ELECTRONICS *

PHY–2100 Section 01, Spring 2016

TTh 8:40–11:25 am; 129 Congdon

Office Hours: TBD; 363 Congdon

Course Description: An introduction to the major aspects of electronics theory and practice found in scientific and computer instrumentation. Topics include DC and AC circuit analysis, diodes and the PN junction, bipolar junction transistors, transistor amplifiers, operational amplifiers, integrated circuits, analog to digital converters, and digital logic. Four credits (6 hours of integrated lecture and lab). Prerequisites: MTH 1420. Offered Spring.

The emphases of this course will be: (1) using electronics for basic lab skills of data acquisition and instrument control; (2) understanding basic electronics concepts and behavior of electronic devices; (3) demonstrating effective use of electronics instrumentation and tools; (4) analyzing and designing circuits. These emphases include the ability to use software to simulate circuits, to use LabView for writing data acquisition programs, and to program the Raspberry Pi microcontroller.

Course Website: `physics.highpoint.edu/~bbarlow/courses/phy2100/phy2100.html`

Attendance Policy: If you have *more than two unexcused absences*, you can be withdrawn from the class. I reserve the right to choose whether to withdraw you or not for lack of attendance.

Textbook: *Hands-On Introduction to LabVIEW for Scientists and Engineers* by John Essick.

Expectations: This class emphasizes experiments, programming, and circuit building for data acquisition and instrument control. As a result, activities will be emphasized and lecture will be de-emphasized. Each class day will have no more than 30 minutes of lecture. Often the lecture will occur at the beginning of the class. If an activity is not finished during class time, then you may be required to come to the lab outside of class to finish the activity. Daily preparation and participation is **absolutely required** for your success in the class, as well as the success of your classmates. Most classes will be arranged according to the following schedule:

- Mini–lecture on lab/theory
- Lab
- Mini–lecture on LabView
- LabView lab/programming
- Daily summary/other exercises

You are expected to do at least five hours of work outside of class each week, including reading, solving problems, working on lab assignments, and working on your class project.

Grade Breakdown:

Proficiency with Standards	70%
Participation	15%
Class Project	15%

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*I reserve the right to change this syllabus based on feedback from you and what I determine is best for the course.

Letter grades will be assigned based off of the following scale:

≥ 97	A+
93.0 - 96.99	A
90 - 92.99	A−
87 - 89.99	B+
83 - 86.99	B
80 - 82.99	B−
77 - 79.99	C+
72 - 76.99	C
70 - 71.99	C−
60 - 69.99	D
< 60	F

Course 'Standards' & Grading Policy: We will use a different approach to assessment called Standards-Based Grading (SBG). I will distribute a list of standards. You will solve problems, build circuits, write programs, and do experiments to show your understanding (i.e. proficiency) on each standard. We will have frequent quizzes where you can demonstrate proficiency on each standard. If you submit homework problems on the standards within one week of homework being distributed, then you can re-assess to demonstrate your proficiency. Your grade is not final until the end of the semester and you can use the entire semester to demonstrate your understanding, reassessing as many times as is needed, as long as you have completed the assigned homework on the standard. However, when being reassessed, it's possible for your proficiency to decrease as well.

Standards Grading Rules: Your score for each individual standard will be calculated in one of two ways: (1) if your most recent standard score is your highest, I will use your most recent score when calculating your course average, or (2) if your most recent standard score is *not* your highest (i.e., your standard score went down), I will use the *average* of all scores for that standard when calculating your course average. The only exceptions to this are L.ORG, L.CLEAN, and T.FERMI which will always be computed from the average of all scores.

Re–assessment Rules: You are only allowed to re–assess **three standards per week**. In order to re–assess a standard, you must send Dr. Barlow an email at least 48 hours ahead of time and let him know which standard(s) you'd like to re–assess. **April 26th is the last day re–assessments will be permitted.**

Using SBG helps address several issues with 'traditional' assessment:

- Sometimes one focuses on points instead of learning.
- When one does poorly on an exam, there is no incentive to study the material that one did not understand. Additionally, one loses the points on that exam even if the material is understood by the end of the semester.
- When you get a grade on an exam, like 70%, it might mean that you understood 70% of the content and do not understand 30%. The overall score does not tell you which concepts/skills you are proficient at and which ones you still need to study or practice. By tying each question on an exam to a standard and grading each question (not the exam), you know exactly which standards you still need to study.
- Cramming for an exam is rewarded, not the habits that lead to life-long learning like persistence and independence.

You can also demonstrate proficiency by solving a problem in front of the professor (i.e. an oral exam). You will be graded on a 4-pt scale for each standard. The rubric for the scale is shown on the next page and is borrowed from Aaron Titus and Andy Rundquist (who cites Frank Noschese).

Four–Point Scale:

0. Not assessed: 0 pts
1. Doesn't meet expectations: 1 pt
   (a) I need lots of help from my instructor (one-on-one).
   (b) I have low confidence on how to do the skills and need more instruction.
   (c) I need my textbook/notes at all times.
   (d) I do not understand the concept/skills.
   (e) I cannot correctly identify concepts and/or define vocabulary.
   (f) I cannot make connections among ideas or extend the information.
   (g) My responses lack detail necessary to demonstrate basic understanding.
   (h) Cannot articulate most of the main ideas involved in the standard
2. Approaches expectations: 2 pts
   (a) I have a general understanding of the content/skills, but I'm also confused about some important parts.
   (b) I need some help from my instructor (one-on-one or small group) to do the skills correctly
   (c) I do not feel confident enough to do the skills on my own
   (d) I need my textbook/notes most of the time.
   (e) I can correctly identify concepts and/or define vocabulary; however I cannot make connections among ideas and/or independently extend my own learning.
   (f) My responses demonstrate basic understanding of some main ideas, but significant information is missing.
3. Meets expectations: 3 pts
   (a) I understand the important things about the content/skills.
   (b) I have confidence on how to do the skills on my own most of the time, but I need to continue practicing some parts that still give me problems.
   (c) I need my handouts and notes once in a while.
   (d) I am proficient at describing terms and independently connecting them with concepts.
   (e) I understand not just the "what," but can correctly explain the "how" and "why" of scientific processes.
   (f) My responses demonstrate in-depth understanding of main ideas.
4. Exceeds expectations: 4 pts
   (a) I understand the content/skills completely and can explain them in detail.
   (b) I can explain/teach the skills to another student.
   (c) I have high confidence on how to do the skills.
   (d) I can have a conversation about the skills.

(e) I can independently demonstrate extensions of my knowledge.

(f) I can create analogies and/or find connections between different areas within the sciences or between science and other areas of study.

(g) My responses demonstrate in-depth understanding of main ideas and of related details.

Your overall standards score (from all standards) will be determined from the following equation:

$$Standards\ \ Score = (\frac{x}{4})^{0.737} \times 100 \tag{1}$$

where x is a number 0–4 that represents the average of all your individual standards scores. In this system, an average of 4 corresponds to 100%; an average of 3 corresponds to $\sim$ 80%; an average of 2 corresponds to $\sim$ 60%; an average of 1 corresponds to 36%; an average of 0 corresponds to 0%.

Participation: It is imperative that you come to class everyday. Unlike other courses in which it might be relatively easy to catch up after an absence of several weeks (by cramming, making up homework assignments, etc.), the nature of our course (mostly lab exercises) makes it **very** difficult to catch up once you have missed 1–2 days. Do not let your partner do all of the work for you during the labs, as this will put you at an enormous disadvantage when it's time to assess by yourself. I will quantify your overall 'participation' in this course by assessing your:

1. daily progress on homework assignments, circuits, programming, etc.
2. level of grit displayed
3. relative contribution to your group
4. performance on pop quizzes and in–class assignments

Project: You will do a class project that is experimental, computational, or theoretical in nature. The project must be approved by Dr. Barlow. It must be related to topics in the course. There are five categories that the project's grade is based on:

1. level of difficulty
2. level of creativity
3. level of independence
4. completeness (i.e. Does the simulation run and give correct results? or Did you report uncertainties in your measurements? or Did you include relevant background material and references)
5. quality of presentation and/or paper.

For full project credit, each student must:

1. write a paper of appropriate length (5000 words is a rough estimate) that describes the details of your project. LaTeX is required. Templates are at: `http://physics.highpoint.edu/Physics/LaTeX.html`.

2. present your project to the class.

Extra Credit: No extra credit is currently planned; however, the instructor reserves the right to provide extra–credit assignments to the entire class when deemed necessary. *If* such an opportunity is provided, details will be announced during the lectures.

Honor Code: The High Point University Honor Code asserts that:

- Every student is honor-bound to refrain from conduct which is unbecoming of a High Point University student and which brings discredit to the student and/or to the University;
- Every student is honor-bound to refrain from collusion;
- Every student is honor-bound to refrain from plagiarism;
- Every student is honor-bound to confront a violation of the University Honor Code;
- Every student is encouraged to report a violation of the University Honor Code.

My obligation is to promote academic integrity and to enforce the University Honor Code. This obligation includes appropriately interpreting the Honor Code, promoting conditions favorable to academic integrity, and reporting violations of the Honor Code.

I encourage collaboration on homework. I encourage you to work together to solve problems. You may check your work with others. You may use solutions manuals, tutors, books, and any other resource on homework. However, you must know how to solve problems independently so that you can solve unfamiliar problems on exams.

You must do your own work on an exam. You may not look at another persons exam. You may not use any other resource except the equation sheet that is given to you and your calculator. You may not store programs or equations in your calculator, and you may not use data stored in your calculator on an exam. Calculators may only be used to input numerical values and perform calculations.

Violation of the honor code will be handled according to procedures outlined in the Faculty Handbook.

Accommodations: Students who require classroom accommodations due to a diagnosed disability must submit the appropriate documentation to Disability Support in the Office of Academic Development, 4th Floor Smith Library. A student's need for accommodations should be made at the beginning of a course because accommodations are not retroactive. To request accommodation letters, please contact Rita Sullivant in Academic Services, 841-9061, rsulliva@highpoint.edu.

Topics:

1. DC Circuit analysis
2. AC Circuit analysis
3. Fourier analysis and filter circuits
4. Semiconductor physics and the pn junction
5. Simple diode circuits
6. Bipolar junction transistors
7. Simple transistor circuits
8. Op-amps and simple op-amp circuits
9. Digital circuits
10. Data acquisition and instrument control with LabView
11. Data acquisition and instrument control with Arduino microcontrollers

Table 1: Tentative Schedule of Activities

Day No.	**Date**	**Topic**
1	12 Jan	Syllabus. Basics of Current, Voltage, Resistance, Power, and Ohm's Law. Breadboards.
2	14 Jan	Ohm's Law experiment by hand.
3	19 Jan	Ohm's Law with LabVIEW.
4	21 Jan	I-V curves for a light bulb and diode.
5	26 Jan	Voltage Divider
6	28 Jan	Thermistor
7	2 Feb	Calibration of a Sensor (Mini–Project)
8	4 Feb	Continue Mini–Project
9	9 Feb	Presentations
10	11 Feb	Kirchhoff's Laws and DC resistive circuit analysis; SPICE
11	16 Feb	Capacitors (Charging and Discharging)
12	18 Feb	AC circuits; using an oscilloscope
13	23 Feb	AC voltage divider
14	25 Feb	High and low pass filters
15	2 Mar	Bode Plot
16	4 Mar	**MIDTERM**
17	16 Mar	Fourier Series, Fourier Transforms with LabView
18	18 Mar	Op-amps
19	23 Mar	Inverting and non-inverting amplifier
20	25 Mar	Bipolar junction transistors (measure β)
21	30 Mar	Transistor amplifier (common-emitter amplifier)
22	1 Apr	Digital logic; building a logic gate from a transistor
23	6 Apr	Digital circuits
24	8 Apr	Raspberry Pi (analog and digital input and output; PWM)
25	13 Apr	Raspberry Pi
26	15 Apr	Project
27	20 Apr	Project
28	22 Apr	Project
29	27 Apr	Presentations

Table 2: Standards

Name	Standard
	LAB:
L.ORG	I can keep an organized lab notebook, and I can organize files on a computer in order to manage my projects.
L.CLEAN	I can clean and organize my lab station.
L.VIR	I can measure current, voltage, node voltage, and resistance using a multimeter.
L.BBcon	I can use a breadboard to properly connect a circuit so that it is correct, organized, and easy to trace
L.BBtest	I can test a circuit on a breadboard and can identify errors in the circuit.
L.SENS0	I understand how to zero a sensor.
L.CAL	I can investigate a sensor to find out how the output voltage (of the sensor) is related to the quantity I wish to measure. I can use a calibration curve or function to calculate the quantity based on the output voltage of the sensor. Examples include a thermistor, photoresistor, strain gauge, microphone, etc.
L.OSC	I can use an oscilloscope to measure the frequency and amplitude of a signal. I can measure the phase difference between two sinusoidal signals.
L.GAIN	I can measure the gain across a capacitor or resistor for a RC circuit with a sinusoidal voltage source.
L.DIOD	I can properly connect a diode in a circuit and can measure and interpret the I-V curve for a diode.
L.BPJ	I can properly connect a bipolar junction transistor in a circuit, and I can measure the current gain (beta) of the transistor.
L.TRANSamp	I can build a transistor amplifier to amplify an AC signal.
L.OPamp	I can use an op-amp as a comparator and as an inverting or non-inverting amplifier.
L.LOG	I can build and test a digital logic circuit with AND, NAND, OR, and NOR gates out of transistors and IC logic gates.
L.RPI	I can program a Raspberry Pi to read analog voltages and digital voltages and I can use it to output a digital signal based on conditions.
L.SOLD	I can solder (and desolder) a circuit board together using proper techniques, producing good and clean solder joints.
L.DISECT	I can take apart a relatively simple electronic device to determine how it was constructed.
L.XX	TBD, if needed
L.XX	TBD, if needed

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Table 2 – continued from previous page

Name	Standard
THEORY:	
T.FERMI	I can work through Fermi problems quickly, without the aid of a calculator.
T.VIR	I know the definitions and units of current, voltage, node voltage, resistance, and power.
T.Rcolor	I can quickly determine a resistor's resistance from banded color codes.
T.SPcon	I can describe and identify series and parallel connections and can describe how each connection affects current and voltage.
T.IVplot	I can interpret an I-V graph.
T.Vdiv	I can apply the voltage divider equation.
T.KIRCH	I can apply Kirchhoff's Laws, Ohm's law, voltage divider equation, current divider equation and basic definitions to analyze DC resistive circuits.
T.SPICE	I can use SPICE to simulate a DC resistive circuit.
T.GAIN	I can derive the gain across a capacitor and the gain across a resistor for a RC circuit with a sinusoidal voltage source.
T.PWM	I can describe a PWM signal.
T.FOURIER	I can analytically determine the Fourier series for a given periodic function.
T.XX	TBD, if needed
LABVIEW:	
LV.labpro	I can write a LabView program that uses a LabPro for control and data acquisition. The program can output a signal, read a channel, graph data, store data and do basic data analysis (if necessary).
LV.daq	I can write a LabView program with a DAQ interface (such as LabPro) and sensors to accomplish a given experiment that may include both outputs and inputs.
LV.fourier	I can write a LabView program to do a Fourier transform on a periodic voltage and can measure the frequencies and amplitudes of the harmonics.
LV.que	I can write LabView programs using a queue-based state machine structure.
LV.XX	TBD, if needed