Physics 342,343 (Instrumentation) - Fall, 2010 Syllabus

Course Instructor: Dr. Donald Isenhower
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Office Hours: MW: 1-2 p.m., TR: 9:30-11:00 a.m.,T: 1:30-4:30 p.m., other times by appointme

COURSE DESCRIPTION

This course has as its goal to teach about the application of electronics to solve practical problems. Instrumentation is a core competency for scientists. Even though many may not actually work directly on hardware or even on the software running actual equipment, it is important to understand how devices interface with each other and the quantities that can be measured in some manner. Calculations of specific circuit quantities will play a minor role in this course. Much more time will be spent showing the different methods that exist to move information from one instrument to another, often converting it to a more useable quantity. Also, there will a large number of devices and methods discussed that will provide the student with the knowledge of the type of solutions exist to various problems. While few people may ever need a lock-in amplifier or a sequencer, but both solve problems that would be difficult to find better or even possible solutions, i.e., it is critical that you know about different technologies that serve diverse purposes. Also, one of the most critical skills for working on any project is the ability to ask the right questions. To ask the right questions one requires a broad knowledge base and attention to detail. Thus many more systems will be introduced than can be "tested" over, so students should understand this so that attention is spent on learning about whole systems of solutions rather than any of the specific details of a specific solution.

TEXT:

Introduction to Instrumentation an Measurements by Robert B. Northrop. This is a text that has the best coverage I have seen of sensors, noise, analog and digital signal conditioning, and all aspects one encounters with moving signals from the external world to digitized form on a computer. Because of its breadth, only specific sections will be discussed in detail, so reading assignments will be made in order to help you know what areas to concentrate on for this course. *Warning: do not let yourself get lost in the mathematics, particularly in Chapter 1. We usually won't use these aspects of the text. Exceptions will be noted.*

SUPPLEMENTAL TEXTS:

The Art of Electronics by P. Horowitz and W. Hill. This is a text with extensive coverage of the field of electronics. There is simply no equivalent text of its type to the knowledge of your instructor. It is literally a "bible" of electronics. The text is one of the primary reference books used worldwide.

Programming and Customizing PICmicro Microcontrollers by Myke Predkio, 2nd Edition will be used for lectures on microcontrollers and their applications. This is the best text for the Microchip PIC microcontrollers available.

Microcomputer Interfacing by Harold S. Stone. This book has an excellent treatment of shielding, grounding, and transmission-line techniques as well as important sections on busses and other aspects of instrumentation. A copy is placed in 320 for your use.

Microelectronics by Jacob Millman and Arvin Grabel. This is an advanced text that is excellent for a in depth explanation of how the different solid state devices work. It does not cover all of the topics that I will cover in class, but will serve as the basic source for many of my lectures.
Instrumentation for Scientists Series (4 Vol.), by H.V. Malmstadt, C.G. Enke, and S.R. Crouch. There are other books by the same authors that you will find very useful since they tend to write at an intermediate level.
Microelectronics: Circuits by A. Sedra and K. Smith. Similar in content to Millman but with a slight difference in selection of topics.
(Spend time in the library and conference room to see what all is available for your use, and if you check out a useful book, be sure that several students in the class know who has it. This way the books will be available to more than one student at a time.)

COURSE OUTLINE:
Week 1: Ch. 1-8, measurement systems overview.
Week 2: Ch. 2, review diodes, BJT and FET transistors, and op-amps.
Week 3: Ch. 2, extended details on amplifiers and analog signal conditioning.
Week 4: Ch. 3, noise sources an how to deal with them, filters etc..
Week 5: Ch. 6-7, physics of sensors, what is available, nanosensors on the way.
Week 6: Ch. 9, digital interfaces RS-232, RS-422/423, CAMAC, FASTBUS, and VME.
Week 7: Ch 9+, ADC, DAC, TDC techniques.
Week 8: Logic families (TTL, ECL, CMOS, etc.).
Week 9: Microprocessors and microcontrollers.
Week 10: Ch. 10, more microcontrollers and digital signal conditioning.
Week 11: Ch. 10+, other digital devices, FPGAs, DSP systems, etc.
Week 12: Ground loops and other problems; transmission lines, impedance matching.
Week 13: Catchup week because of above ambitious schedule.
Week 14: Misc. circuits and useful details (e.g., selection of cables)

CLASS ATTENDANCE:
Good attendance is critical for this course. It is expected that students in this course are serious about learning so that the instructor can spend less time on worrying with forcing the student to read the assigned material and to listen attentively in class. Many things will be discussed that will not be covered anywhere but in lecture. Some of these will not be on any test. Excessive absences (more than 4) will result in the lowering of your grade by one letter-grade. More than 6 absences will result in a failing grade for the lecture part of this course.

HOMEWORK and QUIZZES:
From time to time homework may be assigned to help the student understand the material being presented in lecture and associated with the lab. Quizzes may be given periodically. If I want to see if you are understanding a particular concept, they will be announced. If I want to see if you are reading your text before my lectures, they will probably not be announced. Each of these assignments and quiz questions will be assigned point values since some will be more involved than others. All of these points will be added together and included in your average with the weight indicated below. The number of quizzes will be determined by the class performance in reading assigned material and attention in class. Your instructor would prefer not to give any quizzes!

FINAL GRADES (lecture section - PHYS 342:
Your final grade will be determined as follows:

25% Major exams (two are planned, may have oral components)
25% Final exam (may be oral presentation)
50% Homework, quizzes, class participation. Some of these will deal with laboratory activities.

The following scale will serve as a guide for what grade you will receive after the grades are curved (i.e., I may grade more leniently, but never more strictly). My preference is to have all students work hard to learn so that I don't have to worry about grading. If you put in the effort to never miss class, read all assignments, and strive to keep up with what is going on in the class as I expect of advanced physics majors, you should be able to expect to receive an A.

90 to 100% = A, 80 to 90% = B, 70 to 80% = C
65 to 70% = D, below 65% = F

LABS - This is separately graded as PHYS 343:
All labs must be completed. Any missed labs must be made up for you to complete the course. There will often be a short lecture before each lab and quizzes may be given after these lectures. There will also often be pre-lab assignments that must be turned in within the first 5 minutes of the start of the lab. Since these are to prepare you for the lab, late work cannot be accepted. Many of the labs will require keeping a notebook to write down your comments and observations. Answers will range for acknowledging you observed the expected behavior to detailed calculations and comparisons of results.

Lab material will be gone over in class and in the lab itself. Lab writeups are due at the beginning of your next lab period and will lose 10% if they are not turned in by that time. Labs more than one week late will lose 50%. Exceptions to these penalties will only be given for a university approved reason for an absence. Periodic pop-quizzes will be given during these labs to insure that each student is working to understand the material covered and how to use the lab equipment. Pre-lab assignments may be given that will be treated as homework given to understand an upcoming lecture (i.e., late work not will not be

accepted). Lab quizzes may also be given if I have assigned material for you to read or study before your lab meets. Each question will be worth 10 points.

Initial proposals for special projects are due by September 30, 2010 at the beginning of class. After discussions with your instructor final choice for your special project must be made by the beginning of class on October 21, 2010. You will begin work on your project immediately and will give a report on your results either the last week of class or as part of your final exam. In the event of your presentation being part of your final exam your grade will be obtained by your instructor's grades on your presentation and results (50%), your ability to answer questions presented to you by either the instructor or the other students in the class (25%), and the quality of at least two questions asked during other student presentations (25%).

Laboratory Textbooks:
You are required to purchase the student version of the class notes on how to program the Microchip PIC microcontrollers. This text will provide examples to help you program the PIC devices and help with design and programming of any similar devices needed for your special projects.

Student Manual for the Art of Electronics by T. Hayes and P. Horowitz will be used for labs on transistors and operational amplifiers. This text will be provided in lab. There will be additional information provided, much of which will come from the WWW.

Programming and Customizing PICmicro Microcontrollers by Myke Predkio, 2nd Edition will be used to assist in microcontroller/microprocessor labs some of the labs. A few copies of the text are provided in the lab. Microcontroller labs will rely on the PIC Microcontroller text and material included in the Microchip kits using different PIC processors. Every device has extensive online information that may be useful. If you decide to seriously learn how to program the PIC processors, you should consider ordering a personal copy of this book as it is the most extensive book on the topic available.

The labs will attempt to be coordinate with lecture material. This will be the first year for some of these labs, so I will depend on your active participation in letting me know.
Week 1: Measurement basics, in particular use of equipment in lab.
Week 2-4: Hays Lab 4-7
Week 5-7: TBA
Week 8-10: Begin microcontroller labs, PIC basics, pp. 33-102, PIC programming examples, pp. 103-168. PIC interfacing to other devices. Varied PIC microcontrller and other applications. These will include ADC/DAC, DSP, FPGA, inline emulators, TCP/IP communications.
Weeks 11-14: Work will primarily center on selected special project.
Week 14: Lab final and practical skills(soldering, wire-wrap, etc.)

FINAL GRADES:
Your final grade will be determined as follows:

25% Lab final exam (may have oral component or be a seminar on your special project)
50% Laboratory assignments and special projects
25% Quizzes (some will be oral) and Lab homework assignments

The following scale will serve as a guide for what grade you will receive after the grades are curved (i.e., I may grade more leniently, but never more strictly).

90 to 100% = A, 80 to 90% = B, 70 to 80% = C
65 to 70% = D, below 65% = F

Special note on lab usage: Each student is responsible for cleaning up their area after each lab session. After you are finished, all parts are to be returned to their proper locations. Failure to do so will lower your lab by one letter grade. You are expected to take proper care of components and equipment. Failure to follow guidelines given by your instructor and/or careless use of equipment will result in a lowering of your lab grade. If you do not know how to use something, ASK!