

Rutgers University, Department of Electrical and Computer Engineering
ABET COURSE SYLLABUS
COURSE: 14:332:465

Course Catalog Description:	14:332:465 Physical Electronics (3) Semiconductor fundamentals, pn diodes, bipolar transistors, Schottky diodes, heterojunctions, JFETs, MESFETs, and MOSFETs.
Pre-Requisite Courses:	14:332:361
Co-Requisite Courses:	None
Pre-Requisite by Topic:	<ol style="list-style-type: none">1. Ordinary Differential Equations2. Static Electric Fields3. Terminal characteristics of diodes, BJTs, and FETs
Textbook & Materials:	Robert F. Pierret, <i>Semiconductor Device Fundamentals</i> , Addison-Wesley, 1996
References:	Neamen, <i>Semiconductor Physics and Devices</i> , 3 rd Ed., McGraw Hill, 2002 Edward S. Yang, <i>Microelectronic Devices</i> , McGraw-Hill 1988
Overall Educational Objective:	<ol style="list-style-type: none">1. Introduce students to the physics of semiconductors and the inner working of semiconductor devices2. Provide students the insight useful for understanding new semiconductor devices and technologies.
Course Learning Outcomes:	A student who successfully fulfills the course requirements will have demonstrated: <ol style="list-style-type: none">1. An ability to utilize semiconductor models to analyze carrier densities, carrier transport and recombination.2. An ability to understand and utilize the basic governing equations to analyze semiconductor devices.3. An ability to understand and analyze the inner working of semiconductor pn diodes, Schottky barrier diodes, BJTs, MESFETs, JFETs, and MOSFETs.4. An ability to utilize above abilities to analyze non-ideal and new semiconductor devices
How Course Outcomes are Assessed:	Home works (10%) Two Quizzes (10 %) Mid-Term Exam (35 %) Final Exam (45 %)

N = none S = Supportive H = highly related

Outcome	Level	Proficiency assessed by
(a) an ability to apply knowledge of Mathematics, science, and engineering	H	HW Problems, Quizzes, Exams
(b) an ability to design and conduct experiments and interpret data	S	Design problems in HW, Quizzes and Exams
(c) an ability to design a system, component or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability	N	
(d) an ability to function as part of a multi-disciplinary team	N	
(e) an ability to identify, formulate, and solve ECE problems	H	HW Problems, Quizzes, Exams
(f) an understanding of professional and ethical responsibility	N	
(g) an ability to communicate in written and oral form	S	HW Problems, Quizzes, Exams
(h) the broad education necessary to understand the impact of electrical and computer engineering solutions in a global, economic, environmental, and societal context	N	
(i) a recognition of the need for, and an ability to engage in life-long learning	S	Lectures
(j) a knowledge of contemporary issues	N	
(k) an ability to use the techniques, skills, and modern engineering tools necessary for electrical and computer engineering practice	H	HW Problems, Quizzes, Exams
Basic disciplines in Electrical Engineering	H	HW, Quizzes, Exams
Depth in Electrical Engineering	S	HW, Quizzes, Exams
Basic disciplines in Computer Engineering	N	
Depth in Computer Engineering	N	
Laboratory equipment and software tools	N	
Variety of instruction formats	S	Lectures, Problem sessions, Office hour discussions

Topics Covered week by week:

- Week 1:** Crystal structure, Bohr's atom, Valence-bond model of solid and energy-band model of solid.
Week 2: Effective mass, intrinsic & extrinsic semiconductors, free carrier and carrier concentration and Fermi-level.
Week 3: Scattering and Drift, Mobility, Hall Effect, excess carriers.
Week 4: Surface recombination, electrostatic field and built-in electric field, Quasi-Fermi level, basic governing equations.
Week 5: PN junction electrostatics, equilibrium and depletion approximation.
Week 6: Reverse bias transition capacitance, breakdown in PN junctions.
Week 7: PN junction under forward bias, minority carrier injection, DC current-voltage characteristics, Temperature effect.
Week 8: Non-ideal diodes, tunneling diodes, AC Analysis, charge storage and transient characteristics.
Week 9: Bipolar transistors, derivation of I-V and current gain expressions, Equivalent circuits, Frequency response.
Week 10: Transistor as a switch, breakdown voltage, pnpn structures, Schottky barrier diodes, Image-force lowering effect.
Week 11: Schottky diodes vs. PN diodes, Ohmic contacts, Schottky diode fabrication and applications. Heterojunctions.
Week 12: Theory of JFET, DC and AC characteristics, MESFET's. Enhanced JFET and MESFETs. Ideal MOS structure.
Week 13: MOS capacitors, flatband and threshold voltages, Static MOS transistor.
Week 14: MOS transistor equivalent circuit, cutoff frequency, Body effect, MOS device fabrication.
Weeks 15-16: Review and Final Examination

Computer Usage: None

Laboratory Experiences: None

Design Experiences: ~25% Homework problems are design-oriented problems.

Independent Learning Experiences: 1. Homework, 2. Testing (Quizzes, Exams)

Contribution to the Professional Component:

- (a) College-level mathematics and basic sciences: 0.25 credit hours
- (b) Engineering Topics (Science and/or Design): 2.75 credit hours
- (c) General Education: 0 credit hours

Total credits: 3

Prepared by: J. Zhao

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