Phys 3061 **Instrumentation** **Fall 2018**

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Office hours: To be announced. *E-mail:* jmaps@d.umn.edu
Lecture: Tu,Th 1 pm, MWAH 397 *Lab:* Tu 2-4:50 pm, MWAH 395

Prerequisites: Phys 2022 - Classical Physics; one semester of programming (useful, not essential, for making graphs, etc. in Matlab or your favorite language).

Text: *Hands-on Electronics* by Kaplan and White. The textbook contains the heart of the lab work and some background material. It is distinctly short on background or foundational discussion. *Electronics with Discrete Components* by Galvez is strongly recommended as a supplement.

Two other books come to mind as useful references: *Practical Electronics for Inventors* 4th edition by Scherz and Monk, and *The Art of Electronics* by Horowitz and Hill. Both are much more comprehensive in different parts of the course (and physically much larger) than Kaplan and White or Galvez. There are two copies of Scherz & Monk and Horowitz & Hill 2nd ed. in the lab room for use there. (H&H is out now in a third and thoroughly updated edition. If you become an experimental physicist and have to do any circuit building or design yourself, you will probably use this forever.) A copy of the 2nd edition is floating around in the lab room.

Course content: This is a crash course of laboratory electronics useful to the working physicist. This includes (1) basics of DC and AC circuit analysis with resistors, capacitors, and inductors; (2) properties and application of basic semiconductor devices (diodes and transistors) in circuits; (3) application of operational amplifiers as building blocks for analog circuits; (4) fundamental digital logic gates; (5) more complex digital logic devices that give rise to sequential digital systems and memory (chiefly for us flip-flops and counters); (6) techniques to convert signals between their analog and digital representations.

Learning outcomes: By the end of the course students should be able to:

- apply basic circuit analysis techniques (e.g. Kirchhoff's laws, impedances and rules regarding them, including frequency dependence) to circuits;
- use standard lab instrumentation to make electrical measurements;
- describe the operation of basic semiconductor devices (e.g. diodes, transistors, op-amps, basic digital gates, flip-flops);
- interpret a circuit schematic so as to explain or predict its function;
- design simple circuits to perform desired functions using the components introduced during the course;
- build a working circuit from a schematic;
- debug the operation of a circuit in a systematic way to identify problems or mistakes in the building or design of a circuit.

Grading: Course grades will be based on these contributions and associated weights.

- Lab work 40%
- Homework and classwork 25%
- Midterm 10%
- Final exam 25% (Tuesday Dec. 11, at 12 noon.)

The expected grading scale will be no stricter than: $> 90\% \Rightarrow$A-,A; $> 80\% \Rightarrow$B-,B,B+; $> 70\% \Rightarrow$C-,C,C+; $> 64\% \Rightarrow$D,D+.

Labs: Lab is weekly in MWAH 395. The textbook by Kaplan and White is essentially the lab manual, with some supplementary notes week by week. We will plow through about one chapter each week in lab.

Lab work is kept in a lab notebook. The lab notebook should be a bound notebook, and your life will be much easier if it is ruled like graph paper. There are a couple styles available. While doing the lab, write down what you are doing and what happens on the right hand page. Include schematics/diagrams of the circuits you build. If you have a figure or graph to add later, draw or tape it in on the left hand page. Number such figures so you can refer to them in your commentary. After the lab and before you hand it in, go back to the notebook, elaborate, and clarify. The goal of the lab notebook is for someone who has not done the experiment before (or you, ten years later, when you're in a real research situation and want to remember how to build a notch filter) to be able to pick it up, walk into the lab, and duplicate your work. For the start of the course lab notebooks are due for grading by Monday at 1:00pm.

Homework: Discussion of homework problems with classmates is permitted and encouraged. Use of solution manuals or comparable resources is not permitted. All work turned in must be your own, *i.e.*, you are able to present you solution and explain it to the instructor and class.

Homework assignments are important, and the weight they carry in the grading reflects that. Homework-style work is an essential part of designing and/or understanding an electronic circuit; in practice you would not sit down and do all your work at the lab bench. It involves planning and designing in advance.

When writing out your homework solutions, include not only the schematics and equations which lead to the answer, but elaborate on the reasoning that led you to the steps in your answer. Think of it this way: your homework should be presented in a fashion so another student can present/explain it to the class given a minute or two to look it over. The solution must be presented in a systematic, step-by-step fashion, with brief explanations of what is being done and the reasoning involved. (Yes, that means using words and learning to write/speak the language of circuits!) Without a reasonably complete explanation, you will not get full credit.

Late penalties: For lab notebooks and homework, a penalty of 20% will be deducted for each day the item is late. The final lab notebook will not be accepted late.

Disabilities: If there are aspects of this course that result in barriers to your inclusion or your ability to meet course requirements, please notify the instructor as soon as possible. Contact the Office of Disability Resources (KSC 258) to discuss and arrange reasonable accommodations. Please call 218-726-6130 or visit the DR website at www.d.umn.edu/access for more information.

University Policies: Information about various applicable University policies should be reviewed at http://www.d.umn.edu/academic-affairs/academic-policies/classroom-policies/recommended-syllabi-policy-statements.

Details of the course procedures and policies described here may be amended and posted as deemed appropriate by the instructor.