

# BME 4931: Biomechanics of Human Movement

## Spring 2018

| Day       | Block | Time               | Location        |
|-----------|-------|--------------------|-----------------|
| Tuesdays  | 7     | 1:55 pm – 2:45 pm  | 279 Weil Hall   |
| Thursdays | 6 & 7 | 12:50 pm – 2:45 pm | 106 Rinker Hall |

### Instructor

Jennifer A. Nichols, Ph.D.  
Assistant Professor  
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Office Location: BMS J287

Office Hours: By appointment. Please e-mail Dr. Nichols to schedule.

### Course Description

This course introduces advanced undergraduate students to musculoskeletal biomechanics and the quantitative analysis of human movement. Students will learn how muscles act as mechanical actuators to produce movement. Students will also learn how to apply experimental and computational methods to evaluate how muscles, bones, and joints work together as a mechanical system. Topics covered will include rigid-body kinematics, dynamics, motion capture, external force measurement, electromyography, and mechanical properties of muscles and tendons.

### Course Pre-Requisites / Co-Requisites

There are no required pre-requisites or co-requisites. However, students may find prior coursework in the following areas helpful: Newtonian mechanics (PHY 2048), statics (EGM2511), computer programming (COP2271), calculus (MAC2311), and differential equations (MAP2302).

Note: Course numbers are provided for reference only. The listed classes are not required pre-requisites.

### Course Objectives

By the end of this course, students should be able to do the following:

- *Analyze Human Movement*
  - Describe the musculoskeletal system using appropriate anatomical terms
  - Mathematically define position and orientation in three dimensions
  - Draw free-body diagrams and define equations of motion for linkage systems
  - Solve kinematic and kinetic problems to calculate joint angles, internal forces, and external forces
- *Evaluate Muscle-Tendon Function*
  - Describe the biological, mechanical, and neurological aspects of how muscles produce movement
  - Mathematically model and describe muscles and tendons
  - Analyze the electrical signals used by the nervous system to generate muscle activity
  - Solve forward dynamic problems to calculate muscle forces and joint torques
- *Apply Biomechanics Knowledge to Real-World Problems*
  - Describe experimental and computational engineering tools that are used to study movement
  - Explain the mathematical foundations behind biomechanical engineering tools
  - Identify when to apply experimental and computational tools to solve biomechanics problems

## Professional Component (ABET)

This course provides 3 credits of engineering topics.

## Relation to Program Outcomes (ABET)

| Outcome   | Coverage <sup>1</sup> |
|---|-----------------------|
| a. Apply knowledge                                  | high                  |
| b. Conduct experiments                              |                       |
| c. Design   |                       |
| d. Function on teams                                |                       |
| e. Solve problems                                   | medium                |
| f. Professional and ethical responsibility          |                       |
| g. Communicate                                      |                       |
| h. Global, societal, and environmental impact       |                       |
| i. Lifelong learning                                |                       |
| j. Contemporary issues                              |                       |
| k. Techniques, skills, and tools for degree program | low                   |

<sup>1</sup>Coverage is given as high, medium, or low. An empty box indicates that this outcome is not part of the course.

## Required Textbooks and Software

### Required Textbooks

Course notes and assigned readings are derived from various published sources and professional records of the course instructor. These materials will be distributed through the course website on Canvas.

### Required Software

Matlab (student or professional version) will be used for some in-class examples and homework problems. Students may purchase a student license from UF bookstore, use Matlab in UF computer labs, or access Matlab through UF Apps (<https://apps.ufl.edu>).

## Recommended Materials

The following are useful reference texts:

- *Title:* Biomechanics and Control of Human Movement  
*Author:* David A. Winter  
*Publisher:* Wiley  
*Date & Edition:* 2009, 4<sup>th</sup> Ed.  
*ISBN:* 978-0-470-39818-0
- *Title:* Atlas of Human Anatomy  
*Author:* Frank H. Netter  
*Publisher:* Saunders Elsevier  
*Date & Edition:* 2014, 6<sup>th</sup> Ed.  
*ISBN:* 978-1455704187

or any other good atlas of human anatomy

## Course Schedule

Note: The course schedule is subject to change. Please refer to the course website for current schedule.

| Week  | Date           | Topic                                       | Quizzes | Assignments             |
|---|----------------|---|---------|-------------------------|
| <b>Section 1. Introduction</b>              |                |   |         |                         |
| 1   | Tues. Jan. 9   | What is biomechanics?                       |         |                         |
| <b>Section 2: Kinematics &amp; Kinetics</b> |                |   |         |                         |
|   | Thurs. Jan. 11 | Anatomy Primer & Intro. Kinematics          |         |                         |
| 2   | Tues. Jan. 16  | 2D Transformation Matrices                  |         |                         |
|   | Thurs. Jan. 18 | 3D Transformation Matrices                  |         |                         |
| 3   | Tues. Jan. 23  | Multiple Transformations                    |         | HW 1                    |
|   | Thurs. Jan. 25 | <i>Problem Session – Joint Angles</i>       | Quiz 1  |                         |
| 4   | Tues. Jan. 30  | Kinematic Measurement Methods               |         | HW 2                    |
|   | Thurs. Feb. 1  | <b>Motion Capture Lab Tour</b>              |         |                         |
| 5   | Tues. Feb. 6   | Project Pitches                             |         | HW 3 & Project Pitch    |
|   | Thurs. Feb. 8  | Intro. to Dynamics                          | Quiz 2  |                         |
| 6   | Tues. Feb. 13  | Equations of Motion                         |         | HW 4                    |
|   | Thurs. Feb. 15 | Link-Segment Models                         |         |                         |
| 7   | Tues. Feb. 20  | Dynamic Measurement Methods                 |         | HW 5                    |
|   | Thurs. Feb. 22 | <i>Problem Session – Gait Data</i>          | Quiz 3  |                         |
| <b>Section 3. Muscle</b>                    |                |   |         |                         |
| 8   | Tues. Feb. 27  | Intro. Muscle                               |         | HW 6                    |
|   | Thurs. Mar. 1  | Structure & Biology of Muscles & Tendons    |         |                         |
| 9   | Tues. Mar. 6   | <b>Spring Break</b>                         |         |                         |
|   | Thurs. Mar. 8  |   |         |                         |
| 10  | Tues. Mar. 13  | <b>Exam 1</b>                               |         | Project Progress Report |
|   | Thurs. Mar. 15 | Muscle-Tendon Architecture                  |         |                         |
| 11  | Tues. Mar. 20  | Musculoskeletal Geometry                    |         | HW 7                    |
|   | Thurs. Mar. 22 | Imaging Measurement Methods                 | Quiz 4  |                         |
| 12  | Tues. Mar. 27  | Excitation & Motor Control                  |         | HW 8                    |
|   | Thurs. Mar. 29 | Neuromuscular Measurement Methods           |         |                         |
| 13  | Tues. Apr. 3   | Muscle Adaptation                           |         | HW 9                    |
|   | Thurs. Apr. 5  | <i>Problem Session – Forward Dynamics</i>   | Quiz 5  |                         |
| 14  | Tues. Apr. 10  | Ligaments & Other Tissues                   |         | HW 10                   |
| <b>Section 4. Conclusion</b>                |                |   |         |                         |
|   | Thurs. Apr. 12 | Clinical, Research, & Industry Applications |         |                         |
| 15  | Tues. Apr. 17  | Project Presentations                       |         |                         |
|   | Thurs. Apr. 19 | Project Presentations                       |         | Project Report          |
| 16  | Tues. Apr. 24  | Summary & Final Review                      |         |                         |
|   |                |   |         |                         |
| Final                                       | Wed. May 2     | <b>Exam 2</b>                               |         |                         |

# Course Policies

## Attendance Policy, Class Expectations, and Make-Up Policy

**Class:** Students are expected to attend all scheduled class sessions. Attending class is critical for understanding the course material, as there is no textbook. Class sessions will regularly include presentation of new material, solving sample problems, answering homework questions, in-class quizzes, and discussion. Students who are regularly absent from class (defined as 6 or more unexcused absences) will receive a zero for their participation grade. Excused absences must be consistent with University policies in the undergraduate catalog (<https://catalog.ufl.edu/ugrad/current/regulations/info/attendance.aspx>) and require appropriate documentation.

**Participation:** Students are expected to engage with the course material both inside and outside of class. The participation grade reflects in-class activities and assignments. The highest marks are regularly given to students that come to class having read all of the assigned materials and are prepared to actively discuss them.

**Homework:** Homework assignments provide students with an opportunity to apply concepts learned in class and affirm their understanding of the course material. All assignments are due at the beginning of the class period indicated on the course schedule (refer to course website for most up-to-date deadlines). All assignments should be turned in electronically via the course website. Please use the following convention when naming your homework files: LastName\_HW\_X.pdf (replace “LastName” with your last name and “X” with the homework number). Assignments turned in late will not be graded, except under extreme circumstances at the discretion of the instructor. Students are encouraged to work cooperatively on assignments. However, each student must individually submit assignments consisting of his or her own work. This means that students are encouraged to discuss the solution process for problems. However, copying another student’s work (or allowing a student to copy your work) will be considered a violation of the University honor code. Homework will be graded on a scale from 0 to 3 based on completeness and correctness. The lowest homework grade will be dropped.

**Quizzes:** Quizzes allow the students and the instructor to assess understanding of current course material. They also act as a mechanism to widen the course’s grading scheme (i.e., lower the stakes of each exam). Quizzes will occur approximately every two weeks (refer to course website for most up-to-date schedule). If circumstances do not allow a student to take a quiz on the scheduled date, the student must notify the instructor with enough advanced notice to make arrangements to take the quiz before the scheduled date. Make-up quizzes will only be permitted in exceptional circumstances. The lowest quiz grade will be dropped.

**Exams:** Exams are an opportunity for students to demonstrate their mastery of course concepts. There will be two cumulative exams. Students are expected to be present for exams. Students who miss an exam due to an illness or emergency and who provide proper documentation of the excused absence will take a make-up for full credit as soon as possible after original exam date.

**Project:** The semester-long project allows students to gain an in-depth understanding of a biomechanics topic of their choice. Students will be expected to review the literature, write a report summarizing their findings, and present in class. Further details on the project will be discussed in class and distributed on the course website.

**Re-Grade Policy:** If a student feels that an assignment, quiz, or exam was graded incorrectly, they should return the assignment and a written description of the grading error to the instructor within 5 business days 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.

**Changes to the Syllabus:** Occasionally, course policies may need to be changed due to unforeseen circumstances or to improve the course. The instructor reserves the right to make necessary changes. Additionally, if a student or group of students have a suggestion on how to revise the course and the instructor agrees that the revision would improve the course, the proposed change will be put to an anonymous vote by the entire class. If the majority of the class agrees to the change, it will become part of the syllabus.

## Evaluation of Grades

| Assignment                       | Percentage of Final Grade |
|----------------------------------|---------------------------|
| Homework ( <i>best 9 of 10</i> ) | 10%                       |
| Quizzes ( <i>best 4 of 5</i> )   | 20%                       |
| Exam 1                           | 20%                       |
| Exam 2                           | 20%                       |
| Project                          | 25%                       |
| Participation                    | 5%                        |
|                                  | 100%                      |

## Grading Policy

| Grade        | A          | A-          | B+          | B           | B-          | C+          | C           | C-          | D+          | D           | D-          | E        |
|--------------|------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|----------|
| Percent      | 93.4 - 100 | 90.0 - 93.3 | 86.7 - 89.9 | 83.4 - 86.6 | 80.0 - 83.3 | 76.7 - 79.9 | 73.4 - 76.6 | 70.0 - 73.3 | 66.7 - 69.9 | 63.4 - 66.6 | 60.0 - 63.3 | 0 - 59.9 |
| Grade Points | 4.00       | 3.67        | 3.33        | 3.00        | 2.67        | 2.33        | 2.00        | 1.67        | 1.33        | 1.00        | 0.67        | 0.00     |

More information on UF grading policy may be found at:

<https://catalog.ufl.edu/ugrad/current/regulations/info/grades.aspx>

## Relevant University Policies

### Students Requiring Accommodations

Students with disabilities requesting accommodations should first register with the Disability Resource Center (352-392-8565, <https://www.dso.ufl.edu/drc>) by providing appropriate documentation. Once registered, students will receive an accommodation letter which must be presented to the instructor when requesting accommodation. Students with disabilities should follow this procedure as early as possible in the semester.

### Course Evaluation

Students are expected to provide feedback on the quality of instruction in this course by completing online evaluations at <https://evaluations.ufl.edu/evals>. Evaluations are typically open during the last two or three weeks of the semester, but students will be given specific times when they are open. Summary results of these assessments are available to students at <https://evaluations.ufl.edu/results/>.

For Spring 2018, the online evaluation period is open from April 14, 2018 through April 27, 2018. Please complete these evaluations and provide feedback on how to improve the course for future students.

### 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://www.dso.ufl.edu/sccr/process/student-conduct-honor-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.

### 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 <http://registrar.ufl.edu/catalog0910/policies/regulationferpa.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](mailto: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:** <http://www.counseling.ufl.edu/cwc>, and 392-1575; and the University Police Department: 392-1111 or 9-1-1 for emergencies.

#### **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 support**, 352-392-4357 (select option 2) or e-mail to [Learning-support@ufl.edu](mailto:Learning-support@ufl.edu).  
<https://lss.at.ufl.edu/help.shtml>.

**Career Resource Center**, Reitz Union, 392-1601. Career assistance and counseling.

<https://www.crc.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://www.dso.ufl.edu/documents/UF\\_Complaints\\_policy.pdf](https://www.dso.ufl.edu/documents/UF_Complaints_policy.pdf).

**On-Line Students Complaints:** <http://www.distance.ufl.edu/student-complaint-process>.