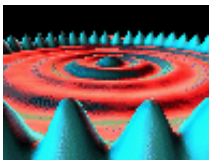

Nanostructure and Nanotechnology I

PHYS 533

Fall 2014

Dr. Carl Rau

TTh 1.00 – 2.15pm

BRK 103

Office Hours

TTh 3.00 - 4.00pm

BRK 340

First meeting: Tuesday, August 26, 2014, 1pm, room BRK 103. The class is scheduled for Tuesday and Thursday, 1.00pm - 2.15pm in room BRK 103.

Course Goals

This course is the first part of a graduate level introduction course covering the general topics of nanostructures and nanotechnology. The goal is to review the broader area of the subject, proving conceptual developments in quantum physics such as reduced dimensionality, confinement, electronic properties and their measurements, and new phenomena at the nano-scale, as well as examples of nanostructures from fabrication to applications.

Anticipated Outcome

This course is suitable for students who have some previous course work (see prerequisite) and who are interested in applying nanotechnology in their graduate research. The students will learn nanotechnology at an overview, but not at a specialized level. A large part of the course is dedicated to advancing and sharpening critical thinking skills. Achieving a deeper and more fundamental understanding of basic concepts of physics at micro- and nanoscales, opens for them a way to explore and discover new phenomena on their own.

Prerequisite
One or more of the following undergraduate courses, or equivalent:
a. one semester of Modern Physics
b. one semester of Introduction to Quantum Mechanics
c. one semester of Solid State Physics

Grader: Jie Zhang: jz38@rice.edu

Texts:
There are no official textbooks. We will provide lecture notes as well as additional materials from a variety of references. We will use Prof. Doug Natelson's (yet unpublished) book copy as reference. (The book is copy-righted). We also recommend: Introduction to Nanoscale Science and Technology by Massimiliano Ventra, Stephane Evoy, James R. Heflin (Springer 2004).

The course grade will be based on homeworks (35%), a term paper (30%) and a group project (35%).
Term paper: approx. 10 – 12 pages. Instructions about topics and the paper will be given in class (due before October 12).
Group project: 2-4 students prepare a 25 min presentation (~ 12 slides) on a topic of their choice and a short paper (~ 4 pages, including figures and references) (due before December 2)

Course Outline

This is a brief outline of topics to be covered in the course. We may have to shift gears and rearrange topics, but we hope to get through all this.

I. Overview and introduction

II. Solid state physics review

The free Fermi gas; nearly-free electrons in periodic potentials; diffraction; tight-binding and molecular orbital; bands; interfaces and defects.

III. Quantum confinement
Two-dimensional electron gases; quantum wells; coupled wells; nanocrystal quantum dots; nanowires and nanotubes.

IV. Nano-fabrication (brief)

V. Electronic transport and mesoscopic phenomena
Basics; semiclassical conduction; mesoscopic (quantum) effects; tunneling; Landauer-Buttiker formalism; quantum dots; quantum point contacts; Landau Levels.

VI. Quantum materials
Graphene and Dirac fermions; topological insulators; quantum spin Hall effect; Meso/nano devices made of quantum materials.

VII. Spintronics
Magnetism at nanoscale; spin-dependent transport; examples for emergent spin devices.

Students with Disabilities: Any student with a disability requiring accommodations in this course is encouraged to contact me after class or during office hours.

For further details on relevant and/or related books and interesting papers, please click this line

March 22, 2014