Physics of Semiconductors and Nanostructrures
ECE 4070 / MSE 6050, Spring Semester 2021

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Instructor:
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Course Website:
https://djena.engineering.cornell.edu/2021_ece4070_mse6050.htm
Class notes and homework assignments will appear on Canvas.

Class Hours:
Mondays and Wednesdays 11:25 am - 12:40 pm.
Location: Kimball B11 and on Zoom.
Discussion Sessions and Office hours: To Be Decided.

Prerequisites:
ECE 4060 or a course in basic quantum mechanics. Assumes exposure to basic quantum mechanics and statistical physics.

Course contents:
Covers basic solid state and semiconductor physics relevant for understanding electronic and optical devices. Topics include crystalline structures, bonding in atoms and solids, energy bands in solids, electron statistics and dynamics in energy bands, effective mass equation, carrier transport in solids, Boltzmann transport equation, semiconductor homo- and hetero-junctions, optical processes in semiconductors, electronic and optical properties of semiconductor nanostructures, semiconductor quantum wells, wires, and dots, electron transport in reduced dimensions, semiconductor lasers and optoelectronics, high-frequency response of electrons in solids and plasmons.

Student Preparation Summary:
Math: Students enrolling in this class must be comfortable with the basics of algebra, linear algebra and matrices, and differential equations.
Physics: Students should be familiar with the basics of classical electromagnetism and fields and waves, charge and current, resistance and capacitance, and Ohm's Law. Familiarity with the notions of statistical mechanics such as Maxwell-Boltzmann, Fermi-Dirac, and Bose-Einstein distributions will aid in the early party parts of the course. Prior exposure to the core ideas of quantum mechanics - that all particles have wave nature, and how to find the allowed energies and states of particles and waves with the Schrodinger equation will help in the early parts of the course.
Programming: Students should be comfortable in solving equations symbolically (e.g. using Mathematica) and numerically (e.g. using Mathematica, MATLAB or Python) and produce graphical plots on a computer.

Outcomes:

- Learn basic principles of solid state and semiconductor physics needed to understand modern electronic and photonic devices
- Learn how engineering materials and structures at the nanoscale enables novel electronic and photonic properties for a wide variety of engineering applications
- Learn the relationship between basic science and engineering applications

Textbook(s):
The main text for the course will be:
Quantum Physics of Semiconductor Materials and Devices: Lecture Notes by the Instructor.

You are encouraged to refer to the following texts through the course:
-Ashcroft and Mermin (Solid State Physics)
-Kittel (Introduction to Solid State Physics)
-Davies (The Physics of Low Dimensional Semiconductors)
-Kroemer (Quantum Mechanics)
-Griffiths (Quantum Mechanics, if you have not had quantum before)

Exams and Grades:
10 Assignments, 2 written prelim exams, and 1 written final exam. The approximate breakup of scores that will go towards your final grade is:
50% Assignments [$\sim$10 assignments, each assignment=5% of final grade!]
10% Prelim 1 [2021 Mid March, Take Home]
15% Prelim 2 [2021 Mid April, Take Home]
25% Final [2021 Early May, To be decided]

Homeworks:

- Homework assignments are an integral part of learning in this course.
- You are allowed to work with other students in the class on your homeworks. The name(s) of the student(s) you worked with must be included in your homework. But what you turn in must be in your *own* writing, and have your *own* plots and figures. Turning in plots/figures/text that are exact replicas of others *is considered cheating* (see below).
- Assignments must be turned in before class on the due date. The time the assignment is turned in should be written. There will be a 10% penalty each day of delay, and assignments will not be accepted beyond 3 days after the due date. There will be no exceptions to this rule.
- Present your solutions *neatly*. Do not turn in rough unreadable worksheets - learn to **take pride in your presentation**. Show the relevant steps, so that partial points can be awarded. $\boxed{\text{BOX}}$ your final answers where applicable. Draw figures wherever necessary. Please print out the question sheet(s) and staple to the top of your homework. Write your name, email address, and date/time the assignment is turned in on the cover.

Taking the Course, Credit vs. Audit:
Taking the course for credit is most effective way to *learn* the course material. For auditing the course for a satisfactory/unsatisfactory final grade, you must pass 25% of the course requirement. This is done <u>at the minimum</u> with a) 5 HWs out of 10, or b) 2 Prelims, or c) Final. You are welcome to do more than 25% to enhance your learning experience. The learning experience when you audit is not at the same level as for credit, but it will ensure that you get some real practice with the course material.

Academic Integrity:
Students are expected to abide by the Cornell University Code of Academic Integrity with work submitted for credit representing the student's own work. Discussion and collaboration on homework and laboratory assignments is permitted and encouraged, but final work should represent the student's own understanding. Specific examples of this policy implementation will be distributed in class. Course materials posted on Blackboard or Piazza are intellectual property belonging to the author. Students are not permitted to buy or sell any course materials without the express permission of the instructor. Such unauthorized behavior will constitute academic misconduct. Please read Cornell's policy on cheating here: `http://cuinfo.cornell.edu/aic.cfm`.
Let's approach the course in the spirit of adventure & enjoy discovering the secrets of materials and devices that power our world today!