Introduction to Mechanics Lab

Department of Mechanical Engineering and Applied Mechanics
University of Pennsylvania
Professor Kuchenbecker

Description

This laboratory class investigates the concepts of classical Newtonian mechanics through weekly hands-on experiments. Mechanics is the branch of physics that deals with forces and motion, and each lab will highlight a different aspect of this field through interactive exploration. MEAM 147 is closely coordinated with MEAM 110, the Introduction to Mechanics lecture course.

Objectives

- Demonstrate and test the fundamental concepts of mechanics through tangible examples, helping students form lasting connections between theory and real-world behavior.
- Train students in reliable methods for obtaining experimental data, presenting numerical results, and extracting meaningful information from such numbers.
- Give students valuable practice in and guidance on clear, concise technical communication, including graphing, writing, and speaking.
- Excite students about science, engineering, and technology, with specific emphasis on the excitement of being a mechanical engineer and the many ways that fundamental mechanics principles affect our everyday lives.

Teaching Team

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Acknowledgments

Many other individuals from the MEAM Department helped design these labs and will contribute to the class over the course of the semester. Faculty members Dr. John Bassani, Dr. Vijay Kumar, Dr. Mike Carchidi, Dr. Robert Carpick, and Dr. Jonathan Fiene; staff members Terry Kientz, Peter Szczesniak, and Peter Rockett; graduate student Paul J. White; and undergraduate students Nicolas Blanchet, Matthew Kalmus, Matthew MacMillan, and Matthew Sylvester were especially influential in the design of this course.

Co-Requisite

MEAM 147 labs are closely integrated with MEAM 110, the Introduction to Mechanics lecture class taught by Dr. Bassani and Dr. Carchidi. Lab students must also be enrolled in MEAM 110, though this co-requisite is waived for students who earned a 5 on the AP Physics C Mechanics examination or the equivalent on an international examination.

Credit

This class is 0.5 credit units. It is required for all declared Mechanical Engineering and Applied Mechanics students entering Penn in Fall of 2008. First-year students who have not yet selected a major within the School of Engineering and Applied Science are also welcome to take this class, as are upper level SEAS students in any major, provided the co-requisite is satisfied. Individuals with significant prior mechanics lab experience who wish to be exempt from this class should talk with the professor for details on this procedure.

Logistics

MEAM 147 will meet once a week on Thursday or Friday in Room 143 of the Towne Building. The three pre-scheduled Thursday lab sessions are 10:00 a.m. to 11:50 a.m., 12:00 noon to 1:50 p.m., and 3:00 p.m. to 4:50 p.m. The one pre-scheduled Friday lab session is 9:00 a.m. to 10:50 a.m. If needed, a fifth lab session will be scheduled to meet the needs of the individuals on the waiting list.

Attendance

You should attend the lab session in which you are enrolled every week, aiming to arrive a few minutes before class begins. As explained below, the first activity of each session is a pre-lab quiz worth 10 points. If you miss the quiz, you will receive a score of 0/10 on it.

If you have a foreseeable, mandatory conflict with your assigned time one week, such as a sports competition or an illness, please contact Professor Kuchenbecker to arrange for an alternative.

If you accidentally miss your lab session, please contact the teaching team as soon as possible and try to attend one of the other lab sessions. You will need to make up the lab, and your total score on it will be marked down by 20% for each day (or fraction thereof) that transpires between the start of your missed lab and the first time when you contact the teaching team.

Regardless of the reason for your absence, our first preference is for you to attend one of the later lab sessions. If this is not possible, we will attempt to arrange a single alternative lab time for everyone in need. Make-up labs are difficult to schedule and will lack the camaraderie of our normal class, so please make every effort to attend your regular lab session.

What to Bring

You should bring a pencil and a calculator to every lab. You may bring your MEAM 110 notes and textbook if you want, but they are not required and will not be referred to in the lab.

Blackboard Website

This course has a website on Penn's Blackboard system. We will post announcements, handouts, and assignments on this site; you will use it for downloading handouts, submitting electronic assignments, and viewing your grades. You access Blackboard at this address:

`https://courseweb.library.upenn.edu/`

Log in to Blackboard using your PennKey and password, and then click on the link for MEAM 147 in your course list. Let the teaching team know if you have any problems with Blackboard.

Projected Schedule

We will meet every week of the fall semester, except for Thanksgiving. As set forth in the schedule below, the first week's session will serve as an introduction, and the last as a conclusion. The intervening eleven weeks will each consist of an interactive lab experiment. Projected lab titles are listed below, but please note that this schedule may be adjusted during the semester to best match the MEAM 110 lectures and the availability of equipment.

Date	Activity	
September 4, 5		Introduction
September 11, 12	Lab 1	Manufacturing and Metrology: Precisely Milling and Measuring an Aluminum Block
September 18, 19	Lab 2	One-Dimensional Motion and Gravity: Camera-Based Motion Capture of a Moving Ball
September 25, 26	Lab 3	Forces and Motion: Camera-Based Motion Capture of Mechanical Oscillation
October 2, 3	Lab 4	Force Equilibrium and Translational Stability: Snap-Through Buckling
October 9, 10	Lab 5	Moment Equilibrium and Rotational Stability: Tipping and Moment-Induced Buckling
October 16, 17	Lab 6	Stress, Strain, and Hooke's Law: Stretching Rods of Varying Material and Geometry
October 23, 24	Lab 7	Interaction Forces at a Distance: Model of an Atomic Force Microscope (AFM)
October 30, 31	Lab 8	Static and Kinetic Friction: Blocks Sticking and Slipping on an Inclined Plane
November 6, 7	Lab 9	Conservation of Energy and Coefficient of Restitution: Camera-Based Motion Capture of a Bouncing Ball

Date		Activity
November 13, 14	Lab 10	Energy, Momentum, and Coefficient of Restitution: Two-Body Collisions
November 20, 21	Lab 11	Planar Rigid Body Motion: Kinematics and Dynamics of Rolling
November 27, 28		Thanksgiving - No Lab
December 4, 5		Conclusion with Photo Project Exhibition

Course Requirements and Evaluation

- **90% Labs:** Ninety percent of your grade in this class will be determined by your work on the labs. Each lab is worth 100 points, and the eleven labs will be weighted evenly. Each lab consists of the following three components:

  - **Pre-Lab Quiz:** 10 points, taken during the first 5 minutes of lab
    The goals of the pre-lab quiz are to make sure you are familiar with the activities of that week's lab session and ready to do the lab.

    Before you come to lab, you should download the week's lab workbook from our class's Blackboard website. This document will be available by 8:00 a.m. on the Tuesday before the lab in the *Assignments* area of the site. Read through the lab workbook on your computer screen, focusing on the goals of the experiment and its main steps. You do not need to print it out because we will give you a paper copy when you arrive in lab.

    The pre-lab quiz will be administered at the start of your lab session. It will consist of approximately five questions of varying formats, which you will answer on paper and submit immediately. The quiz will take no longer than five minutes, and you will not be permitted to refer to any materials while you work on it. Unless you have pre-arranged for a late arrival with the teaching team, you will not receive any points for the pre-lab quiz if you arrive after it is over.

  - **Lab Workbook:** 40 points, should take approximately 1 hour and 45 minutes
    The goals of the lab workbook are to guide you through the activities of the lab, to emphasize important aspects of the physics involved, to give you a structured place to record hand-drawn diagrams and hand-written data, and to encourage you to articulate your own understanding of the phenomena you observe. You will receive a printed copy of the lab workbook at the start of your lab session. Below the next bullet is a copy of the guidelines that will be printed on the front of every lab workbook.

  - **Post-Lab Assignment:** 50 points, should take approximately 2 hours
    The goals of the post-lab assignment are to test your comprehension of the lab experiment and the related mechanics concepts, to help you learn to write effectively about technical material, and to give you the opportunity to ask important questions.

You will complete the post-lab report on the class's Blackboard website. The post-lab will become available in the *Assignments* area by the end of your lab. It is due by 8 a.m. on the following Tuesday.

MEAM 147 Lab Guidelines

1. Read this handout before the day of your lab to familiarize yourself with its activities.
2. Arrive at the lab classroom a few minutes early and form a group of three students. We encourage you to work with different partners over the course of the semester.
3. Take the pre-lab quiz during the first five minutes of the session to show you are ready for the lab.
4. After the teaching team briefly overviews the lab, work through this handout with your group. Each person should complete his or her own lab workbook, but you should confer with your partners throughout the session.
5. If you run into technical difficulties, get help from a member of the teaching team right away.
6. If you find that you are progressing slower or faster than your partners, ask for or offer help. *It is more important that you each understand what you are doing than it is to finish all of the activities.*
7. If you are struggling to figure out an aspect of the lab after consulting with your partners, call over a member of the teaching team for guidance.
8. Turn in this workbook at the end of the lab session, along with any other requested materials.
9. Submit your post-lab assignment on Blackboard by 8:00 a.m. on the Tuesday following your lab.

- **10% Individual Photo Project:** Ten percent of your grade in this class will be determined by your work on an individual project: create a photograph that illustrates a fundamental aspect of mechanics, title it, and write a short essay explaining its relationship to mechanics. This project is inspired by the work of Harold Edgerton and adapted from the "Physics Photo" project by Dolores Gende in Dallas, Texas. The initial guidelines for this project appear below.
  - **Originality:** You must take the photograph yourself. It is not acceptable to download a picture from the Internet or use one that someone else took. If you do not own a camera, please borrow one from a friend or a member of the teaching team.
  - **Subject:** The photograph needs to illustrate a fundamental principle or set of principles from mechanics, such as gravity, inertia, friction, momentum, or energy. Your subject matter can be naturally occurring (a spontaneous scene) or one that you contrived (non-spontaneous). You should be creative in selecting your subject material. You may not feature any of the MEAM 147 experiments in your photograph.
  - **Image Manipulation:** Your photo may be either black and white or color. It is acceptable to make minor adjustments to improve the visibility of the subject of your photograph, such as small changes to brightness, color balance, contrast, and sharpness, or an adjustment in cropping. It is not acceptable to make any other changes to your image.
  - **File:** You will submit your photograph as a digital image file in JPEG format. Your photograph should be high resolution (at least 800 pixels wide and 800 pixels tall) so that it can be printed in a large format. More details about file format, size, and aspect ratio may be released later in the semester.
  - **Title:** Artists typically name their pieces because a title can add meaning. Pick a name for your photograph that is straightforward, funny, or poetic.

- **Essay:** You will also write a short description of the mechanics principles at work in the photograph. Explain to the reader what is happening in your image and (more importantly) why it is happening that way. This essay should be approximately 150 to 200 words long. It should be well written and polished (excellent organization, clarity, spelling, grammar, etc.) You are encouraged to seek guidance from the peer counselors in the Technical Communication Program if you would like help with your writing on this assignment.
- **Submission:** You will submit your photo, title, and essay electronically, probably via our class's Blackboard website. More details will be available as the deadline draws nearer.
- **Deadline:** You must submit your individual photo project by noon on Monday, December 1. Note that this is the Monday immediately following Thanksgiving break. You are strongly encouraged to submit your individual photo project before Thanksgiving break. Late submissions will be penalized 20% per day (or fraction thereof).
- **Project Exhibition:** All student submissions for this project will be exhibited in print form on the last day of class. The teaching team will take care of printing your submission. After the show for our class, we will attempt to arrange for a longer-term exhibition of your photographs somewhere in the School of Engineering and Applied Science.

Grading

We will do our best to grade your submitted assignments quickly and accurately. Your numeric scores will each be recorded on the Blackboard site in the *My Grades* area. In addition to your score, you will often receive written feedback on your electronic assignments and your paper lab workbooks. Reading this feedback will help you understand what you are doing well and how you could improve your work.

If you believe that we have made a grading error, please see the teaching team in office hours or send us an email. Please refrain from bringing up such issues during lab sessions so we can focus that time on the labs themselves.

Feedback

You are always welcome to share your thoughts on how to improve this course with the teaching team, either in person or in email. There will also be two formal opportunities for students to provide their opinions: a custom mid-semester evaluation, administered anonymously on Blackboard, and the standard Penn paper-based end-of-semester survey. All of the comments you provide will be used to help make the course better.

Photography

Professor Kuchenbecker will often take photographs during class to document the design of the labs and how they are being executed. The best photographs will be shared with the class at the end of the semester in a slide show. If you do not want to be photographed for such purposes, please send an email to the professor.

Some of the best photographs will be submitted to the MEAM office to be featured on the department's plasma screens. If you appear in any of these, a MEAM staff member will ask you for your permission before your photo is used.