DEPARTMENT OF BIOMEDICAL ENGINEERING
INSTRUCTIONAL INCUBATOR
UNIVERSITY OF MICHIGAN

BME Course Summary

Introduction

1. Course Information

Course Name	**Biomechanics Laboratory**
Institution	**University of Minnesota**
Course Number	**BMEn 3015**
# credits	**1 credit**
Meeting times	**Four sections: T 9:05 am - 11:00 am, 11:15 am - 1:10 pm; Th 8:00 am - 9:55 am, 11:15 am - 1:10 pm**
Is this a required course?	**Yes**
Pre-requisites	**Upper Division major admission, Math 2374 (Multivariate Calc), Phys 1302 (Intro Physics II)**
Target audience (e.g. 1st, 2nd year):	**3rd year (Instructor/department desire to move to 2nd year/4th semester)**
Textbook	**N/A**
Course Website (if it exists)	**Moodle**

2. Course Description

In the space below, “paste” the description of the course. This can be the actual description listed in the syllabus from the course.

Statics, dynamics, and deformable body mechanics applied to biological/biomedical problems. Mechanical properties of biological and commonly used biomedical engineering materials. Techniques for numerical solution of biomechanics problems. Laboratory.

3. Course Learning Objectives

In the space below, "paste" the course learning objectives if explicitly stated.

The courses required for the Bachelor of Biomedical Engineering degree program are designed to meet the Program Educational Objectives (PEOs), as defined by the BME Department (BMED), and the Program Outcomes (POs), as defined by the Accreditation Board for Engineering and Technology (ABET). Achieving the PEOs and POs is necessary to maintain program accreditation by ABET. For a full description of the PEOs, the POs, and the accreditation of the program, please refer to the BMED web site (www1.bme.umn.edu). With respect to the BMEN 3015 course, there are two PEOs that the course is meant to partially achieve:

PEO1: Learn the scientific and engineering principles underlying the 6 major elements of biomedical engineering (BME): cellular and molecular biology, physiology, biomechanics, bioelectricity/instrumentation, biomedical transport processes, and biomaterials.

PEO 3: Learn experimental, statistical, and computational techniques in the context of BME.

The PEOs that the BMEn 3015 course is meant to at least partially achieve are that students should have:

(a) an ability to apply knowledge of mathematics, science, and engineering (HIGH priority)
(b) an ability to design and conduct experiments, as well as to analyze and interpret data (HIGH priority)
(c) an ability to design a system, component, or process to meet desired needs (LOW priority)
(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice. (LOW priority)
(l) an understanding of biology and physiology, and the capability to apply advanced mathematics (including differential equations and statistics), science, and engineering to solve problems at the interface of engineering and biology. (MEDIUM priority)
(m) the ability to make measurements on and interpret data from living systems, addressing the problems associated with the interaction between living and non-living materials and systems. (MEDIUM priority)

4. Fundamental Tools and Skills

In the space below, describe the fundamental tools and skills that are addressed in the class. For example, labvview, arduino's, the design process etc.

Introduction to LabView: very superficial dive, mostly set up by grad student instructor; continuous and discrete data acquisition
DAQ boards: also very superficial and limited student involvement
Calibration techniques: load cells and kinematic linkage systems (rotary potentiometers)
Project proposal, experimental design, poster presentation: key experiential component of course; Students propose, design, and present group projects that utilize equipment available in the lab
Short report writing: first exposure to short-form lab reports (1-2 pages); focus on succinct reporting of results and answering canned laboratory questions (open-ended discussion questions, closed-solution methods/results within lab)
Group long report writing: first exposure to long-form lab reports (13-15 pages + appendices); some students have had prior experience in chemistry/physics labs, but inconsistent experiences

5. Exercises or Experiential Projects of Interest

Exercise/Project	Project Overview	Learning Activities and Assessments	Required Resources for Project Completion

Exercise/Project	Project Overview	Learning Activities and Assessments	Required Resources for Project Completion
Lab 1	Lab Intro and Strain Measurement	**Learning Activities** • Students will use strain gauges and simple measurement of metal beams to assess quantitative sources of error. • In a short report, students determine sources of error and identify differences between intra-observer and inter-observer errors. **Assessment** • Students complete a short-form laboratory report that explains their experimental methods, includes graphical representation and textual description of results, and discussion of sources of error.	Voltmeters, rulers, stop watches, metal beams
Lab 2	Center of Mass Experiments	**Learning Activities** • Students will learn how to calibrate force plates (four load cells sandwiched between steel plates) using proper linear algebra methods and also learn how to acquire data using LabVIEW and DAQ boards. • Students will learn how to measure their own centers of mass in three dimensions by standing vertically on force plates and systematically setting up scales to lay down on them. • In a short report, students determine group member's centers of mass and assess sources of error. **Assessment** • Students complete a short-form laboratory report that explains their experimental methods, includes graphical representation and textual description of results, and discussion of why COM is an important measurement in biomechanics.	Laptops, LabVIEW software, DAQ boards, amplifiers, wiring, force plates (aluminum plates + four load cells), three scales, tape measure

Exercise/Project	Project Overview	Learning Activities and Assessments	Required Resources for Project Completion
Lab 3	Estimation of Joint Reaction Forces: Where to Hold a Cane?	**Learning Activities** • Students will use force plates, a scale, and a cane to determine on which side to hold a cane for someone with a right hip injury. • In a short report, students determine how moving the cane shifts the COM and solve a force diagram to assess how forces act at the hip joint. **Assessment** • Students complete a short-form laboratory report that explains their experimental methods, includes graphical representation and textual description of results, and discussion of how cane placement affects reaction forces in the hip joint.	Laptops, LabVIEW software, DAQ boards, amplifiers, wiring, force plates (aluminum plates + four load cells), three scales, tape measure, walking cane
Lab 4	Vertical Jump: Impulse	**Learning Activities** • Students will use force plates, tape measures, and LabVIEW to obtain continuous data and measure the impulse of group members' jumps. • In a short report, students determine how height of jump affects impulse delivered to force plates. **Assessment** • Students complete a short-form laboratory report that explains their experimental methods, includes graphical representation and textual description of results, and discussion of how impulse relates to different forms of energy.	Laptops, LabVIEW software, DAQ boards, amplifiers, wiring, force plates (aluminum plates + four load cells), tape measure

Exercise/Project	Project Overview	Learning Activities and Assessments	Required Resources for Project Completion
Lab 5	Kinematic Transformations and Intro to Clinical Kinematics	**Learning Activities** • Students will use two kinematic linkage systems to learn how to calibrate equipment and determine location/movement using kinematic principles. • Students will create outputs for various kinematic actions, including tracing of a secret message by TA, by using MATLAB to plot kinematic movements. **Assessment** • Students complete a short-form laboratory report that explains their experimental methods, includes graphical representation and textual description of results, and discussion of how kinematics translate to the clinic.	Laptops, LabVIEW software, DAQ boards, tabletop kinematic linkage system (two rotary potentiometers, metal bars, pointer), clinical kinematic linkage system (three rotary potentiometers, plastic adjustable bars, velcro), goniometers (for calibration)
Lab 6	Gait Kinematics and Kinetics	**Learning Activities** • Students will use two force plates and a clinical kinematic linkage system to assess the mechanics of gait in two conditions: toe-up (in the air) and toe-down (taking a step). • Students will combine force and kinematic data to quantitatively characterize motion and forces involved in the human gait cycle. • Students will assess subject variability in gait cycle. **Assessment** • Lab groups complete a long-form laboratory report that thoroughly explains their experimental methods, includes graphical representation and textual description of results, and discussion of how kinetic and kinematic principles can be utilized to assess gait and determine pathologies.	Laptops, LabVIEW software, DAQ boards, amplifiers, force plates (2), spacer frames for force plates (2x4s and plywood), clinical kinematic linkage system (three rotary potentiometers, plastic adjustable bars, velcro)

Exercise/Project	Project Overview	Learning Activities and Assessments	Required Resources for Project Completion
Lab 7	Three-Point Bending/Tensile Testing	**Learning Activities** • Students will use a tabletop testing apparatus to complete two common technical testing protocols: (1) three-point bending and (2) uniaxial tensile testing. • In a short report, students determine a variety of mechanical properties for materials tested, including shear moduli, Young's moduli, ultimate tensile strength, failure stress, etc. **Assessment** • Students complete a short-form laboratory report that explains their experimental methods, includes graphical representation and textual description of results, and discussion of material properties, methods of mechanical testing, and how both affect mechanical properties.	Laptops, LabVIEW software, DAQ boards, amplifier, tabletop three-point bending/tensile testing apparatus (metal plate, braces or grips, crank for compression/tension), testing supplies (chalk, wooden dowels, dogbones made of different materials, etc.), rulers
Final Project	Student-driven Final Project	**Learning Activities** • Students will use knowledge gained from labs completed during the semester to propose a testable biomechanics-related problem/question. • Students will utilize equipment available in the laboratory to answer their question using sound experimental design and focusing on repeatability of results. **Assessment** • Lab groups complete a long-form laboratory report that details the relevant background related to their project question, explains the experimental methods they developed, includes graphical representation and textual description of results, and discussion of their methodology (pros and cons), why their results are important, and sources of error introduced. • Lab groups present their findings at an end-of-semester poster session and are assessed by mechanical and biomedical engineering graduate students.	Any previous equipment listed may be used by students in completing projects

6. Additional thoughts

If you have any other thoughts about this course, but have not been able to reflect it elsewhere in the document, please feel free to do so here.

While this is currently a junior-level course, there has been much discussion to try to bump it up to the Spring semester of sophomore year. This course serves as the first formal introduction of UMN BME students to technical writing/lab report creation and is also the first experiential/practicum learning environment to which students are exposed (in parallel with electronics course/lab), aside from basic physics/chemistry/biology labs. As with most curriculum changes, this proposed change has been met with resistance in trying to work out the logistics of bumping the class up. **Random additional thought: Students are allowed to pick their own groups, and these groups are maintained throughout the semester. Pros: maintaining report and developing chemistry prior to project proposal/work; students mostly get to pick who they're comfortable working with, etc. Cons: limited diversity in a lot of groups, easy to coast/stay in comfort zone if in a group with friends, no mixing of ideas/ways to think about problems as the semester progresses (there is some inter-group collaboration, but mostly limited in the lab…can't speak for outside the lab).** **Struggle points: The biggest issue is student engagement, especially those who prefer to skate by. Given that this first foray into experiential learning is so delayed, this barrier is arguably even higher for this course. Another struggle is the initial preparation of short-form reports. Almost all students struggle, as this is their first experience in writing such reports. The logistics of the course also make it impossible to return feedback to students prior to preparation of their second short-form report. However, once students receive feedback, the vast majority correct errors and greatly improve the quality of their work moving forward.**