Electronic properties of materials: Quantum mechanics

MSE 580C2

Spring 2020
Class location: MRB 109
Class Meeting time: Tuesdays/Thursdays 12:00 – 1:20 PM
from Jan 22 to Feb 21

Instructor: Diego Krapf Scott 318, diego.krapf@colostate.edu, 970-4914255
Office Hours: By appointment

I. Rationale:
This course is a core course for students in the MSE program. The overall objective of the MSE program is to develop students to be science and engineering professionals who use their multidisciplinary problem solving skills to address global challenges in the field of materials science and engineering. Electronic properties of materials constitute the fundamental basis for new materials design and discovery with application in electronic and optical devices. Quantum mechanics is the first module within the electronic properties of materials series. The second and third modules within the series are (2) band structures and (3) electronic and optical properties.

II. Course Aims and Outcomes:
Description and Aims
Introductory quantum mechanics regarding the electronic properties of materials. The course provides fundamental quantum mechanical properties that are needed to study of the band structures and optical properties of materials.

Specific Learning Outcomes:
By the end of this course, students will:

1. Illustrate inadequacies of classical concepts regarding electrical and thermal properties
2. Write the wavefunctions of a free and a confined particle.
3. Solve the Schrodinger wave equation for simple geometries in 1D
4. Explain occupation statistics for fermions and bosons.
5. Describe the uncertainty principle.
6. Derive the equations for the transmission of electron through a barrier.

III. Format and Procedures:

(a) **Use of mobile devices, laptops, etc. during class:** I expect students to refrain from using laptops, cell phones and other electronic devices during class. The use of mobile phones (including sending and/or reading text messages) is not accepted during class.

(b) **Recording of Classes:** Classroom activities may be recorded by a student for the personal, educational use of that student or for all students presently enrolled in the class only, and may not be further copied, distributed, published or otherwise used for any other purpose without the express written consent of the instructor.

(c) **Policy on contacting the instructor:** You can contact me at any time via email using the Inbox Canvas tool to communicate. Note that there are no make-up credits and that questions about the topics to be included in the exam are only answered in class.

IV. Course Requirements: Whatever tasks and assignments you include in your course should be aligned with the specified learning outcomes (final learning state, skills, knowledge, attitudes and values the students leave the course with) you have defined and specified earlier.

1. Class **attendance** and participation policy:

Regular attendance in class is mandatory. Notifications regarding material covered in the exam, homeworks, etc. will be provided only in class.

2. Course **readings**:

Reading materials will be provided by the instructor directly in Canvas

3. Assignments:

Homework assignments and solutions will be posted on canvas once a week. Each assignment will be due at the start of the class meeting a week from the assignment date. I plan for there to be a total of three assignments.

Assignments are turned in as a hard copy in class. Electronic copies are not accepted. Your first and last name, homework number, and course number must be written in the first page. Your homework must be stapled, and your solutions to the problems must be in the correct order. Your solutions must be clear and you must include how you reach your results. Writing only the final solution is not acceptable.

Homework turned in after the due date without prior approval from the instructor or not complying with these guidelines will not receive credit.

4. Final exam

Final exam is closed book but you are allowed to bring one hand-written sheet of notes (front and back). You should bring to the exams enough blank paper to solve the problems, a calculator, and your handwritten note sheet. The use of cell phone, smart phone, or computer is not allowed.

5. Team Quizzes

Quizzes will be given at the start of class once or twice a week. All quizzes will be solved in pre-established teams of 3 or 4 students. The quizzes may cover any portion of the material covered in class. You are not allowed to use any electronic device during quizzes (including calculators, smart phones, etc.) and all quizzes are closed book. The use of a phone during a quiz will automatically result in a grade of zero in all the quizzes in the semester. No make-up quizzes are offered. An unexcused absence from a quiz is graded as zero. One excused absence from one quiz will result on your grade being set according to the remaining quizzes. It is your responsibility to arrive to the classes on time for the quizzes, the quiz will be graded as a team and only students that arrive on time for the quiz receive a grade.

V. Grading will be based on:

Quizzes 10%
Assignments 50%
Final exam 40%

VI. Academic Integrity

The course will adhere to the Academic Integrity Policy of the CSU General Catalog (page 7, http://www.catalog.colostate.edu/FrontPDF/1.6POLICIES1112f.pdf) and the Student Conduct Code (http://www.conflictresolution.colostate.edu/conduct-code).

VII. Accommodations for students with disabilities

In compliance with the University policy, I am available to discuss appropriate academic accommodations that may be required for student with disabilities. Requests for academic accommodations are to be made during the first two weeks of the semester, except for unusual circumstances, so arrangements can be made. Students with disabilities are encouraged to find appropriate resources at https://disabilitycenter.colostate.edu/ .

VIII. Tentative Course Schedule (*May change during the course*)

Topics	Readings to be discussed / Assignment
Week 1 Solids. Classical electron theory.	Ashcroft Mermin Chapter #1
Week 2 Wavefunctions, energy, momentum, spin states. Electron interference experiments. Dirac notation. Schrodinger equation.	Neamen Section #2.1, 2.2 Postulates of quantum mechanics Assignment 1 due
Week 3 Hamiltonian for single electron. Uncertainty principle.	Neamen Section #2.3 Assignment 2 due
Week 4 Pauli exclusion principle. Bose-Einstein and Fermi-Dirac statistics. Tunneling.	Assignment 3 due
Week 5 Quantum wells	Final exam