

Physics 212 Project Information (Spring 2023)

Schedule

| | | |
|------------|--------------------|--|
| Mon | January 9 | Project Information Distributed |
| Mon | February 20 | Project Teams formed |
| Fri | February 24 | Lab Project proposals due |
| Mon | February 27 | Proposals Returned/Begin Lab Projects |
| Mon | April 3 | Formal Lab Report Version 1 due in class (IN PRINTED FORM) |
| Mon-Fri | April 3 – 7 | Review and Critique another team's report |
| Fri | April 7 | Individual Written Critiques Due (in class) |
| Mon | April 10 | Version 1 Report is returned for rewrite with critiques attached |
| Wed | April 26 | Team Reports Due (including versions 1 and 2 and all critiques) |

Physics Laboratory Project

The goals of your laboratory project are to: (1) help you extend your understanding of a topic in physics of special interest to you and one or two partners; (2) give you experience with teamwork; (3) help you learn more about the processes of scientific investigation and library research, and (4) enhance your ability to write a well organized and lucid scientific report using contemporary computer tools. Our graduates often mention that the investigative, cooperative, and computer skills they acquired in doing their semester projects were very useful in their jobs and graduate work.

Because your report is a collaborative effort with 2 or 3 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 20 pages.** The 20 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.

You are encouraged to choose a team of 3 or 4 to investigate one of the following areas: simple harmonic motion, electricity, circuits, magnetism, thermodynamics, optics, or modern physics. 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.*

Project Options

This semester, we are giving you three options for your project:

1. Rewrite a set of activities in the Activity Guide that introduces and develops a particular concept. How would you write the activities and design the experiments so that they make more sense to you, or are more coherent and unambiguous?
2. Take a set of activities from the Activity Guide and go into the concepts more deeply, developing the theory in more detail and designing additional experiments to explore additional aspects of the concepts.
3. Design your own project, as described in more detail below.

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 or in other departmental libraries. 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.

For Data Collection and Analysis

The major experimental analysis tools available for projects will be computer-based laboratory systems (including the computer interface and sensors such as those for temperature, pressure, current, voltage, and nuclear radiation), the video analysis system (including a video camera, VCR, and software), electrical meters and ordinary and digital thermometers.

Project Ideas

The following are suggestions for projects in advanced mechanics, electricity, magnetism, thermodynamics, and nuclear radiation. You and your partner might think of a project that interests you more. If so, discuss your ideas with your instructor.

INTEGRATIVE PROJECT FOR CHEMISTRY MAJORS:

Exploring Chemical Bonds: The March 1996 issue of Scientific American has an exciting Amateur Scientist column that describes how to build apparatus to measure the very small amount of heat energy transferred to or from chemical solutions after an endothermic or exothermic reaction occurs. The project would involve wiring a very sensitive differential temperature sensor from integrated circuits, wiring a small heater circuit to transfer a small amount of heat energy to a test tube, and making voltage and current measurements to determine the minute amount of heat energy involved in a single chemical reaction. This project draws together electricity, electronics, and thermodynamics to do a basic experiment in physical chemistry. This would be an excellent project for collaboration of two or three teams of students who are interested in basic physical chemistry.

ELECTRICITY, MAGNETISM, AND CIRCUITS:

Mechanical Analog to Current Flow: In Unit 22 you considered how a person might pick up balls, give them gravitational potential energy, and let them roll down a ramp with pegs in it. This system can be used as an analogy to the flow of charge through a wire and a resistor connected to a battery. A team could build an experimental ramp. This ramp would be outfitted with metal contacts at the top and bottom allowing us to monitor the rate of flow of balls by computer.

Coulomb's Law: In Unit 19 (Section 19.6) you will use video analysis to study the electrostatic interaction between two point charges. This study can be extended to allow you to study the electric field created by extended charge distributions such as the charged rod and charged disk, and use spreadsheet modeling to compare experimental results with those obtained theoretically from the application of Coulomb's Law. Those choosing this project should be prepared to videotape interactions between a "test" charge and a charge distribution early some morning when the weather is unusually cold and dry and people with humid breath haven't been walking around in the room.

Exponential Growth and Decay: In Unit 24 you studied the exponential decay of electrical charge in capacitors. The decay of charge from a capacitor that is placed in a simple circuit with a resistor is exponential and has a characteristic half-life. There are several other exponential decay processes in physics such as radioactive decay and the cooling of a hot object. In biology and chemistry there are a number of exponential growth and decay processes. In this project, other examples of exponential processes can be studied and can lead to a deeper understanding of why systems that seem to be entirely different also undergo exponential processes. What do such systems have in common?

Electronic Design: If you enjoy the wiring of the amplifier or digital stopwatch in Unit 25, you might want to do a library research project in which you learn more about how integrated circuits are constructed and what other integrated circuit elements can do, and then attempt to design your own simple electronic device. This type of project would be appropriate for those interested in electrical or computer engineering.

The e/m Experiment: Although the mass and charge of an electron are incredibly tiny by everyday standards, in Unit 26 you will do an experiment to determine the charge to mass ratio by bending a beam of electrons in a magnetic field. By doing more careful measurements under different circumstances, how close can you come to the accepted value of the e/m ratio? This is a good project for those who would like to do a careful repeat of a historically significant experiment.

Faraday's Law: In Unit 27 you will do a Faraday's Law experiment. Faraday's Law is one of the most significant discoveries in electricity and magnetism. The projects you will do in Activity 27.11 deserves to be expanded and done with much more care. For example, how does the waveform in the pickup coil differ when the waveform in the field coil changes? Is the amplitude of the waveform detected in the pickup coil really proportional to the frequency of the waveform delivered to the field coil? How good are the data. Does the flux through the pickup coil really vary as the cosine of the angle between the plane of the pickup coil and the plane of the field coil? By using a magnetic field that varies sinusoidally in the experiment you can explore some important properties of alternating current circuits.

RLC Circuits: You can combine in-class experience with both capacitor decay and Faraday's Law to study the behavior of alternating current circuits. Just as any pair of conductors separated by an insulator can be a capacitor (C), any coil of wire can be an inductor (L). An RLC circuit consisting of a resistor, inductor and capacitor can be made to behave like a mechanical harmonic oscillator that is driven sinusoidally. It is interesting to study the behavior of RLC circuits.

HEAT AND TEMPERATURE:

Heating/Cooling: In Unit 16 Section 16.7 you studied cooling rates. The actual law of cooling used to analyze this experiment is believed to represent a combination of different cooling processes. An extension of the Activities in Section 16.7 could include studying the cooling processes that might come into play in different situations. You could study the cooling of a light bulb filament or of the air on a cold night, or of different liquids. If you want to do a cool project, talk to your instructor about possibilities.

Mechanical and Thermal Properties of Rubber Bands: Rubber behaves very differently than metals when stretched and when heated. How and why rubber behaves so differently can be the subject of a fascinating open-ended investigation.

A Rubber Band Heat Engine: In Unit 19 you studied heat engines. In general, a heat engine is a device that extracts thermal energy from a hot body, does useful work, and deposits some waste thermal energy into a cold body. Like gases, rubber bands can change their size when heated and cooled and do mechanical work in the process. Using a simple design and making careful adjustments of the engine components, it is possible to construct an ultra low power working heat engine out of rubber bands, cardboard, a heat lamp, a wooden dowel and small ball bearings and also to study the properties of rubber bands as they are heated and cooled. This project is a good one for budding mechanical engineers.

Temperature and Athletic Performance: In general, engines convert various forms of energy into mechanical work. For example, an athlete uses chemical energy released during the oxidation of molecules obtained from food to do mechanical work. The efficiency of the athlete's muscles in transforming chemical energy into work is at best only about 20%. Thus, 80% of the chemical energy released during physical activity is ultimately converted into heat energy. Since an athlete must maintain his or her internal body temperature at about 37 degrees Celsius to do muscular work, the waste heat energy must be transferred to the surroundings. How is the performance of a marathon runner affected by the temperature of the surroundings? We have compiled a spreadsheet in which the running times of the first ten male finishers of the Boston Marathon can be compared to weather conditions. There is over 100 years of data. What can you conclude from these data about the relationship between human performance and weather conditions?

Solar Heating: There are three ways that heat energy can be transferred: conduction, convection, and radiation. In this project you can be challenged to use cardboard panels cut out of cartons, saran wrap, and a heat lamp, and other materials to see if you can design a solar house which is efficient in the collection and storage of solar energy from a "heat lamp sun" that cycles on and off. By doing some basic measurements you can construct a computer model of the behavior of your house.

ACOUSTICS /NUCLEAR RADIATION:

The following acoustics and nuclear radiation projects can be quite exciting. Since topics involving sound and radioactivity are not covered in the course, these projects are only recommended for those who are willing to learn the basics of a new topic. There will be advice available from instructors and physics majors about how to do this.

Properties of Sound: The computer-based laboratory system and a small microphone can be used to study some basic properties of sound waves as a system of harmonically driven air molecules. A particularly interesting aspect of this study could be to measure the speed of sound in air as a function of air temperature using a length of PVC pipe and a reflector, or to study how a magnet and speaker cone can be used to generate sound from electrical signals.

Half Life Experiments: The radioactive nuclei of atoms become stable after giving off radiation so that the activity of a large sample of radioactive nuclei can diminish as time goes on. Each radioactive element has a characteristic average time before decay. Decay from short-lived isotopes of indium and silver produced in a neutron howitzer can be studied, and the half-lives of these radioactive elements can be measured. Since the measurements are relatively straight forward, those doing this project should also couple it with a study of the statistical aspects of exponential "decay" using dice to discover more about why radioactive nuclei undergo exponential decay.

Requirements for Writing the Formal Laboratory Report

The process of doing 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. We ask you to work with your team and do only one formal laboratory project each semester so that it can receive special attention. We would like you to have the time to engage in the real world process of doing science and give you a chance to communicate the outcome of research 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 Introductory Physics but who have not done the project you are writing about.*

Please review the separate pages titled **Elements of a Laboratory Report** for details on what is expected in the laboratory report. *You must include all 9 elements 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. The lab report must be word-processed using any word processing software that you are comfortable with. Microsoft Word is available on all campus computers and is highly recommended. In version I (first submission) your team may submit hand drawings. *You are required to do your drawings on the computer for the second submission.*

During the two days after you hand in the first draft of your laboratory report your team is to exchange reports with another team. Each member of your team is responsible for reading the other report assigned to your team very carefully. You and each member of your team must independently write a critique of your cohort teams report. Your critique is due during the class period after version I of the report is due. **Note:** You are to give carefully thought out suggestions for improvement of the report you are assigned. You should try to catch errors, make suggestions on organization, format and so on. *The quality of your individual critique will be graded and will count as 20% of your individual laboratory grade.*

Once the critiques are completed you should work with members of your team to refine your report based on those comments. 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. The final version of your report must be *submitted to your instructor for grading along with all of the critiques of your team's report and version I of the team report.*

Grading Criteria for the Project Report:

For the first version of your report, *seventy-five percent* of the grade is based on its scientific merit including the clarity of your writing, the accuracy and completeness of your data and its analysis, and the quality of your conclusions. *Twenty-five percent of the grade is based on its appearance.* This includes how well are you using the word processing and other software to create a well formatted, attractive final report with drawings, data tables, and graphs integrated smoothly into the report.

For the final version of your report, *fifty-five percent* of the grade is based on its scientific merit and *twenty-five percent is based on its appearance.* Another *twenty percent* of your project grade is based on the quality of your critique of the paper of another student team.

Each of the reports will count equally in determining your grade on formal laboratory reports.

Individual grades on the project report will be based on a combination of the team's grade on the project report and the quality of your contribution to the project as reported by fellow team members. Thus, you will be asked to estimate the relative % that each member, including yourself, has contributed to the overall quality of the project. I will distribute a form for this purpose shortly before Version II of the project report is due.

Grading Summary

| | Version One | Version Two |
|---------------------------|--------------------|--------------------|
| Scientific Merit | 75%* | 55%* |
| Appearance | 25%* | 25%* |
| Critique of Another Paper | | 20% |

*These grades are adjusted to take the quality of the individual contribution to your team's effort into account as detailed above.

Physics 212 Project Report Sample Critique

Your team will be required to revise the report based on this critique and any other ideas you have for improving it. A copy of Version I must be attached to the revision and this combination should be handed in no later than 5 p.m. on Monday, April 23. In order to get the same grade on the second draft your team must make improvements. In most cases the revisions will involve such activities as re-analysis of data, rewriting to improve its 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. 75% of the grade on this draft is based on its scientific merits (i.e. the clarity of your writing, the accuracy and completeness of your data and its analysis, and the quality of your conclusions). 25% of the grade is based on its appearance. For the final version of your report, 55% of the grade is based on its scientific merit and 25% is based on its appearance. Another 20% of your final version grade is based on the quality of your critique of the paper of another student team.

Name: Effectiveness of Residential Insulators

Date: 4/8/19

| Scientific Merit (75%) | Score | Comments |
|--------------------------------|--------------|---|
| Depth of Treatment | 80 | Your descriptions of the equations for conduction, C , and k -value are very thin. Where did the equations come from and why do they have the form they do? You may want to go into the mechanism of why Pink Foam would be the best insulator and Gypsum would be the worst. |
| Clarity of the writing | 88 | Except for a few sentences in various places, the paper reads fairly well. You'll want to change most of the direct quotes to your own words. You want to be careful about making your writing too colloquial. |
| Quality of the data | 92 | Your temperature data looks pretty good, but you want to wait until the outside temperature sensor reads a constant value before you start collecting data for the inside of the box. |
| Accuracy of data analysis | 80 | There is a definite problem with comparing your "experimental" k -value with the published value, since your calculated k -value only involves the thickness of the material divided by the R -value, a number that you look up instead of finding experimentally. You would have gotten the same "experimental" k -values without doing any of the experiments. Instead of using the k -values, why don't you just compare the warming and cooling curves from the temperature graphs for each of the different materials? You would need to make sure that the outside temperature is the same for all experiments for a good comparison. |
| Format/Appearance (25%) | Score | Comments |
| Use of 9 element sequence | 90 | You're missing element 1. Everything else seems to be there. |
| Spelling, proof errors, units | 90 | As noted in the report. Be sure to double-check yourself. |
| Tables, graphs & diagrams | 75 | All graphs, tables, and diagrams should have a figure/table number and a descriptive title underneath. The main text should refer to the graphs, etc. by figure number in a more descriptive way. Equations should be on their own line, with an equation number and a description of each symbol in the following paragraph. Remember, all mathematical symbols should be italicized (but the units that go with values should not be italicized), both in equations and when used in the main text. |
| Integrated computer use | 95 | This looks good. |

SUMMARY GRADE ON DRAFT ONE: 86%