**Instructor:** Dr. Richard Grant, Trexler 266A, Phone #: 375-2430, Email: grant@roanoke.edu  
**Office Hours:** Monday 10:50 – 12:00 and 2:00 – 3:00,  
Tuesday 1:00 – 2:00,  
Wednesday 10:50 – 12:00,  
Friday 10:50 – 12:00,  
or by appointment.

**Class Hours:** 8:30 - 11:30 a.m. Tuesday and Thursday, Trexler 272 & 274.

**Text:** John R. Taylor; An Introduction to Error Analysis, 2\textsuperscript{nd} ed. 1997 (University Science Books).

**Grading:** Reports 45\%, Notebook 5\%, Homework 10\%, Midterm Test 10\%, Short Oral Presentation 5\%, Poster Presentation 10\%, Final Oral Presentation 15\%.

**Overview:** The purpose of this course is to introduce you to a number of experimental techniques and to develop skills in the collection, analysis, interpretation, and presentation of experimental data. The goal is not to complete as many experiments as possible, but rather to give you the opportunity to delve into an experimental project. You are required to record all your work in a lab notebook. Furthermore, one of the primary objectives of the physics major program is to develop “the students' ability to clearly communicate their scientific thoughts to their peers and faculty, both through written reports and oral presentations”. To achieve these goals the majority of your grade will be based on the organization, completeness, quality, and presentation of your work as reflected in your notebook, formal reports, poster session, and oral presentations. Also, weekly homework assignments and a midterm exam will help you develop skills in data reduction and error analysis.

**Intended Learning Outcomes:** By the end of this course, successful students will be able to,  
1. demonstrate an understanding of the physical principles and concepts underlying the experiments they perform.  
2. design an experiment to demonstrate a physical principle/determine a particular physical constant.  
3. use experimental apparatus to make accurate physical measurements, and understand the limitations of various measuring devices.  
4. analyze data using the proper statistical techniques and error propagation.  
5. draw appropriate conclusions from their results.  
6. construct a comprehensive, professional technical paper.  
7. present graphical, quantitative, and qualitative results, both through written and oral communication.  
8. use Powerpoint to give an effective oral presentation.

**Course Format:**  
**Pre-lab preparation:** You are required to research the necessary theories, experimental techniques, and historical background of an experiment prior to coming to lab. Before starting an experiment, you must meet with the instructor on an individual basis and demonstrate that you have the necessary preparation to perform the experiment safely and intelligently.

**Experiment:** Although you may work with a partner on some experiments, all work handed in must be your own. Typically, experiments will require 1-2 weeks to complete; however, it may be necessary to work outside the regular class hours in order to finish particularly difficult experiments.

**Lab reports:** A formal report is required for each experiment. Reports are due prior to starting the next investigation. If at any point in the semester you have two overdue reports, then you will not be allowed to start a new experiment until all work is completed.

Note: All reports must be typed and all graphs generated using a spreadsheet or some other graphical program.

MCSP Colloquium Series: The MCSP department offers a series of discussions that appeal to a broad range of interests related to these fields of study. These co-curricular sessions will engage the community to think about ongoing research, novel applications, and other issues that face our discipline. Members of this class are invited to attend all of these meetings; however participation in at least three of these sessions is mandatory. After attending and within one week of the meeting, you will post to your personal blog a reflection paper reflecting on the discussion (approximately 1-page in length). This should not simply be a regurgitation of the content, but rather a personal contemplation of the experience. These papers will be read by me, and graded. The grade will be included in the homework percentage.

Attendance: Students are expected to attend every class. Attendance is checked at each meeting. If a student is going to be absent from class, the instructor must be notified. If 2 classes are missed without prior notification, then I will assume you are not interested in completing the course and you will be dropped from the class (DF). Students are accountable for all work missed because of an absence.

Grading Scale:  
- A: >93  
- A-: 90-92.9  
- B+: 87-89.9  
- B+: 83-86.9  
- B+: 80-82.9  
- C+: 77-79.9  
- C: 73-76.9  
- C-: 70-72.9  
- D+: 67-69.9  
- D: 63-66.9  
- D-: 60-62.9  
- F: <60

The Writing Center: The Writing Center @ Roanoke College is located in the Goode-Pasfield Center for Learning and Teaching in Fintel Library. Student writers working in any field of study at any level of competence meet with trained peer writing tutors in informal, one-on-one sessions. Writers may meet with tutors at any point in the writing process, from brainstorming to drafting to editing. The Writing Center is open Sunday through Thursday from 4 to 9 pm starting Sunday, September 6th. Simply stop in or schedule an appointment ahead of time by going to MyRC: Academics and looking for the Writing Center Schedule link. Questions? Email us at writingcenter@roanoke.edu or call 375-4949. The Writing Center also sponsors writing workshops, grammar crammers, and creative writing playshops. The Fall 2009 schedule will be posted on our website at [www.roanoke.edu/writingcenter](http://www.roanoke.edu/writingcenter).

Academic Integrity: The College academic integrity policies are vigorously enforced. Although you are encouraged to discuss your work with others, all work turned in for a grade must be your own. Please familiarize yourself with the College’s academic integrity policies, particularly the section on plagiarism.

Rubric for Grading Scientific Papers: I will use the following criteria for grading your formal reports:

**Title: (5-points)**
The fewest words that accurately describe the paper.
5 – Is appropriate in tone and structure to a science journal; contains necessary descriptors, and allows reader to anticipate design; concise.
4 – Is appropriate in tone and structure to science journal; most descriptors present; identifies function of experimentation, suggests design.
3 – Identifies function and descriptors but does not allow reader to anticipate design.
2 – Identifies function or descriptor but not both; lacks information or is misleading.
1 – Is patterned after another discipline or missing.

**Abstract: (15-points)**
Limit the abstract to 250 words or fewer and concisely summarize the basic content of the paper without presenting extensive experimental details. Avoid abbreviations and do not include diagrams. When it is essential to include a reference, use the same format as shown in the References section. Because the abstract may be published separately by abstracting services, it must be complete and understandable without reference to the text.
Introduction: (15-points)
Purpose of this section is to introduce the investigation. The introduction should supply sufficient background information to allow the reader to understand and evaluate the results of the present study without referring to previous publications on the topic. The introduction should also provide the rationale for the present study. Use only those references required, to provide the most salient background rather than an exhaustive review of the topic.
(a) With clarity and conciseness, using a tone appropriate for a science journal, present the nature and scope of the problem being investigated.
(b) Review the pertinent literature to orient the reader - cite references!
(c) Briefly, state the method of the investigation (if necessary defend the reasons for your choice of a particular method over competing methods).
(d) State the principle conclusion(s) suggested by the results.

Procedure: (15-points)
Purpose of this section is to describe the experimental design. For commonly used materials and methods a simple reference is sufficient. If several alternative methods are commonly used, it is helpful to identify the method briefly as well as to cite the reference. The reader should be allowed to assess the method without constant reference to previous publications. Describe new methods completely, and give sources of unusual equipment or materials.
(a) Provide enough detail that a competent worker could repeat the experiments including sources of all data collected.
(b) Standard methods that have been previously cited need only a literature citation. Basic lab techniques, which upper-level physics majors would know, do not need to be explained - simply noted. For example, if you are measuring the voltage across and current through a device in order to calculate its resistance, simply explain that you used a standard digital multimeter to measure these quantities. You don't need to explain how you hooked up the multimeters in the circuit.
(c) Most (if not all) of the Procedure section should be written in the past tense and passive voice and should be constructed to match the chronology and "subheadings" of the Results section.
(d) Statistical methods should be stated without a lengthy discussion.
(e) Do not mix the Results section with this section.
(f) Do not list materials or present the methods in tabular form.

Data and Results: (15-points)
The purpose of this section is to report the data obtained during the experiment. Present the results as concisely as possible in one of the following: text, table(s), or figure(s). Avoid extensive use of graphs to present data that might be more concisely presented in the text or tables. Limit photographs to those that are absolutely necessary to show the experimental findings. Number figures and tables in the order in which they are cited in the text, and be sure to cite all figures and tables.
(a) A text written in the past tense which summarizes representative data from the study.
If only a few determinations are to be presented, they should be treated descriptively in the text. Be sure to include ALL observations.

Repetitive determinations should be given in properly organized and labeled tables or graphs and referred to in the text. (Do not be verbose in citing figures or tables.)

Any statistical analysis of the data should be reported in summary form.

Be sure to include uncertainties of all measurements.

The results need to be clearly and simply stated.

Don’t interpret or evaluate the results in this section.

Do not present raw data, instead report means, percentages, etc. Present the data in a form where trends are easily seen and conclusions are easily drawn. If raw data must be included, attach it at the end of the paper as an appendix.

Follows the same chronological sequence that was given in Procedure section.

5 – Clearly presents all results in proper order without interpretation including summary in past tense.
4 – Same as 5, but uses wrong tense or tables/graphs not referred to in text.
3 – Same as 4, but tables/graphs not properly labeled or organized.
2 – Presents only numerical results in tables or graphs or data presented in disorganized fashion.
1 – Missing critical data, data presented not summarized or put into appropriate form.

Discussion/Conclusions: (20-points)
Purpose of this section is to show the relationships among observations, that is to interpret your data in the context of existing knowledge. The Discussion should not contain extensive repetition of the Results section nor reiteration of the Introduction.

Present the principles, relationships and generalizations shown by the results. Do not recapitulate the results, but refer to the tables and graphs in results. Do not draw conclusions that are beyond the scope of your data to support.

Point out any exceptions or any lack of correlation and define unsettled points. (Do not cover up or fudge data that do not quite fit).

Show your results and interpretations agree (or contrast) with previously published work (include citations).

Discuss theoretical and/or practical applications of your work.

State your conclusions as clearly as possible.

Summarize your evidence for each conclusion.

The Discussion should end with a short summary or conclusion regarding the significance of the work. This does NOT mean you should comment on how successful the lab was, how much you liked it, or how much it meant to you.

5 – Student summarizes the purpose and findings of the research; student draws inferences that are consistent with data and scientific reasoning; student explains expected results and offers explanations or suggestions for further research for unexpected results; interpretations are appropriate, distinguishing between fact and implication, and avoids over generalizing; student organizes existing knowledge to support conclusion; student accepts or rejects hypothesis.
4 – As in 5, but does not accept or reject the hypothesis.
3 – As in 4, but the student over generalizes or fails to organize existing knowledge to support conclusions.
2 – Student summarizes the purpose and findings of the research; student explains results but ignores unexpected results; does not put results in context of existing knowledge.
1 – Student may or may not summarize the results but fails to interpret their significance.

References: (5-points)
Purpose of this section is to give the full reference citation for work cited in text. You must give credit for the work of others Only your own work and words do not need to be cited.

List citations in alphabetical order (last name of first author) in this section.

Within the text, properly cite others using a standard method.

Cited articles must be relevant to paper.

5 – Adequate number of relevant references listed and cited properly.
4 – Same as five but inadequate number of relevant references used.
3 – Adequate number of relevant references but errors in citation and listing.
2 – References listed but not cited in text.
1 – No citations in paper.

Overall Organization and Appearance of Paper: (10-points)
In order for the reader to be able to understand what you did, how to replicate your work, and what the significance of your work is, the paper must be written in a standard, well organized format using a word processor.
5 – All material placed in the correct sections; organized logically within each section; runs parallel among different sections; excellent graphics and formatting.
4 – All material placed in the correct sections; organized logically within sections; but lacks parallelism among sections; good graphics and formatting.
3 – Material placed in proper sections but not well organized within the sections; disregards parallelism; adequate graphics and formatting.
2 – Some materials are placed in wrong sections or are not adequately organized wherever they are placed. Some parts of paper not done on computer.
1 – Material placed in wrong sections or not sectioned; poorly organized wherever placed; not done on a computer, sloppy tables and graphs.

Additional Hints:
1. Use headings and subheadings.
2. Do not cite common physics knowledge; assume the reader has at least the knowledge of a college physics major.
3. Citations should be placed at that point in the sentence to which it applies, do not wait until the end of a paragraph to give the citation.
4. Avoid redundancy in your paper. (i.e., do not repeat the Procedure in the Results and Results in the Discussion, etc.).
5. Do not be unnecessarily verbose in your writing or go so far in avoiding verbiage that you violate the rule of antecedents. (The most common violation being the ubiquitous "it.").
6. Run spell checker through your document and then read it aloud to catch the grammatical errors. (Remember, data is a plural noun).
7. Have someone else read your paper.