PHY 402G/EE 402G: Electronic Instrumentation and Measurements

Fall 2026

Lectures: MW 1-1:50, CP179; Labs: MW 2-3:50, CP167

Instructor: Joseph Brill CP 393, 7-4670, jwbrill@uky.edu

Office Hours: by arrangement

Text: *Basic Electronics for Scientists and Engineers*, 2nd ed. Dennis L. Eggleston.
(Cambridge University Press, ISBN 978-1-009-62239-4)

Physics/EE 402G is primarily a laboratory course in which students will design, build, and analyze electronic circuits. The prerequisites for Physics/EE 402G are EE305 or Physics 242. The students should have also completed a course in calculus based introductory electricity and magnetism (e.g. PHY 232).

1. Overview and Goals

Electronic devices surround us every day and it is difficult to imagine living without them. In particular, the invention of the transistor revolutionized society and the last 70 years have been called the "silicon age" due to the ubiquity of electronic devices based on silicon semiconductors. Similarly, experimental science depends on a host of electronic instruments for both measurement and data storage. In this course we will study some of the most common components used in ***analog*** electronics: resistors, inductors, capacitors, diodes, transistors, and operational amplifiers ("op-amps", the simplest integrated circuits containing the previous components). These are the basic building blocks of more complex instrumentation and equipment, including digital logic circuits and memories. As a lab course, you will not only learn the properties of circuits containing these components but will be able to put these components to use in simple circuits. The goal is for you to be able to approach electronic instruments as something more than black boxes, and after the course you should have enough knowledge to i) handle instrumentation and measurement problems in a research lab, ii) understand and analyze simple circuitry and locate and repair simple problems in these circuits, and iii) communicate with an electronic technician about needs and problems you have with electronic devices. A common theme for many of the circuits you build will be measuring (and understanding) their frequency dependences and input and output impedances.

The lectures in the course will primarily be focused on preparing you to do the labs, so attendance at the lectures is essential for you to work productively in the lab. (Lecture notes will also be posted in Canvas.) The textbook is meant as a reference to complement the lectures and help you understand the material; it discusses most of the devices and circuits you will be building, as well as applications we will not have time to cover. Chapters 1-2 also review material you covered in PHY 232. (The instructor also has other texts that describe the circuits in much more detail, and you may wish to borrow these.)

The course webpage (on Canvas) will include information on instruments and components used in the lab as well as copies of the laboratory instructions and lecture notes.

2. Laboratory Procedures

During the semester, you will be doing 10 "experiments", each with several parts, as listed in the attached schedule. The instructions for each experiment will be posted in Canvas and handed out at least one class beforehand; you should look these over before coming to class so you are

ready to work when you arrive in the lab. (*Also, the lecture material for each lab will generally be covered a few periods beforehand and you should review the relevant material before coming to lab.*)

You will be given bound laboratory notebooks in which you must record all the data you collect during the lab periods. While you should try to keep your lab book neat and organized, experiments rarely proceed exactly as planned or wanted and your lab book should record everything you do in the lab, including false starts and even spectacular screw-ups (e.g. "I fried another transistor!"). The laboratory book should be viewed as an active journal and workbook: i) errors should be simply crossed out and never erased; ii) do NOT take data on other pieces of paper (or tablets/PCs) and later transfer them to the notebook; iii) the instructor may at times ask to review your notebook.

It is very important that you try to understand the experiment as you go, and your notebook should reflect this. If you have time, you should perform calculations (***always bring a calculator !***) and (roughly) graph relevant results during the lab period (with the results in your notebook). This will help ensure that things make sense so that when you prepare your lab report, you don't feel the need to go back and take more data.

All of the experiments contain a few different circuits you will build and analyze and will take 2 or 3 lab periods to complete. Hardware and electronic components are kept in a few locations around room 167. If you don't finish working on a circuit during one period, intending to complete it the next class, you should keep the circuit intact at your workstation, but turn off all electronic instruments you use. At the end of class, you should return all material that you won't need in the next class to the relevant boxes and cable racks in the room. In general, you will be using many different value resistors and capacitors kept in compartments in boxes on a table in the lab. Since they generally "look alike", you may find that some components have been placed in the wrong compartment. You should therefore check the R and C values with meters kept on the table. When returning the components to their boxes, please again check their values and put them in the correct compartments.

You are expected to perform all the experiments completely. If you miss a lab period due to illness or another valid reason, you should schedule a time to make up the laboratory as soon as possible, since each experiment may affect your understanding of later material. If you make-up a lab, the lab report will be due the Monday after you complete the experiment. The university rules concerning excused absences and make-up classes can be found here: https://ombud.uky.edu/students/academic-policies/absences .

3. Lab Reports

Your grade for each experiment will be based (50%) on satisfactorily completing the experiments (with data in your notebook) and (50%) on a lab report, which you must submit for each experiment (except #10). These must include ***labeled circuit diagrams**** for all circuits used, ***lists (e.g. tables) of your "final" data*** (i.e. if you made mistakes and took the data more than once), ***graphs*** of appropriate data, and ***answers to all questions*** in the lab instructions. If you like, you can prepare these reports on a computer, but if done by hand, write them on graph paper. (***All graphs must be at least one half-page in size and hand drawn graphs MUST be on graph paper***.) In preparing a report, you may discuss assignments with other students or an instructor or tutor, but the actual lab report must contain only the data taken by you in the laboratory period. The university rules about cheating and plagiarism can be found here:

https://wrd.as.uky.edu/plagiarism-policy-procedures .

*Knowing how to prepare clear circuit diagrams is an important skill, and you must draw (either on paper or using a computer app) the circuit diagrams in your lab reports; do not simply photocopy or cut-and-paste the diagrams from the lab instructions.

The lab reports will be due at the beginning of class on the dates shown on the attached schedule. In general, you should submit them as hard copies, but if occasionally that is not possible, you may email the report as a PDF to the instructor. If you must turn the report in late because of illness or other university-excused absence, you should contact the instructor (ahead of time if possible). Unexcused late reports will be penalized.

4. Examinations and Grading

There will be three 90-minute exams, as listed on the attached schedule (the last one will be during a time period reserved for us in finals week). The exam questions will generally be closely related to the laboratory experiments. The first exam will cover passive device circuits: resistors, capacitors, inductors, and diodes. The second exam will cover transistor circuits (including logic circuits). The last exam will cover op-amp circuits.

55% of your course grade [*45% for graduate students*] for the course will be based on your lab reports and completion of labs and 45% from the three exams (15% each), but you must take all exams (with a passing average) to get a passing grade for the course. [*Graduate students will be assigned two additional (more complex) circuits to build and analyze for 10% of their course grade.*] The grading scale will be A = 85%-100%, B = 70% - 84%, C = 55% - 69%, D = 40% - 54%, E<40%.

.5. Course evaluations:

Course evaluations are an important component of our Department's instructional program. An online course evaluation system will be used to allow each student ample time to evaluate each component of the course and instructor, thus providing the Department with meaningful numerical scores and detailed commentary. The evaluation window will be open for ~ 2 weeks at the end of the semester.

6. Course "Handouts"

All lecture notes and lab instructions for the course are the intellectual property of the instructor and cannot be reproduced or sold without prior permission from the instructor. While students may use the material for reasonable educational and professional purposes extending beyond this class, such as preparing for other courses, exams, or jobs, the material must not be distributed in any form (i.e. electronically or by hardcopy) to anyone who is not a student in this class.

Tentative Laboratory Schedule

Date	Eggleston Sections	Lab Report Due	Experiment
Mon., 8/24			Lecture Only
Wed., 8/26	Ch. 1		Introduction to DC Instruments
Mon. 8/31			Exp. I: DC Circuits
Wed. 9/2			Exp. I: DC Circuits
Mon. 9/7	Labor Day		
Wed. 9/9		Exp. I	Introduction to AC Instruments
Mon. 9/14	2.1-2.7		Exp. II: RC and RCL Filters
Wed. 9/16			Exp. II: RC and RCL Filters
Mon. 9/21			Exp. II: RC and RCL Circuits
Wed. 9/23	2.10, 3.1-3.5	Exp. II	Exp. III: Diode Circuits
Mon. 9/28			Exp. III: Diode Circuits
Wed. 9/30			Exp. III: Diode Circuits
Mon. 10/5	4.1-4.4.11	Exp. III	Exp. IV: Bipolar Transistor Circuits
Wed. 10/7			Exp. IV: Bipolar Transistor Circuits
Mon. 10/12			**Exam 1: Passive Devices**
Wed. 10/14			Exp. IV: Bipolar Transistor Circuits
Mon. 10/19		Exp. IV	Exp. V: Differential Amplifier
Wed. 10/21			Exp. V: Differential Amplifier
Mon. 10/26	Fall Break		Fall Break
Wed. 10/28	8.1-8.4, 8.7-8.9.1	Exp. V	Exp. VI: Transistor Logic Circuits
Mon. 11/ 2			Exp. VI: Transistor Logic Circuits
Wed. 11/4	4.4.12, 6.1, 6.3	Exp. VI	Exp. VII: Op-Amp Amplifiers
Mon. 11/9			Exp. VII: Op-Amp Amplifiers
Wed. 11/11			**EXAM 2: Transistors**
Mon. 11/16			Exp. VII: Op-Amp Amplifiers
Wed. 11/18	6.4	Exp. VII	Exp. VIII: Op-Amp Rectifier & Offsets
Mon. 11/23			Exp. VIII: Op-Amp Rectifier & Offsets
Wed. 11/27	Thanksgiving		Thanksgiving
Mon. 11/30	6.2, 6.5	Exp. VIII	Exp. IX: Positive Feedback Circuits
Wed. 12/2			Exp. IX: Positive Feedback Circuits
Mon. 12/7		Exp. IX	Exp. X: Adder and Lock-In Amplifier
Wed. 12/9			Exp. X: Adder and Lock-In Amplifier

EXAM 3 (Op-Amps): Monday, 12/14 3:30-5:30