Rensselaer

Course Information

Course Title: Advanced Electronic Properties of Materials
Course Number: MTLE-6120
Credit Hours: 3
Semester / Year: Spring 2017
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
Office Telephone: (518) 276-6757
Office Hours: Wednesdays, 5-7 pm
Email Address: sundar@rpi.edu

Teaching Assistant(s)

None

Course Description

Review of essential quantum mechanics, including exact models and approximate methods. Application to behavior of electrons in solids. Electronic energy bands in metals, semiconductors, and insulators. Charge carrier statistics and transport. Maxwell's equations. Dielectric, optical, and magnetic properties. 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
    - Band theory of solids
- Material properties
    - Fermi theory of metals
    - 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
    - Two-dimensional materials
    - Electrical and optical properties of polymers
- Interface properties
    - Metal-vacuum interfaces: thermal and field emission
    - Metal-metal junctions: Seebeck effect, thermocouples, Peltier effect
    - Metal-semiconductor Schottky diodes
    - Semiconductor p-n junction diodes
    - Light-emitting diodes, photodetectors and semiconductor lasers
- Technological applications
    - Semiconductor transistors for logic and memory
    - Magnetic storage devices: giant magnetoresistance
    - Solid-liquid interfaces: photocatalysis, supercapacitors

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 homework assignments (posted Mondays and due following Mondays); one lowest homework score will not be counted towards the grade
- An in-class midterm examination on March 2, which along with all previous homeworks will be used to provide you with performance feedback by March 3
- A short oral presentation on an area of active research in electronic, optical or magnetic materials in the last few classes (April 27 and May 1)
- A final examination at the officially scheduled time in the week of May 8-12.
- Participation in class by asking questions and contributing to discussions

Grading Criteria

- Homework 40%
- Midterm 10%
- Final 30%
- 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, all assignments that are turned in for a grade must represent the student's own work. Discussions are allowed, and in fact strongly encouraged, for homework assignments, but the submitted work should be written individually and all collaborators and other sources (books, websites etc.) should be explicitly acknowledged. In all examinations, books and printed notes are allowed, but collaboration is of course forbidden.

Submission of any assignment that is in violation of this policy will result in zero score for that assignment the first time, and an F grade for the course the second time.

If you have any question concerning this policy before submitting an assignment, please ask for clarification.