Rensselaer

Course Information

Course Title: Advanced Electronic Properties of Materials
Course Number: MTLE-6120
Credit Hours: 4
Semester / Year: Spring 2019
Meeting Days: Mondays and Thursdays, 12:00 to 1:50 pm
Room Location: MRC 136
Website: http://abinitiomp.org/teaching/mtle6120
Prerequisites: None

Instructor

Full Name: Ravishankar Sundararaman
Office location: MRC 208B
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Teaching Assistant(s)

None

Course Description

Review of essential electromagnetic theory and quantum mechanics, including exact models and approximate methods. Application to behavior of electrons in solids including electronic band structure, charge carrier statistics and charge transport in metals, semiconductors, and insulators. Dielectric, optical, and magnetic properties. Solid-vacuum, solid-liquid and solid-solid interfaces. Applications to semiconductor, optoelectronic, and magnetic devices.

Course Text(s)

Primary text: *Principles of Electronic Materials and Devices* by S.O. Kasap
Background reading (as needed):

- *Introduction to Solid State Physics* by C. Kittel
- *Introduction to Quantum Mechanics* by D.J. Griffiths
- *Introduction to Electrodynamics* by D.J. Griffiths

Course Content

- Theoretical background
  - Maxwell's equations in materials

- Classical Drude theory of conduction
- Review of basic quantum mechanics
- Atoms, many-electron theories and the periodic table
- Quantum kinetics: Fermi's Golden rule
- Band theory of solids

- Material properties
  - Fermi theory of metals
  - Electron transport: phonons and electron-phonon scattering
  - Intrinsic and extrinsic semiconductors
  - Insulating materials: dielectrics, ferroelectrics, piezoelectrics etc.
  - Magnetism: dia-, para- and ferro-magnetism, hysteresis
  - Superconductivity
  - Optical properties: absorption, emission, luminescence, fluorescence, lasing
  - Low-dimensional materials
- Interface properties
  - Metal-vacuum interfaces: thermionic and field emission
  - Metal-metal junctions: Seebeck effect, thermocouples, Peltier effect
  - Metal-semiconductor Schottky junctions
  - Semiconductor p-n junction diodes; LEDs, lasers and photovoltaics
  - Semiconductor transistors for logic and memory

Student Learning Outcomes

- Students should understand how the physics of electrons in materials results in a variety of electronic, magnetic and optical properties of materials
- Students should understand how these properties are exploited and optimized for in technological applications
- Students should be able to navigate literature in active areas of research in electronic, magnetic or optical materials

Course Assessment Measures

- Weekly 10-minute quiz at the start of every Thursday class based on material from two previous classes and most recent homework assignment; one lowest quiz score will not be counted towards the grade. (Homework assignments should be completed and self-graded with posted solutions in preparation for the quiz.)
- An in-class midterm examination on Feb 25, which along with all previous quizzes will be used to provide you with performance feedback by Feb 27.
- A short oral presentation on an area of active research in electronic, optical or magnetic materials in the two penultimate classes (April 18 and 22)
- An in-class final examination on the last day of classes (Apr 25).
- Participation in class by asking questions and contributing to discussions

Grading Criteria

- Quizzes 20%
- Midterm 20%
- Final 40%
- Presentation 10%
- Participation 10%

Academic Integrity

Student-teacher relationships are built on trust. For example, students must trust that teachers have made appropriate decisions about the structure and content of the courses they teach, and teachers must trust that the assignments that students turn in are their own. Acts that violate this trust undermine the educational process. The Rensselaer Handbook of Student Rights and Responsibilities and The Graduate Student Supplement define various forms of Academic Dishonesty and you should make yourself familiar with these.

In this class, collaboration is strongly encouraged for the self-graded homework assignments (which do not contribute towards the course grade). In all quizzes and examinations, books and printed notes are allowed, but collaboration is, of course, forbidden.

Violation of this policy in any assignment / examination will result in a zero score the first time, and an F grade for the course the second time.