ECE-656: Fall 2009

Introduction
to
Carrier Transport

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the drift-diffusion equation

$$\vec{J}_p = pq\mu_p\vec{\mathcal{E}} - qD_n\nabla p$$

- where does the DD equation come from?
- how are B-fields and temperature gradients included?
- how is mobility related to material parameters?
- how are the mobility and diffusion coefficient related?
- when does the DD equation fail?
- what do we do then?

course objectives

- *To **introduce** students to the fundamentals of charge carrier transport in semiconductors and nanoscale electronic devices.*

- To give students a **foundation** so that they can learn what they need to when confronted with a new problem.

course outline

Course Introduction	1 lecture
Part 1: Near-equilibrium transport:	
Low bias transport –the Landauer approach	3 weeks
Low bias transport – the Boltzmann equation	2 weeks
Percolative transport	1 week
Part 2: Carrier scattering	
Relaxation times and lengths	1 week
Carrier scattering in semiconductors	4 weeks
Part 3: High-field and non-local transport	
Balance equations	1 week
Monte Carlo simulation	1 week
Off-equilibrium transport in bulk semiconductors and devices	1 week
Quantum transport	1 week

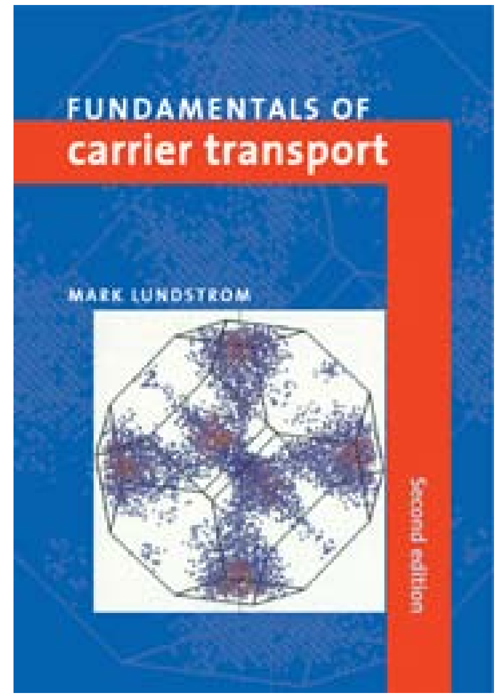
course prerequisites

» Introductory level understanding of semiconductor physics and devices (ECE 606 at Purdue). A course on solid-state physics (Phys. 545 at Purdue) is helpful, but not essential.

This is a course for those interested in electronic materials and devices. The focus is not on theory and computation but, rather, on the physics of transport.

course text

Fundamentals of
Carrier Transport, 2nd Ed.
Mark Lundstrom



supplemented with class notes

Cambridge Univ. Press, 2000
www.cup.cam.ac.uk/

lecture format

- ~50 minute (PowerPoint) lectures. Please interrupt with questions.
- Recorded and deployed online soon after.
- Approximately every two weeks, “discussion” sessions will be held. These may include some additional clarifications on previous lectures, discussion of HW, and applications to current research problems.

course grading

Exam 1: 30%

-near-equilibrium transport

Exam 2: 30%

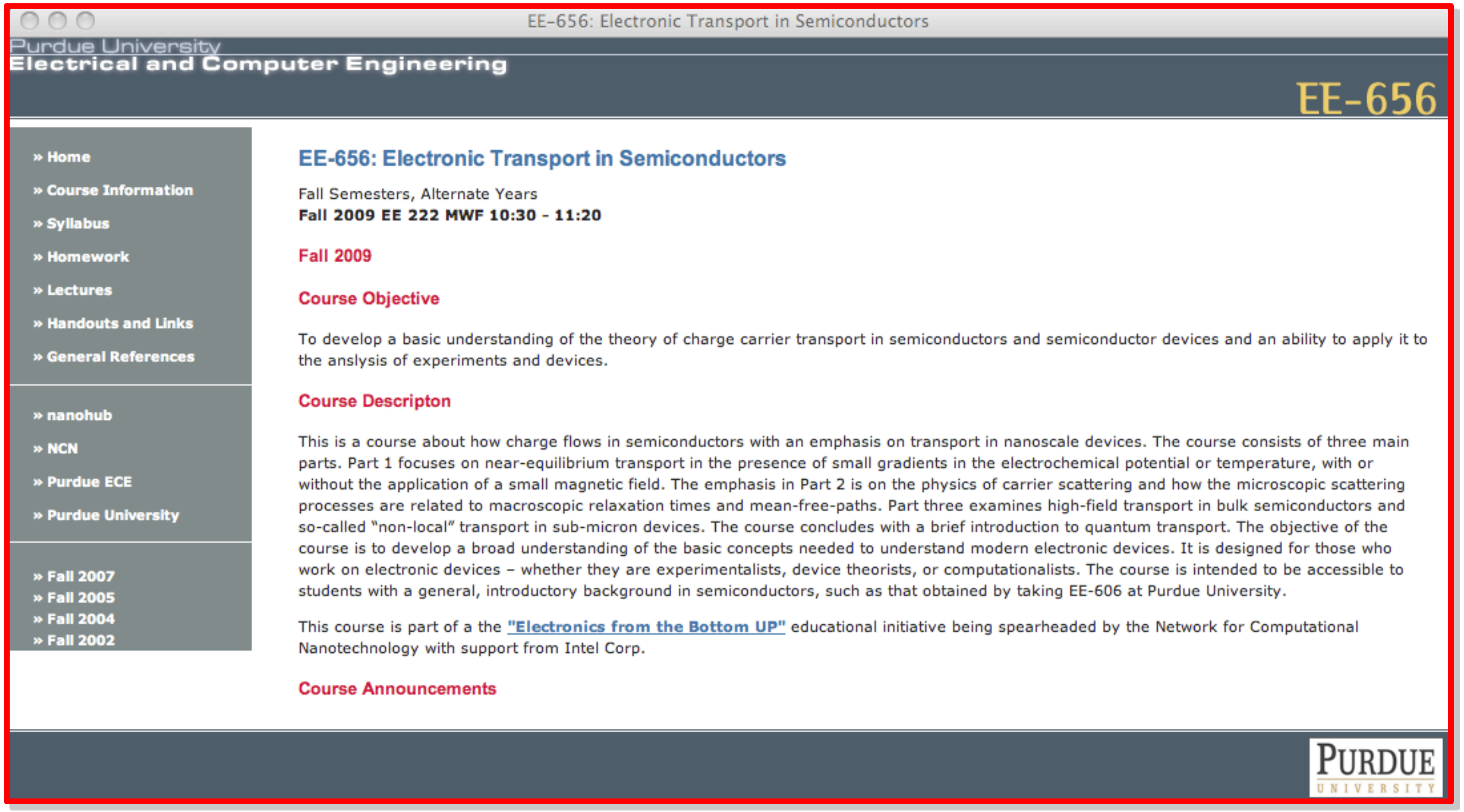
-scattering and high-field transport

Homework: not graded (solutions posted)

Final: 35%

-comprehensive

course web page



EE-656: Electronic Transport in Semiconductors

Purdue University
Electrical and Computer Engineering

EE-656

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» nanohub
» NCN
» Purdue ECE
» Purdue University

» Fall 2007
» Fall 2005
» Fall 2004
» Fall 2002

EE-656: Electronic Transport in Semiconductors

Fall Semesters, Alternate Years
Fall 2009 EE 222 MWF 10:30 - 11:20

Fall 2009

Course Objective

To develop a basic understanding of the theory of charge carrier transport in semiconductors and semiconductor devices and an ability to apply it to the anslysis of experiments and devices.

Course Descripton

This is a course about how charge flows in semiconductors with an emphasis on transport in nanoscale devices. The course consists of three main parts. Part 1 focuses on near-equilibrium transport in the presence of small gradients in the electrochemical potential or temperature, with or without the application of a small magnetic field. The emphasis in Part 2 is on the physics of carrier scattering and how the microscopic scattering processes are related to macroscopic relaxation times and mean-free-paths. Part three examines high-field transport in bulk semiconductors and so-called "non-local" transport in sub-micron devices. The course concludes with a brief introduction to quantum transport. The objective of the course is to develop a broad understanding of the basic concepts needed to understand modern electronic devices. It is designed for those who work on electronic devices – whether they are experimentalists, device theorists, or computationalists. The course is intended to be accessible to students with a general, introductory background in semiconductors, such as that obtained by taking EE-606 at Purdue University.

This course is part of a the "Electronics from the Bottom UP" educational initiative being spearheaded by the Network for Computational Nanotechnology with support from Intel Corp.

Course Announcements

PURDUE UNIVERSITY

http://cobweb.ecn.purdue.edu/~ee656

some suggestions

1) Do the reading ***before*** class.

2) Review lectures **after** class.

3) **Do the homework!**

4) Keep up with the field (TED, EDL, APL, JAP, etc. and local seminars.

5) **Ask questions.**

6) Monitor the course homepage for announcements, handouts, etc. (http://cobweb.ecn.purdue.edu/~ee656).

two things to do

1) send me an e-mail:

-name (first name, last name)

-preferred e-mail address

-background (ECE-494N?, ECE-606, ECE -659
Phys. 545, Phys, 550, etc.)

-1 or two sentences on why you are taking the course and what you hope to get out of it

-if you are auditing the course, let me know

2) Visit the course web site and download HW1

http://cobweb.ecn.purdue.edu/~ee656

questions