Fundamentals of Nanoelectronics

Course objective: To convey the basic concepts of nanoelectronics to undergraduate students with no background in quantum mechanics or 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.
Authorized equivalent courses or consent of instructor may be used in satisfying course prerequisites.

Corequisite: ECE 305, Basic semiconductor device physics
Co-requisite is recommended but not required.

Recommended References 1. S. Datta, Quantum Transport: Atom to Transistor, Cambridge University Press (2005), ISBN 0-521-63145-9.

2. *MatLab: Student Version*, Current Edition, The MathWorks, Inc.

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	Questions by email are also encouraged
TA	Vinh Quang Diep, email: vdiep@purdue.edu
Office hours	EE 350, Tu-Th 1PM - 3PM
	For homework-related questions, please discuss first with Mr. Diep

Course outcomes

1. Ability to perform simple analysis of nanoelectronic devices (Exam I).
2. Ability to calculate the density of states in nanoelectronic devices (Exam II).
3. Ability to perform in-depth analysis of nanoelectronic devices (Final Exam).

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.

**** 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. In such an event, information will be provided through Blackboard.**

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.

	Pages
1 / An atomistic view of electrical resistance	1-18, 21-27
See also http://www.nanohub.org/courses/cqt, CQT Lecture 2 (80 mins)	
2 / Schrodinger equation	33-49
Hydrogen atom, Method of finite differences	
3 / Self-consistent field / Coulomb blockade	18-20, 51-78
One-electron versus the many-electron picture	
See also http://www.nanohub.org/courses/cqt, CQT Lecture 4 (70 mins)	

HW#1, 2, 3: Due 9/4, 9/11, 9/25 respectively
Exam I (Oct.2)

4 / Bandstructure	81-93, 104-116
Toy examples, general result, common semiconductors	
5 / Subbands	129-137
Quantum wells, wires, dots and nanotubes	
6 / Density of states and density of modes	138-176
minimum resistance, quantum versus electrostatic capacitance	

HW#4, 5, 6 : Due 10/16, 10/23, 10/30 respectively
Exam II (Nov. 6)

7 / Probabilities, wavefunctions and Green functions	183-223, 232-248
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)	
8 / Spins and magnets	
See http://nanohub.org/resources/6041, 6063	
9 / Incoherent processes, Atom to transistor,	
Nanoscale energy conversion	285-318
Of possible interest: http://www.nanohub.org/courses/cqt, CQT Lecture 1 (80 mins)	
and S.Datta, Nanodevices and Maxwell's Demon, http://arxiv.org/abs/0704.1623	

HW# 7, 8, 9: Due 11/13, 12/4, 12/11 respectively
FINAL EXAM (Cumulative, Week of Dec.14)

Related website of possible interest
A New Approach to Electronic Devices and Materials
http://nanohub.org/topics/ElectronicsFromTheBottomUp

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