This laboratory course is a survey of electronic principles and circuits useful to experimental physicists and engineers. Topics include the design and analysis of circuits using transistors, operational amplifiers, feedback and analog-to-digital conversion. Also covered is the use of electronics for automated control and measurement in experiments, and the interfacing of computers and other data acquisition instruments to experiments. Laboratory eight hours a week. Prerequisite: PHYS B201.

One of the primary goals of this course is for you to learn to design, build, and test electronic circuits. This will be done in the context of several projects described below. You will also learn to communicate your findings to others. This will be done formally through research papers, as well as informally through postings to a blog and presentations.

The Projects

*Lock-in amplification:* In this project you will build a lock-in amplifier, which is a device used to detect very weak signals. We will use the lock-in amplifier to build a simple barcode scanner.

*Raspberry Pi:* The Raspberry Pi is an inexpensive, single board computer that runs a version of the Linux operating system. In this project you will learn to program the Raspberry Pi as well as connect it to other circuits and devices through the “general purpose input/output” pins. We will use the Raspberry Pi to process the codes from our barcode scanner.

*Analog temperature control:* In this project you will build a feedback loop that controls the temperature of a block of aluminum.

*Arduino:* Arduino is a microcontroller that is designed to interface with a variety of sensors and devices. In this project you will learn how to program the Arduino and use it to read a variety of sensors.

*Independent project:* Finally, each of you will develop your own project in which you will design, build, and test your own circuitry and software.

Formal Lab Reports

One goal of Physics 305 is to learn how to present your work to the scientific community. This is done in three main formal ways: talks, posters, and papers. You will learn how to produce research papers in a format used by research physicists when they submit a paper for publication in a refereed scientific journal by writing up the results of your first project in a formal research paper. You will also prepare a formal write-up of your independent
project. These papers will go through several drafts and will undergo a peer review process similar to that used in peer reviewed research journals.

Fortunately, the major aspects of format design do not vary a great deal among the pure sciences. We will therefore adopt the particular format of one of the major physics publications, The American Journal of Physics, published by the American Association of Physics Teachers. You can take a look at this journal on line at [http://aapt.org/](http://aapt.org/). When articles are submitted, however, they are, generally, in a different format from that of the final published version. Preparation guidelines can be found by clicking on the Authors tab, which will ultimately lead to [http://ajp.dickinson.edu/index.html](http://ajp.dickinson.edu/index.html). Here you will find a wealth of information. One document that is of particular importance is the AIP Style Manual. You should read this document carefully and continue to refer to it and other documents found on the contributor resources pages as you write your papers.

We will learn to use a scientific typesetting program called LaTeX to prepare these papers. You might find “LaTeX, A Document Preparation System,” by Leslie Lamport, a useful introduction to this typesetting program, but there is also a wealth of information available on line.

**Informal communication**

Learning to speak about the projects you are exploring is an important goal for this class. We will develop these skills in three ways, by listening to others present their results in research colloquia, through informal postings to a blog, and by presenting your independent project to the class.

**Colloquia:** You are required to attend two research colloquia this semester and summarize the results of each colloquium in a 1-2 page essay. The BMC physics department will host two colloquium speakers this spring. If you are unable to attend these you can look for colloquia in other departments at BMC or at Haverford College or at any of the many area universities.

**Blog postings:** Each of you should set up a blog on which you will write about your activities in the laboratory. You should post to this blog regularly (at a minimum once per week).

**Project presentations:** We will set aside one lab session near the end of the term to use for project presentations. More details will be provided in advance of this event.

**Laboratory Notebooks**

While you are doing your experiments you should keep a careful diary of what you are doing in a laboratory notebook. Careful records give the work you are doing meaning. They allow others to trust your results and perhaps confirm them by reproducing the experimental conditions that you used. These records will be particularly important as you prepare your research papers and blog posts.

**Homework**
Throughout the semester you will be assigned reading and homework. The primary text for the course is “Practical Electronics for Inventors, Third Edition,” by Paul Scherz and Simon Monk. In addition to this text, several others are available in the laboratory, and of course many resources are available online. You should do the assigned reading before coming to class and be prepared for an occasional reading quiz.

**Grading**

Colloquium summary 1: 10 points  
Colloquium summary 2: 10 points  
Paper draft 1: 5 points  
Paper final draft: 20 points  
Project concept: 5 points  
Project report: 20 points  
Project presentation: 10 points  
Blog postings: 10 points  
Homework/reading quizzes: 10 points

**Missed Classes**

Since this is a laboratory class, attendance is very important. We meet only twice a week, with a total of 27 class meetings. For each missed class, your grade will be reduced by 10 points (10%).

That said, I realize that there may be a good reason to miss a class, say if you are ill, have a job interview, are attending a conference, or competing in an athletic event. For an excused absence (see below) you may make up these points by making arrangements with me to do a makeup lab session. You must make up your missed time with one week of your excused absence. You may make up a maximum of three excused absences in this way.

An excused absence (one that may be made up as described above) is one that you have discussed with me well in advance of missing the class, and one that I agree is missed for a compelling and unavoidable reason. In the case of illness you should make every effort to contact me before the class meeting, but I do realize that in some cases this is not possible.

**Accommodations**

Students who think they may need accommodations in this course because of the impact of a disability are encouraged to meet with me privately early in the semester. Students should also contact Stephanie Bell, Coordinator of Access Services, at 610-526-7351 or sbell@brynmawr.edu, as soon as possible to verify their eligibility for reasonable accommodations. Early contact will help to avoid unnecessary inconvenience and delays.