Physics 1251
Laboratory Activities & Worksheets

Seventh Edition

Department of Physics
The Ohio State University

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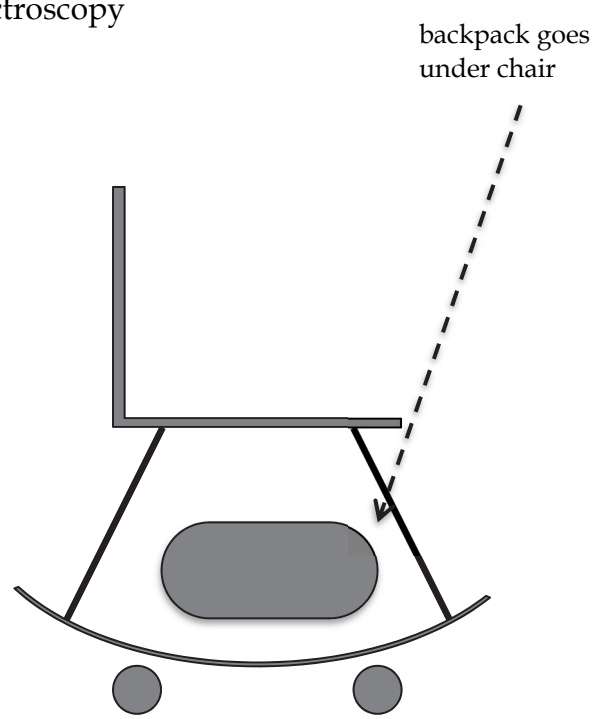


COURSE INFORMATION: PHYSICS 1250 – 1251

Complete course policies are available at the course web site:
http://www.physics.ohio-state.edu/phys1251

Only the course manager has the authority to grant excuses.

Dr. Michael Ziegler, ziegler.2@osu.edu, SM 1036A, 614-292-2067.

University Required Statement

Physics 1250 – 1251 (1240, 1241) are Physical Science courses in the Natural Science category of the GEC. The goals and objectives for this category are:

Goals/Rationale: Students in natural sciences gain understanding of the principles, theories, and methods of modern science, the relationship between science and technology, the implications of scientific discoveries and the potential of science and technology to address problems of the contemporary world.

Learning Objectives for Physical Science:

1. Students understand the basic facts, principles, theories and methods of modern science.

2. Students understand key events in the development of science and recognize that science is an evolving body of knowledge.

3. Students describe the inter-dependence of scientific and technological developments.

4. Students recognize social and philosophical implications of scientific discoveries and understand the potential of science and technology to address problems of the contemporary world.

How the Learning Objectives are Met:

1. Student preconceptions and alternate conceptions of physical law are addressed head-on in P125x and P124x. This is a necessary component of any contemporary introduction to physics, and is addressed in all components of the courses.

2. Students learn the scientific theories that have developed from the 1600s to the present day. They learn different modes of approaching the same phenomena, such as force and energy methods in mechanics.

3. Students understand that P125x and P124x introduce the basic physical laws that underlie all engineering applications. Examples of applications are provided in the textbook and in demonstrations in lectures.

4. Students understand that the social implications lie in the applications, and that in the case of physics the social implications are taken up more appropriately in the engineering courses that teach the applications. The reason for this is that physics does not go into details of how to build instruments or devices.

Assignment sheets: Assignment sheets are distributed in the first lecture session of the semester; thereafter, they are available on-line at the P125x and P124x websites, and in a rack next to room SM 1011V. Assignment sheets include information about required textbooks, specific course policies, and grading.

Students with Disability: Please contact the course supervisor at the start of the semester so that arrangements can be made to accommodate you. Students needing the services provided by the Office for Disability Services (ODS) will need to be certified by that office. The ODS is located in 092L Baker Hall, 113 W. 12th Avenue; 614-292-3307, VRS 614-292-0901; http://www.ods.ohio-state.edu/. **ODS sets deadlines to be certified and to register for its services. Failure to meet the deadlines will result in delayed access to ODS services. The physics department has no control over the deadlines.**

Tutoring: A free tutoring service is available in SM 1011A and B – see the schedule posted there for times. A private tutor list is available at http://pgsc.physics.osu.edu/tutors.

Academic Misconduct: Not to report academic misconduct is itself regarded as academic misconduct. Everyone in the university community has a duty to report suspected academic misconduct.

Academic Misconduct in Lab: Students are not always aware of what constitutes proper academic conduct in a laboratory situation. As a general rule, one should not bring into the lab any material with data taken at other times, or with any sort of answers written in ahead of time, whether in the lab report or in the lab manual or on any sort of substance, paper or not. The presence of any such material in the lab will be considered evidence of intent to commit academic misconduct. Any such materials used for study prior to the lab should be tucked away where they cannot be retrieved easily, in a backpack or other such carrying case. To receive credit, the lab report must be handed in or checked off at the end of the period. If it is removed from the lab, in fairness to other students it cannot be accepted. In no case may a lab report be taken home and be handed in later.

Academic Misconduct in Lecture: When credit is given for use of "clickers", use of another student's clicker to obtain credit for that student must be reported to the Committee on Academic Misconduct.

Academic Misconduct in Recitation: The procedures of the Ohio State University Committee on Academic Misconduct include the following in the definition of academic misconduct: "Providing or receiving information during quizzes and examinations such as course examinations...". The Physics Department refers all suspected cases of academic misconduct to the Committee on Academic Misconduct and usually follows the committee's recommendations, but there can be exceptions. Exams and quizzes may be photocopied for comparison with exams handed in for regrading. All homework handed in for grading must be your own work. If an exam states that no notes or books may be used, you must demonstrate to your recitation instructor that your calculator memory is clear before the exam begins.

Students are permitted to work constructively with other students, and to obtain help from instructors when solving on-line homework problems. Study by cooperative or collaborative methods is an excellent way to learn and retain understanding. Use of a complete solution or final equation provided by another student, a paid tutor, or any form of web site or consultation defeats the purpose of the homework assignment, and must be reported to the Committee on Academic Misconduct by instructors and other students. Posting of or provision of a complete solution or final equation by any form of transmission to other students, including, but not limited to, those listed above also defeats the purpose of the homework assignment and must be reported to the Committee on Academic Misconduct.

FAST FACTS

Time Conflicts: By university rules, no excuses are granted to miss your regular final exam, midterm, quiz, or lab for an exam, or lab, or any other activity in another course. The other class must offer you an alternate time.

There are no makeup quizzes and labs in this course.
Every student is excused for missing two quizzes for any reason including illness, family emergency, an interview, representing the university, etc. Therefore, no documentation is needed for the first two missed quizzes.

Quiz Excuse: Two missed quizzes, or two lowest quizzes, are dropped automatically; missed quizzes are dropped first, regardless of reason. If you miss more than two quizzes, contact the Course Manager with documentation within two weeks, or by the first day of exam week, whichever is first.

Lab Excuse: NO DROPS. If you miss a lab, contact the Course Manager with documentation within two weeks of the missed lab, or by the first day of exam week, whichever is first.

HW Excuse: HW is typically not excused because at least a week is given to complete each homework assignment. Deadline extensions are not granted for last minute illnesses or computer failures. A request for a homework excuse must be made to the Course Manager within two weeks of the missed homework, or by the first day of exam week, whichever is first.

Missed Midterm: No Make-ups. If a student misses a midterm, the student must seek permission from the Course Manager to be excused for missing the midterm. If the student's absence is excused, a grade for the missed midterm will be replaced by a prorated final exam grade. **The absence must be excused within two weeks of the midterm.**

Missed Final Exam: Permission is required for a makeup exam. A makeup final exam will be given, if missed for a valid documented reason. Please contact the Course Manager by the last day of exam week to request permission to take a makeup final exam.

Early Final Exam: **FINAL EXAMS ARE NEVER GIVEN EARLY.**

Only course supervisors have the authority to grant excuses.

COURSE MANAGER: Dr. Michael Ziegler, (ziegler.2@osu.edu), SM 1036A, 614-292-2067.

Regrade Requests: These must be submitted within one week of the return of an exam to you, and no more than two weeks after the exam has been returned to the rest of the class, but the last day to summit a request is the first day of exam week. **Regrade requests are not possible for the final exam.** Request forms are available on the P125x websites, and in the rack next to room 1011V Smith Lab. See the document **GENERAL COURSE POLICY AND INFORMATION** for more detailed information.

1/17/19

On-Line Homework Instructions

Homework will be submitted and graded via the on-line software package WebAssign. Go to https://www.webassign.net/osu/student.html and use your Ohio State name.# and password to log in.

A registration access code is required to use WebAssign, but at the beginning of the term there is a grace period of about two weeks in which an access code is not required. An access code is included as part of the valuepack with the textbook when a new textbook is purchased from the local bookstores or can be purchased through WebAssign's online store.

Problems with WebAssign access: Contact the WebAssign Administrator in the Physics Department, Dr. Bolland (bolland.1@osu.edu, 614-292-8065). Contact Dr. Bolland ONLY if you believe there is a problem with WebAssign itself; consult your recitation instructor or lecturer or a tutor for help with the homework.

You may submit answers to part or all of the assignment at any time before its due date. You get more than one try at most problems, and your goal is to eventually get it right. The number of tries you have used and may use are shown at the upper left of each problem (click the +).

Responses should be either in decimal numbers or the "E" format for scientific notation. For example: Enter "0.5" NOT "1/2" or "1E-3" rather than "10^-3".

WebAssign checks your answer to see if it is within 1% of the correct answer. As you calculate, you should keep at least 4 significant figures in intermediate steps and enter your answer to at least 3 significant figures, even if there are fewer significant figures in the problem.

WebAssign records the grade for the LAST answer submitted, even if that answer is incorrect and a previous answer is correct.

You may work on any assignment up to its due date/time. NO EXTENSIONS will be granted for online homework assignments. You may be excused from an online homework assignment ONLY in the following special cases:

- enrolling late in a course
- hospitalization or extended illness of the student --- (requires a physician's note stating that the student should be excused from school for that week)
- death of a parent or sibling
- military duty for the entire week.

Should one of the above special cases arise, contact the course manager with appropriate documentation in order to obtain an excuse. Also, if you find that you are not in the database and fail to contact the administrator, you will receive zero for your homework grade.

Lab Instructions

The two-hour lab session lies at the heart of this course. In it a combination of problems and laboratory activities is worked in small groups with the assistance of the instructor. These sessions are where you can best learn the material, in order to be able to complete the homework assignments and be prepared for the quizzes and exams that will determine your grade. The following are answers to questions you might have.

Typically, you and your group will be given a combination of problems and laboratory activities to do in a set order. The problems and some of the laboratory activities are not graded, but some of the laboratory activities may be graded. The graded activities, indicated clearly in this manual, together constitute the "lab score." Your lecturer will explain how the lab score combines with other course elements to determine your grade.

Your group is not expected to finish every problem! We would rather that you work a few problems well with complete understanding than a large number using guess-work.

You should record all measurements and calculations in your individual lab manual. (The other members in your group are expected to do the same.) Your instructor may ask to examine it at any time. You are encouraged to ask for help from your instructor at any time. You are welcome to use your textbook and class notes. Also, do not forget that you are part of a group. Bring this manual and a scientific calculator to class.

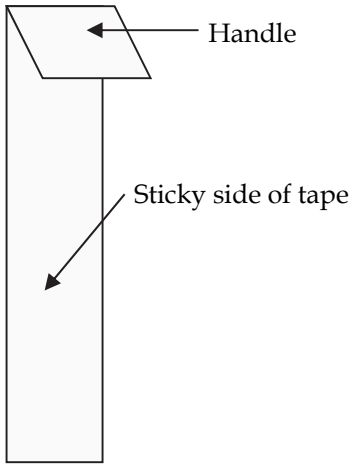
Be on time. If you come late, you may not be allowed to perform the lab.

Academic Misconduct: (These considerations are in addition to the general University rules.) All laboratory work will be done during the laboratory period. Do not bring completed lab work to the laboratory. The presence of completed material in the lab book can be considered evidence of intent to commit academic misconduct. Do "graded activities" only when your instructor is watching. Do not mistreat the laboratory equipment -- in particular, do not write on the apparatus. If you are uncertain what is permitted while doing a given graded lab activity, ask your instructor before proceeding.

Experiment I – Electric Force

Twenty-five hundred years ago, the Greek philosopher Thales found that amber, the hardened sap from a tree, attracted light objects when rubbed. Only twenty-four hundred years later, in the latter part of the nineteenth century, systematic investigations led to the formulation of a conceptual model of electricity that explains Thales' experiments. In this lab, we will develop our own conceptual model for electricity by analyzing a series of simple experiments. Although you have already learned a number of basic concepts in lecture, these rules, such as the one stating that objects with opposite electric charges attract one another, were stated without proof. In this lab, you will conduct a series of simple experiments to convince yourself that your observations are consistent with these empirical rules. When performing the activities, be careful to avoid assumptions that might not be consistent with your observations. Construct explanations and conclusions from your observations alone.

Activity 1 Remove two 10-cm long pieces of regular clear tape from a roll of tape. Curl the ends of the tape over to make handles (see the sketch at the right). Press the sticky sides of the tape to the top of the lab table and rub them so that they make good contact with the table. Then, quickly pull the strips of tape off the surface and bring the non-sticky sides of the tape near each other.



What happens? Does it matter which sides of the strips face each other? How does the distance between the strips affect what happens?

Activity 2 Stick a new 10-cm strip of Scotch tape with a handle to the lab table. Label the handle of this strip with a "b" for bottom strip. Place a second new strip on top of the first strip. Label the handle of this strip with a "t" for the top strip. Rub the strips so they make good contact with the table and with each other. Quickly pull the bottom ("b") strip (with the t-strip still attached to it) off the table and then pull the two strips apart and bring their non-sticky sides near each other.

What happens? Does it matter which sides of the strips face each other? How does the distance between the strips affect what happens?

Activity 3 Attach the two pieces of tape from the previous experiment to the wood dowel so that the strips hang down from the dowel. Repeat Activity 2, to create a second b-strip and a second t-strip. Hold each of the new strips first near the original b-strip and next near the original t-strip.

If two similar objects are prepared in the same way (i.e. tapes that are pulled off a lab bench), it is reasonable to believe that the two objects have the same type of charge. What can you say about the force between two objects of the same type? About two objects of different type?

We will give the name "charge" to the properties you have just observed. We will find later that objects with no electric charge can exert attractive forces on both the b-tape and the t-tape. Your body is such an object. When performing the following experiments, hold the rubbed objects away from your body so that you do not measure a force of your body on the hanging tapes. Also, in humid conditions, the electric charge on the pieces of tape can "leak off" causing them to become discharged. You may have to repeat Activity 2 from time to time to recharge your t- and b-strips.

Activity 4 Rub a soft white cloth vigorously against a blue Styrofoam insulation board. Hold the board near the t-strip and then near the b-strip. Does the blue board have the same electric charge as the t-strip or as the b-strip. Why?

Activity 5 You have other objects at your lab table. Try rubbing some of these objects with different materials (for example, a glass rod with silk, or a plastic tube with wool) to determine whether the objects have "t-type" electric charge or "b-type" electric charge after rubbing. List only those objects and materials that result in clearly t-type or b-type. Try to find two objects of each type.

t-type object, and material	b-type object, and material

Did any *charged* objects attract both t-strips *and* b-strips? Be sure to consider only objects that were charged sufficiently and that had a clear attraction to both. What does this imply (but not prove) about the number of different types of electrical charge?

You have charged objects electrically, by pulling tape off a lab table or by rubbing an object. You have observed two charged objects exert forces on each other. The electric force is similar to the force of gravity in that it is a non-contact force; the objects do not have to be in physical contact in order to exert a force on each other. Being charged

electrically is a property that an object may or may not have. The presence of this property is inferred from observations of forces that objects exert on other objects in experiments like those you have made in this lab.

For now, we will arbitrarily state that the b-tape pulled off the lab bench has a negative electric charge (-) and the t-tape pulled off the back of the tape has the opposite positive charge (+). This labeling by (+) and (-) dates back to Benjamin Franklin. Keep in mind, we could have chosen other names for the charge; these signs are just words to help us describe a property of matter that produces electric force.

Activity 6 Be sure that you have charged b-type (- charge) and t-type (+ charge) tapes hanging from the wooden dowels. Hold an empty aluminum pop can first near the t-tape and then near the b-tape. This experiment requires careful observation.

Question Does the can seem to have + electric charge, - electric charge, no charge, or is some other explanation needed?

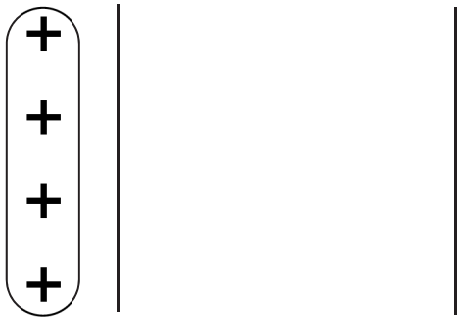
Activity 7 Cut or tear a piece of paper into many small bits and lay them on the lab bench. Very vigorously rub the Styrofoam board with a soft cloth or a wool cloth. Then, bring the charged foam board near the paper but do not touch the board to the paper. What happens?

Using the table of the previous page, select an object that has an opposite charge to that of the foam board. Try the same experiment with this new object. What happens when this oppositely-charged object is brought near the paper?

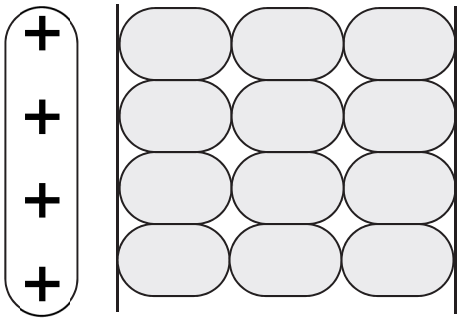
Based on the outcome, decide if the paper seems to have electric charge and if so, the sign of the charge. Or, is some other explanation needed for your observations?

Here we have seen an example of a charged object attracting a neutral object. The attraction occurs whether the charge object is positively charged or negatively charged. The model that explains this describes a neutral object as a body containing a very large number of charged particles, called protons and electrons. In a *conductor*, some of the electrons can move around. In an *insulator*, electrons cannot move, but they may "shift" so that their average position is not the same as the average position of the nucleus. We call this *polarization*.

To model what you have observed, draw the distribution of charges "induced" in opposite sides of the conducting can by the charged rod.



Draw the distribution of charges "induced" within the insulating paper by the charged rod.



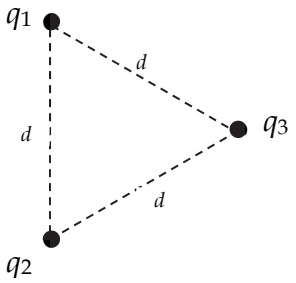
Activity 8 Connect both aluminum cans to the same side (either side) of the Wimhurst machine (get your lab instructor's help). Arrange the cans so that they are very close to but not touching each other. As you crank on the Wimhurst machine, the cans will repel each other. (What does this say about the charges on the two cans? What would happen if we attached the cans to opposite sides of the machine?)

Estimate the amount of charge on each can (assume that they have the same charge). Be sure you start with a free body diagram.

Instructor Initials: _____	Date: _____

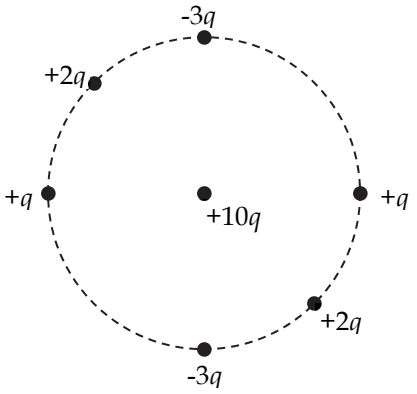
Coulomb's Law

(1) The figure shows three point charges positioned in an equilateral triangle. $q_1 = q_2 = 20.0$ mC, $q_3 = 30.0$ mC and $d = 1.50$ m.



What is the force on q_3? (A harder problem would be to find the force on q_1. If you can work that, you know what you need to know about vectors at this point in the class.)

(2) A number of charges are placed as shown in the figure, where q = 1.2 nC and the circle radius is 2.3 cm. What is the electrostatic force on the charge in the center?
[Notation: $2q$ simply means a charge that is twice q where q can be any value and any sign. $+2q$ means that the charge is definitely positive.]



(3) Two charges, q_1 and q_2, are fixed in place some distance apart. Both charges are negative, but the magnitude of charge q_2 is larger than the magnitude of q_1. Sketch a picture of the situation. Indicate on your sketch those places, if any, where a positive charge q_3 could be placed and experience zero electrostatic force. How does your answer change if q_3 is negative?

(4) Point charges are positioned as shown in the figure. What is the net force, ***F***, on the $-Q$ charge due to the other charges? Try to not perform calculations that aren't necessary.