ECE-656: Fall 2009

Introduction to Carrier Transport

Professor Mark Lundstrom
Electrical and Computer Engineering
Purdue University, West Lafayette, IN USA
EE-310 / 765-494-3515
lundstro@purdue.edu
the drift-diffusion equation

\[ J_p = pq\mu_p \vec{E} - qD_n \nabla p \]

- 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 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.
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

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](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