Engineering Faculty Document No. 37-05
April 27, 2006

TO: The Faculty of the College of Engineering
FROM: The Faculty of the School of Electrical and Computer Engineering
RE: ECE 453 Changes in Course Description, Prerequisite, and Text

The faculty of the School of Electrical and Computer Engineering has approved the following title changes of the undergraduate level course, ECE 453. This action is now submitted to the Engineering Faculty with a recommendation for approval.

From: ECE – Introduction to Nanoelectronics

Sem. 1, Class 3, Cr. 3
Prerequisite: ECE 305
Corequisite: ECE 311. Authorized equivalent courses or consent of instructor may be used in satisfying course pre- and co-requisites.

Introduction to the operating principles of a new class of quantum devices made possible by revolutionary semiconductor fabrication techniques. Quantum concepts are emphasized and specific device examples given.

To: ECE 453 – Fundamentals of Nanoelectronics

Sem. 1, Class 3, Cr. 3
Prerequisite: MA266 & MA265 or MA262
Prerequisites by topic: Familiarity with matrix algebra, MATLAB, Elementary differential equations. Basic semiconductor device physics.
Corequisite: ECE 305. Authorized equivalent courses or consent of instructor may be used in satisfying course prerequisites.

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.

Reason: To provide an updated course description

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Mark Smith, Head
School of Electrical & Computer Engineering

Required Text(s): Class notes

Recommended Reference(s):
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.

Lecture Outline:
All page numbers refer to the recommended reference.

Weeks 1 through 5	Pages
1 . An atomistic view of electrical resistance	1-18, 21-27
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	
HW#1, 2, 3 , Exam I	
Weeks 6 through 10	
4. Basis functions	81-93
Converting a differential equation to a matrix equation	
5. Bandstructure	104-116
Toy examples, general result, common semiconductors	
6. Subbands	129-149
Quantum wells, wires, dots and nanotubes	
Density of states, minimum resistance of a quantum wire	
HW#4, 5, 6, Exam II	
Weeks 11 through 15	
7. Capacitance: Quantum versus electrostatic	155-176
8. Level broadening	183-213
Self-energy, Local density of states, Lifetime, Golden rule	
What constitutes a “contact”?	
9. Current-voltage characteristics	217-223, 232-248
Coherent transport, Transmission, Green’s function method	
HW# 7, 8, 9	
Atom to transistor	285-318
and new paradigms in nanoelectronics	
Exam III (Finals week)	

Course outcomes
1. Ability to perform simple analysis of nanoelectronic devices [1,2;a,k].

2. Ability to calculate the density of states in nanoelectronic devices [1,2;a,k].
3. Ability to perform in-depth analysis of nanoelectronic devices [1,2;a,k].

The numbers/letters in the square brackets denote the program objectives/outcomes that the course outcome maps to.

Assessment Method for Course Outcomes: Exams I, II and III respectively.

Engineering Design Content: None