Electrical and Computer Engineering
ECE 874: Physical Electronics
Fall 2019 Syllabus

Part 1: Course Information

Instructor Information

Instructor: Tim Hogan
Office: C136 (Engineering Research Complex)
Class Times: Tuesdays and Thursdays 8:30am-9:50am, Room 2205 EB
and online (asynchronously)
Office Hours:
In person: Mondays and Wednesdays 4:00pm-5:00pm, Thursdays 10:00am-11:00am, Room 2308A EB
Online: Wednesdays 7:30pm – 8:30pm (D2L Zoom/Discussion Board)
Office Telephone: 517-432-3176
E-mail: hogant@egr.msu.edu (Note: "I plan to reply to all emails within 48 hours")

Course Description

Applications of quantum mechanics and statistical mechanics in solids: Lattice dynamics, energy bands, equilibrium/non-equilibrium properties, charge scattering and transport in semiconductors.

Prerequisite

None.

Textbook & Course Materials

Solid State Physics for Engineering and Materials Science, by John P. McKelvey, Krieger Publishing Company, Malabar, FL, (2003). ISBN: 978-0894644368

Course Pack consists of Chapter 1 from: *Principles of Electronic Materials and Devices*, by S. O. Kasap. See instructions for purchase and download provided on the course website.

Recommended Texts & Other Readings

1. *Solid State Physics for Engineering and Materials Science*, by John P. McKelvey (QC176 .M38 2003)
2. *Principles of Electronic Materials and Devices*, by S. O. Kasap (TK453 .K26 2002)
3. *Advanced Semiconductor Fundamentals*, by R. F. Pierret (TK7871.85 .P483 2003)
4. *Physics of Semiconductor Devices*, by S. M Sze (TK7871.85 .S988 1981)
5. *Introduction to Solid State Physics*, by C. Kittel (QC176 .K5 1996)

Course Requirements

- Internet connection (DSL, LAN, or cable connection desirable)
- Access to Desire2Learn (D2L).

Course Structure

This course will be delivered online through the course management system and you will need your MSU NetID to login to the course from the D2L homepage (http://d2l.msu.edu).

In D2L, you will access online lessons, course materials, and additional resources. Activities will include reading, watching video lectures, watching video examples, participation in discussion forums, online group projects using MATLAB.

Technical Assistance

If you need technical assistance at any time during the course or to report a problem you can:

- Visit the Distance Learning Services Support Site
- Visit the Desire2Learn Help Site (http://help.d2l.msu.edu/)
- Or call Distance Learning Services: (800) 500-1554 or (517) 355-2345

Resource Persons with Disabilities (RCPD)

- To make an appointment with a specialist, contact: (517) 353-9642
  Or TTY: (517) 355-1293
- Web site for RCPD: http://MYProfile.rcpd.msu.edu

Part 2: Course Objectives

At the completion of this first graduate level course in solid state, the students should be able to:

- Explain in terms a bright undergraduate student could understand the basic concepts in quantum mechanics,
- Identify common semiconductor crystal structures,
- Select compatible semiconductor materials used in bandgap engineering and justify the selection
- Explain in terms a bright undergraduate student could understand the basic concepts of lattice vibrations, and their influences on several material properties
- Calculate energy bands in a free electron model for simple crystal structures
- Extract material properties such as effective mass, or energy bandgap from given energy band diagrams
- List common charge carrier scattering mechanisms and explain the movement of charge carriers under equilibrium and non-equilibrium conditions in different materials
- Explain the process of literature searching and report writing on a course-related research topic

You will meet the objectives listed above through a combination of the following activities in this course:

- Exam I (closed book) [100 points total]
  - This exam will be written and graded by the instructor, and will consist of four parts and covering a portion of the course material. The first part is meant for broad coverage of the material and short answer type question such as true/false, matching, fill-in-the-blank, or short answer type questions. The remaining three parts are meant for more in-depth coverage typically consisting of problems to be worked out, or properly set up the problems in a manner that could be calculated if there were more time available.

- Final Exam (closed book) [150 points total]
  - This exam will be written and graded by the instructor, and will consist of six parts and covering material for the entire course (comprehensive). The first question is meant for broad coverage of the material and short answer type question such as true/false, matching, fill-in-the-blank, or short answer type questions. The remaining four questions are meant for more in-depth coverage typically consisting of problems to be worked out, or properly set up the problems in a manner that could be calculated if there were more time available.

- Homework [10 points per homework question]
  - Working out the problems and putting pencil to paper is an essential component of learning. The purpose of the homework is to apply the concepts from the lectures and reading material so as to reinforce those concepts and to help identify

areas where further learning is needed. You are encouraged to contact the instructor with questions you have regarding these homework problems, but you should do your own work in solving these problems. The course grade for this component will be calculated as the ratio of total points earned for all homework questions divided by the total points possible for all homework questions in the course.

- Group Projects
  - These project problems will be group efforts (~ 4 students per group). The projects will consist of more involved questions, typically with a MATLAB simulation or calculation component, other times might be to submit a report that explains a course topic in greater detail. Grading of these projects will include 50% for the project deliverables, 30% for project writeup, and 20% for group participation that will be determined based on your involvement in a group discussion board (through D2L) for the project, and group self-assessment.

Part 3: Course Outline/Schedule

Important Note: Refer to the course calendar for specific meeting dates and times. Activity and assignment details will be explained in detail within each week's corresponding learning module. If you have any questions, please contact your instructor.

Approximate Timeline:

Week	Day	Date	Topics Covered	Readings	Assign.
1	Th	8/29	Module 1: Introduction and Website Navigation	---	
2	Tu	9/3	Module 2: Atomic Bonding Module 3: Dulong Petit Law	Course Pack: sect. 1.1-1.3 Textbook: section 6.6	HW1 assigned
	Th	9/5	Module 3: Dulong Petit Law Module 4: Drude Model, Nordheim's Rule, and the Wiedemann-Franz Law	Course Pack: sect. 1.4-1.6 Textbook: sections 6.1-6.2 Textbook: sections 7.1-7.2	
3	Tu	9/10	Module 5: Crystals Module 6: Crystal Structures	Course Pack: sect. 1.7-1.12	HW1 due
	Th	9/12	Module 6: Crystal Structures Module 7: Miller Indices and Reciprocal Lattice	Textbook: sections 1.1-1.7	
4	Tu	9/17	Module 8: X-Ray and Bragg Diffraction Module 9: X-Ray Analysis Structure Factor	Textbook: sections 2.1-2.5	HW2 due
	Th	9/19	Module 9: X-Ray Analysis Structure Factor Module 10: Lattice Vibrations	Textbook: sections 3.1-3.3	
5	Tu	9/24	Module 11: Phonon Dispersions and DOS Module 12: Diatomic 1D Lattice Dynamics	Textbook: sections 3.4-3.7	HW3 due
	Th	9/26	Module 12: Diatomic 1D Lattice Dynamics Module 13: Dispersion in a 2D Lattice	Textbook: sect. 3.8-3.11	
6	Tu	10/1	Module 14: Force Constant Models Module 15: Introduction to Quantum Mechanics	Textbook: sections 4.1-4.4	Project 1 due
	Th	10/3	Module 15: Introduction to Quantum Mechanics Module 16: Wave Particle Duality	Textbook: sections 4.5-4.7	
7	Tu	10/8	Module 17: Schrödinger's Equation Module 18: Infinite Well and Finite Well	Textbook: sections 4.8-4.9	HW4 due
	Th	10/10	Module 18: Infinite Well and Finite Well Module 19: Single Barrier and Tunnel Barrier	Textbook: sect. 4.10-4.11	
8	Tu	10/15	Review		
	Th	10/17	Exam1 (8:30am room 2205 EB)		
9	Tu	10/22	Module 20: Harmonic Oscillator Module 21: Atomic Orbitals	Textbook: sect. 4.12-4.15	
	Th	10/24	Module 21: Atomic Orbitals Module 22: Kronig-Penney Model	Textbook: sections 8.1-8.3	HW5 due
10	Tu	10/29	Module 23: Energy Bands Module 24: Energy Bands in 1D, 2D, and 3D Lattices	Textbook: sections 8.4-8.5	
	Th	10/31	Module 24: Energy Bands in 1D, 2D, and 3D Lattices Module 25: Models for Energy Bands	Textbook: section 8.6	HW6 due

Week	Day	Date	Topics Covered	Readings	Assign.
11	Tu	11/5	Module 26: Effective Mass and DOS Module 27: Statistics MB, BE, FD	Textbook: section 8.4 Textbook: sections 5.1-5.8	
	Th	11/7	Module 27: Statistics MB, BE, FD Module 28: Carrier Concentrations	Textbook: section 9.1	Project 2 due
12	Tu	11/12	Module 29: Energy Surfaces & Non-Equilibrium Module 30: Boltzmann Transport Equation	Textbook: sections 9.7-9.8	
	Th	11/14	Module 30: Boltzmann Transport Equation Module 31: Generalized Boltzmann Eqn.	Textbook: sections 7.3-7.6	HW7 due
13	Tu	11/19	Module 32: Thermal & Electrical Transport Module 33: Equilibrium & Non-Equilib.	Textbook: section 9.8	
	Th	11/21	Module 34: Einstein & Debye Specific Heat Module 35: Thermal Conductivity, and Heat Capacity	Textbook: sect. 6.3 – 6.5	
14	Tu	11/26	Module 35: Thermal Conductivity, and Heat Capacity Module 36: Hall Effect Measurement	Articles provided	
	Th	11/28	Holiday – University Closed		
15	Tu	12/3	Module 37: Thermopower Measurement Module 38: Nernst Effect Measurement	Articles provided	
	Th	12/5	Module 39: Onsagar Relations Review	Articles provided	Project 3 due
		12/10	Final Exam (7:45am room 2205 EB)	Comprehensive	

Part 4: Grading Policy

Graded Course Activities

The table below describes the percentage that each graded course activity contributes toward your course grade.

Percentage of Course Grade	*Description*
20%	*Exam 1*
20%	*Homework*
10%	*Group Project 1*
10%	*Group Project 2*
10%	*Group Project 3*
30%	*Final Exam*
100%	Total

Late Work Policy

Late work cannot be accepted after solutions are posted and a grade of zero for that assignment will be entered in the gradebook in this case. Work that is late, but before the solutions are posted will receive a 20% deduction if received within one day after being late, and additional 20% deduction for every day late after that.

Viewing Grades

Assignments will be graded by the instructor and the grades for each assignment will be entered in the course website in D2L. Grading marks on the assignments can be viewed within the Feedback area for each assignment where a scanned version of the graded assignment can be found. Assignments will be graded within approximately 7-10 days after turning them in.

Proctored Testing

Students taking this course have four options for taking exams: The MSU Testing Center, a NCTA testing site, an approved proctor near you, or coming to MSU and taking the exam(s) with the on-campus students.

Exams can be taken at a convenient location near you by obtaining an approved proctor for the exam. Information regarding proctoring can be found at: (https://www.egr.msu.edu/graduate/taking-exams).

Students will identify and will need approval for an on-site proctor.
Options for obtaining a proctor:

1. *The Michigan State University Testing Center (https://testingcenter.msu.edu/)*
2. *National College Testing Association (NCTA) (https://www.ncta-testing.org/cctc)*
3. *A proctor of your choosing who is one of the following:*
   - *Local college or university faculty member*
   - *Test administrator at a professional testing center*
   - *Librarian at a public or school library*
   - *Military officer (only for members of the military and their spouses)*
   - *Corporate education coordinator or human resources representative at your place of employment*

Please Note: depending on the option you choose, there may be a cost per exam.
The proctor approval form can be found here:
https://www.egr.msu.edu/graduate/form/proctor-approval-form

Letter Grade Assignment (Grading Scale)

Grading will be based on the following scale. Exams will be out of 100 points. Homework problems (each problem) will be worth 10 points. The grade for any assignment, or problem within an assignment, can be determined by normalizing to the 100 point scale below.

Score (out of 100)	Letter Grade	Grade (4.0 scale)
90.1-100	A	4.0
85.1-90	B+	3.5
80.1-85	B	3.0
75.1-80	C+	2.5
70.1-75	C	2.0
65.1-70	D+	1.5
60.1-65	D	1.0
≤ 60	F	0.0

Part 5: Course Policies

Participation

Students are expected to participate in all online activities as listed on the course calendar or in the individual assignments.

Inform Your Instructor of Any Accommodations Needed

From the Resource Center for Persons with Disabilities (RCPD): Michigan State University is committed to providing equal opportunity for participation in all programs, services and activities. Requests for accommodations by persons with disabilities may be made by contacting the Resource Center for Persons with Disabilities at 517-884-RCPD or on the web at rcpd.msu.edu. Once your eligibility for an accommodation has been determined, you will be issued a Verified Individual Services Accommodation ("VISA") form. Please present this form to me at the start of the term and/or two weeks prior to the accommodation date (test, project, etc.). Requests received after this date may not be honored.

Understand When You May Drop This Course

Drops and Adds

The last day to add this course is the end of the first week of classes. The last day to drop this course with a 100 percent refund and no grade reported is 9/23/2019 (8:00pm). The last day to drop this course with no refund and no grade reported is 10/16/2019 (8:00pm). You should immediately make a copy of your amended schedule to verify you have added or dropped this course.

Commercialized Lecture Notes

Commercialization of lecture notes and university-provided course materials is not permitted in this course.*

*Note: The Code of Teaching Responsibility requires instructors who permit students to commercialize their class lecture notes to include a statement in their course syllabi that gives such permission. Absent such permission, students may not do so.

Complete Assignments

Assignments for this course will be submitted electronically through D2L unless otherwise instructed**.** Assignments must be submitted by the given deadline or special permission must be requested from instructor before the due date. Extensions will not be given beyond the next assignment except under extreme circumstances.

All discussion assignments must be completed by the assignment due date and time. Late or missing discussion assignments will affect the student's grade.