Fundamentals of Nanoelectronics

Course objective: To convey the basic concepts of nanoelectronics to electrical engineering students with no background in quantum mechanics and statistical mechanics.

Brief course description: The development of "nanotechnology" has made it possible to engineer materials and devices on a length scale as small as several nanometers (atomic distances are ~ 0.1 nm). The properties of such "nanostructures" cannot be described in terms of macroscopic parameters like mobility or diffusion coefficient and a microscopic or atomistic viewpoint is called for. The purpose of this course is to convey the conceptual framework that underlies this microscopic viewpoint using examples related to the emerging field of nanoelectronics.

Prerequisites: MA266 & MA265 or MA262
Prerequisites by topic: Familiarity with matrix algebra, MATLAB, Elementary differential equations.
Homeworks will often involve problems that require the use of MATLAB.

Corequisites: ECE 305
Corequisites by topic: Basic semiconductor device physics
Authorized equivalent courses or consent of instructor may be used in satisfying course prerequisites. Co-requisites are recommended but not required.


Instructor Supriyo Datta, email: datta@purdue.edu
TA Seokmin Hong, email: hong37@purdue.edu
For homework-related questions, please discuss first with Mr. Hong

Course outcomes
1. Ability to perform simple analysis of nanoelectronic devices (Exam I).
2. Ability to calculate density of states / modes in nanoelectronic devices (Exam II).
3. Ability to perform in-depth analysis of nanoelectronic devices (Exam III).

Grades: Home Work (20) + Exams I, II (2x25 = 50) + Cumulative Final Exam (30)
You are welcome to discuss homeworks amongst yourselves, but what you turn in should be your own work.
ECE 495N, Fall’08    ME118, MWF 1130A – 1220P

Fundamentals of Nanoelectronics: Lecture Outline

All page numbers refer to the recommended reference #1. Please note that this reference is a graduate level text (no comparable undergraduate texts are available yet) and the classroom lectures + class notes are very important in being able to understand the material.

1 / An atomistic view of electrical resistance
   See also http://www.nanohub.org/courses/cqt, CQT Lecture 2 (80 mins)  
   Pages 1-18, 21-27

2 / Schrodinger equation
   Hydrogen atom, Method of finite differences
   Pages 33-49

3 / Self-consistent field / Coulomb blockade
   One-electron versus the many-electron picture
   See also http://www.nanohub.org/courses/cqt, CQT Lecture 4 (70 mins)
   Pages 18-20, 51-78

   HW# 1, 2, 3: Due 9/3, 9/10, 9/24 respectively

   Exam I (Oct.1)

4 / Bandstructure
   Toy examples, general result, common semiconductors
   Pages 81-93, 104-116

5 / Subbands
   Quantum wells, wires, dots and nanotubes
   Pages 129-137

6 / Density of states and density of modes
   minimum resistance, quantum versus electrostatic capacitance
   Pages 138-176

   HW# 4, 5, 6 : Due 10/8, 10/22, 10/29 respectively

   Exam II (Nov. 5)

7/ Probabilities, wavefunctions and Green functions
   Local density of states, Lifetime, Golden rule, Transmission,
   Current-voltage characteristics for coherent devices.
   See also http://www.nanohub.org/courses/cqt, CQT Lecture 3 (90 mins)
   Pages 183-223, 232-248

8 / Spins and magnets

9 / Incoherent processes, Atom to transistor,
   Nanoscale energy conversion
   See http://www.nanohub.org/courses/cqt, CQT Lecture 1 (80 mins)
   Pages 285-318


   HW# 7, 8, 9: Due 11/19, 12/3, 12/10 respectively

   Exam III (Cumulative, Week of Dec.15)

Office hours: MWF 1230P-130P or anytime by appointment
(please send email to request an appointment). Questions by email are also encouraged.