Student%20Email%20Policy_0.pdf).

## **Student financial responsibility**

Students assume the responsibility of full payment of tuition and fees generated from their registration and all charges for housing and dining services, and other applicable miscellaneous charges. Students are ultimately responsible for any unpaid balance on their account as a result of the University Financial Aid Office or their third party sponsor canceling or reducing their award(s).

## **Students representing the university – excused absences**

Students who represent the university (athletes and others) do not choose their schedules. Student athletes are required to attend games and/or meets. All student athletes should provide their schedules to their instructors at the beginning of the semester. The Intercollegiate Athletic Council strongly encourages faculty to treat missed classes or exams (because of a scheduling conflict) as excused absences and urges faculty to work with the students to make up the work or exam.

## **Students with disabilities**

Section 504 of the Rehabilitation Act of 1973 and the Americans with Disabilities Act of 1990, as amended, require that VCU provide "academic adjustments" or "reasonable accommodations" to any student who has a physical or mental impairment that substantially limits a major life activity. To receive accommodations, students must register with the Office of Student Accessibility and Educational Opportunity on the Monroe Park Campus (828-2253) or the Division for Academic Success on the MCV campus (828-9782). Please also visit the [Student Accessibility and Educational Opportunity website](http://saeo.vcu.edu/) and/or the [Division for Academic Success website](http://das.vcu.edu/) for additional information.

Once students have completed the registration process, they should schedule a meeting with their instructor (s) and provide their instructor (s) with an official accommodation letter. Accommodation letters will outline the required classroom accommodations. Additionally, if coursework requires the student to work in a lab environment, the student should advise the instructor or a department chairperson of any concerns that the student may have regarding safety issues related to a disability. Students should follow this procedure for all courses in the academic semester.

## **Withdrawal from classes**

Before withdrawing from classes, students should consult their instructor as well as other appropriate university offices. Withdrawing from classes may negatively impact a student’s financial aid award and his or her semester charges. To discuss financial aid and the student bill, visit the [Student Services Center](http://www.enrollment.vcu.edu/student-services/) at 1015 Floyd Avenue (Harris Hall) and/or contact your financial aid counselor regarding the impact on your financial aid.

**Faculty communication about students**

VCU instructional faculty, administrators and staff maintain confidentiality of student records and disclose information in accordance with the Family Educational Rights and Privacy Act (FERPA). This means that VCU officials may disclose student record information without the consent of the student in certain situations. To support university operations, for example, VCU officials share information about students with other educational officials as necessary to perform their job duties. FERPA permits this disclosure to school officials who have a legitimate educational interest in the student information. In addition, VCU officials have obligations to report information shared by a student depending on the content of that information, for example, in compliance with VCU’s policy on the duty to report ([policy.vcu.edu](http://www.policy.vcu.edu/)). Unless FERPA permits a certain disclosure, VCU generally requires consent from a student to disclose information from their education record to another individual. You may find additional information on the VCU FERPA website: <http://rar.vcu.edu/records/family-educational-rights-and-privacy-act/>.

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