

# EC(MS)574 Physics of Semiconductor Materials

Fall Semester 2024

Instructor: Prof. Enrico Bellotti

Graduate Teaching Assistant TBD

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## General Information

- EC(MS)574A1 is a course intended to provide students with the quantum mechanical basis to understand various aspects of solid state theory, quantum optics, device physics and other topics that will be encountered in more advanced classes of the electrical engineering, photonics, solid state devices, and material science curriculum. The course will focus on those applications of quantum mechanics related to semiconductor materials that are important to understand the operation of electronics, optoelectronics and photonic devices.
- Time: Tuesday and Thursday from 9.00 to 10.15.
- Place: Room B53 (To be revised).
- Things you will learn: intermediate quantum mechanics and its applications to the study of semiconductor materials.
- WARNING! This is not an easy class and will require a substantial out-of-the-classroom effort.
- ECE PhD Students! This class will count toward your Math Qualifying Exam requirement if you have a grade A- or A. Furthermore, if you want to use this class for your departmental qualifying exam you will need to do A- or better. MSE PhD students will need to take the written and oral qualifying exam.
- EC575/EC7XX! This class is a prerequisite for EC575/EC771. If you are a Solid State Device/Photonics PhD student you should take EC574/EC575/EC771 to be successful in obtaining an RA.
- Suggested Prerequisites:
  - SC410 Intro to Electronics or equivalent.
  - SC453 Electromagnetic Engineering or equivalent.
  - SC471 Physics of Semiconductor Devices or equivalent.
- More important than prerequisite: **things you need to know:**

- Classical mechanics, solution of Newton's equations.
- Mathematics: vector calculus, solution of first and second order linear ODEs, separation of variables for PDEs.
- Electromagnetism: solution of Poisson and wave equations.
- Circuit theory: basic knowledge of device operation.
- Grading and Exams
  - Homework and exam samples will be provided. The solution of the assigned homework is your responsibility. If you do not work on the homework you will not be able to solve the exam problems. It is strongly suggested that you start solving the homework sets immediately without waiting the day before the exam. **Solved homework problems are due the day of the exams.**
  - Three exams, 1/3 of the grade each. More information about the exams will be provided at the beginning of the semester.
  - **NOTE - Make up exams only for medical reasons - you will need to be available at the date of the final exam, please adjust your travel accordingly.**
- Suggested Textbooks
  - B.H. Brandsen, and C.J. Joachain, *Introduction to Quantum Mechanics*, Longman Scientific and Technical, ISBN 0582444985
  - Additional notes and papers will be provided for all topics not present in the textbook.
- Student hours
  - Student hours with the teaching assistant will be announced after the final fall schedule is available.
  - To convince you to get the homework done on time, I will not have student appointments starting a week before exams.
- Classroom Behavior
  - It is assumed you come to class to learn.
  - Audio/video recording is not allowed due to Privacy Laws.
  - You can use your PCs to take notes.
  - Phones: playing/texting/calling/"whatever-else-you-do-with-them" is not allowed. Please turn them off and put them away or leave them at home.
- Academic Misconduct
  - BU takes academic integrity very seriously. Academic misconduct is conduct by which a student misrepresents his or her academic accomplishments, or impedes other students' opportunities of being judged fairly for their academic work. Knowingly allowing others to represent your work as their own is as serious an offense as submitting

another's work as your own. More information on BU's Academic Conduct Code, with examples, may be found at <http://www.bu.edu/academics/policies/academic-conduct-code>.

- Collaboration Policy - In this class you may use any textbooks or web sources when completing your homework, and/or one human collaborator (from class) per homework, subject to the following strictly enforced conditions:
  - You must clearly acknowledge all your sources (including your collaborators) on the top of your homework.
  - You must write all answers in your own words.
  - You must be able to fully explain your answers upon demand.
  - You may not use any human resource outside of class (including web-based help services, outside tutors, etc.) in doing your homework.
  - You may not collaborate with anyone on exams.
  - Failure to meet any of the above conditions could constitute plagiarism and will be considered cheating in this class. If you are not sure whether something is permitted by the course policy, ask the instructor or TA.

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## Class Syllabus

### ⇒ **Part I – Quantum Mechanics**

- Quantum mechanical description of a physical system, operators and physical observables, properties of operators, operator and linear vector spaces.
- Solution of one-dimensional problems.
- Angular momentum, solution of two- and three-dimensional problems, hydrogen atom, concept of spin.
- Approximate solutions for time-independent problems, degenerate and non degenerate perturbation.
- Approximate solutions for time-dependent problems, Fermi's golden rule.

### ⇒ **Part II. – Applications**

- Semiconductor quantum wires, dots and impurities in semiconductors.
- Solution of periodic potential problems
- Application to the calculation of the band structures of semiconductors: Tight-binding and pseudopotential methods.
- Electron motion in solids.

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## Class Calendar

### September

September 3

September 5

September 10

September 12

September 17

September 19

September 24

September 26

September 28

### October

October 1 – II-VI Workshop

October 3

October 8

October 10

October 15 – No Class, Monday Schedule

October 17 – Exam-I

October 22

October 24

October 29

October 31

### November

November 5

November 7

November 12

November 14

November 19

November 21

November 26

November 28 – No Class, Recess

November 30 – Exam-II

### December

December 3

December 5

December 10

Final Exam TBA