

**EBME 307 – PROSTHETIC SYSTEMS**  
**EBME 427 – MOVEMENT BIOMECHANICS AND REHABILITATION**  
**DEPARTMENT OF BIOMEDICAL ENGINEERING, CASE WESTERN RESERVE UNIVERSITY**

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<b>INSTRUCTOR:</b>	A. Bolu Ajiboye, PhD ( <a href="mailto:drbolu@case.edu">drbolu@case.edu</a> ) Wickenden 109 Office hours by appointment only. Sign up @ <a href="http://tinyurl.com/AjiboyeOfficeHours">http://tinyurl.com/AjiboyeOfficeHours</a>	Ph: 216.368.6814
<b>TEACHING ASSISTANT:</b>	Nabeel Chowdhury ( <a href="mailto:nhc22@case.edu">nhc22@case.edu</a> ) Office hours by appointment only.	
<b>DESCRIPTION:</b>	Introduction to the basic biomechanics of human movement and applications to the design and evaluation of artificial devices intended to restore or improve movement lost due to injury or disease. Measurement techniques in movement biomechanics, including motion analysis, electromyography, and gait analysis. Introduction to musculoskeletal modeling and simulation. Survey of movement pathologies and engineered interventions, including arthritis and joint replacements, amputation and upper and lower limb prostheses, and spinal cord injury and neuroprostheses.	
<b>COURSE GOALS:</b>	This course focuses on applications of mechanics to the design and evaluation of artificial devices intended to restore or improve movement deficits due to injury or disease. The material in this course is a combination of lectures on relevant principles of biomechanics and prosthetics, laboratory sessions to learn and use basic biomechanical measurement techniques, and visits to external manufacturers and prescribers of prosthetic technology to see and appreciate practical issues in the design and use of prosthetic devices. This course focuses upon joint replacements, upper and lower limb mechanical prostheses, and neuroprostheses. Finally, students will explore current research in a relevant biomechanics / prosthetics topic and write a proposal to expand this research topic.	
<b>ABET OBJECTIVES:</b>	A) Ability to apply mathematics, science and engineering principles. B) An ability to design and conduct experiments, as well as to analyze data G) An ability to communicate effectively. H) The broad education necessary to understand the impact of engineering solutions in a global and societal context K) Ability to use the techniques, skills and modern engineering tools necessary for engineering practice.	
<b>PRE-REQUISITE:</b>	EBME 201 & EBME 310, or Graduate Standing	
<b>TEXTBOOK:</b>	Winter, David A. (2009). <u>Biomechanics and Motor Control of Human Movement, 4<sup>th</sup> Edition</u> . John Wiley and Sons, Inc. Hoboken, NJ.  Schurr, Donald G. & Cook, Thomas M. (1990). <u>Prosthetics and Orthotics</u> . Appleton & Lange. Norwalk, Connecticut.	
<b>LECTURE:</b>	Tu Th, 11:30 – 12:45 AM in Nord Hall Rm 410	
<b>WEBSITE:</b>	<a href="https://canvas.case.edu">https://canvas.case.edu</a>	
<b>LATE POLICY:</b>	Late HW will not be accepted (it will not be graded and no credit will be given) unless due to an emergency or prior permission by the instructor.	
<b>ACADEMIC INTEGRITY:</b>	Violations of Case Academic Integrity Standards (e.g. cheating, plagiarism) will be handled according to the published policies. Violators should expect the maximum sanction. To understand the policy and what actions constitute violations, students are encouraged to review the standards and policy at <a href="http://www.cwru.edu/provost/ugstudies/acintegrity.htm">http://www.cwru.edu/provost/ugstudies/acintegrity.htm</a> . .	

# TENTATIVE LECTURE SCHEDULE – SUBJECT TO CHANGE

Date		No.	Topic	Supplemental Reading	Lecturer
<b>J-me</b>	14	1	Overview and Introduction	Winter, Ch 3 (45 – 64)	Ajiboye
	16	2	Rotations and Translations	Winter Ch 7 (176-187)	Ajiboye
	21	3	Kinematics and Kinetics	Winter, Ch 4 (82-106)	Ajiboye
	23	4	Kinematics and Kinetics, cont.	Winter, Ch 5 (107 – 116)	Ajiboye
	28	5	Muscle and Joint Mechanics	Winter, Ch 9	Ajiboye
	30	6	EMG: mechanisms, measurements, and signal processing	Winter, Ch 10	Ajiboye
February	4	7	NO CLASS – EMG Lab (Wickenden 104)		Ajiboye
	6	8	NO CLASS – EMG Lab (Wickenden 104)		Ajiboye
	11	9	Introduction to amputation and prosthetics	Shurr & Cook, Ch 1-3	Ajiboye
<b>NIH</b>	13		<b>Exam #1: Lectures 1-8</b>		Ajiboye
	18	10	Lower and Upper Extremity body-powered prostheses	Shurr & Cook, Ch 4-8	Ajiboye
	20	11	Myoelectric control of prostheses	Handouts	Ajiboye
	25	12	Current topics in prosthetics	Handouts	Ajiboye
<b>BNVT</b>	27	13	Sensory Prosthetics	Select papers	Chowdhury
March	3		<b>Exam #2: Lectures 9-15</b>		Ajiboye
	5	14	Field Trip to Prosthetics Clinic		Ajiboye
	10		Spring Break		Ajiboye
	12		Spring Break		
	17	17	Special Topic: Functional Electrical Stimulation (Upper Extremity)	Select papers	Ajiboye
	19	18	Special Topic: Brain Computer Interfaces for Neuroprostheses	Select papers	Ajiboye
<b>SB</b>	24	19	Special Topic: Sensory Integration / Targeted Muscle Re-innervation	Select papers	Marasco
<b>SB</b>	26	20	Principles of Gait Analysis	Select papers	Hardin
	31	21	Motion Analysis Lab I: Familiarization with Equipment (VAMSL)		Hardin
<b>CMU</b>	2	22	Motion Analysis Lab II: Data Collection (VAMSL)		Hardin
	7	23	NO CLASS - Work on Motion Lab and Proposal		
<b>J-me SB</b>	9	24	<b>Exam #3: Lectures 17-23</b>		Ajiboye
	14	25	Student Presentations		Students
	16	26	Student Presentations		Students
	21	27	Student Presentations		Students
	23	28	Student Presentations		Students

## IMPORTANT DATES

February 2 <sup>nd</sup> , 11:59 PM	Homework #1 Due
February 9 <sup>th</sup> , 11:59 PM	Homework #2 Due
February 13 <sup>th</sup>	Exam #1, Proposal topics due
February 27 <sup>th</sup> , 11:59 PM	EMG Lab Due
March 3 <sup>rd</sup>	Exam #2
March 23 <sup>rd</sup> , 11:59 PM	Proposal Outlines Due
April 9 <sup>th</sup>	Exam #3
April 17 <sup>th</sup> , 11:59 PM	Motion Analysis Lab Due
April 14 <sup>th</sup> – 23 <sup>rd</sup>	Student Presentations
April 29 <sup>th</sup> , 11:59 PM	Final Proposals Due

## GRADING

Homework	5%
Exams	45% (15% each)
EMG Lab Report	10%
Gait Lab Report	5%
Outline	5%
Presentation	10%
Proposal	20%

## RESEARCH PAPER

### Objective of Assignment

This project will give you a chance to increase your knowledge in an area of biomechanics and/or prosthetics that interests you. We expect that you will remember what you learn from writing this paper long after this class is over. This assignment will get you into the literature, where you can see for yourself the results of biomechanics research. This paper may also serve as a springboard for a future independent study or research project. Finally, it will help you hone your critical reading and writing skills. Undergraduate student will work in groups of 3, while graduate students will work independently.

### Overview

Survey the literature on a specific topic in the field of movement biomechanics and/or prosthetics. Describe the current state of knowledge in the field and suggest areas that require further research. The briefly describe how you would investigate a specific problem in the form of a research proposal.

Some general areas from which you can choose from include: muscle mechanics, muscle modeling, electromyography, joint biomechanics, rehabilitation engineering (stroke, SCI rehab, etc...), sports biomechanics, biomechanics of surgical reconstructions (joint replacements, etc...), gait analysis, dynamics simulations of movement, animal locomotion, prosthetics and orthotics, motor control, relevant robotics, computer-assisted surgery, sensory restoration in prosthetics, or other pre-approved areas related to biomechanics and prosthetics

### Research Paper Outline

The purpose of this assignment is to help you get your paper organized relatively early in the semester, and to allow us to assess your progress and approach to the research topic.

This outline counts as 5% of your overall grade, so it is to be taken seriously. Feel free to discuss your topic and outline with us before the due date if you would like some assistance.

The format of your outline should be as follows:

- Introduction and Background
  - Briefly describe your topics and discuss why it is important. Do this in bullet point format.
  - State the purpose of your proposed research and your hypotheses
- Previous investigations
  - List, in expanded form, a number of papers that are relevant to your topic. For each paper, state
    - The goal of the paper
    - How this paper relates to your topic
    - BRIEFLY summarize methods
    - Major results and conclusions of the paper
    - Shortcomings of the paper
    - The next logical steps resulting from the work of this paper
- References
  - List your cited papers as a bibliography in the style of IEEE Transactions on Biomedical Engineering

### Oral Presentation

Each student / team will give a 10-minute oral presentation on their research topic, followed by 3-5 minutes of questions from the instructor and other students. Your presentation should state succinctly and clearly the problem you are investigating, the significance of the problem (i.e. why should anyone care if you were to solve this), what has been done in the past to address this or similar problems, and what you preliminarily propose to solve your problem. The goal of this presentation is to receive constructive criticism BEFORE your final proposal is due. So while this presentation should be thorough, you may still implement some changes before the final version of your paper. To make sure you can complete your presentation in the time allotted, make sure you PRACTICE.

## Paper Format

- **Title Page**
  - Should include name(s), course, date (Spring 2016), and a statement signed by all group members that the proposal represents solely the efforts of the members of the group, that this work has not been performed for another class previously, and that all group members satisfactorily contributed to the end result.
- **Abstract (max 150 words)**
  - The abstract should state the primary objectives of your research project, summarize your key findings of your literature review, and indicate the significance of your proposed research plan.
- **Introduction and Background (1-2 pages)**
  - Briefly describe your research topic and why it is important. Relate concisely the anatomical, biological, and clinical aspects of your topic. Be sure to state the purpose of your work very clearly.
- **Pervious Investigations (4-6 pages)**
  - Present a critical review of previous research on your topic. Do not simply just list papers, but rather try to assimilate what you have learned from each paper into an underlying knowledgebase. State the shortcomings of each paper, in a way that respectfully acknowledges the pros of the paper, but at the same time naturally leads the reader to understand where the gaps are in the knowledgebase.
- **Proposed Research (2-4 pages)**
  - Your proposed research should naturally come about from the shortcomings in the previous section. State concisely and specifically a particular research problem that you propose to address. State specific hypotheses that you would propose to test. In broad terms, describe how you would go about testing your hypotheses using human experiments, mathematical or computer models, or any other appropriate experimental protocols. Point out difficulties that you are likely to encounter, and any alternative approaches you would consider. State what you believe to be the impact of your research, should you be successful in validating your hypotheses. State what benefit your research would be even if your hypotheses were invalidated. Finally, provide a realistic timetable for the completion of your work.
- **References**
  - Citations and the bibliography should conform to the style of the Journal of Biomechanics. You can do your citations and bibliography manually or using a number of free managers, including Mendeley. Your references do not count towards the 10-pages of the manuscript, but do not exceed more than 1 page.

The manuscript should be well-organized and clearly written. Your research topic should be referenced from primarily journal articles (i.e. minimally on books...absolutely NO WIKIPEDIA). The following sources may be useful

Journal of Biomechanics  
Journal of Biomechanical Engineering  
Journal of Bone and Joint Surgery  
Journal of Rehabilitation Research and Development  
International Journal of Sports Biomechanics  
Journal of Prosthetics and Orthotics  
Prosthetics and Orthotics International  
IEEE Transactions on Biomedical Engineering  
IEEE Transactions on Neural Systems and Rehabilitation Engineering  
Biological Cybernetics  
Journal of Biomedical Materials Research  
Gait & Posture  
Archives of Physical Medicine and Rehabilitation  
Journal of Neural Engineering  
Many, many others...