ECE 4243/ENGR 4243 Nanoscience and Nanotechnology-I

Credits and contact hours: 3 Credits (One 150-minute lecture per week)

Instructor: Faquir Jain

Textbook and References:
1. G. Hanson, Fundamentals of Nanoelectronics, Prentice Hall, 2008.
2. G. Cao, Nanostructures and Nanomaterials: Synthesis, Properties and Applications, ICP, 2004.
3. C. Weishbuch and B. Vinter, Academic Press, *Quantum Semiconductor Structures*.
4. F. Jain Supplementary Notes, SEMICONDUCTOR DEVICES AND NANOSTRUCTUES, F. Jain (2018)
5. Other supplemental materials: Selected reference materials/articles posted online

***Specific course information*:**

Catalog Description: Fundamentals of electron and hole confinement in quantum well, wire and dot heterostructures, confinement of photons in photonic band gap structures, density of states in quantum wires; transport in quantum wires and dots including single wall (SWNT) and multi-wall carbon nanotubes; operation of nano field-effect transistors, absorption and emission in quantum wires and dot structures; fabrication methodology to grow and assemble quantum wires and dots including self-assembly techniques for light-emitting diodes, transistors, lasers, and nanoelectromechanical (NEM) structures.

a. *Prerequisite*: ECE 4211 or PHYS 2300 or 3401 or MSE 4001, and CHEM 1127 or equivalent.
b. *Required, elective, or selected elective:* Elective

***Specific goals for the course*:**

a. *Specific outcomes of instruction*: Students will be able to
- Apply the principles of electronic devices (from ECE 3201) to derive current transport equations relating to semiconductor material parameters and device structures.
- Rationalize the development of equivalent circuit models of semiconductor devices.
- Select, specify, and design lasers and nano-FETs.
- Communicate the design of lasers and nano-FETs using an iterative process.
- Search for, acquire, and use new knowledge from multiple sources.

b. *ABET Criterion 3 Student Outcomes addressed by the course*:

(1) an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
Students learn to analyze semiconductor devices and formulate design to specifications provided by applying techniques from mathematics, science and engineering,

(2) an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors
Solar panel design is investigated in terms of alternative energy sources for improved environment.

(3) an ability to communicate effectively with a range of audiences
Students write a technical report on their final designs.

(4) an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts
n/a

(5) an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives
n/a

(6) an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions
n/a

(7) an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.
Students use the web, library databases, and other resources for their technical reports.

Topics covered:

- Introduction to nanoelectronics and nanoPhotonics.
- Fundamentals of electron and hole confinement in quantum well, wire and dot heterostructures
- Density of states in quantum wells, quantum wires, and quantum dots;
- Transport in quantum wires and dots including conductance quantization and universal conductance fluctuation
- Light-emitting diodes, laser diodes, solar cells, and photodetectors, and Si nanophotonics.
- NanoFET design, nonvolatile/flash memories.
- Systems: Imaging systems, Nanophotonics, and Displays