Spring 2021

University of Illinois at Urbana-Champaign

ELECTRICAL AND COMPUTER ENGINEERING 340

Semiconductor Electronics

The course coordinator is **Prof. John Dallesasse**

The course structure consists of three lecture/discussion meetings per week. Final course grades are based on the distribution of total points accumulated on the 3-hour final exam, two 110 minute exams, and assigned homework, as described in the section on grading criteria.

The Course information listed below is included on the pages, which follow:

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Prerequisite: Physics 214 and credit or concurrent registration in ECE 329.
Graduate credit not allowed toward degrees in electrical and computer engineering.

3 HOURS.

Purpose of the Course

The purpose of this course is to provide the student with the essential background on semiconductor materials and a basic understanding of the following semiconductor devices that will be required for a successful career in electrical engineering:

p-n Junctions
Light-Emitting Diodes/Photodetectors
Bipolar Junction Transistors
Field Effect Transistors

These topics are important to the professional electrical or computer engineer because these devices are utilized in almost every area of electrical or computer engineering. To be productive and remain employed throughout a 40+ year career in electrical or computer engineering, the electrical or computer engineer needs to understand the fundamentals of semiconductors and the operation and limitations of these devices. A successful engineer will be able to apply this knowledge in the different areas of electrical engineering, whether he or she works directly in circuits and system design, control systems, communications, computers, electromagnetic fields, bioengineering, power systems, directly in the semiconductor industry, or in areas yet to develop that will certainly rely heavily on semiconductor devices and/or integrated circuits.

The material in this course will provide the background that will give the student the ability to learn and understand the performance and limits of improved devices that will be required throughout your electrical or computer engineering career.

ECE 340 Instructor, TAs and Office Hours

Course Coordinator: Professor John Dallesasse
2114 Micro and Nanotechnology Laboratory
217-333-8416
jdallesa@illinois.edu

Spring 2021 ECE 340 Instructors and TAs:

	Section	Time	Class Location	Office Hours Location	Tel. #	Email
Prof. Y. Vlasov	**A**	**10:00**	Online	Zoom	217-300-1870	yvlasov@
Prof. J. Dallesasse	**C/E**	**11:00**	**3017 ECEB & Online**	Zoom	217-333-8416	jdallesa@
Prof. K. Kim	**X**	**12:00**	Online	Zoom	217-333-7162	kevinkim@
			Office Location			
TA: Frank Kelly			-	Zoom	-	fpkelly2@
TA: Irene Xiong			-	Zoom	-	mxiong5@
TA: Manaav Ganjoo			-	Zoom	-	ganjoo2@

Room 2120 ECEB is the office for registration, section changes, lost & found.

TIME	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY
8 – 9				-	
9 - 10				Mingye Xiong	
10 - 11		Prof. Vlasov		Mingye Xiong	
11 - 12				Frank Kelly	
12 - 1				Frank Kelly	
1 – 2			Prof. Dallesasse	-	
2 – 3				-	
3 – 4				-	
4 – 5			Prof. Kim	-	
5 – 6				-	
6 – 7				Maanav Ganjoo	

Required Textbook:

Solid State Electronic Devices
Ben G. Streetman and Sanjay Banerjee, **Seventh** Edition
Prentice Hall, 2000/2006

Reference Textbooks are Available in Grainger Engineering Library:

Semiconductor Device Fundamentals
Pierret, Robert F.
Addison-Wesley, 1996

Call No: 621.3817M91D1986
Author: Muller, R.S./Kamins, T.I.
Title: Device Electronics for Integrated Circuits, 2nd ed.

Call No: 621.381sa19f
Author: Sah, Chih-Tang
Title: Fundamentals of Solid-State Electronics

Call No: 621.38152si64s
Authors: Singh, Jasprit
Title: Semiconductor Devices, An Introduction

Call No: 621.38152P615s1989
Authors: Pierret, Robert F./Neudeck, G.W.
Title: Modular Series on Solid State Devices, Volumes 1-4

Call No: 537.622N26S
Authors: Neamen, Donald A.
Title: Semiconductor Physics and Devices

Modern Semiconductor Devices for Integrated Circuits
Chenming C. Hu
2009, First Edition, 384 pages (not yet in Grainger)

Free online textbook, see: http://ecee.colorado.edu/~bart/book/contents.htm
By Prof. Bart Van Zeghbroeck at the University of Colorado

Requirements of the Course

Class Etiquette: Students are strongly encouraged to study the assigned material before class to help better understand the material being discussed, attend class regularly, be attentive, and ask questions. There is a strong correlation between completing the required work satisfactorily and your grade – don't miss an assignment as a "0" is difficult to overcome. For in-person classes electronic devices can be a source of distraction to you and for the fellow students around you so please be respectful and don't use them in class.

Homework: You will need a scientific calculator for the homework. The homework will consist of several types of problems: There will be a few simple problems to illustrate and reinforce the concepts covered in the assigned reading and lectures, and derivations of equations given in the textbook or in class. Another type of problem that is important in developing the understanding of semiconductor devices and their applications is the application or extension of the concepts that have been studied to new situations. Occasionally, a problem will be assigned on topics that are not studied in class. This type of problem is probably the most important because it teaches the student how to learn new material on their own, an ability that will be essential for a successful career in electrical or computer engineering. Another type of problem that will be assigned on certain topics is the design problem, where judgment must be used and there may be a number of acceptable answers. The final type of problem is the computer-based problem in which the variation of a particular quantity can be plotted as a function of some variable for different parameters. Examples are the variation of the free electron concentration in a semiconductor sample as a function of temperature for different values of the doping concentrations, N_D and N_A, and the characteristics of a field effect transistor where the drain current is plotted as a function of the drain voltage for different values of the gate voltage. These types of problems are tedious to analyze using a simple calculator, but are trivial using a computer and plotting routines.

If you have not already acquired the ability to write simple computer programs and produce computer generated graphs using Mathematica, Excel, Matlab, MathCAD, or some other program, this ability should be acquired in the first four weeks of the course.

The homework will typically be assigned on Friday and must be submitted the following Friday, unless otherwise specified. In the Spring 2021 term if a homework assignment occurs during a week with a designated day off (break day related to modified Spring Semester schedule due to COVID), homework will be due on Monday as opposed to Friday. All homework will be submitted online via Compass. Late homework will NOT be accepted. Only the top 10 of the 11 assigned homework assignments will count toward the course grade, but you are encouraged to do all assignments to best prepare for the exams and final.

Homework Guidelines:
Homework must be done on 8-1/2 x 11 paper. The pages must be numbered, and the following information must be on the first page: (1) your name, (2) Net ID #, (3) assignment number, date, (4) class section, and (5) instructor's name. The homework must be neat and easily readable, in pen, dark pencil, or computer output, and **all work leading to your answer must be shown.**

Homework format: The solution to each homework or exam problem *must* include all of the following that are appropriate for the particular problem:

- A diagram and/or the equations required for the problem.
- Solution of the equations for the appropriate quantities, using only variable symbols.
- In the final expression, numbers and units must be substituted. Note: units for each physical quantity in the equation must be *explicitly* included.

The units of the quantity in the final answer must be converted to those desired by using unity multiplication factors. ***The units commonly used in semiconductor device work are those in the SI system of units, with the exception that it is common to use centimeters - cm (10^{-2} m) or sometimes microns - μm (10^{-6} m), instead of meters for length measurements, and cm^3 rather than m^3 for volume measurements.***

Finally, and only after all of the above have been done, use a calculator to complete the necessary numerical calculations, and then **draw a box around your answer.**

Significant Figures: In the calculation of quantities from theoretical models or from experimental measurements, it is important to be aware of in the number of significant figures that are meaningful in your final result:

(1) If an expression involves the product or quotient of several quantities, the number of significant figures retained in the answer should only be as many as the number of significant figures in the least precise quantity used in the calculation (unless this leads to an answer which does not make physical sense or does not properly answer the question – see note below).

(2) If a calculation involves sums and differences, the number of significant figures retained should be determined by the smallest number of decimal places in any term in the expression: e.g., 12.5 + 1.3295 = 13.8.

(3) **For calculations in this course, assume that the quantities given are sufficiently accurate to justify retaining at least three significant figures in your final result.**

Display your results in the form of a graph whenever appropriate.

Note: Your answer must make physical sense – **if you have questions regarding the number of significant figures in a specific problem you should ask**.

You will not receive **full** credit for a homework or exam problem unless all of these requirements are complied with. If we cannot read your work on the homework or exams, you will receive zero credit!

You are encouraged to work together and discuss the homework assignments, but not to share completed answers. Please see the professors and/or the TAs during their office hours for assistance on material or homework problems that you do not understand. If you are having difficulty with a particular topic, try reading about the same topics in the books that are available for ECE 340 in the Grainger Engineering Library (See the list on page 4). ***However, the homework assignments that you turn in must be your own work and not copied from someone else's solutions. (Copying someone else's solution and submitting it as your own is cheating!)***

Note: Homework or exam problems that are illegible or difficult to read and follow, or do not include the appropriate units explicitly, will not receive full credit.

Be neat!

Quizzes, Exams, and Grading

Midterms & Final: There will be two 110-minute exams and a comprehensive 3-hour final exam. Both exams and the final exam will consist of several problems or questions. The exams will be closed book. An equation sheet and the physical parameters and constants that are required in the solutions will be provided with the exam, not before. Equation sheets will not be provided for quizzes. The exams are given in the evening at the dates and times shown in the syllabus. The format of your exam solutions should be the same as that used for the homework assignments: units must be shown explicitly, your answer must be circled and your work must be readable. Numerical answers should contain three significant figures unless more are justified by the given data. The final exam is a three hour combined exam, which will be given at a time to be scheduled.

Hour Exam I:	**Tuesday March 9th, 7:00 - 8:50 pm, CBTF**
Hour Exam II:	**Thursday April 15th, 7:00 - 8:50 pm, CBTF**
Final Exam:	**Thursday May 13th, 1:30 – 4:30 pm, CBTF**

Students need to register with CBTF to take the exam. Conflicts need to be approved by the course director, Prof. Dallesasse.

Exams are proctored by CBTF and therefore must follow CBTF policies. A key point is that the rules related to exam submission (uploading images of your written pages) must be followed. CBTF will compare the time you log off of the Zoom proctoring session to the time images are uploaded to look for discrepancies. You must upload your exam images under proctor supervision.

Grading Criteria: Your grade in ECE 340 is based primarily on your scores on the homework assignments, midterm exams, final exam, and your class participation as follows:

Final Score = Homework + Quizzes + Midterm + Final Exam score as follows:

Homework =	20% (top 10 of 11)
Midterm Exam I =	22%
Midterm Exam II =	22%
Final Exam =	36%
Total =	100%

Letter grades will be assigned to different ranges of the Final Scores at a meeting of the course staff at the end of the semester. Plus and minus grades may be given to the highest and lowest 1/3 in each letter grade range.

Study the material ahead of time, attend class, pay attention and ask questions! Your performance and contributions in class will help you learn the material. Because of this grading procedure, **it is not possible to accurately determine your letter grade from your scores before the course is completed.** We can, however, provide your rank in the class as a whole upon request.

As a guide, the grade distributions for the last semesters are given below:

Spring 2018:	26% A's	28% B's	29% C's	12% D's	5% F's
Fall 2018:	26% A's	29% B's	23% C's	13% D's	9% F's
Spring 2019:	25% A's	32% B's	30% C's	8% D's	5% F's
Fall 2019:	25% A's	27% B's	26% C's	13% D's	8% F's
Fall 2020:	23% A's	32% B's	28% C's	10% D's	8% F's

From this grade distribution, you can make a rough estimate how you are doing throughout the semester by obtaining your percentile ranking from the TAs. Any questions regarding course grading should be addressed to Professor J. Dallesasse.

The topics covered in this course build on each other, so what you learn early in the course will be needed to understand later topics. Therefore, keep up with the schedule, study the daily assignments, do the homework, and don't get behind. The material for this course is covered in a number of textbooks listed on page 4 that are available in the Engineering Library. If a subject is not understood clearly try another book or attend office hours. Be resourceful!

Course Policy on Absences

If you miss a quiz, exam, or homework assignment the following procedures apply:
1) Do not come to the in-person section if you feel ill.
2) Absences for specific university-sponsored events outlined in the student code that impact your ability to take an exam **must be pre-arranged** with the course coordinator, Prof. Dallesasse. Upon verification that the excuse is valid and complies with the UIUC Student Code, the course coordinator will issue an excused absence. **Pre-arranged excused absences will not be given for exams or the final except in the case of specific university-related events as described in the UIUC Student Code.**
3) Excused absences are not given for missed homework assignments, as only the top 10 of the 11 assigned homework assignments count towards the course grade.
4) In the event of severe illness, you must receive an Excused Absence from the Undergraduate College Office, Room 207 Engineering Hall, indicating what work you have missed and the reason for the absence. This absence must be approved by the Office of the Dean of Students (Emergency Dean) for an excuse due to personal illness, family emergencies, or other uncontrollable circumstances. The office may be reached at 333-0050.

For missed classes or hour exams, e-mail the excused absence letter to the course director Prof. Dallesasse and your instructor as possible after you return.

Scores on hour exams missed due to excused absences **will not be made up** if the exam cannot be taken within a reasonable time after the regular exam**.** Your grade will be determined based on the average of the grades that you have completed in that case. Specifically, the average of your completed scores will be used to determine the total, homework or hour exam score and the final total score.

Work missed due to an unexcused absence will be counted as a 0.

You **must** take the final exam to receive a grade for the course. If you miss the final exam for a legitimate reason, you will automatically receive a final course grade of INCOMPLETE. In this case to complete the course, you must make arrangements through your Dean's office and with the instructor to take a makeup final exam that will be given at the scheduled time at the end of the following semester. An unexcused absence from the final will result in a grade of "0" on the final.

Students with Disabilities

Students with disabilities who may qualify for extra time while taking tests must provide a current DRES letter to the course coordinator (John Dallesasse) and their section instructor immediately. Specific arrangements will be made on a case-by-case basis.

Grainger College of Engineering Syllabus Statements:

The following statements reflect the policies of the College and have been provided for inclusion in course syllabi:

COVID
Following University policy, all students are required to engage in appropriate behavior to protect the health and safety of the community, including wearing a facial covering properly, maintaining social distance (at least 6 feet from others at all times), disinfecting the immediate seating area, and using hand sanitizer. Students are also required to follow the campus COVID-19 testing protocol.

Students who feel ill must not come to class. In addition, students who test positive for COVID-19 or have had an exposure that requires testing and/or quarantine must not attend class. The University will provide information to the instructor, in a manner that complies with privacy laws, about students in these latter categories. These students are judged to have excused absences for the class period and should contact the instructor via email about making up the work.

Students who fail to abide by these rules will first be asked to comply; if they refuse, they will be required to leave the classroom immediately. If a student is asked to leave the classroom, the non-compliant student will be judged to have an unexcused absence and reported to the Office for Student Conflict Resolution for disciplinary action. Accumulation of non-compliance complaints against a student may result in dismissal from the University.

Emergency Response Recommendations
Emergency response recommendations can be found at the following website: http://police.illinois.edu/emergency-preparedness/. I encourage you to review this website and the campus building floor plans website within the first 10 days of class. http://police.illinois.edu/emergency-preparedness/building-emergency-action-plans/.

Academic Integrity
The University of Illinois at Urbana-Champaign Student Code should also be considered as a part of this syllabus. Students should pay particular attention to Article 1, Part 4: Academic Integrity. Read the Code at the following URL: http://studentcode.illinois.edu/.

Academic dishonesty will result in a sanction proportionate to the severity of the infraction, with possible sanctions described in 1-404 of the Student Code (https://studentcode.illinois.edu/article1/part4/1-404/). Every student is expected to review and abide by the Academic Integrity Policy as defined in the Student Code: https://studentcode.illinois.edu/article1/part4/1-401/. As a student it is your responsibility to refrain from infractions of academic integrity and from conduct that aids others in such infractions. A short guide to academic integrity issues may be found at https://provost.illinois.edu/policies/policies/academic-integrity/students-quick-reference-guide-to-academic-integrity/. Ignorance of these policies is not an excuse for any academic dishonesty. It is your responsibility to read this policy to avoid any misunderstanding. Do not hesitate to ask the instructor(s) if you are ever in doubt about what constitutes plagiarism, cheating, or any other breach of academic integrity.

In this course you are expected to produce your own work in all assignments. Where appropriate written assignments will be submitted through SafeAssign, a software tool that compares your writing against a large database as well as to the work of your current classmates and previously submitted assignments. Assignments with close matches to other work will be flagged and investigated.

Unless otherwise informed, the use of calculators or electronic devices (cell phones or others) will not be allowed during examinations. If you are found using one, it will be investigated as potential cheating.

Anti-Racism and Inclusivity Statement

The Grainger College of Engineering is committed to the creation of an anti-racist, inclusive community that welcomes diversity along a number of dimensions, including, but not limited to, race, ethnicity and national origins, gender and gender identity, sexuality, disability status, class, age, or religious beliefs. The College recognizes that we are learning together in the midst of the Black Lives Matter movement, that Black, Hispanic, and Indigenous voices and contributions have largely either been excluded from, or not recognized in, science and engineering, and that both overt racism and micro-aggressions threaten the well-being of our students and our university community.

The effectiveness of this course is dependent upon each of us to create a safe and encouraging learning environment that allows for the open exchange of ideas while also ensuring equitable opportunities and respect for all of us. Everyone is expected to help establish and maintain an environment where students, staff, and faculty can contribute without fear of personal ridicule, or intolerant or offensive language. If you witness or experience racism, discrimination, micro-aggressions, or other offensive behavior, you are encouraged to bring this to the attention of the course director if you feel comfortable. You can also report these behaviors to the Bias Assessment and Response Team (BART) (https://bart.illinois.edu/**).** Based on your report, BART members will follow up and reach out to students to make sure they have the support they need to be healthy and safe. If the reported behavior also violates university policy, staff in the Office for Student Conflict Resolution may respond as well and will take appropriate action.

Disability-Related Accommodations

To obtain disability-related academic adjustments and/or auxiliary aids, students with disabilities must contact the course instructor and the Disability Resources and Educational Services (DRES) as soon as possible. To contact DRES, you may visit 1207 S. Oak St., Champaign, call 333-4603, e-mail disability@illinois.edu or go to https://www.disability.illinois.edu. If you are concerned you have a disability-related condition that is impacting your academic progress, there are academic screening appointments available that can help diagnosis a previously undiagnosed disability. You may access these by visiting the DRES website and selecting "Request an Academic Screening" at the bottom of the page.

Family Educational Rights and Privacy Act (FERPA)

Any student who has suppressed their directory information pursuant to Family Educational Rights and Privacy Act (FERPA) should self-identify to the instructor to ensure protection of the privacy of their attendance in this course. See https://registrar.illinois.edu/academic-records/ferpa/ for more information on FERPA.

Religious Observances

Illinois law requires the University to reasonably accommodate its students' religious beliefs, observances, and practices in regard to admissions, class attendance, and the scheduling of examinations and work requirements. You should examine this syllabus at the beginning of the semester for potential conflicts between course deadlines and any of your religious observances. If a conflict exists, you should notify your instructor of the conflict and follow the procedure at https://odos.illinois.edu/community-of-care/resources/students/religious-observances/ to request appropriate accommodations. This should be done in the first two weeks of classes.

Sexual Misconduct Reporting Obligation
The University of Illinois is committed to combating sexual misconduct. Faculty and staff members are required to report any instances of sexual misconduct to the University's Title IX Office. In turn, an individual with the Title IX Office will provide information about rights and options, including accommodations, support services, the campus disciplinary process, and law enforcement options.
A list of the designated University employees who, as counselors, confidential advisors, and medical professionals, do not have this reporting responsibility and can maintain confidentiality, can be found here: wecare.illinois.edu/resources/students/#confidential.

Other information about resources and reporting is available here: wecare.illinois.edu.

Spring 2021 ECE 340 COURSE SCHEDULE AND OUTLINE			
Class #	**Date**	**Topic**	**Assigned §'s - Study from Streetman**
1	M 01/25	**Introduction to the course and general introduction to semiconductor electronics**	**Read Info Packet**
2	W 01/27	**General introduction to semiconductor electronics (cont'd)**	
3	F 01/29	**Semiconductors, crystal structure** *1.1Solid-State Materials* *1.2 Crystal Lattices*	§'s 1.1, 1.2, Read §'s 1.3.1, 1.4
4	M 02/01	**Bonding forces and energy bands in solids** *3.1.1 Bonding Forces in Solids* *3.1.2 Energy Bands*	(Review topics in Chap. 2 from Phys. 214) §'s 3.1, 3.1.1, 3.1.2
5	W 02/03	**Energy bands (cont'd) and charge carriers in semiconductors** *3.1.3 Metals, Semiconductors, and Insulators* *3.2.1 Electrons and Holes*	§'s 3.1.3, 3.2.1
6	F 02/05	**Intrinsic material, extrinsic material** *3.2.3 Intrinsic Material* *3.2.4 Extrinsic Material*	§'s 3.2.3, 3.2.4 **HW1 Due**
7	M 02/08	**Distribution functions, Fermi-Dirac statistics, Maxwell-Boltzmann statistics, and carrier concentrations** *3.3.1 The Fermi level* *3.3.2 Electron and Hole Concentrations at Equilibrium*	§'s 3.3.1, 3.3.2
8	W 02/10	**Distribution functions, Fermi-Dirac statistics, Maxwell-Boltzmann statistics, and carrier concentrations (cont'd)** *3.3.1 The Fermi level* *3.3.2 Electron and Hole Concentrations at Equilibrium*	§'s 3.3.1, 3.3.2
9	F 02/12	**Carrier concentrations (cont'd) and temperature dependence** *3.3.3 Temperature Dependence of Carrier Concentrations* *3.3.4 Compensation and Space Charge Neutrality*	§'s 3.3.3, 3.3.4 **HW2 Due**
10	M 02/15	**Drift of carriers in electric fields** *3.4.1 Conductivity and Mobility*	§'s 3.4.1
	W 02/17	**Break Day (COVID)**	
11	F 02/19	**Resistance, temperature, impurity concentration,** *3.4.2 Drift and Resistance* *3.4.3 Effects of Temperature and Doping on Mobility*	§'s 3.4.2, 3.4.3,
12	M 02/22	**Invariance of the Fermi level at equilibrium** *3.5 Invariance of the Fermi Level at Equilibrium*	§'s 3.5 **HW3 Due (Extra Day)**
13	W 02/24	**Optical absorption and luminescence / carrier generation and recombination** *4.1 Optical Absorption* *4.3.1 Direct Recombination of Electrons and Holes*	§'s 4.1, 4.3.1

14	F 02/26	**Carrier generation and recombination (cont'd)** *4.3.1 Direct Recombination of Electrons and Holes* *4.3.3 Steady State Carrier Generation; Quasi-Fermi Level*	§'s 4.3.1, 4.3.3 **HW4 Due**
15	M 03/01	**Carrier generation and recombination (cont'd) and photo-conductivity** *4.3.3 Steady State Carrier Generation; Quasi-Fermi Level* *4.3.4 Photoconductive Devices*	§'s 4.3.3, 4.3.4
16	W 03/03	**Diffusion of carriers** *4.4.1 Diffusion Processes* *4.4.2 Diffusion and Drift of Carriers*	§'s 4.4, 4.4.1, 4.4.2
17	F 03/05	**Diffusion of carriers (cont'd)** *4.4.2 Diffusion and Drift of Carriers; Built-in Fields* *4.4.3 Diffusion and Recombination;*	§'s 4.4.2, 4.4.3 **HW5 Due**
18	M 03/08	**Review, discussion and problem solving**	
	Tu 03/09	**MIDTERM EXAM I** (Chaps. 1, 3, & 4, up to 4.4.2 included) **7:00 - 8:50 P.M.** combined sections, CBTF	
19	W 03/10	**Steady state carrier injection; diffusion length** *4.4.4 Steady State Carrier Injection; Diffusion Length*	§'s 4.4.4
20	F 03/12	**p-n junctions in equilibrium, contact potential** *5.1 Fabrication of p-n Junctions,(short intro)* *5.2 Equilibrium Condition* *5.2.1 The Contact Potential*	Read § 5.1 Study §'s 5.2, 5.2.1, 5.2.2
21	M 03/15	**p-n junctions in equilibrium, space charge** *5.2.2 Equilibrium Fermi Levels* *5.2.3 Space Charge at a Junction*	Study §'s 5.2, 5.2.1, 5.2.2, 5.2.3
22	W 03/17	**Space charge at a junction** *5.2.3 Space Charge at a Junction*	§ 5.2.3
23	F 03/19	**Current flow in a P-N junction** *5.3. Forward- and Reverse-Biased Junctions; Steady State Conditions* *5.3.1 Qualitative Description of Junction Current Flow*	§ 5.2.3, 5.3, 5.3.1 **HW6 Due**
24	M 03/22	**Carrier injection, the diode equation** *5.3.2 Carrier Injection*	§ 5.3.2
	W 03/24	**Break Day (COVID)**	
25	F 03/26	**Minority and majority carrier currents** *5.3.2 Carrier Injection* *5.3.3 Reverse Bias*	§'s 5.3.2, 5.3.3
26	M 03/29	**Reverse-bias breakdown** *5.4 Reverse-Bias Breakdown* *5.4.1 Zener Breakdown* *5.4.2 Avalanche Breakdown*	§'s 5.4, 5.4.1, 5.4.2 **HW7 Due (Extra Day)**
27	W 03/31	**Stored charge, diffusion capacitance, and junction capacitance** *5.5.4 Capacitance of p-n Junctions*	§'s 5.5.4

28	F 04/02	**Optoelectronic devices (photodiodes)** *8.1.1 Current and Voltage in an Illuminated Junction* *8.1.2 Solar Cells* *8.1.3 Photodetectors*	§'s 8.1.1, 8.1.2, 8.1.3 **HW8 Due**
29	M 04/05	**Optoelectronic devices (cont'd)** *8.2 Light-Emitting Diodes* *8.4 Semiconductor Lasers*	§'s 8.2.1, 8.2.2, 8.3, 8.4.1, 8.4.2, 8.4.3, 8.4.4, 8.4.5
30	W 04/07	**Metal semiconductor junctions** *5.7.1 Schottky Barrier* *5.7.2 Rectifying Contacts* *5.7.3 Ohmic Contacts*	§'s 5.7.1, 5.7.2, 5.7.3
31	F 04/09	**Metal-insulator-semiconductor FET** *6.4.1 Basic Operation* **Metal-insulator-semiconductor FET (Cont'd)** *6.4.2 The Ideal MOS Capacitor*	§'s 6.4.1, 6.4.2 **HW9 Due**
32	M 04/12	**MOS capacitor** *6.4.3 Flatband Voltage* *6.4.4 Threshold Voltage*	§'s 6.4.3, 6.4.4
	Tu 04/13	**Break Day (COVID)**	
33	W 04/14	**Review, discussion and problem solving**	
	Th 04/15	**MIDTERM EXAM II** (Chaps. 4.4, 5 & 8) **7:00 - 8:50 P.M.** combined sections, CBTF	
34	F 04/16	**MOS capacitor (Cont'd)** *6.4.5 MOS Capacitance-Voltage Analysis*	§'s 6.4.5
35	M 04/19	**MOS field-effect transistor** *6.5.1 Output Characteristics* *6.5.2 Transfer Characteristics*	§'s 6.5.1, 6.5.2
36	W 04/21	**MOSFET (Cont'd):** *Small-signal analysis* *Resistive load-NMOSFET-common-source amplifier* *CMOS inverter (Integrated Circuits)*	§'s 6.5.8, 9.3.1, 9.5.1
37	F 04/23	**Narrow-base diode** Handout on narrow-base diode	§'s handout on BJT **HW10 Due**
38	M 04/26	**Introduction to bipolar junction transistor** *BJT Fundamentals* *Relationship between narrow-based diode and BJT*	§'s 6.1.1, 6.1.2, 7.1, 7.2, 7.3 and handout
39	W 04/28	**Introduction to bipolar junction transistor** *BJT specifics*	§'s 7.3, 7.4.1, 7.4.2, 7.4.3, 7.4.4 and handout
40	F 04/30	**Introduction to bipolar junction transistor (cont'd)** *Normal mode operation*	§'s 7.3, 7.4.1, 7.4.2, 7.4.3, 7.4.4 and handout **HW11 Due**
41	M 05/03	**Bipolar junction transistor (Cont'd),** *Common-emitter amplifier and small-signal current gain*	§'s 7.4.1, 7.4.2, 7.4.3, 7.4.4 and handout
42	W 05/05	**Review, discussion and problem solving**	
		FINAL EXAM, (Chaps. 1, 3, 4, 5, 6, 7, 8, & 9) **Thursday, May 13, 1:30 – 4:30 pm, CBTF**	