

## Electron Theory in Solids

EMA 6110 Section 08EC (non-EDGE) and 11F3/11F4/2E14 (EDGE)

**Class Periods:** MWF, 6<sup>th</sup> period, 12:50-1:40pm

**Location:** NEB 102

**Academic Term:** Fall 2017

### **Instructor:**

Jiangeng Xue

[jxue@mse.ufl.edu](mailto:jxue@mse.ufl.edu)

846-3775

Office Hours: Fridays, 2-3pm, RHN 237, or by appointments

**Teaching Assistants:** N/A

### **Course Description**

Wave equation and its application to free electrons, bound electrons, and electrons in crystals. Electron-band theory and its applications. Electrical properties of metals, alloys, and semiconductors, heat capacity and thermal properties. 3 credit hours

### **Course Pre-Requisites / Co-Requisites**

EMA 3010, PHY 2049, and MAP 2302, or equivalents

### **Course Objectives**

Understanding the fundamental electronic/electrical, dielectric, optical, and magnetic properties of solid materials

### **Materials and Supply Fees**

N/A

### **Required Textbooks and Software**

- "Principles of Electronic Materials and Devices," by S. O. Kasap, McGraw Publishing, 3rd edition, ISBN 0073104647
- "Solid State Physics for Engineering & Materials Science," by John McKelvey, Krieger Publishing, ISBN 0-89464-436-X

### **Recommended Materials**

- N/A

### **Course Schedule**

Table below is a list of topics to be covered in the lectures along with the corresponding reading assignment in the textbooks. This list is subject to change.

Section subject	Lecture no.	Lecture topic	Reading assign. (Kasap, 3rd ed.)	Reading assign. (McKelvey)
Electrons and Classical Physics	1	Review of Crystalline Properties	<b>1-81</b>	1-56
Classical electron theory	2	Free electrons in metals	<b>113-145</b>	267-285
	3	Electrons and bonding in crystalline solids		56-69
	4	Quantum vs. classical mechanics	191-205	<b>106-117</b>
Quantum Mechanics	5	Intro to wave mechanics	205-212	<b>28-33, 63-74</b>
	6	The quantum mechanics formalism and Schrödinger's eqn		<b>117-129</b>
	7	Solution for free electron		<b>129-134</b>
	8	Infinite and finite potential wells	212-231	<b>134-145</b>

	9	Particle incident on step barrier		<b>145-150</b>
	10	Quantum harmonic oscillator		<b>150-163</b>
	11	Hydrogen atom	231-254	<b>164-174</b>
	12	Pauli exclusion principle and the periodic potential		<b>177-181</b>
Statistical Mechanics	13	Intro to statistical mechanics	285-303	<b>187-192</b>
	14	Density of states for "confined" free particle		<b>192-196</b>
	15	Maxwell-Boltzmann statistics	303-315	<b>199-214</b>
	16	Fermi-Dirac statistics		<b>214-224</b>
Q.M. for crystals	17	Periodic crystal lattices		<b>315-321</b>
	18	Kronig-Penney Model		<b>321-327</b>
	19	Crystal momentum and effective mass	303-305	<b>328-333</b>
	20	Band structure		<b>361-367</b>
Semiconductor properties	21	Intrinsic semiconductors	<b>373-388</b>	<b>372-380</b>
	22	Extrinsic semiconductors	<b>388-396</b>	<b>381-385</b>
	23	Quantitative derivation of carrier density	<b>396-424</b>	<b>385-393</b>
	24	Conductivity and Hall effect		<b>306-308, 393-402</b>
	25	pn junction physics	<b>476-494</b>	<b>443-457</b>
	26	Pn junction as rectifier	<b>494-506</b>	<b>458-467</b>
	27	Junction between dissimilar materials		
Dielectric materials	28	Dielectric materials	<b>583-593</b>	
	29	Clausius-Mosotti relationship	<b>593-595</b>	
	30	Dielectric properties in alternating field	<b>597-603</b>	
	31	Frequency and temperature dependence	<b>603-614</b>	
	32	Ferroelectricity and piezoelectricity	<b>638-654</b>	
Magnetic properties	33	Intro. to magnetism	<b>685-705</b>	
	34	Paramagnetism and diamagnetism		
	35	Ferromagnetism and Antiferromagnetism		
	36	Microscopic theory and quantum models		
Optical properties	37	Electromagnetic waves and polarization	<b>773-804</b>	
	38	Optical dielectric function	<b>804-825</b>	
	39	Non-linear polarization	<b>825-841</b>	

### **Attendance Policy, Class Expectations, and Make-Up Policy**

Sections of this course are offered on UF EDGE. The lecture videos are available on the UF e-Learning (Canvas) website for all students (not just those who registered for the EDGE section) to review at any time. However, attendance is strongly encouraged for all non-EDGE students to enhance classroom learning and interaction. Special conditions for absence will be accepted only with prior approval by the instructor. Electronic devices are allowed in classroom as long as they do not cause a distraction to other students. Cellular phones should be turned off or put to silent.

Excused absences are consistent with university policies in the undergraduate catalog (<http://gradcatalog.ufl.edu/content.php?catoid=10&navoid=2020#attendance>) and require appropriate documentation. Except for emergencies, make-up exams are only allowed if requested at least one week before the regular exam time AND approved by the instructor. Make-up exams will differ from regularly-scheduled exams.

### **Evaluation of Grades**

<b>Assignment</b>	<b>Total Points</b>	<b>Percentage of Final Grade</b>
Homework Sets (~10)*	N/A	N/A

Exam 1	100	1/3
Exam 2	100	1/3
Exam 3	100	1/3
		100%

\* Homework will be assigned weekly, but not graded. Students are strongly recommended to solve the homework problems to enhance learning and seek help from the instructor during office hours if needed.

**Grading Policy**

The final letter grade will be assigned based on student’s overall performance in the course. The following scale will be used as a guideline:

Percent	Grade	Grade Points
90.0 – 100.0	A	4.00
86.0 – 89.9	A-	3.67
82.0 – 85.9	B+	3.33
79.0 – 81.9	B	3.00
76.0 – 78.9	B-	2.67
73.0 – 75.9	C+	2.33
70.0 – 72.9	C	2.00
67.0 – 69.9	C-	1.67
64.0 – 66.9	D+	1.33
61.0 – 63.9	D	1.00
60.0 – 60.9	D-	0.67
0 – 59.9	E	0.00

In order to graduate, graduate students must have an overall GPA and a major GPA of 3.00 or better (B or better). Note: a B- average is equivalent to a GPA of 2.67, and therefore, it does not satisfy this graduation requirement. More information on UF grading policy may be found at:

<http://gradcatalog.ufl.edu/content.php?catoid=10&navoid=2020#grades>

**Students Requiring Accommodations**

Students with disabilities requesting accommodations should first register with the Disability Resource Center (352-392-8565, <https://www.dso.ufl.edu/drc>) by providing appropriate documentation. Once registered, students will receive an accommodation letter which must be presented to the instructor when requesting accommodation. Students with disabilities should follow this procedure as early as possible in the semester.

**Course Evaluation**

Students are expected to provide feedback on the quality of instruction in this course by completing online evaluations at <https://evaluations.ufl.edu/evals>. Evaluations are typically open during the last two or three weeks of the semester, but students will be given specific times when they are open. Summary results of these assessments are available to students at <https://evaluations.ufl.edu/results/>.

**University Honesty Policy**

UF students are bound by The Honor Pledge which states, “We, the members of the University of Florida community, pledge to hold ourselves and our peers to the highest standards of honor and integrity by abiding by the Honor Code. On all work submitted for credit by students at the University of Florida, the following pledge is either required or implied: “On my honor, I have neither given nor received unauthorized aid in doing this assignment.” The Honor Code (<https://www.dso.ufl.edu/sccr/process/student-conduct-honor-code/>) specifies a number of behaviors that are in violation of this code and the possible sanctions. Furthermore, you are obligated to report any condition that facilitates academic misconduct to appropriate personnel. If you have any questions or concerns, please consult with the instructor or TAs in this class.

### **Software Use**

All faculty, staff, and students of the University are required and expected to obey the laws and legal agreements governing software use. Failure to do so can lead to monetary damages and/or criminal penalties for the individual violator. Because such violations are also against University policies and rules, disciplinary action will be taken as appropriate. We, the members of the University of Florida community, pledge to uphold ourselves and our peers to the highest standards of honesty and integrity.

### **Student Privacy**

There are federal laws protecting your privacy with regards to grades earned in courses and on individual assignments. For more information, please see: <http://registrar.ufl.edu/catalog0910/policies/regulationferpa.html>

### **Campus Resources:**

#### Health and Wellness

##### **U Matter, We Care:**

If you or a friend is in distress, please contact [umatter@ufl.edu](mailto:umatter@ufl.edu) or 352 392-1575 so that a team member can reach out to the student.

**Counseling and Wellness Center:** <http://www.counseling.ufl.edu/cwc>, and 392-1575; and the University Police Department: 392-1111 or 9-1-1 for emergencies.

##### **Sexual Assault Recovery Services (SARS)**

Student Health Care Center, 392-1161.

**University Police Department** at 392-1111 (or 9-1-1 for emergencies), or <http://www.police.ufl.edu/>.

#### Academic Resources

**E-learning technical support**, 352-392-4357 (select option 2) or e-mail to [Learning-support@ufl.edu](mailto:Learning-support@ufl.edu).  
<https://lss.at.ufl.edu/help.shtml>.

**Career Resource Center**, Reitz Union, 392-1601. Career assistance and counseling. <https://www.crc.ufl.edu/>.

**Library Support**, <http://cms.uflib.ufl.edu/ask>. Various ways to receive assistance with respect to using the libraries or finding resources.

**Teaching Center**, Broward Hall, 392-2010 or 392-6420. General study skills and tutoring.  
<https://teachingcenter.ufl.edu/>.

**Writing Studio**, 302 Tigert Hall, 846-1138. Help brainstorming, formatting, and writing papers.  
<https://writing.ufl.edu/writing-studio/>.

**Student Complaints Campus:** [https://www.dso.ufl.edu/documents/UF\\_Complaints\\_policy.pdf](https://www.dso.ufl.edu/documents/UF_Complaints_policy.pdf).

**On-Line Students Complaints:** <http://www.distance.ufl.edu/student-complaint-process>.