Physics 211 Project Information (Fall 2021)

Schedule

Wed	August 18	Project Information Distributed
Mon	September 27	Project Teams formed
Fri	**October 1**	**Team Project proposals due**
Mon	October 4	Proposals Returned/Begin Lab Projects
Tue	**November 16**	**Formal Lab Report Version 1 due (IN PRINTED FORM)**
Mon	November 22	Version I Report is returned for rewrite with critiques attached
Wed	**December 8**	**Team Reports Due (Versions 1 and 2 and all critiques)**

The process of working collaboratively to do research, data analysis, writing, more research, and rewriting is one that scientists at universities, colleges, and industrial and government laboratories engage in on a regular basis. You will work in a **group of three or four** on only one formal project each semester so that you can give it special attention. We would like you to have the time to engage in the real-world process of working as a member of a scientific research team. Your team will have the opportunity to communicate its findings effectively to peers in the form of a formal written report. Your audience for this report is not your instructor but rather students *who are taking Physics 211 but who have not done the project you are writing about*.

Analysis of Motion

The goal of this semester's project is to help you consolidate your understanding of the applications of Newton's Laws as well as momentum and energy concepts. Thus, in this project you are to consult with your project team members once they are selected and identify a set of "real-world" motions to analyze *both* experimentally and theoretically. Your team should be able to answer questions such as: (1) do Newton's laws (including the Law of Conservation of Momentum) actually work outside of the idealized world of the introductory physics laboratory? or (2) if we truly believe that Newton's laws apply to the motion of objects what are the nature of forces causing changes in motion of an object?

Because your report is a collaborative effort with 3 or 4 investigators it should be a substantial report backed by both experimental data your team has obtained and by library research on theoretical aspects of the topic you are studying. **An appropriate report length is about 10-15 pages.** The 10-15 pages is a guideline and not an exact requirement, so don't bother padding the report with unorganized ramblings, irrelevant data or wide margins and big spaces.

Each project must involve both theoretical and experimental research that can be done collaboratively. The intended audience for your report is a classmate with a similar physics background to yours who has not done your specific project. You and your partners can work together to prepare data tables, graphs, and apparatus drawings. *The culmination of each project will be a written team report in which the details of organization, the actual writing, and the derivation of needed equations are worked out by your team.*

Things to consider in all projects:

- Error analysis using the standard deviation of least squares fit slope, if fitting routines are used to analyze your data.
- Techniques for comparing data to theory
- Checking each other's writing and making improvements
- Visiting the Writing Center for helpful suggestions

For Theoretical Background

A required component of every project is to learn about your topic and write about it in an organized way in your laboratory report citing important references. References to books and journal articles will be essential to help you with historical background, qualitative discussions of phenomena, and the derivation of key equations used for data analysis. In fact, you are required to cite relevant references in your report.

In addition to the introductory physics textbooks available in the lab there are a number of other books and journals in the library. If you are curious about something, ask your instructor to suggest some references. Students working in interdisciplinary areas may find references in the main library. There is one book in particular that is full of project ideas: Jearl Walker, The Flying Circus of Physics (Wiley, New York). This book is available through your instructor. Other books available in the University of Utah library include:

Armenti, The Physics of Sports	Marriott Library Level 1: General Collection (QC26 .P49 1992)
Brancazio, SportScience	Marriott Library Level 1: General Collection (RC1235 .B73 1984)
Laws, The Physics of Dance	Marriott Library Level 1: General Collection (QP310.D35 L39 1984)
Adair, The Physics of Baseball	Marriott Library Level 1: General Collection (QC26 .A23 1994)

For Data Collection and Analysis

The major experimental analysis tools available for motion projects will include meter sticks and stop watches; computer-based laboratory systems (including the Logger Pro with motion and force sensors); and a video analysis system (including a video or phone camera and Logger Pro software).

If your team decides to use video analysis, you will need to do one or more of the following:

1. Use a digital video camera to make your own video tapes of motions of interest;
2. Record motions from televised sports events
3. Use or rent other videos

Once you identify frames of interest you will need to get them into a QuickTime file. Logger Pro has many features that you haven't used yet to help you cope with "real" projects such as frame by frame origin setting or scaling and automatic center-of-mass determination for humans or other systems of objects.

Requirements for Writing the Formal Laboratory Report

Please review the separate pages titled **Physics Project Rubric** for details on what is expected in the laboratory report. *You must include all sections in your report that are listed in that document*. You and your partners will work together to create diagrams, graphs, analyze data, and do the write-up of the project including theory and conclusions. *Each formal report must be word-processed with data and graphs included in appropriate places in the main body of the text rather than tacked on at the end. You are required to do your drawings using the computer*. Each project report will be graded and returned for revision. After it is revised by you, it will be resubmitted, and the instructor will assign a second grade to it. In professional science, this is the process of peer review. (Where your "peer" here is a fellow scientist, though more senior in their career than you – aka your instructor.)

Writing the Final Report (Version 2)

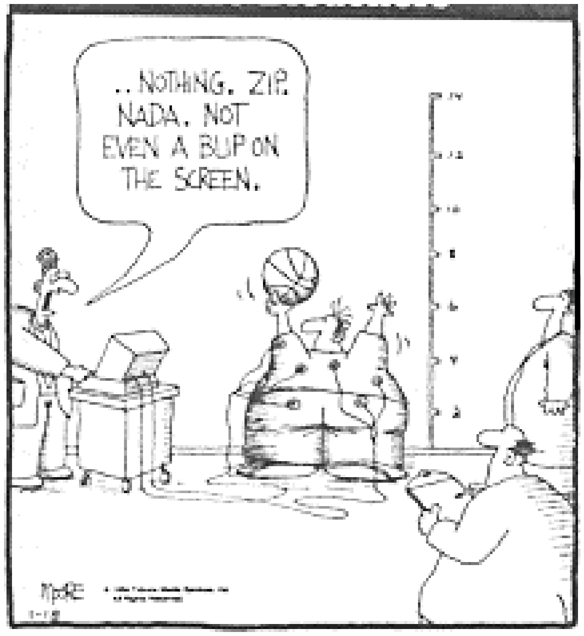
Your instructor will read and critique the first version of your report. Once the instructor's critiques are completed you should work with members of your team to rewrite the report based on comments you receive on your written reports. In most cases the revisions will involve such activities as re-analysis of data, rewriting to improve clarity, and reformatting your report to improve its appearance. However, in cases where the data your team obtained is poor or not very complete your team may want to get together to retake and re-analyze the data.

On the due date for the final report, you and your team must submit:

1. The final version of your team report, as well as version 1 and the instructor's critique.
2. A Group Assessment Summary from each team member (submitted separately directly to your instructor – no grade can be assigned until all summaries are turned in).

Project Ideas

The following are suggestions for projects in mechanics. Your team might think of a project that is more interesting, such as a physical analysis of a favorite sport or dance move, the motion of a favorite animal, etc. If so, talk to your instructor.



A team of specialists confirms Jeff's worst fears: He has zero hang time.

<u>Floating</u>: Study the question of whether accomplished ballet dancers performing leaps (Grand Jetés) or basketball players performing slam dunks can really "fly" for awhile. In other words do they have "hang time"? How about long jumpers? Why to they appear to hang in the air so long? Can great dancers and athletes defy the laws of gravity for a short while? Why or why not?

<u>Maximum Jumping Heights</u>: What are some of the reasons why high jumpers, using new techniques, are able to break world records? What is the limit to how high an athlete can raise his or her center of mass? Can a jumper clear the bar without his or her center of mass going over the bar? If so, how is this achieved?

<u>Energy Transformations in Pole Vaulting or Diving</u>: Athletes have amazing methods for transforming muscle energy into gravitational potential energy in these sports events. A careful video analysis of either of these events makes a challenging project.

<u>Relative Motion of an Accelerating Cart</u>: If you are observing motions from a cart moving at a constant velocity instead of from a frame of reference fixed in the laboratory, what stays the same? What is different? Do Newton's laws still hold? What is the significance of Newton's first law in this consideration? For example, you could track the path of a ball tossed vertically in the reference frame of a cart rider and in the laboratory reference frame.

<u>Relative Motion in Collisions</u>: You could look at one-dimensional collisions in different reference frames. By modifying the origin in each frame, it is possible to pretend to ride on an object that appears to be moving in the laboratory fame and reconstruct the world view of an insect moving along at a constant velocity with respect to the laboratory. What stays the same? What is different? Do Newton's laws still hold? What is the significance of Newton's first law in this consideration?

<u>Lunar Module Ascent</u>: The NASA movies of the ascent to the Apollo 17 lunar module are quite a challenge to analyze. Is the measured acceleration constant? What is the thrust of the LM ascent engines? How do the measured values compare with the theoretical calculations done by NASA engineers? One of the major difficulties is that the camera is zooming out during the whole time. The frame rate in fps needs to be confirmed and some geometry must be applied to the LM dimensions to find a good scale factor.

<u>Bottle Rockets</u>: A 2 liter plastic soda pop bottle can be filled with a mixture of air and water under pressure. If stabilizers are added the bottle will take off “like a rocket.” Since the initial mass of the fuel, the air pressure and angle of launch can be varied, there are many opportunities for scientific investigation. For more information check out the following web site:

https://www.nasa.gov/sites/default/files/atoms/files/rockets-educator-guide-20-water-rocket-construction.pdf
https://www.nasa.gov/sites/default/files/atoms/files/rockets-educator-guide-20-water-rocket-launcher.pdf

<u>Air Drag</u>: So far we have studied one and two-dimensional motions near the surface of the Earth in circumstances where air drag is negligible and does not affect the motion noticeably. We know however that instead of continuing to accelerate objects such as coffee filters or sky divers reach what is known as terminal velocity. How does air act to retard motion? What factors affect the terminal velocity reached by an object. By video taping objects dropped from one of the three story buildings on campus or carefully studying the fall of objects such as coffee filters in the laboratory, air drag phenomena can be explored.

<u>Friction, Shoes, and Falling</u>: Rock climbers and runners depend on having shoes that do not slip. What factors in terms of both the design of shoes and the stance of the athlete in a given sport affect the performance of the shoes in preventing accidents and injuries?

Do Seat Belts and Air Bags Save Lives?: Automobile manufacturers and the government have taken slow motion films of mannequins during controlled head-on collisions. You can study the impulse forces that these "dummies" experience with no restraints, with seat belts, and with air bags by studying their momentum changes. Research has shown that an impulse involving 900 N of force for more than 0.006 s will cause a typical cheekbone to break. Under what conditions will the various types of restraints prevent bone-breaking injuries?

The Projectile Motion of a Spinning Object: When a boomerang, ax, baseball bat, or twirling baton is thrown so that it spins as it moves, we believe that its center of mass undergoes a parabolic motion. Is there a point on a non-symmetric spinning object that undergoes parabolic motion? If so, what is the location of that point on the spinning object? Does that point behave like the center of mass when we try to balance the object? This project involves equation derivation and spreadsheet modeling.

Evaluation of Alternative Methods for Finding the Center of Mass of Humans: A number of investigators have used balance techniques, mass determination of body segments of cadavers, and other methods for finding the CM of humans in motion. You can evaluate the accuracy of a couple of these methods for determining the path of an athlete or dancer.

Optimum Performance in the Shot Put: A projectile has a maximum range in the absence of air drag when it is launched at 45 degrees with respect to the horizontal and allowed to fall back to the same vertical height from which it is launched. But a shot putter shoots from shoulder height and lets the shot fall to the ground. Also, the shot may be influenced by air drag. How do these factors affect the optimum angle of launch? Is the path really parabolic or does air drag matter?

Underwater Motion: Within the last ten years, the backstroke world record was shattered as a result of a new swimming technique known as the extended underwater dolphin kick. It is clear that anyone who wanted to remain competitive needs an understanding the physics of motion in water. You could begin to develop an understanding by designing an apparatus that allows you to observed the motion of small objects in dropped in water. Some other questions you may want to explore are: Does the shape of the object affect the way it falls? What about its weight? What is the "best" shape for an object so that it falls in the quickest time? Based on your experimental results, can you describe the forces exerted on objects falling in water quantitatively? In the recent past, some students have investigated the motion of a swimmer as he/she turns at the end of a lane (flip-turn). (You may be able to devise a gadget that allows our video camera to record under-water motion.)

The Motion of Rockets Leaving a Launch Pad: The launching of space probes and satellites takes a tremendous effort and is also very expensive. As such, it is important not to have anything go wrong. How do various rockets move as they are launched. Factors such as mass loss from ejected fuel, air drag, and diminished gravitational forces may come into play. What happens when a rocket fails and it undergoes projectile motion? You can analyze various launches from a history of space travel video.

Motion in Movies and Videos—Real or Fake?: Are the motions realistic or faked in old movies, TV shows, or cartoons? Do Newton's Laws seem to hold for the situations you choose to analyze. Why or why not? Care must be taken to find analyzable motions from these movies in which the camera axis is perpendicular to the plane of motion.

Animal Locomotion: Some unusual projects have been undertaken by biologists. Examples include studies of crayfish motility, the energy expended by a hummingbird that is hovering, and studies of the relationship between speed and stride length (as measured by footprints) of running humans and/or four legged animals. For example, Martin Lockley, a paleontologist from the University of Colorado, reconstructs the habits and behavior of dinosaurs by studying their tracks. Tracks such as the one at the Davenport ranch in Texas has 23 distinct sets of footprints that were made 27 million years ago. Dr. Lockley is not only interested in identifying the prints but also in determining social behavior as well as how fast various dinosaur species moved. Because Dr. Lockley can't record the stride length of various dinosaur species as a function of running speed, he has spent a considerable amount of time filming wild animals in Africa to obtain these relationships for elephants and zebras on Tanzania's Serengeti Plain.

Galileo's Law of Chords: In 1602 Galileo made the assertion that "The time of descent along any chord of a vertical circle to its lowest point remains the same, regardless of the length and slope of the chord." Consider the three chords shown on the right. Can you use Newton's Laws to prove the validity of this assertion theoretically? Can you design simple apparatus and verify the assertion experimentally?