Boston College, Department of Physics, Fall 2017

PHYS351001 Contemporary Electronics Laboratory

(Subject to change. Last Revised: September 21, 2017)

Scheduled meeting times
Monday (Lecture): 12 – 12:50 PM
Thursday (Laboratory): 3-5:50 PM

Room: Higgins 156

Text: The Art of Electronics, 3rd Ed. by Horowitz & Hill, Cambridge University Press, 2015, ISBN-13: 978-0521809269, ISBN-10: 0521809266 (This book will also be referred to as "Horowitz & Hill" or "H&H".)

Instructor
Dr. Michael Burns
Senior Research Associate
Office: Higgins Hall 330M, 617-552-6024
Email: michael.burns.3@bc.edu
https://www2.bc.edu/michael-burns-3/
Office Hours: By appointment.
At any given time, the most up-to-date syllabus & schedule can be found at
https://www2.bc.edu/michael-burns-3/PHYS351001/ClassStuff.html

Teaching Assistant
Chaobin Yang
Office: Higgins 150
Email: yangcj@bc.edu
Office Hours: By appointment.

Course Description: This course (2 credits) is designed as an introduction into the basics of contemporary electronics (resistors, capacitors, transistors, op-amps, etc.). The primary focus of this course is a series of laboratory exercises created to give a hands-on building of analogue and digital circuits along with a knowledge of their integrated function. Lectures, scientific article reading assignments, textbook readings, and homework problems are provided to aid the student in understanding the "physics behind" and "application of" electronic components in circuits.

Attendance, Participation, and Academic Honesty: Continuity and active participation are crucial to the success of this course. You are responsible for all information from each class session (lecture or laboratory) whether you attend or not. Since this is a laboratory course, all laboratory assignments must be performed at the assigned times. The laboratory exercises are designed to be completed in a 2-2.5 hour period. Missing laboratory exercises beyond this accommodation will negatively affect your grade in the course. Excused sports absences are to be discussed with the instructor prior to the planned absences. Reasonable accommodation will be made to allow students to make up labs due to illness, but it is the responsibility of the student to take the time to make up the work from the student's schedule, not the responsibility of the instructor or TA to reschedule their other work to accommodate the student's schedule. Academic honesty is expected at all times in accordance with published Boston College policies.

Textbook Reading Assignments: Members of this course are responsible for reading chapters of the textbook as we move through the material. Specific chapters are delineated in the course schedule, as well as optional reading that expands on the topics covered in class.

Homework Exercises: Occasionally homework problems will be assigned (~3), usually on a Thursday, throughout the course to emphasize certain skills. Homework assignments should be written clearly. It is not the grader's job to spend an infinite about of time deciphering sloppily written homework, so handing in hard-to-read homework is not in the student's interest.

Notebooks: All work in the laboratory should be appropriately recorded ***in ink*** in your notebook. A photocopy (or scan) of each page your notebook work from the previous week's laboratory exercise is be attached to your lab report. *Please, put your name on all assignments before submitting them*. Notebooks will be provided to the students.

Responses to the Questions: At the end of the laboratory exercise there are a series of questions or an assignment. Your answers to the questions are due at the same time as the copy of your notebook, but separate from it. These will be graded separately from the notebook copies. Typed answers are preferred, but neatly hand written responses will be acceptable.

Laboratory Exercises: Students will perform the in-lab laboratory work in pairs but each student will maintain their own laboratory notebook. (In the case of an odd number of students, an in-lab triplet will be allowed.) Always bring your lab books to the laboratory. All work is to be recorded in the lab book. At the beginning of each laboratory period an exercise will be distributed. The exercises have been tailored to be accomplished by one student in our given laboratory time period (2 hours, 50 minutes) except for a few in which longer class time is allocated, either the time normally used for lecture or two lab periods. All equipment — oscilloscopes, voltmeters, circuit components, wires, breadboards, wire connectors, etc. — will be supplied by the instructor. Student pairs should try to accomplish the laboratory exercises by themselves, but should feel free to ask questions of the instructor or TAs to facilitate progress. Each student will submit an independently written lab report. A handout of what is expected in a lab report is at the end of this syllabus. Lab reports are due 1 week after the experiment was completed. Lab reports should be written clearly following guidelines given later in this syllabus. It is not the grader's job to spend an infinite about of time deciphering sloppily written lab reports, so handing in hard-to-read reports is not in the student's interest.

Reading Assignments: Short scientific articles are scheduled to be read throughout this course. A short multiple choice quiz will be given on each reading according to the Course Schedule and Reading Assignments List below.

Midterm and Final Exams: No midterms nor final exams are scheduled for this course.

Eating and Drinking: ***Absolutely*** no food or beverage is to be brought into the laboratory (Higgins 156). This is a safety requirement, so if you do bring any food or drink into the room (even on Tuesdays), you'll be required to dump it.

Cell phones & Wearable Computing (e.g. Google Glass): No cell phone use during class, and no wearable computing that allows surreptitious photography, audio or video recording. Massachusetts is a "2 party consent" State, so please respect the privacy of others. If as part of a lab, you want to photograph or video something, you need permission of anyone who may be within the field of view or may be recorded by the device in any way. (In other words, if you need to photograph/record/video something, either make sure other people are not photographed or recorded, or get their permission.)

Medical Issues & Disabilities: If you have a medical issue/emergency or disability and will be requesting accommodations for this course, please register with Kathy Duggan [kathleen.duggan@bc.edu], Director, The Connors Family Learning Center (learning disabilities and ADHD) or Paulette Durrett [paulette.durrett@bc.edu], Assistant Dean for Students with Disabilities (all other disabilities). Advanced notice and appropriate documentation are required for accommodations. *This includes situations where you have an illness or injury during the semester and want extra time to perform or turn in assignments.*

Course Grading

Reading Assignments/Quizzes:	25%
Lab Reports:	50%
Questions/Homework Prob.:	25%

PH351001 Reading Assignment List Spring 2017

The purpose of the article reading assignments is to expose students to a broader swath of topics related to electronic technology than we have time to cover in class. Many are histories of discoveries such as the invention of the transistor, while other are discussions of modern technology with direct relevance to your life such as how long your data will last stored on different media. While many of these articles are old, they are still probably the best introductory articles that exist on the device physics of their topics. These readings are available from links in my BC website at https://www2.bc.edu/michael-burns-3/PHYS351001/Reading_Assignments/ReadingAssignments.html or you can get them from the web by simply searching using the citations below, or if you want to search the literature like a real Physicist, use BC's subscription to Science Citation Index (http://apps.webofknowledge.com.proxy.bc.edu/WOS_GeneralSearch_input.do?product=WOS&search_mode=GeneralSearch). (Google has only indexed a tiny fraction of the Scientific literature, so it's not a legitimate literature search tool if you are doing real research.)

Note that you might find that downloading some of these from off campus may be blocked as use of the Boston College Library subscription system may be required.

RA01: M. Riordan and L. Hoddeson, "Birth of an Era", *Scientific America: The Solid-State Century*, Special Issue **8**, No. 1, 10-15, 1997.

RA02: R. H. Rockett, "The Transistor", *Scientific American*, 1948. Reprinted in *Scientific America: The Solid-State Century*, Special Issue **8**, No. 1, 18-21, 1997.

RA03a: M. J. Riezenman, "Where Tubes Rule", *Scientific America: The Solid-State Century*, Special Issue **8**, No. 1, 44-45, 1997.

RA03b: W. W. Gibbs, "The Law of More", *Scientific America: The Solid-State Century*, Special Issue **8**, No. 1, 62-63, 1997.

RA03c: Rachel Courtland, "The Status of Moore's Law: It's Complicated", IEEE Spectrum, 28 Oct 2013 | 20:21 GMT

RA04: J. Page, "Making the Chips that Run the World" *Smithsonian*, **30** (10) January, 36-45, 2000.

RA05: Oliver Kommerling and Markus G. Kuhn, "Design Principles for Tamper-Resistant Smartcard Processors", *Proceedings of the USENIX Workshop on Smartcard Technology (Smartcard '99),* Chicago, Illinois, USA, May 10-11, 1999, USENIX Association, pp. 9-20, ISBN 1-880446-34-0

RA06a: Shuji Nakamura and Michael Riordan, "The Dawn of the Miniature Green Lasers" *Scientific American* **300**, 70-75 (April 2009) doi:10.1038/scientificamerican0409-70

RA06b: Milton A. Rothman, "Things that go faster than light" *Scientific American* **203**, 142-152 (July 1960) doi:10.1038/scientificamerican0760-142

RA07: Steven H. Voldman, "Lightning Rods for Nanoelectronics", *Scientific American **287***, 90-97 (October 2002) doi:10.1038/scientificamerican1002-90

RA08a: N. G. Hignorani and K. E. Stahlkopf, "High-Power Electronics" *Scientific American* **269**, No. 5, 78-85, November 1993.

RA08b: B.M. Lunt, "How Long Is Long-Term Data Storage?", Proceedings of "Archiving 2011", Los Angeles CA, pp29-33 (2011).

RA09: Graham P. Collins, "Next Stretch for Plastic Electronics", *Scientific American* **291**, 74-81 (August 2004) doi:10.1038/scientificamerican0804-74.

RA10: The Editors, "The Next 20 Years of Microchips", *Scientific American* **302**, 82-89 (January 2010) doi:10.1038/scientificamerican0110-82

RA11: Mikael Ostling and B. Gunnar Malm, "High-Speed Electronics", *Ion Beams in Nanoscience and Technology (2009)*.

Phys 351001 Class Schedule (subject to change) Fall 2017

I want to stress that the dates below that the class will meet are preliminary at this stage. Dates set below as “No Class” are especially vulnerable to changes.

Week	Date	Activity	Due	Textbook Reading
1	Aug 28 (Mon)	LEC 1:Introduction, Roster, Syllabus, Expectations, Components, & Laboratory Safety		Ch 1 H&H
	Aug 31 (Thu)	LEC 2: Components and Instrumentation (~1 hour)		
2	Sept 4 (Mon)	No Class		Ch 1 H&H
	Sept 4 (Mon)	Start Reading Assignment 1		
	Sept 7 (Thu)	LEC 03 More Components and Instrumentation LAB 01: sec 1 & 2: Measuring R, AC Volts (RMS) and DC Volts	9/14/2017	
3	Sept 11 (Mon)	LEC 04: Passive Circuits AC Circuits		Ch 1 H&H
	Sept 11 (Mon)	Quiz on Reading Assignment 1		
	Sept 11 (Mon)	Start Reading Assignment 2		
	Sept 14 (Thu)	LAB 02: R-L//C Resonance Circuit	9/21/2017	
4	Sept 18 (Mon)	LEC 05: Semiconductors & Diodes		Ch 2 H&H
	Sept 18 (Mon)	Quiz on Reading Assignment 2		
	Sept 18 (Mon)	Start Reading Assignment 3a-c		
	Sept 21 (Thu)	LAB 03: Diodes, P-N Junction & LEDs	9/28/2017	
5	Sept 25 (Mon)	LEC 06: Semiconductors - Bipolar Transistors		Ch 2 H&H
	Sept 25 (Mon)	Quiz on Reading Assignment 3a-c		
	Sept 25 (Mon)	Start Reading Assignment 4		
	Sept 28 (Thu)	LAB 04: Transistor (start)		
6	Oct 2 (Mon)	LEC 07: Operational Amplifier 1		Ch 4 H&H
	Oct 2 (Mon)	Quiz on Reading Assignment 4		
	Oct 2 (Mon)	Start Reading Assignment 5		
	Oct 5 (Thu)	LAB 04: Transistor (finish)	10/16/’17	
	Oct 5 (Thu)	Homework #1 assigned	10/19/’17	
7	Oct 9 (Mon)	No Class (Columbus Day)		Ch 4 H&H
	Oct 12 (Thu)	No Class		
8	Oct 16 (Mon)	LEC 08: Operational Amplifier 2		Ch 4 H&H
	Oct 16 (Mon)	Quiz on Reading Assignment 5		
	Oct 16 (Mon)	Start Reading Assignment 6		
	Oct 19 (Thu)	LAB 05: Transistors/Operational Amplifier	10/26/’17	

9	Oct 23 (Mon)	LEC 09: Boolean Logic Gates		Ch 4 H&H
	Oct 23 (Mon)	Quiz on Reading Assignment 6		
	Oct 23 (Mon)	Start Reading Assignment 7		
	Oct 26 (Thu)	LAB 06: Operational Amplifier	11/2/2017	
10	Oct 30 (Mon)	LEC 10: Case Study 555 Timer Chip		Ch 10 HH
	Oct 30(Mon)	Quiz on Reading Assignment 7		
	Oct 30 (Mon)	Start Reading Assignment 8		
	Nov 2 (Thu)	LAB 07: Boolean Logic Gates (start)	11/9/2017	
11	Nov 6 (Mon)	LAB 07: Boolean Logic Gates (Finish)		Ch 10 HH
	Nov 9 (Thu)	LAB 08: The 555 Timer		
	Nov 9 (Thu)	Homework #2 assigned	11/27/'17	
12	Nov 13 (Mon)	LAB 09: 555 Timer Chip Dielectric Constant (start)	11/27/'17	Ch 7 H&H
	Nov 13 (Mon)	Quiz on Reading Assignment 8		
	Nov 13 (Mon)	Start Reading Assignment 9		
	Nov 13 (Mon)	Start Reading Assignment 10		
	Nov 16 (Thu)	LAB 09: 555 Timer Chip Dielectric Constant (finish)	11/27/'17	
13	Nov 20 (Mon)	No class		
	Nov 23 (Thu)	No class (Thanksgiving)		
14	Nov 27 (Mon)	LAB 10: LabView1 T/Cs and Specific Heat of Metals, Part 1		
	Nov 27 (Mon)	Quiz on Reading Assignment 9		
	Nov 27 (Mon)	Quiz on Reading Assignment 10		
	Nov 27 (Mon)	Start Reading Assignment 11		
	Nov 27 (Mon)	Homework #3 assigned	12/14/'17	
	Nov 30 (Thu)	LAB 10: LabView1 T/Cs and Specific Heat of Metals, Part 2	12/7/2017	
	Nov 30 (Thu)	Quiz on Reading Assignment 11		
15	Dec 4 (Mon)	No class		
	Dec 7 (Thu)	No class		

PHYS351001 Contemporary Electronics

Lab Reports:

The bottom line is that your report should be a complete enough description of what you did that it could be handed to another student in the course, and based only on your report, they should be able to reproduce your work without them having the written lab instructions that you were given. (In other words, write your lab report as if the grader has no prior knowledge of the lab assignment.) In addition, the report should contain:

1. Make sure your name is on your lab report, and if you worked with a lab partner, that their name is on the lab report clearly identified as your lab partner.
2. State the purpose of each part of the experiment in a separate section.
3. Describe the equipment used (including brand and model numbers) and give all appropriate circuit diagrams.
4. Be sure to include error limits for each type of measurement.
5. Put graphs and tables of data on separate pages. In other words, one graph per page, 1-3 tables per page. (The idea is to make things big and easy to see.)
6. Work out numerical examples (if asked for) clearly in each section.
7. Discuss any difficulties and problems. How did these affect your conclusion?
8. State and discuss your conclusions – for each major section.
9. Give a summary (one page maximum) of the whole experiment.
10. Make sure your lab report lists the names of your lab partner(s). If you didn't have a lab partner (i.e. odd number of people in class that day), say so.

How to Keep a Lab Notebook

What makes an experiment a genuine work of science? An experimental procedure? Experimental observations? Maybe. But procedures and observations become useful (and interesting) to scientists only when both can be described with enough detail and precision to allow another scientist to repeat the full experiment.

Your lab notebook contains the descriptions of your experimental procedures and observations. It is the formal record of your lab work. As such, it should contain three types of information for each experiment:

- A complete description of the procedure that you **actually** performed
- A full account of the observations that you **actually** made

You should organize your information into several categories:

- **Methods and Materials (or Equipment)** can usually be a simple list, but make sure it is accurate and complete. In some cases, you can simply direct the reader to a lab manual or standard procedure: "Equipment was set up as in the manual."

- **Experimental Procedure** describes the process in chronological order. Using clear paragraph structure, explain all steps in the order they actually happened, not as they were supposed to happen. If your professor says you can simply state that you followed the procedure in the manual, be sure you still document occasions when you did not follow that exactly (e.g. "At step 4 we performed four repetitions instead of three, and ignored the data from the second repetition"). If you've done it right, another researcher should be able to duplicate your experiment.
- **Results** are usually dominated by calculations, tables and figures; however, you still need to state all significant results explicitly in verbal form, for example: Using the calculated I gives R = 0.1244 ohms.

Graphics need to be clear, easily read, and well labeled (e.g. Figure 1: Input Frequency and Capacitor Value). An important strategy for making your results effective is to draw the reader's attention to them with a sentence or two, so the reader has a focus when reading the graph.