Fall 2019	MSCI-222C	Introduction to Electronics

Credits: 3
Type of Course: Lecture
Class Meetings: 15
Prerequisites: None *(Recommended: Any basic physics course)*
Instructor: Prof. Charles Rubenstein, Ph.D., CEng Email → crubenst@pratt.edu
Office Hours: Mon 4pm – 5pm, & Tues 1pm-2pm: ARC Room G-49 or E-13, Brooklyn
Time and Location: Monday (01): 1-3:50pm; Tuesday (02): 2-4:50pm ARC Room E-13, Brooklyn
Class Resources: http://www.charlesrubenstein.com/222
Syllabus date: 25 August 2019 – Revision 1

I. Course Overview:

This is a science course intended for the student curious about modern electronics and its use in enhancing their own designs as well as in preparation for Pratt's DDA and ID courses in interactive installations and robotics. Covering basic physics and electronics theory with practical applications in circuit design and interfacing, the course requires students to use critical and logical thinking to construct working electronic circuits that provide for control of input and output devices, the safe and reliable connection of one circuit to another, to an embedded controller (Arduino, Raspberry Pi, etc.), smart device or computer port.

II. Course Goals:

Using logic and critical thinking skills students will construct, and troubleshoot as necessary, at least ten working circuits using individual electronic components, transistors, integrated circuits, sensors (microphones and photoresistors) and output devices (light-emitting diodes, relays and speakers). These circuits include multi-component 'analog' circuits using diodes, transistors and 'analog' integrated circuits (e.g., comparators, operational amplifiers and 555 timing circuits) as well as use 'digital' integrated circuits configured as logic functions (AND, NAND, OR and NOR) and/or used in flip-flops, digital counters and shift registers – the building blocks of microcontrollers and microcomputers.

III. Learning Outcomes:

Upon completion of the course (including the assembly of all circuit assignments) students will be able to:

- explain the concepts of voltage, current, resistance, Ohm's Law, and voltage divider circuits
- describe the basic properties of semiconductors - how diodes and transistors work
- demonstrate how electronic components and devices work
- interconnect electronic components and devices to make useful circuits
- construct working circuits from circuit diagrams with electronic symbols for resistors, capacitors, diodes, transistors, and integrated circuits
- use critical, logical and creative thinking to troubleshoot circuits to make them work
- analyze the voltages, currents, and power dissipation in simple circuits
- determine the logical function of several logic gates interconnected in different ways

IV. Course Requirements:

a. Attendance: Arriving more than fifteen minutes late will constitute a class absence.
Two (2) unexcused absences may result in a whole letter grade deduction from your final grade.
Three (3) unexcused absences will result in an automatic "F" for the course.

b. Readings: *Reading assignments should always be completed before the next session. They should be regarded as required and questions from these will be included in homework assignments and on exams.*

c. Homework: *Homework assigned at a class session will be due at the next class session. Homework will be reviewed via a five minute in class quiz the week AFTER the assignment is due. The answers to all homework and quizzes will be reviewed in class and become part of the class note set posted online.*

d. Exams: *There will be a take-home midterm and an in-class comprehensive final exam*

e. Lab Modules: *There are ten required lab experiments. Each requires the student write a paragraph or two on how they might use the circuit(s) studied in their own work.*

f. Research Paper: *A midterm 'Draft' and a 'Final' research paper on intellectual property are required.*

V. Method of Assessment and Grading:

Your final grade will be comprised of four parts; (a) a take home midterm (10%) and final (20%), (b) ten supervised in class hands-on lab assignments (30%), (c) ten weekly homework quizzes (20%), and (d) a WTC-reviewed research paper on intellectual property: midterm draft (5%) and final paper (15%) .

a. Exams: (30% of Final Grade)
There will be a **2.5-hour written, take-home Midterm exam worth 10%** of your final grade.
There will be a **2.5-hour written, in-class comprehensive Final exam worth 20%** of your final grade.

b. Homework and Homework Quizzes: (20% of Final Grade)
There will be **ten (10) Quizzes *(2% per quiz),* Worth 20% of final grade.** There will be a quiz for each of the ten homework assignments. *Although homework only accounts for 20% of your final grade, the content of the homework assignments is used as the primary basis for midterm and final exams.*

c. Lab Assignments: (30% of Final Grade)
There are **ten (10) required Hands-on Lab Modules *(3% per completed lab project),* worth a total of 30% of your final grade.** *These hands-on, in-class, projects involve wiring working electronic circuits (without soldering) and writing a one or two paragraph review of how you might use these circuits in your future designs. Your lab grade is based on completion at least ten hands-on labs. There are two OPTIONAL lab modules that you can complete after the required labs worth 5% extra credit each.*
Note: *No lab work will be accepted after the **WEEK BEFORE** the Final Examination.*
Please also see the Institute Policies in Section VIII.

d. Research Paper on Intellectual Property: (20% of Final Grade; Draft=5% and **Final=15%)**
You are required to write a term paper that addresses the challenges of intellectual property (IP) you may experience in the future. You must include in your paper an analysis of the assigned reading on Edwin Armstrong's life and how his experiences with patents might impact you with respect to your own IP. Your research paper must include ***at least four*** additional references about electronics and intellectual property and a bibliography and may include legal, web and other IP resources.

Your three-page **draft** paper must be reviewed by the Pratt Writing & Tutorial Center (WTC) ***prior*** to the date of the midterm. This draft as well as a WTC Visit Form and review, is due the day the midterm exam is due. It will be reviewed for appropriateness of the work to be done and returned. (**Draft Paper = 5%**).

Your **final** paper, which also must be reviewed by the WTC, is due at the final exam and must consist of at least six (6) pages in 12-point type, double-spaced (about 1500 words) (**Final Paper = 15%**).

See "**TermPaper.pdf**" for additional information and bibliography, etc., requirements.

VI. Supplemental Material:

a. REQUIRED TEXTS *are all electronically available on the class website in the **_references** folder at:*

http://www.charlesrubenstein.com/222/_references

*The **_references** folder includes an electronics component catalog as well as these pdf texts:*
1. **armstrong.pdf**: Lessing, Lawrence 1969. "Man of High Fidelity: Edwin Howard Armstrong" Bantam Books #P4483. *(This scanned and edited version of the original, out-of-print, classic paperback text covers the history of FM radio and the life of inventor Edwin Howard Armstrong.)*
2. **sensors.pdf**: Mims, Forest M. 2001. "Radio Shack Electronic Sensors Lab" Radio Shack Corp.
3. **ew1.pdf**: Mims, Forest M. 2000. "Electronics Workbook 1: Basic Electronics - Transistors & Integrated Circuits" Radio Shack Corp.
4. **ew2.pdf**: Mims, Forest M. 2000. "Electronics Workbook 2: Digital Logic Projects" Radio Shack Corp.

(Please note that in addition to the online Electronics Workbooks, a limited number of print copies of the Mims texts as well as of Lessing's "Man of High Fidelity: Edwin Howard Armstrong" are available on request for semester loan.)

b. Each student will be assigned the following lab equipment for use *in class* only:

1. Pratt Electronics Toolkit (*includes various electronic tools, parts and a digital multimeter*).
2. A Radio Shack "Electronics Learning Lab" console (Model: 28-280, Catalog #: 28-027)

VII. SEMESTER SCHEDULE: MONDAYS & TUESDAYS - ARC Building Room E-13
Section 01: Mon 1:00pm-3:50pm / Section 02: Tues 2:00pm-4:50pm
PRELIMINARY SCHEDULE – SUBJECT TO CHANGE

Session 01 – Introduction and Basic Concepts
What is physics? What is engineering? How are they useful for an artist? Review of the basic concepts of voltage, current, power, energy, resistance, resistors in series, and resistors in parallel.
Readings: Mims: *Electronics Workbook 1* (***ew1.pdf***): Pgs. 1-27
Lessing: *Man of High Fidelity-Edwin Howard Armstrong* (***armstrong2.pdf***): Ch. 1 – 3

No Classes – Labor Day Holiday – MONDAY 2 September 2019

Session 02 – Basic Electronic Devices
Switches, resistors, filament lamps, electromagnets, inductors, capacitors, time delays achieved by charging and discharging capacitors, and diodes (details of semiconductor diodes will be covered in Meeting 3), the *Voltage Divider equation*, power dissipation for resistors.
Readings: Mims: *Electronics Workbook 1* (***ew1.pdf***): Pgs. 28-65
Lessing: *Man of High Fidelity-Edwin Howard Armstrong* (***armstrong2.pdf***): Ch. 4 – 6

Session 03 – Semiconductor Materials and Semiconductor Diodes
What are semiconductors and doped semiconductors? The PN junction: how semiconductor diodes manage to pass current preferentially in only one direction? Light emitting diodes (LEDs) vs. incandescent (filament) lamps. Review of scientific notation (1E3, 10E-6, etc.).
*The basic device preservation rule: "**Do not exceed voltage, current, and/or power ratings**"*
Readings: Mims: *Electronics Workbook 1* (***ew1.pdf***): Pgs. 66-76
Lessing: *Man of High Fidelity-Edwin Howard Armstrong* (***armstrong2.pdf***): Ch. 7 – 9

Session 04 – Transistors as Switches and Amplifiers
How do bipolar (BJT) and field effect (FET) transistors work as analog amplifiers and digital switches?
Readings: Mims: *Electronics Workbook 1* (***ew1.pdf***): Pgs. 77-**END**
Lessing: *Man of High Fidelity-Edwin Howard Armstrong* (***armstrong2.pdf***): Ch. 10 – 11

No Class / OPEN LAB – Instructor's Holiday – 30 September & 1 October 2019
No Class – Pratt Midterm Break – TUESDAY 8 October 2019

Session 05 – Analog and Digital Concepts
What do "analog" and "digital" really mean? How can an analog music waveform be converted into a digital file or compressed digital file (such as mp3)? Binary number system and digital coding concepts.
Readings: Mims: *Electronics Workbook 2 – Digital Electronics* (***ew2.pdf***): Pgs. 1-50 and page 90
Lessing: *Man of High Fidelity-Edwin Howard Armstrong* (***armstrong2.pdf***): Ch. 12 – 13

Session 06 – The Operational Amplifier (*"Op-Amp")*
An op-amp is a high-gain amplifier that can be used to amplify signals from sensors or for speech and music. Op-amps can also be used as an inverter, a comparator, or an oscillator. *In-Class Demonstration:* Using an operational amplifier and power transistors to build an audio power amplifier.
Readings: Mims: *Electronics Workbook 2* (***ew2.pdf***): Pgs. 51 - 79; review page 12
*See especially pg. 10 (**CD4001** and **CD4011**) and pages 13 and 90 (**CD4511**).*
Lessing: *Man of High Fidelity-Edwin Howard Armstrong* (***armstrong2.pdf***): Ch. 14 – **END**

Session 07 – Digital Integrated Circuit (IC) Logic Gates
We'll see how to use electrical circuits in the form of compact integrated circuits (ICs) that implement the Boolean algebraic logical functions of AND, NAND, OR and NOR.
Readings: Mims: *Electronics Workbook 2* (***ew2.pdf***): Pgs. 80 - **END**; review page 12
Concentrate on the **CD4013** (an *IC "flip-flop" with two stable states that can remember a **0** or **1***) and the **CD4017** (*a digital IC that can count from 0 to 9*).

***The TAKE HOME Midterm will be distributed on Mon/Tues, 21/22 October 2019.**
You are responsible for obtaining the midterm exam (worth 10% of final grade).
If you miss class you MUST get a copy from the Math/Science Department Office.
You must complete the exam on your own – not with friends, colleagues, etc.
You should prepare up to TWO (2) double-sided 8.5" x 11" sheets (4 sides) handwritten reference sheets from your notes. These notes pages must be turned in with any scrap paper notes.
All equations and work must be shown on scrap paper.

VII. SEMESTER SCHEDULE: *continued*

Session 08 - Flip-Flops and "Clocks" (*Pulse Train Sources*)
Why "clocked logic" is more reliable than "un-clocked logic?" What does "computer clock speed" mean.
Readings: Mims: *Electronics Workbook 2* (***ew2.pdf***): Review page 12 (**CD4013** and **CD4017**).

The Midterm and Research Paper DRAFT and WTC Form will be collected from each student on Mon/Tues, 28/29 October 2019.
You are responsible for returning these materials today. If you were not in class when the midterm exam was distributed you must obtain it from the Department Office. ***No excuses will be accepted****.*

Session 09 – Digital Counters
We will test and discuss applications for the CD4017 IC digital counter. We'll also see how a CD4013 IC can be used to "de-bounce" a pushbutton so that one reliable pulse is obtained even if metal contacts in the button bounce open and closed a few times for each press.
Readings: Mims: *Electronics Workbook 2* (***ew2.pdf***): Review page 12 (**CD4013** and **CD4017**).

Session 10 – Digital Shift Registers
See how a shift register (a row of flip-flops that can store many 0's and 1's and shift them down a line) could be used for 'serial to parallel' or 'parallel to serial' data conversion.
Readings: Mims: *Electronics Workbook 2* (***ew2.pdf***): Review page 37 (**NE555** Timer IC).

Session 11 - Using Analog and Digital IC Circuits Together
Details of operation & application of the partly analog, partly digital NE555 integrated circuit. We'll see why the NE555 IC has been a favorite of hobbyists world-wide for years and how it can be wired as a timer or as a pulse source. What is an optoisolator?
Possible In-Class Demonstration: How can our 5-volt electronic circuits safely control 117VAC devices?

Session 12 – Interfacing to Computers
Comparison of serial and parallel communications; true RS-232 vs. 5V serial ports; USB vs. "firewire" ports; and alternate ways of connecting external electronic circuits to a computer.

Session 13 – RFID Concepts & Review
Review of the analog (Modules 1-6) and digital (Modules 8-13) portions of the course

This is the LAST DAY FOR LAB WORK SUBMISSIONS

Session 14 – In-class Final Exam (*worth 20% of final grade*)
Your six-page Final Research Paper and WTC Form and midterm materials are due today
(*worth 15% of final grade*). ***The Final Exam will be a written exam similar to the Midterm but covering the entire semester's work. Up to FOUR (4) double-sided, handwritten, 8.5"X11" reference sheets permitted.***

VIII. PRATT INSTITUTE or Departmental POLICIES *(URLs correct as of August 2018)*

a. Disability Statement:
If you have a physical or learning disability that we should know about, please contact Elisabeth Sullivan at 718-636-3711, to discuss your needs and how we can best serve you. To receive any classroom accommodations and other services, you must have documentation of your disability ***on file*** with the instructor and in the Department of Math and Science Office. Your records will be kept completely confidential. For more information, please see the Pratt Learning/Access Center webpage:
https://www.pratt.edu/student-life/student-affairs/learning-access-center/

b. Community Standards:
Students are expected to adhere to Pratt's community standards. These are listed on the Pratt Institute Student Policies webpage at;
https://www.pratt.edu/student-life/student-affairs/office-of-the-vice-president-for-student-affairs/student-policies/
The Pratt Student Handbook is also available online.
Students should familiarize themselves with the Academic Integrity Code and Plagiarism.

c. Attendance and Conduct:
The continued registration of any student is contingent upon regular attendance, the quality of work and proper conduct. Irregular attendance, neglect of work, failure to comply with Institute rules and official notices, or conduct not consistent with general good order is regarded as sufficient reasons for dismissal.
There are no unexcused absences or cuts. Students are expected to attend all classes.
Any unexcused absences will affect the final grade as noted on page 1 in Section IV.a.