ECE215B/Materials206B Spring 2008

Fundamentals of Solids for Electronics II

Professor E. R. Brown, 2205C Engineering Sciences Bldg, erbrown@ece.ucsb.edu

Lecture Hours: Monday/Wednesday, 4:00 - 5:50pm; 1437 Phelps

Office Hours: Tuesday, 4:00 - 5:50pm

First lecture: Wednesday 2 April 2008

No lecture: Monday 31 March (make-up lecture to be announced)

Last lecture: Wednesday 4 June 2008

Six Homeworks: Assigned periodically

Grading: Best of two quizzes: 50%; Final exam: 50%

Quiz#1: Monday 5 May 2008, 5:00 - 5:50pm (tentative)

Quiz#2: Monday 2 June 2008, 5:00 - 5:50pm

Final Exam: Friday 13 June 2008, 4:00-7:00 PM, 1437 Phelps

Lecture style: One 10-minute break at ~4:55 PM.

Exam style: Closed book, closed notes, but lots of clues. Calculators required.

Suggested Text#1: *Solid State and Semiconductor Physics*, by J. P. McKelvey, (R. E. Krieger Publish. Co.,1986). Excellent introductory coverage of transport theory.

Suggested Text #2: "Introduction to Solid State Physics" by C. Kittel. Coverage to include Chapter 13, optionally Chapters 14-15.

Syllabus

- Electrical Properties (Macroscopic + Microscopic Viewpoint)
- Classical Electrostatics
- Microscopic Dipoles and Relation to the Macroscopic
- Electrostatic Feedback Loop and Ferroelectricity
- Piezoelectricity and Ultrasonic Transducers
- Pyroelectricity and "Uncooled" Infrared Detectors
- Magnetic Properties (Macroscopic + Microscopic Viewpoint)
- Classical Magnetostatics
- Microscopic Dipoles and Relation to the Macroscopic
- Magnetostatic Feedback Loop and Ferromagnetism
- (Optional) Quantum Theory of Ferromagnetism
- Heisenberg Hamiltonian
- Spin waves and their Quantization (magnons)
- Transport theory I: Kinetic Theory of charge-carrier transport in E and B fields
- Equations of motion and scattering.
- dc and ac electrical conductivity; Drude-Lorentz model.
- Drift and diffusion of electrons.
- Transport of phonons (heat transport).
- Transport theory II: Boltzmann Transport Formalism
- Statistical description of a population of carriers.
- Inclusion of scattering in relaxation-time approximation.
- Transport conductivities.
- Drift and diffusion.
- Transport theory III: Semi-classical Transport Theory
- Transport of carriers within a band; hole theorem.
- Inclusion of scattering: relaxation time and quantum-mechanical derivations.
- Bipolar behavior and recombination mechanisms.
- Development of the semiclassical drift-diffusion equations.
- Transport theory IV: Elementary Quantum Transport Theory
- Tunneling theory: stationary state and transfer-Hamiltonian approaches.
    - Resonant tunneling in envelope function approximation.
    - Interband tunneling in $\mathbf{k}\cdot\mathbf{p}$ model
- Quantum conductance: Landauer's formula.
- Quantum Boltzmann transport.