TO: The Faculty of the College of Engineering

FROM: Elmore Family School of Electrical and Computer Engineering

RE: New Graduate Course, ECE 50641 Semiconductor Fundamentals

The faculty of the School of Electrical and Computer Engineering has approved the following new course. This action is now submitted to the Engineering Faculty with a recommendation for approval.

ECE 50641 Semiconductor Fundamentals
Sem. 2, Lecture 3, Cr. 1, 5 weeks.
Prerequisite: Basic knowledge of undergraduate physics, chemistry, and mathematics including basic differential equations

Description: This course about semiconductors is designed to provide a foundation to understand the operation of devices such as transistors, diodes, solar cells, light-emitting devices, etc. The course does not discuss devices – it prepares students to understand the operation of semiconductor devices. The treatment is physical and intuitive, and not heavily mathematical. Technology users will gain an understanding of the semiconductor physics that is the basis for devices. Semiconductor technology developers may find it a useful starting point for diving deeper into condensed matter physics, statistical mechanics, thermodynamics, and materials science. The course presents an electrical engineering perspective on semiconductors, but those in other fields may find it a useful introduction to the approach that has guided the development of semiconductor technology for the past 50+ years. Topics include semiconductor fundamentals such as energy bands, bandgaps, effective masses, electrons and holes, and elements of quantum mechanics. The Fermi function, doping, and carrier densities are then discussed. Carrier transport and generation-recombination are examined along with the important concept of quasi-Fermi levels. The course concludes with the "semiconductor equations," which provide a complete, mathematical description of electrons and holes in semiconductors (subject to some important simplifying assumptions) and ends with a discussion of how energy band diagrams provide a qualitative solution to these equations.

Reason: This course is broadly accessible to students in any branch of science or engineering who would like to understand basic semiconductor physics. Those who use semiconductor devices will gain an understanding of the physics that underlies the operation of devices. Semiconductor technology developers may find it a useful starting point for diving deeper into condensed matter physics, statistical mechanics, thermodynamics, and materials science.
The course presents an electrical engineering perspective on semiconductors, but those in other fields may find it a useful introduction to the approach that has guided the development of semiconductor technology for more than 50 years. The treatment is physical and intuitive, and not heavily mathematical. This material corresponds to the first 5 weeks of ECE-305 and ECE-606. The level is above that of 305 and a little below that of 606. It is designed to cover the same material as in ECE-606, but to be more broadly accessible to students not in the MN Area and to students with undergraduate degrees outside of EE.

Course Enrollment History: Spring 2021 – 12, Spring 2022 – 36, Spring 2023 – 45

Mithuna Thottethodi,
Associate Head for Teaching and Learning
Elmore Family School of Electrical and Computer Engineering

Course Information

- **ECE 50641, Semiconductor Fundamentals, Spring 2023**
- **CRNs:**

On-campus	13995-020
Online	20751-EP2

- **Run dates:** 1/10-2/13/2021 (5 weeks)
- **Instructional Modality:** Asynchronous online for fully online students; the instructor will share information about optional course meetings and office hours in the Brightspace course.
    - Optional course meetings will be recorded and posted to Brightspace.
- **Course credit hours:** 1
- **Prerequisites:** A basic knowledge of undergraduate physics, chemistry, and mathematics including basic differential equations is assumed.

Instructor Contact Information

Note: The course lectures were pre-recorded by Prof. Mark Lundstrom. During Spring 2022, this course will be facilitated by Assistant Professor Dallas Morisette.

- **Name of the instructor:** Dallas Morisette, Research Assistant Professor of Electrical and Computer Engineering, Purdue University
    - **Purdue Email Address:** morisett@purdue.edu
- **Instructor in lecture videos:** Mark S. Lundstrom, Don and Carol Scifres Distinguished Professor of Electrical and Computer Engineering; National Academy of Engineering member

- **Office hours:** See the Brightspace course for office hours information.

Course Description

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Learning Resources, Technology & Texts

- A link to a textbook is provided in the Brightspace course:
    - Lundstrom, M. (2021) *Semiconductor Fundamentals*. Draft.
- Those who wish to dive deeper may consult this text: *Advanced Semiconductor Fundamentals*, (2nd edition) by R.F. Pierret, Pearson Education, Inc., 2003 [ISBN-0-13-061792-X (paperback)]

Learning Outcomes

After completing this course, you will be able to:

- Understand basic semiconductor materials properties such as crystal structure, bandgap, effective mass, etc.
- Understand the behavior of electrons and holes in semiconductors.
- Simplify the set of equations to specific problems.
- Draw and interpret energy band diagrams.

Assignments

Your grade in this course is based on your performance on the following criteria:

Assessment	Description	% of Final Grade
Quizzes	Multiple choice quizzes on lecture topics	30%
Exam 1	Proctored & timed exam	35%
Exam 2	Proctored & timed exam	35%

Additional information on course activities:

- **Lectures:** All lectures are available immediately.
- **Short Problems (ungraded)**
    - A short problem is provided after most lectures.
    - You should be able to quickly work these problems after understanding the lecture.
    - These problems are not graded, but solutions will be posted.
    - You are encouraged to discuss the problems and solutions with your classmates in the discussion forum.
- **Homework (ungraded)**
    - The homework provided in this course is for your information and practice.
    - Solutions to homework are posted for your convenience.
- **Practice Exams (ungraded)**
    - There are 2 practice exams.
    - The best way to prepare for exams is to be familiar with the homework problems, the short problems, and the practice exams.
    - You are encouraged to complete the assessments before viewing the solutions.
    - The practice exams are not graded.

- **Quizzes (graded)**
    - Multiple-choice quizzes will follow most lectures to assess your understanding of the material.
    - These quizzes are worth 30% of your course grade.
- **Exams (graded)**
    - There are 2 proctored exams.
    - Each exam is worth 35% of your course grade.
    - Each exam is available for 72 hours.
    - Exams are designed to be completed in 50 minutes. You will have 60 minutes to complete each exam and submit your answer sheet to Gradescope.
    - The timer cannot be paused.
    - Exams are closed book, closed notes.
    - A calculator is required; a scientific calculator without online/internet capabilities may be used during exams.
    - A formula sheet and answer sheet will be provided. These will need to be printed before beginning the exams.

Grading Scale

A	> 90%
B	80% - 89%
C	70% - 79%
D	60% - 69%
F	<60%

Discussion Guidelines

Please follow the Discussion Guidelines when contributing to discussions in this course. Here are a few of the key points you should remember:

- Do not use offensive language. Present ideas appropriately.
- Be cautious in using Internet language. For example, do not capitalize all letters since this suggests shouting.
- Avoid using vernacular and/or slang language. This could possibly lead to misinterpretation.
- Keep an “open-mind” and be willing to express even your minority opinion.
- Make substantive posts or comments. Avoid comments that do not contribute to the discussion, like "thanks" or "good post."
- Do not hesitate to ask for feedback.
- Be concise and to the point. Give other students the opportunity to join in the discussion.
- Think and edit before you push the “Send” button.

Course Schedule

Week/Date	Tasks to Complete	Due Dates

1
January 10-16
	Materials Properties and Doping
	• Review Syllabus
	• View Lectures L1.1 – L1.7
	• Complete:
	  • L1.1 – L1.6 Short Problems
	  • L1.1 – L1.6 Quizzes
	  • Unit 1 Homework
		Examity Practice Quiz & Gradescope Practice Submission:
		Due: Sunday, January 16, 11:59 PM ET (04:59 UTC)
		
		Week 1: Lecture Quizzes
		Due: Friday, January 14, 8:00 AM ET (13:00 UTC)

2
January 17-23
	Rudiments of Quantum Mechanics
	• View Lectures L2.1 – L2.6
	• Complete:
	  • L2.1 – L2.5 Short Problems
	  • L2.1 – L2.5 Quizzes
	  • Unit 2 Homework
	  • Practice Exam 1
	  • Proctored Exam 1
		Week 2: Lecture Quizzes
		Due: Friday, January 21, 8:00 AM ET (13:00 UTC)
		
		Proctored Exam 1:
		Opens: Friday, January 21, 8:00 AM ET (13:00 UTC)
		Due: Monday, January 24, 8:00 AM ET (13:00 UTC)

3
January 24-30
	Equilibrium Carrier Concentration
	• View lectures L3.1 – L3.6
	• Complete:
	  • L3.1 – L3.5 Short Problems
	  • L3.1 – L3.5 Quizzes
	  • Unit 3 Homework
		Week 3: Lecture Quizzes
		Due: Friday, January 28, 8:00 AM ET (13:00 UTC)

4
January 31-February 6
	Carrier Transport, Recombination and Generation
	• View lectures L4.1 – L4.6
	• Complete:
	  • L4.1 – L4.5 Short Problems
	  • L4.1 – L4.5 Quizzes
	  • Unit 4 Homework
		Week 4: Lecture Quizzes
		Due: Friday, February 4, 8:00 AM ET (13:00 UTC)

5
February 7-13
	The Semiconductor Equations
	• View lectures L5.1 – L5.5
	• Complete:
	  • L5.1 – L5.4 Short Problems
	  • L5.1 – L5.4 Quizzes
	  • Unit 5 Homework
	  • Practice Exam2
	  • Proctored Exam 2
		Week 5: Lecture Quizzes
		Due: Friday, February 11, 8:00 AM ET (13:00 UTC)
		
		Proctored Exam 2:
		Opens: Friday, February 11, 8:00 AM ET (13:00 UTC)
		Due: Monday, February 14, 8:00 AM ET (13:00 UTC)

Academic Integrity

Academic integrity is one of the highest values that Purdue University holds. Individuals are encouraged to alert university officials to potential breaches of this value by either emailing integrity@purdue.edu or by calling 765-494-8778. While information may be submitted anonymously, the more information is submitted the greater the opportunity for the university to investigate the concern. More details are available on our course Brightspace table of contents, under University Policies.

Nondiscrimination Statement

Purdue University is committed to maintaining a community which recognizes and values the inherent worth and dignity of every person; fosters tolerance, sensitivity, understanding, and mutual respect among its members; and encourages each individual to strive to reach his or her potential. In pursuit of its goal of academic excellence, the University seeks to develop and nurture diversity. The University believes that diversity among its many members strengthens the institution, stimulates creativity, promotes the exchange of ideas, and enriches campus life. A hyperlink to Purdue's full Nondiscrimination Policy Statement is included in our course Brightspace under University Policies.

Accessibility

Purdue University strives to make learning experiences as accessible as possible. If you anticipate or experience physical or academic barriers based on disability, you are welcome to let me know so that we can discuss options. You are also encouraged to contact the Disability Resource Center at: drc@purdue.edu or by phone: 765-494-1247.

Mental Health/Wellness Statement

If you find yourself beginning to feel some stress, anxiety and/or feeling slightly overwhelmed, try WellTrack**.** Sign in and find information and tools at your fingertips, available to you at any time.

If you need support and information about options and resources, please contact or see the Office of the Dean of Students. Call 765-494-1747. Hours of operation are M-F, 8 am- 5 pm.

If you find yourself struggling to find a healthy balance between academics, social life, stress, etc. sign up for free one-on-one virtual or in-person sessions with a Purdue Wellness Coach at RecWell. Student coaches can help you navigate through barriers and challenges toward your goals throughout the semester. Sign up is completely free and can be done on BoilerConnect. If you have any questions, please contact Purdue Wellness at evans240@purdue.edu.

If you're struggling and need mental health services: Purdue University is committed to advancing the mental health and well-being of its students. If you or someone you know is feeling overwhelmed, depressed, and/or in need of mental health support, services are available. For help, such individuals should contact Counseling and Psychological Services (CAPS) at 765-494-6995 during and after hours, on

weekends and holidays, or by going to the CAPS office on the second floor of the Purdue University Student Health Center (PUSH) during business hours.

Additional Wellness Resources

TaskHuman offers private, real-time, on-demand, 1-on-1 video calls with wellness coaches covering over 800+ topics such as anxiety, mindfulness, reducing stress, clean eating, time management, in- home workouts, relationship tensions, financial issues, spiritual guidance and many more. You can access these wellness coaches from around the world 24/7. The College of Engineering has an exclusive agreement with TaskHuman which gives you **FREE and UNLIMITED** access to these resources. Over 3,200 calls have been made by College of Engineering people so far with an average satisfaction rating of 4.89/5.

Learn more here: https://engineering.purdue.edu/ECE/TaskHuman.

To download TaskHuman:

1. Scan the QR Code to download the TaskHuman App or download the TaskHumanApp directly from the App Store or Google Play Store.
2. Create an account.
3. Go to **Settings** and tap **Check for Discounts**.
4. Insert your code: **purdue63**

Basic Needs Security

Any student who faces challenges securing their food or housing and believes this may affect their performance in the course is urged to contact the Dean of Students for support. There is no appointment needed and Student Support Services is available to serve students 8 a.m.-5 p.m. Monday through Friday. Considering the significant disruptions caused by the current global crisis as it related to COVID-19, students may submit requests for emergency assistance from the Critical Needs Fund.

Emergency Preparation

In the event of a major campus emergency, course requirements, deadlines and grading percentages are subject to changes that may be necessitated by a revised semester calendar or other circumstances beyond the instructor's control. Relevant changes to this course will be posted onto the course website or can be obtained by contacting the instructors or TAs via email or phone. You are expected to read your @purdue.edu email on a frequent basis.