Meeting location: Trexler 273
Instructor: P. Nelson
Email: nelson@roanoke.edu

Meeting time: T 1450 – 1750 (Blocks 12 – E3)
Office: Trexler 266B, x5250
Office Hours: M, 1530 – 1630
TW, 1000 – 1130

REQUIRED MATERIALS:

LAB HANDBOUTS: Lab handouts will be made available on Blackboard (Bbd). I will also distribute them in class. Pre-lab materials are also available on Bbd; these should be printed and completed before you come to class.

SUPPLIES: Bound (not looseleaf) lab notebook; scientific calculator

GOAL: The following learning goals will serve as an overall framework for the laboratory activities: The Art of Experimentation, Experimental & Analytical Skills, Conceptual Learning, Communication and Collaborative Learning Skills.

This course is designed to enhance your learning and understanding of the topics covered in lecture via hands-on application of the physical principles introduced in the lecture text. The main emphasis will be on clarifying and expanding your understanding of these topics. You will be introduced to new experimental techniques and methods of error analysis. You will also receive practice in clearly communicating your experimental results via technical writing.

INTENDED LEARNING OUTCOMES: Upon completing this course, successful students will
- be able to conduct scientific experiments in a manner that allows them to obtain thorough, accurate data;
- formulate hypotheses and cogently and coherently discuss the results of an experiment in light of these hypotheses, both qualitatively and quantitatively;
- be able to specify sources of error that appear in an experimental process and present experimental results in a coherent, well-organized, written manner.

FOOD & DRINKS: Do not bring any food items (lunch, candy, gum, drinks, etc.) to class. This is a lab environment and, as such, we have many pieces of equipment that run much more smoothly if you do not drop crumbs or spill sticky liquids on them.

ELECTRONIC DEVICES USAGE POLICY: If it beeps, whistles, rings, vibrates or runs off batteries of any kind, leave it at home (unless it functions solely as a calculator). The use of all cell phones, pagers, PDAs, MP3/CD players, portable gaming consoles or any other electronic entertainment or communication device is strictly prohibited during class time. This means that these devices must be turned completely off (not set to vibrate) before class begins.

During class, the computers in this room are to be used only for the completion of assignments directly associated with this course. You may not use them for completing assignments for other
courses, checking email, IMing, 'social networking,' general web-surfing or for any other activity which is not directly associated with the current class assignment in this course. You may use your own, personal laptop for note taking, if you wish. You may not use it in any manner that violates the above policies and procedures.

SAVE YOUR WORK OFTEN! Do not save any work to the lab computers. The C: drives are purged when you log out and you will lose all your work. Instead, you should save all data collected and all work performed in this course to your Z: drive or onto a personal USB drive.

ATTENDANCE: A portion (15%) of your Physics 104 grade is based upon your performance in the laboratory; therefore, you must register for both a lecture and a lab section. (Registering for a lecture does not automatically enroll you in the lab.)

You must attend all labs. You may only attend the lab section for which you are registered, unless you obtain permission from both lab instructors at least 24 hours prior to the earlier of the two lab sections. It is your responsibility to contact the relevant instructors. Your lab report is still due by the date & time specified below.

Lab start and end times are non-negotiable. Most labs, however, will not require the entire class period. You are expected to arrive prepared and on time! Anyone who arrives more than 10 minutes late will not be permitted to perform the lab activity that day.

LAB NOTEBOOK: Every student is expected to record data in a bound (not loose-leaf) lab notebook. You will create a table of contents on the first 1 – 2 pages of the lab notebook. Subsequent pages should be labeled with the date of the experiment, the lab title and a page number. Start each lab on a new page.

Right-hand pages should include data - neatly recorded in tables – results, all sample calculations for the results and error analysis; units should be included in column headers and in all calculations and results. Graphs produced during lab should be pasted onto the left-hand pages. Everyone should record answers to discussion questions in their lab notebook as well.

Before you leave lab each week, you must show me your lab notebook. I will assign it a score based upon the following scale

<table>
<thead>
<tr>
<th>Score</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>10</td>
<td>Your notebook entries are organized and thorough. All data was recorded using the acceptable format, with graphs correctly pasted. Results are in table format. Error and sample calculations are shown and are correct. Units are included where appropriate. Graph axes are labeled.</td>
</tr>
<tr>
<td>5</td>
<td>Your notebook entries are haphazard, illegible, do not include units or you were tardy, not prepared for class or left early. Graphs are not properly secured in the notebook. Data was recorded in lab notebook, but not in table format. Error or sample calculations were not shown, or were incomplete. Results were not stated, or were not in table format.</td>
</tr>
<tr>
<td>0</td>
<td>You did not attend class or you did not bring your lab notebook to class.</td>
</tr>
</tbody>
</table>

WEEKLY LAB EXERCISES: You will conduct the in-class portion of the lab exercise in groups of no more than three people, unless the instructor gives permission otherwise. At the end of the period, each group member should have an identical copy of all data collected during the lab,
recorded in your lab notebook and possibly in electronic form (Excel tables, graphs, etc.). For each lab exercise, you will submit the following items:

**PRE-LAB:** [10 points] The purpose of the pre-lab assignment is to introduce the material that will be investigated during the lab. Pre-lab materials will be posted on Bbd. Pre-labs are due at the *beginning* of lab (i.e., before I give the intro). Pre-labs submitted by the end of class will only receive half credit; no pre-labs will be accepted once I leave the classroom. Pre-lab solutions should be *neat* and *typed*. Your name should appear in the upper-right corner of the first page; pages should be stapled *before* coming to class.

**WEEKLY "REPORTS":** [50 points] Lab reports in Physics 104 consist of the four sections outlined below. Since one of the course objectives is to communicate experimental results in a coherent, well-organized, written manner, each lab will emphasize a different section of a lab report, as listed on the course outline. **All submissions must be typed**¹.

I will discuss the content of each section throughout the semester. This is but a brief description of the elements of each section.

**A. Abstract**— A brief summary of the experiment and your findings. It should include:

* **Grammar, Capitalization & Neatness** [10 pts.]. Same as above.

* **Purpose** [5 pts.]. This is a brief (2 – 3 sentences) statement of the phenomena investigated during the lab.

* **Procedure** [5 pts.]. 2 – 3 sentences that summarize how you obtained your data.

* **Principle Results** [10 pts.]. This section includes a few sentences that highlight your results, including uncertainties and proper units. **No data should appear in this section.** Instead, you should include all computed values obtained in each lab section.

* **Error Analysis** [10 pts.]. What were the (3 – 4 most prominent) sources of error in your measurements? **"Human error" is a broad categorization and is not considered an acceptable answer.** Instead, you should list specific errors or experimental procedures that could have resulted in inaccurate results. What would you do to eliminate these errors and make your uncertainties smaller?

* **Validity** [10 pts.]. Based upon your computed uncertainties, were your results valid? That is, did your results agree with the intended purpose of the experiment? Did they support your hypothesis or prove the validity of the physical phenomenon being investigated? Justify your assertions.

**B. Introduction**— This provides background information on the phenomena studied. The elements of a well-written introduction are:

* **Grammar, Capitalization & Spelling** [10 pts.]. Sentences should be organized in well-written paragraphs. Use of proper capitalization, sentence structure (no run-ons, fragments, etc.) and spelling is expected. Refer to the *Hacker’s Guide* for assistance.

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¹ Equations must be typed using the MS Word equation editor.
• **Background Information** [10 pts.]. Briefly explain the phenomenon you are studying. Provide just enough detail that someone who did not perform this lab exercise knows what phenomena were studied.

• **Definition of terms** [10 pts.]. Define each of the important terms and concepts.

• **Relevant equations** [10 pts.]. List all of the equations used in computing the principle results. Explain what each variable represents and their associated units.

C. **Data & Results** – All numbers recorded and results obtained from calculations:

• **Neatness & Significant Figures** [10 pts.]. Entries within data tables are aligned. Numbers do not contain an excess of digits.

• **Data** [10 pts.]. All data is organized in tables that include proper units. Data tables are organized by section. Data is displayed in graphs as appropriate. Graphs include a title and labeled axes.

• **Results** [10 pts.]. Results are the quantities that you are asked to compute in the lab handout; these are the ultimate goal of your experiment. Results are organized in tables with the correct units. Graphs include trend lines, trend line equation and R² values, all of which contain correct units.

• **Error Analysis** [10 pts.]. Calculate all uncertainties or percent differences, as required in the lab handout. All numbers and calculations include units. A document detailing how to perform error analysis is available on Bbd.

• **Sample Calculations** [10 pts.]. You must provide an example of each calculation requested in the lab handout. Before plugging numbers into equations, you must first state the equation(s) used and explain what the symbols mean (i.e., formally give a definition of each variable and state which units are used to describe that quantity).

D. **Discussion** – This document contains your well-reasoned answers to the discussion questions in the lab handout, written in paragraph form.

• **Grammar, Capitalization & Neatness** [10 pts.]. **Same as above.**

• **Discussion Questions** [40 pts. total.]. Answers should be thorough. Justify your answers based upon your results from lab (i.e., tell how you arrived at the answer to the question being posed and cite overall trends, do **not** quote data).

In addition to alternating which section of the lab report is submitted each week, we will also alternate between group and individual submissions, as noted on the course outline. The first time that a new section is introduced, each group will submit that section; graded, commented copies will be provided to each group member the following week. You are expected to use the comments provided on the group activity to enhance your individual submissions.

The lab #10 report will include all of the above elements. It will be worth 200 points and is due by 5:50 PM on Tuesday, April 13.

Group reports are due by the end of the lab period, unless the instructor specifies otherwise. Individual reports must be submitted electronically (via email) within 48 hours of the end of lab (i.e., 5:50 PM Thursday). The time stamp placed on the email by the server will determine...
when your individual work was submitted. Any items submitted within 24 hours after the deadline will only receive half credit. No work will be accepted more than one day late unless you made prior (i.e., before the work was late) arrangements with me.

All group members will receive the same grade on the group reports. The assumption is that everyone participated equally in all aspects of the lab exercise (data collection, analysis or written work). If any group member feels that another was only a passive participant in any aspect of the lab, email me and I will investigate the matter.

Additionally, do not discard any graded work until the end of the semester. If there is a discrepancy between the grades recorded on the report and on Bbd, I will ask to see the graded report. If you cannot produce the report, the grade will stand as recorded.

MAKE-UP LABS: All missed labs must be made up. If you are unable to attend your regularly scheduled lab session due to an unavoidable circumstance (death, medical emergency, court appearance, etc.), you may attend the 1420 – 1720 lab on Monday of the same week. HOWEVER, you must obtain the permission of both instructors by 5 PM on Friday of the previous week. You must also provide a note signed by a governing official (doctor, law enforcement officer, etc...).

Make-up lab sessions will also be offered during the last full week of the semester (see course outline). If you attend either of these sessions because of a legitimate academic conflict, your attendance at the make-up session will be considered ‘excused’ and you will receive full credit for the lab. (You must still provide documentation.) Otherwise, you will receive only half credit. In either case, you must register (i.e., email me your intent) within 1 week of the missed lab.

GRADING: At the end of the semester, I will report your overall lab percentage score to your lecture instructor. No curves will be applied; I leave that up to your lecture instructor. Your lab percentage score is

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<table>
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<tbody>
<tr>
<td>Pre-labs</td>
<td>10%</td>
</tr>
<tr>
<td>Lab notebook</td>
<td>15%</td>
</tr>
<tr>
<td>Weekly lab sections</td>
<td>60%</td>
</tr>
<tr>
<td>Mirror &amp; Lenses Lab</td>
<td>15%</td>
</tr>
</tbody>
</table>

ACADEMIC INTEGRITY: All work submitted must reflect your own (in the case of individual submissions) or your group’s (for group submissions) effort and expertise! I expect you to adhere to the academic integrity policies as outlined in the brochure, Academic Integrity at Roanoke College. As applied to this course, this means (but is not limited to): data collected must illustrate your honest effort to perform the experiments; falsifying data is considered cheating. The data collected by your group may not be shared with other groups. You may work with others on the individual lab reports; however, all analyses, discussion and conclusions must reflect your own understanding of the phenomena studied—that is, individual lab submissions must be your own work.

Although students working within the same group will have the same data, recording of the data into the lab notebook is to be completed individually and should be done neatly. Excel graphs created during lab time may be shared by group members, and secured in each student’s lab notebook. Error values and sample calculations using the data obtained by your group are to be calculated in each individual’s lab notebook.
# Tentative Lab Schedule

Note: This schedule may change without prior notice.

<table>
<thead>
<tr>
<th>Date</th>
<th>Topic</th>
<th>“Report”</th>
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<tbody>
<tr>
<td>12-Jan</td>
<td>Course Policies&lt;br&gt;Lab 0: Dimensional Analysis, Units, Algebra Review &amp; Graphing</td>
<td>Worksheet</td>
</tr>
<tr>
<td>19-Jan</td>
<td>Lab 1: Standing Waves</td>
<td>Group Data &amp; Results</td>
</tr>
<tr>
<td>26-Jan</td>
<td>Lab 2: Sound</td>
<td>Individual Data &amp; Results</td>
</tr>
<tr>
<td>02-Feb</td>
<td>Lab 3: Heat Transfer</td>
<td>Group Abstract</td>
</tr>
<tr>
<td>09-Feb</td>
<td><strong>No lab meetings</strong></td>
<td></td>
</tr>
<tr>
<td>16-Feb</td>
<td>Lab 4: Ideal Gases</td>
<td>Individual Abstract</td>
</tr>
<tr>
<td>23-Feb</td>
<td>Lab 5: Electric Fields &amp; Potentials</td>
<td>Group Introduction</td>
</tr>
<tr>
<td>02-Mar</td>
<td><strong>Spring Break – No lab meetings</strong></td>
<td></td>
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<tr>
<td>09-Mar</td>
<td>Lab 6: Ohm’s Law</td>
<td>Individual Introduction</td>
</tr>
<tr>
<td>16-Mar</td>
<td>Lab 7: RC Circuits</td>
<td>Individual Data &amp; Results</td>
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<tr>
<td>23-Mar</td>
<td>Lab 8: Properties of Magnetic Fields</td>
<td>Group Discussion</td>
</tr>
<tr>
<td>30-Mar</td>
<td>Lab 9: Electromagnetic Induction</td>
<td>Individual Discussion</td>
</tr>
<tr>
<td>06-Apr</td>
<td>Lab 10: Mirrors &amp; Lenses</td>
<td>Complete Report, Individual</td>
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<tr>
<td>13-Apr</td>
<td><strong>Make-up labs² (By appointment only!)</strong>&lt;br&gt;Mirrors &amp; Lenses Lab report due</td>
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</table>

² Make-up labs are offered on Monday, Apr. 12 from 1420 – 1720 and during our normal class time, Apr. 13 from 1450 – 1750. You must specify which session you plan to attend.