ECE 5550

SOLID STATE ELECTRONICS I, 4 CREDIT HOURS

DEPARTMENT OF ELECTRICAL & COMPUTER ENGINEERING (ECE)

SYLLABUS AND PROCEDURES FOR COURSE REFERENCE NUMBER 10391

FALL 2007

INSTRUCTOR: JAMES R. WOODYARD

OFFICE: 3137 ENGINEERING BUILDING

MEETING TIMES: 5:30-7:20 P.M. MONDAY AND WEDNESDAY

MEETING PLACE: First Class Meeting in 3145 Engineering Building (call 313-610-3038 for access in the event the door is locked)

FINAL EXAMINATION: WEDNESDAY, DECEMBER 19, 2006, 7:30-10:00 P.M.

LOCATION: To be announced.

CONSULTATIONS: Students are encouraged to seek course assistance and to provide the instructor with formative teaching comments via telephone, e-mail and office visits.

TELEPHONE: 313-577-3758 Please leave a voice-mail message in the event voice mail is activated. The instructor will respond to messages in a timely manner.

E-MAIL: woodyard@wayne.edu.

OFFICE HOURS: DAY(S) TIME(S) LOCATION

**COURSE SYLLABUS:** The course continues with the development of the subject matter introduced in ECE 4570. The first six chapters in Streetman's book, *Solid State Electronic Devices* will be reviewed. Then the following topics in Streetman will be covered: Chap. 6 Field Effect Transistors, Chap. 7 Bipolar Junction Transistors, Chap. 8 Optoelectronic Devices, Chap. 9 Integrated Circuits, Chap. 10 High-Frequency and High-Power Devices. Personal computer based device modeling will be introduced during the course and will serve as the basis for a project that involves the design and simulation of the characteristics of a device.

The course is designed to serve as an ECE elective for graduate and undergraduate students who either successfully completed ECE 4570 and ECE 4800, or have suitable background that insures they will be successful in the course. The goal of the course is to develop solid-state device literacy. It is also the first course in the curriculum for graduate students interested in studying and carrying out research in solid-state devices.

*Students are strongly advised to obtain the textbook.* The instructor encourages students to bring the textbook to class and refer to the graphics in the book during lectures. The instructor will use an overhead projector to project the graphics from the textbook during lectures instead of attempting to sketch them on the blackboard. Additionally, the textbook may be used to expedite note taking.

**ACCREDITATION BOARD FOR ENGINEERING AND TECHNOLOGY (ABET) GOALS AND OBJECTIVES SURVEY:** The ABET goals and objectives for this course are listed below. An ABET survey, in addition to the WSU SET (Student Evaluation of Teaching) will be administered at the end of the course wherein students will be asked to evaluate their success in meeting the goals and objectives. ABET information may be viewed at: http://en.wikipedia.org/wiki/ABET.

Goals: The goals of this course are to learn the fundamentals of solid state devices and approaches to problem solving.

Learning Objectives: After completing this course, students should be able to do the following:

1. Define and describe semiconductor materials, crystal lattices, periodic structures, cubic lattices, crystal planes, crystal directions and diamond lattice.
2. Define and describe semiconductor crystal growing methods.
3. Calculate physical quantities using classical and quantum models of the atom.
4. Define terms such as bonding force, energy band, metal, semiconductor, insulator, direct and Indirect semiconductors, charge carriers in semiconductors, effective mass, intrinsic and extrinsic materials and Fermi-Dirac function.
5. Calculate electron and hole concentrations, and the temperature dependence of carrier concentrations.

6. Discuss drift of carriers in electric and magnetic fields and the effects of temperature and doping on mobility.

7. Discuss mechanisms due to excess carriers in semiconductors and calculate excess carrier concentrations and lifetimes under given conditions.

8. Define and discuss methods for fabricating p-n junctions in semiconductors.

9. Derive the two-sided step-junction model for the p-n junction and calculate junction variables.

10. Discuss deviations from the simple model of the p-n junction.

11. Discuss the operation of the bipolar-junction transistor and derive a model for its operation. Use the model to explain and calculate characteristics of the bipolar-junction transistor.

12. Discuss the operation of the field-effect transistor and derive a model for its operation. Use the model to explain and calculate characteristics of the field-effect transistor.

13. Define and discuss the operation of devices that employ p-n junctions.


15. Discuss the operation of charge-transfer devices.

16. Discuss the models and operation of high-frequency and high power devices such as the IMPATT, Gunn and p-n-p-n diodes.

17. Design a device in a computer-based simulator and calculate its characteristics.

OUTCOME COVERAGE

(a) An ability to apply math, science and engineering knowledge. The course is an intensive problem solving course. Theoretical derivations and and homework problems in the textbook are assigned. Students are informed that the home work problems are in the pool of test material, along with the material presented in class including derivations, definitions, etc. Three examinations serve to motivate students as well evaluate their ability to apply math, science and engineering knowledge to solving problems.

(e) Identify, formulate and solve engineering problems. Students are taught an algorithm for use in problem solving. The algorithm is designed to teach the process of problem solving. It emphasizes identifying the resources available and those that are needed. The steps used in solving a given problem are to be explained using terms defined in a narrative or figure that are included in the solution. The algorithm is used by the instructor and students throughout the course.

(g) an ability to communicate effectively: Students are required to solve problems in a manner that clearly shows the processes employed. Theory is to be stated and mathematical terms defined in a narrative form or on figures. The project proposal and report are to be written using journal-level technical writing.

(k) An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice: Students learn to use a state-of-the-art solid-state device simulator to design and simulate the characteristics of devices. A variety of problems are solved that require facility with engineering techniques and skills.

DROP POLICY: Students may drop the course before Tuesday, October 2 2007 without the
instructor's signature. The last day to drop any class with a tuition refund is the end of the second week of classes. All drop/add activity up to October 1, 2006 must be done through Pipeline; after this date, the form available at the following link must be used: http://sdcl.wayne.edu/registrar/Resources/adddrop.pdf#search=%22Add%2FDrop%20Form%22. The last day to drop the class, without a notation of a withdrawal grade on the transcript, is October 1, 2007; after this date a permanent grade will be entered on the transcript of WP for withdrawal passing, WF for withdrawal failing or WN for withdrawal never attended class. The instructor’s records will be used to award the appropriate withdrawal grade. Grades on tests and activities will be used to compute an average grade base 100; grade break points from the preceding semester will be used to award a withdrawal grade.

For the Fall 2007 semester, the following are the important dates pertaining to registration:

- C September 117th - Last day for tuition cancellation for classes officially dropped.
- C October 2rd - Instructors' signatures are required to drop classes. Grade of WP, WP or WN assigned and permanently entered on transcript. Classes cannot be dropped by Web or phone.
- C December 13th – Last day to drop classes.

**GRADING POLICY:** Three examinations will be administered. Each examination will be weighted 25% of the final grade. The examination date and content will be announced in class at least one class meeting in advance. The last examination will be administrated during the final examination period. The examinations will not be comprehensive; they will test on the material covered between examinations. A zero grade will be received for not sitting for an examination. No make-up examinations will be administered. The examinations will be weighted equally. A student missing an examination may petition the instructor to weigh the points with the final examination points. The petition must be in writing and include the appropriate documents. A student wishing to make up the final examination must also petition the instructor using the same procedure. Submission of a petition does not guarantee its approval.

**GRADING POLICY:**  
Examination I.........................25%  
Examination II......................25%  
Examination III.....................25%  
Activities............................. 5%  
Device Simulation Project........ 20%

**INCOMPLETE GRADE:** The I grade will not be awarded to students failing the course. The University policy on awarding an incomplete grade, I, will be used; the detailed policy may be read in the WSU Undergraduate Bulletin at: http://www.bulletins.wayne.edu/ubk-output/ubk-index.html. Students are advised to read the policy before approaching the instructor for an I grade in ECE 5550. The policy states in part: “The mark of `I' is inappropriate if, in the instructor's judgment, it will be necessary for the student to attend subsequent sessions of the class regularly.”

**CONSULTATIONS:** Students are encouraged to seek assistance from the instructor. The instructor is available in person during office hours and by appointment. Students should also feel
free to seek consultations by both telephone and e-mail. Students are urged to meet with the instructor on a regular basis to review concepts and solutions to problems. Students are urged to arrange notes and problem solutions in a three-ring binder. No more than one problem should be on a page; write only on one side of a page in order that problems that require multiple pages can be viewed by placing the pages side by side.

TESTING POLICY: Examinations will be closed book. Only calculators, pen or pencil, and drivers' license may be in the testing area. Paper will be provided for the tests. All books and personal possessions must be placed outside the testing area. Please don't bring valuables to testing sessions. 110 minutes will be allowed for examinations.

A section will be provided on examinations that will be labeled USEFUL INFORMATION. It will contain course material that may be useful in solving problems. The instructor will indicate during lectures the material to be memorized and as well as that to be provided as USEFUL INFORMATION for examinations.

WRITTEN REQUEST FOR REGRADING: A student who believes an examination has been incorrectly graded, or differs with the method used in the grading of a solution, is strongly encouraged to submit a written request for regrading (WRR) to the instructor. The WRR must include the examination with a petition written on a clean sheet of paper. The WRR must be on a separate sheet of paper. Do not write on an examination that is to be submitted with a WRR. A student writing on an examination following grading will be charged with academic dishonesty. The petition should state detailed reasons for the WRR and provide documentation from the course materials to substantiate the request. The instructor will respond in writing and the grade changed if the WRR is successful. Students are encouraged to submit WRRs if there are any concerns about the manner in which tests are graded.

PROFESSIONAL INTEGRITY: As global competition increases, the U.S. must produce the best possible products in order to secure its share of the marketplace. This is possible only with the highest levels of integrity in the engineering profession. Institutions of higher education must provide society with engineers who subscribe to the highest principles of integrity. It is for this reason that the instructor encourages integrity and works to insure the learning environment is intolerant of cheating. Hence, a student cheating will receive an E course grade. Students have appeal rights and the instructor urges students to exercise their rights. Space does not permit listing all forms of cheating. Some of the common forms of cheating include the following activities during a test: talking, copying, cribbing, storing information in a calculator prior to the test, looking around, test paper exposures, and altering a test paper for a WRR. In general, the instructor defines cheating as any activity which gives a student an unfair testing advantage or credit where it is not appropriate. The instructor welcomes comments, in person or otherwise, that will insure testing is conducted in a just manner.

PREREQUISITES: ECE 4570 and 4800 are prerequisites for ECE 5550. The prerequisites for all the courses that are prerequisites for ECE 4570 and 4800 are also prerequisites for ECE 5550. The instructor will request students lacking the prerequisites, or who have a suitable background to insure success in the course, to drop the course both because of departmental policy and concerns related to the quality of the academic experience.
GENERAL COMMENTS: The text will be followed closely. It presents the material at a reasonable level for students preparing for engineering careers. Engineering schools with both national and international reputations use the text.

1. Final course grades will be determined using a combination of straight scale and a curve. The instructor would be delighted to use a straight scale and give the A grade to all students in the class, assuming they achieve a final overall score of 90% or higher.

2. Solutions to ECE 5550 problems are available from a variety of sources. The instructor encourages you not to obtain and use other solutions in an effort to be successful in the course. Your success as an engineer will depend in part on your ability to solve problems. Solving problems is the corner-stone activity of the engineering profession and we all need experience solving problems in order to learn the process for solving problems. ECE 5550 is an opportunity to learn how to solve problems with the assistance of the instructor. The course offers students an opportunity to invest in themselves and grow professionally, a lifelong process that is essential for a successful engineering career.

3. The instructor welcomes the opportunity to assist students during office hours and by appointment, as well as by telephone and e-mail, for the purpose of discussing course content, methods of solving problems and techniques for success in the course. Students are urged to see the instructor outside of class on a regular basis.

4. This is a challenging course. ECE 5550 does not lend itself to cramming the night before tests. Students are advised that they should be able to work assigned problems, state definitions and carry out derivations completed in class in order to be successful in the course. Examinations will emphasize definitions, theory, derivations and problem solving. Plan on working on ECE 5550 continuously during the semester, and not just a few days before each test. If you follow this advice, you may get lucky on examinations.

5. Lifelong learning is essential for a successful and rewarding engineering career. One way of facilitating lifelong learning is to belong to an engineering professional organization. The instructor encourages students to join the Institute of Electrical and Electronics Engineers (IEEE) as a student member in order to access the resources available for both professional development as a student as well as for lifelong learning as a graduate engineer. An IEEE Student Membership Application is available from the instructor. It lists the benefits of IEEE membership, the publications received by student members, and some of the Internet resources. Respond "Yes" to "IEEE Info" on the Student Information Form if you would like to receive an IEEE Student Membership Application.

6. Should you join IEEE and have the interest and time, consider becoming active with the Wayne State University IEEE Student Branch. IEEE student members are not required to be active with the student branch. The student branch has both professional and social activities, and offers members opportunities to develop leadership skills and meet other ECE students. The Wayne State University IEEE Student Branch is an outstanding student organization as evidenced by the number of awards that is has received over the years.
7. Solid state devices is an important area in electrical engineering. Students are advised to develop resources in this course, e.g., notes in Cheng’s textbook and a three-ring binder, that will serve as resource materials for this course as well as for the Fundamentals in Engineering (FE) Examination, Part 1, and the Principals and Practice of Engineering Examination (PE Examination), Part II. Students are urged to plan to take the FE Examination in the last semester of their studies before graduating. Below is a statement from the www.engrpress.com Web site on professional registration:

“Professional registration is a two-step process: the first level is the FE license; the second level is the PE license. There are a number of reasons why an engineering student or engineer would want to seek professional registration. For the student, passing the FE exam is an essential asset to list on a resume because this achievement demonstrates a level of technical proficiency that many others competing for the same job(s) will not have. The FE license also completes a major step toward full professional registration, which for many engineers is necessary to fully practice their profession. Without becoming a licensed engineer, one will not be eligible for many jobs in public and private employment, and cannot do consulting or jobshop work. Even if there does not seem to be an immediate requirement for preparing for professional registration, it is likely that registration will become important at some point in one's professional career.”

General information on the examinations may be found at: http://www.michigan.gov/cis/0,1607,7-154-35299_35414_35472-114639--,00.html. The requirements for the examinations are:

Part I (FE). Although Michigan has no admission pre-requisites for the FE, the examination is typically taken on or around graduation.

Part II (PE). May be taken after the applicant has met the statutory education requirement and at least 4 years of acceptable work experience following receipt of that degree.

The dates and locations for the Michigan examinations are listed at: http://www.els-examreg.org/michigan.php#procedure.

The pass rates for the April 2007 Electrical and Computer Engineering FE examination are given at: http://www.ncees.org/exams/pass_rates/#fe_pass_rate and show that 69 % of first time takers passed and 19 % of repeat takers passed. For the PE examination, 58 % of first time takers passed and 22 % of repeat takers passed. Using a search engine with the search words “professional engineer” will show the resources that are available for use in preparing for the FE and PE examinations. Your career options will be enhanced if you are a licensed professional engineer.

8. Insure that you complete a Student Information Form and respond to the item on posting
grades. The instructor may circulate a copy of the course statistics at various times during the semester. This may be done to insure the statistics are correct. The last four numerals of your Wayne State University Personal Identification Number, PID, will be used in reporting statistics during the semester as well as in the posting of final grades. A response of "Yes" to the item Post Grades means you give the instructor permission to both circulate and post your statistics and final grade using the last four numerals of your PID. A response of "No" means that your statistics and final grade will be deleted from all circulations and postings. Note, if you respond "No", you must await receipt of your final grade from the registrar at the end of the semester; this is the policy of Wayne State University. Your signature on the Student Information Form means either you have participated in the ECE 5550 orientation session and/or read the syllabus. It also means that you understand and will follow the course policies.

9. The progression of the subject matter may be too slow for some students. Students may move through the material at a faster rate in order to pursue a research project. They must review the first six chapters in the textbook and complete the remaining chapters. Then they can study current research literature and work with state-of-the-art device simulation software on a research project. Please arrange a meeting with the instructor to pursue the directed study option.

10. I hope you enjoy the course. I know it will be challenging, however, it is with challenges that we learn and grow professionally. Please give me both positive and negative feedback as the course proceeds in order that I may make it more rewarding for both of us.

James R. Woodyard
ECE 5550 Instructor
November 9, 2007