

PRAIRIE VIEW A&M UNIVERSITY
DEPARTMENT OF ELECTRICAL & COMPUTER ENGINEERING
ELEG 3033 – Physical Principles of Solid State Devices (Physical Electronics)
Fall 2018

*Study and, in general, the pursuit of truth and beauty
is a sphere of activity in which we are permitted
to remain children all our lives.*
-Albert Einstein

To not know is bad; to not want to know is worse.
-African Proverb

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- Office hours:** MWF 10AM-12 PM, TR 1 pm – 3 pm, by appointment or just stop in.
- Required Text:** *Solid State Electronic Devices*, Latest Edition by Ben G. Streetman and S. Banerjee, Prentice Hall. (The fourth edition onward will work fine.) Please note that we will be following the COE required text book policy.
- Prerequisites:** PHYS 2523, CHEM 1034 & MATH 2043. These are required.

BRIEF DESCRIPTION OF THE COURSE

This course deals with the basics of semiconductor device physics and chemistry. This includes concepts and models needed to understand the fundamental operation and characteristics of semiconductor microelectronic devices. We will study the basic physics and chemistry of semiconductors and how electrons move (or do not move) through solids. We will explore ways to control this movement that make semiconductor devices useful. The first part of the course will be devoted to a physical understanding of the concepts needed to utilize electron energy band diagrams. This will include an introduction to the modern physics concepts of quantum mechanics and quantum states. We will then discuss the dynamics of charge carrier movement in a semiconductor. Finally we will integrate these concepts for a qualitative understanding of electronic devices and to quantitatively calculate their characteristics. Current topics in microelectronics devices and nano-science and technology will also be introduced.

TENTATIVE OUTLINE OF THE TOPICS & SCHEDULE

(An approximate timeline is given; however, the exact time spent on a subject will vary.)

Dates for all exams will be announced at least one week before the exam.

Introduction to Semiconductors and Crystals: (Chapter 1)

Overview of the semester; importance of microelectronics to new technologies and society; orientation introduction to microelectronics; introduction to various solid types; general discussion of semiconductor materials; crystal properties, introduction to device fabrication and scaling. (Week 1-2)

Microscopic concepts: (Chapter 2)

Concept of physical modeling of systems, simple models of atoms and molecules, quantum concepts, energy levels. (Week 3 - 4)

Electron Energy Bands: (Chapter 3)

Atomic bonding, energy bands, comparing metals, semiconductors and insulators; direct vs. indirect gap semiconductors. (Week 5-7)

EXAM 1

Charge Carriers & Carrier Concentrations: (Chapter 3)

Electrons and holes, effective mass, intrinsic and extrinsic materials, doping, the Fermi level, the Fermi distribution, carrier concentrations in equilibrium, conductivity and mobility, drift current, temperature effects. (Week 7-10)

Excess Carriers in Semiconductors: (Chapter 4)

Optical properties, carrier lifetimes, diffusion current, diffusion lengths. (Week 11-12)

EXAM 2

Basic Devices & Nanotechnology: (Chapter 5, parts of Chapter 6 and 7)

Basic operation of the MOS transistor. Physical limitations to device scaling. Introduction to nanotechnology. Some notes and handouts will be included on these topics. (Week 13-15)

Final

Student Outcome Objectives:

Student should obtain a basic understanding of concepts in semiconductor physics and chemistry, including relevant quantum and statistical concepts. This means:

1. Students should be able to apply these concepts to describe semiconductor physics phenomena and how these phenomena are related to device operations.
2. The student should also be familiar with some of the current scientific and engineering issues and limitations relevant to device operation and fabrication.

3. The students will learn about resources that will enable them to maintain a growing knowledge of developments in nano-science and technology.

The above specific outcome objectives address areas in which the Department of Electrical and Computer Engineering will be judged for accreditation of the program. This accreditation assessment is performed by an organization that originated as the Accreditation Board for Engineering and Technology, but is now simply known by their acronym: ABET. Engineering and technology programs across the country are evaluated by this organization to insure the quality of these programs. Currently, programs are being evaluated using a set of criteria referred to as "ABET 2000". Part of these criteria is a set of "Program Outcomes and Assessment" criteria referred to as "a-k", because there are eleven individual criteria under this title. This course (ELEG3033) fulfils three of these eleven criteria and they are as follows:

"Engineering programs must demonstrate that their graduates have:

- (a) an ability to apply knowledge of mathematics, science and engineering.
- (i) a recognition of the need for and ability to engage in life-long learning.
- (j) a knowledge of contemporary issues."

eCourse postings: To the extent possible, all course materials (syllabus, homework, project assignments, etc.) will be posted on eCourse. I also send emails regarding the course from eCourse. You are expected to monitor your emails messages accordingly.

FINAL GRADE

Your final grade will be determined upon these factors:

1. **Exams:** A large portion of the course's points come from the exams. There will be a total of three exams. The first two exams will be in-class exams, each will be worth 100 points. The in-class exams will be roughly scheduled after 2-3 homework assignments. There will also be some homework after Exam 2 that will be covered in the **cumulative final**. The cumulative final will have two parts. One part will be multiple choice and be designed to assess your "minimum performance" (how well you know the basics of the class) and an additional part on later topics in the class. The final exam will be worth 150 points. The content of all exams will be based largely on the material covered by the homework, along with information covered in the text, projects (see below), quizzes, and in class.

It is therefore essential that you do and understand your homework.

For exams: You will not be allowed, nor will you need, any notes or other papers of any kind for the exams. Most formula and all graphs and constants needed to

complete the exam will be included in the exam. You will only need a writing utensil and a simple calculator. No devices with communication capabilities will be allowed (cell phones, smartphones, tablets, etc). Anyone using these devices during an exam will have their paper collected and be given a zero for the exam.

You will be expected to adhere to the university policy on academic integrity during all exams.

Make-ups for exams will only be given at the discretion of the instructor and the decision for a make-up will be based on **documented reasons** for absence at an exam.

2. Quizzes: You will be given a series of quizzes throughout the semester, some in class, perhaps some on-line. The content of the quiz will be on materials covered in class during previous classes, from the last completed homework assignment, from materials that will be viewed online, and/or from materials covered in the projects described below. The quizzes will be worth a total of 50 points toward the final grade for the class. For example, if you receive 85% of the points on the quizzes given, you will be awarded 43 points toward your final grade. **For in class quizzes, quizzes will be given in the first 10 minutes of class only.**

3. Projects: A set of projects related to the science of electronic devices will be assigned throughout the semester. Each will be worth 25 points, and some of these points may come from quizzes and exam problems.:

A. A computer based project based relevant to the science and engineering of the course. (Relevant to Outcome a).

B. A project relevant to current issues in device fabrication and operation. (Relevant to Outcome j).

C. A project that compares the content of two websites on a subject related to solid state devices and/or nano-science and technology. The student will be asked to assess the content of the websites and form and defend an opinion on the rigor, relevance and presentation of the information given on the websites. (This assignment is relevant to Outcome i.)

D. A “virtual tour” of websites on device scaling trends and nano-science relevant to solid state devices. This project has two parts, and will involve writing and creating PowerPoint slides on relevant nano-technology. (Relevant to Outcome i & j).

4. Class Attendance (participation) and Timeliness: Your presence at lectures at the appointed time is essential. (See university policy on attendance and lateness.) Class attendance and timeliness will be worth 50 points or about 10% of the grade. It will be calculated based on the fraction of the classes where your attendance is recorded. For example if the attendance sheets show you were present for 80% of the classes, you would receive 36 points. Note: If attendance is NOT taken for some reason for a particular class, it will not be counted against anyone. Absences or tardiness will be excused according to the university policy.

Note: Announcements of upcoming exams and their content are given in class, quizzes will be given unannounced and quizzes can be based on previous class content. Make every effort to come to class so you keep informed. It is your responsibility to remain current with the class.

Homework: I cannot stress enough the importance of doing and understanding your homework. (Notice use of larger font!) Please note: Some homework assignments will include readings in the text. Your exams will be based on your homework and class notes (along with other things discussed above, but homework is crucial). There is roughly a one-to-one correspondence between exam problems and related homework problems. **Your final grade for the class will depend to a great extent on your ability to solve the homework problems and understand those concepts covered by the homework.** As the course progresses I will provide homework solutions and possibly problem review sessions. Studying the solutions and attending review sessions are probably NOT enough to insure good performance on exams. I will be available during office hours to help you with your work. I encourage you to take advantage of this. Homework assignments may be collected for grading, and regularly turning in your homework may work in your favor for borderline grades. **However, the homework assignments themselves will not constitute any significant part of your grade.** The homework will be due about 1 week after it is assigned.

Some of the projects and/or quizzes may be placed on line for completion. More on this as the semester progresses.

Final Grade

Your final grade will be determined by your percentage of the total points possible from the in-class exams, final, quizzes, projects, and attendance compared to your classmates. Any offered extra credit will simply be added to your point total.

Total Points (450 points possible) = Final Exam Score (150 points possible) + Highest score between Exam 1 score and Exam 2 score (100 pts. possible) + Composite score of Quizzes (50 points possible) + Projects (100 points possible) + Attendance (50 points possible).

Grade=(Your point total/450) x 100

Note that 300 of the possible 450 points are from the exams and/or quizzes!

It is possible that exceptional performance on the final will help borderline grades. Your final grade will be determined by your performance with respect to your classmates. However the **maximum** grading schedule will be: 90-100%=A, 80-89%=B, 70-79%=C, 60-69%=D, below 59%=F. This means that if everyone in the class scores above 90%, everyone will get A's; **scores less than 60% will NOT get a passing grade.**

Extra Credit: Opportunities for extra credit points may be offered during the semester. The assignments will be designed to encourage you to acquire a better understanding of engineering and scientific concepts and foster "life-long" learning. Stay tuned...

Other Items:

No "I" will be given for this course unless the conditions specified by the university are satisfied.

Note: If you have any needs that fall under the Americans with Disabilities Act, please inform me so that appropriate actions can be taken.

Please see the current university undergraduate catalog for a summary of all university academic policies (A catalog is available on the university's web site). This course will be conducted in accordance with these policies. Per university policy, attached are pages from the undergraduate catalog regarding student academic appeals process.

Finally, if you have any questions or concerns about the class, I will be happy to discuss them with you.

HAVE A GOOD SEMESTER!

University Rules and Procedures

Disability statement (See Student Handbook):

Students with disabilities, including learning disabilities, who wish to request accommodations in class should register with the Services for Students with Disabilities (SSD) early in the semester so that appropriate arrangements may be made. In accordance with federal laws, a student requesting special accommodations must provide documentation of their disability to the SSD coordinator.

Academic misconduct (See Student Handbook):

You are expected to practice academic honesty in every aspect of this course and all other courses. Make sure you are familiar with your Student Handbook, especially the section on academic misconduct. Students who engage in academic misconduct are subject to university disciplinary procedures.

Forms of academic dishonesty:

1. Cheating: deception in which a student misrepresents that he/she has mastered information on an academic exercise that he/she has not mastered; giving or receiving aid unauthorized by the instructor on assignments or examinations.
2. Academic misconduct: tampering with grades or taking part in obtaining or distributing any part of a scheduled test.
3. Fabrication: use of invented information or falsified research.
4. Plagiarism: unacknowledged quotation and/or paraphrase of someone else's words, ideas, or data as one's own in work submitted for credit. Failure to identify information or essays from the Internet and submitting them as one's own work also constitutes plagiarism.

Nonacademic misconduct (See Student Handbook)

The university respects the rights of instructors to teach and students to learn. Maintenance of these rights requires campus conditions that do not impede their exercise. Campus behavior that interferes with either (1) the

instructor's ability to conduct the class, (2) the inability of other students to profit from the instructional program, or (3) campus behavior that interferes with the rights of others will not be tolerated. An individual engaging in such disruptive behavior may be subject to disciplinary action. Such incidents will be adjudicated by the Dean of Students under nonacademic procedures.

Sexual misconduct (See Student Handbook):

Sexual harassment of students and employers at Prairie View A&M University is unacceptable and will not be tolerated. Any member of the university community violating this policy will be subject to disciplinary action.

Attendance Policy:

Prairie View A&M University requires regular class attendance. Excessive absences will result in lowered grades.

Excessive absenteeism, whether excused or unexcused, may result in a student's course grade being reduced or in assignment of a grade of "F". Absences are accumulated beginning with the first day of class.

Student Academic Appeals Process

Authority and responsibility for assigning grades to students rests with the faculty. However, in those instances where students believe that miscommunication, errors, or unfairness of any kind may have adversely affected the instructor's assessment of their academic performance, the student has a right to appeal by the procedure listed in the Undergraduate Catalog and by doing so within thirty days of receiving the grade or experiencing any other problematic academic event that prompted the complaint.

Technical Considerations for Online and Web-Assist Courses (not relevant to this class)

Minimum Hardware and Software Requirements:

- Pentium with Windows XP or PowerMac with OS 9
- 56K modem or network access
- Internet provider with SLIP or PPP
- 8X or greater CD-ROM
- 64MB RAM
- Hard drive with 40MB available space
- 15" monitor, 800x600, color or 16 bit
- Sound card w/speakers
- Microphone and recording software
- Keyboard & mouse
- Netscape Communicator ver. 4.61 or Microsoft Internet Explorer ver. 5.0 /plug-ins
- Participants should have a basic proficiency of the following computer skills:
 - Sending and receiving email
 - A working knowledge of the Internet
 - Proficiency in Microsoft Word
 - Proficiency in the Acrobat PDF Reader
 - Basic knowledge of Windows or Mac O.S.

Netiquette (online etiquette): students are expected to participate in all discussions and virtual classroom chats when directed to do so. Students are to be respectful and courteous to others in the discussions. Foul or abusive language will not be tolerated. When referring to information from books, websites or articles, please use APA standards to reference sources.

Technical Support: Students should call the Prairie View A&M University Helpdesk at 936-261-2525 for technical issues with accessing your online course. The helpdesk is available 24 hours a day/7 days a week. For other technical questions regarding your online course, call the Office of Distance Learning at 936-261-3290 or 936-261-3282

Communication Expectations and Standards:

All emails or discussion postings will receive a response from the instructor within 48 hours.

You can send email anytime that is convenient to you, but I check my email messages continuously during the day throughout the work-week (Monday through Friday). I will respond to email messages during the work-week by the close of business (5:00 pm) on the day following ***my receipt*** of them. Emails that I receive on Friday will be responded to by the close of business on the following Monday.

Submission of Assignments:

Assignments, Papers, Exercises, and Projects will distributed and submitted through your online course. Directions for accessing your online course will be provided. Additional assistance can be obtained from the Office of Distance Learning.

Discussion Requirement:

Because this is an online course, there will be no required face to face meetings on campus. However, we will participate in conversations about the readings, lectures, materials, and other aspects of the course in a true seminar fashion. We will accomplish this by use of the discussion board.

Students are required to log-on to the course website often to participate in discussion. It is strongly advised that you check the discussion area daily to keep abreast of discussions. When a topic is posted, everyone is required to participate. The exact use of discussion will be determined by the instructor.

It is strongly suggested that students type their discussion postings in a word processing application and save it to their PC or a removable drive before posting to the discussion board. This is important for two reasons: 1) If for some reason your discussion responses are lost in your online course, you will have another copy; 2) Grammatical errors can be greatly minimized by the use of the spell-and-grammar check functions in word processing applications. Once the post(s) have been typed and corrected in the word processing application, it should be copied and pasted to the discussion board.