ESE 332 Quantum Mechanics for Engineers
Spring 2021

Syllabus

Important notes

- Class will take place on Mondays and Wednesdays from 5:00 to 6:20 PM in Light Engineering, Room 154.

- This course includes bi-weekly problem sets, a midterm, and a final exam.

- If you have a physical, psychological, medical, or learning disability that may impact your coursework, please contact the Student Accessibility Support Center, ECC (Educational Communications Center) Building, Room 128, (631) 632-6748. They will determine with you what accommodations, if any, are necessary and appropriate. All information and documentation is confidential.

1. Course Staff and Office Hours

Instructor: Prof. Hyeongrak Choi ("Chuck")

hyeongrak.choi@stonybrook.edu

617-335-5420

Office Hours: Monday 10:00am to 12:00p, Light Engineering 279

*Office hours and locations may change. Please check Brightspace for the most up-to-date information.

2. Course Description

Introductory undergraduate-level first course in quantum mechanics geared towards engineers and applied physicists. Comprehensive introduction to quantum mechanics and its application to real-world problems. Concepts covered will include blackbody radiation, the photoelectric effect, the quantization of the electromagnetic field, wave-particle duality, Heisenberg's uncertainty principle, the electron wave function, superposition, stationary states, the Pauli exclusion principle, many-body systems, tunneling, quantum mechanics in crystalline materials, quantum measurement, wavefunction collapse, entanglement, and teleportation. Applications covered will include lasers, LEDs, solar cells, MOSFETs, flash memory, quantum cryptography, quantum computation, and quantum teleportation, among others.

Prerequisites: PHY 122/124 or PHY 126 and 127 and 134 or PHY 132/134 or PHY 142/134; MAT 127 or 132 or 142 or 171 or AMS 161. Advisory Corequisite: AMS 261 or MAT 203 or 205 or 307

Credits: 3

3. Textbook

OPTIONAL (NOT REQUIRED) TEXTBOOKS

- Peter Deák, Essential Quantum Mechanics for Electrical Engineers, Wiley-VCH, 2017. ISBN-13: 978-3527413553.
- David A. B. Miller, Quantum Mechanics for Scientists and Engineers, Cambridge University Press, 2008. ISBN-13: 978-0521897839.
- Leonard Susskind and Art Friedland, Quantum Mechanics: The Theoretical Minimum, Basic Books, 2014. ISBN-13: 978-0465062904.

Arthur Beiser, Concepts of Modern Physics, McGraw-Hill, 2003. ISBN-13: 978-0072448481.

4. Course Learning Objectives

At the end of this course, students will:

- Know how to solve introductory problems in quantum mechanics.

- Understand quantum mechanical concepts relevant to electronic devices.

5. Student Learning Outcomes

Student Outcomes	% contribution
An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.	90%
An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.	
An ability to communicate effectively with a range of audiences.	
An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.	

An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.	
An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.	
An ability to acquire and apply new knowledge as needed, using appropriate learning strategies.	10%

6. Schedule

Dates	Topics	Text
8/26, 8/28	**Intro:** Logistics, Classical physics, A brief history of quantum mechanics, Photoelectric effect, Wave-particle duality, Quantization, Heisenberg Uncertainty Principle, Overview of how quantum mechanics is essential to modern technology / engineering	Deák 1-3
9/2	Labor day, **No class**	NA
9/4	**Mathematics Review:** Fourier Transform	Notes
9/9, 9/11	**Concepts:** Wave function, Schrödinger's equation **Applications:** Infinite potential wells, finite potential wells	
9/16, 9/18	**Concepts:** Tunneling **Applications:** Moore's Law and MOSFETs in classical computing, flash memory, tunnel diodes	Deák 16-17
9/23, 9/25	**Concepts:** Periodic potentials, Bloch waves **Applications:** Electronic bands in solids, charges in semiconductors	Deák 8-9, 16-17
9/30, 10/2	**Concepts:** Fermi Level, semiconductor doping, pn junctions **Applications:** solar cells, photodetectors, LEDs	Deák 8
10/7	**Concepts:** Density of states, Quantum wire, Quantum well **Applications:** Carbon nanotube, Graphene	Notes
10/9	**Midterm Exam**	
10/14	Fall break, **No class**	
10/16 10/21	**Concepts:** Blackbody radiation, absorption and emission **Applications:** solar cells, lasers, LEDs	Deák 15
10/23	**Mathematics Review:** Linear Algebra	Notes
10/28 10/30	**Concepts:** The postulates of quantum mechanics, matrix representation, spin matrices, expectation values **Applications:** Quantum mechanical calculations	Deák 4-5
11/4 11/6	**Concepts:** Spins, Interaction with magnetic fields, Larmor precession **Applications:** NMR, MRI, quantum computation	Notes, Deák 9
11/11 11/13	**Concepts:** Atomic states **Applications:** atomic clocks, GPS, lasers - part 2	Notes
11/18 11/20	**Concepts:** Quantum information **Applications:** Quantum cryptography, Quantum key distribution,	Deák 18, Notes

11/25	Quantum Computation	
11/27	Thanksgiving Break, **No class**	
12/2 **12/4**	**Concepts:** Quantum Information, Part II, specific quantum algorithms, physical implementations of quantum information systems **Applications:** Quantum cryptography, Quantum key distribution, Quantum Computation	Notes
12/9	**Last day of class**. Review and Q&A.	NA
12/11	**Final Exam**	

7. Assignments (Problem sets)

Problem sets will be distributed at the end of lectures with due dates and must be submitted in class. They are due at 5:15 PM, which is the start of class, with a 15-minute courtesy period for late arrival. Late problem sets will not be accepted—no exceptions. Please turn in what you have at the start of class.

Calculations and intermediate results should be clearly written to receive full credit. Graded problem sets will be returned within two weeks. Students have one week after the return to dispute the grading of the problem set.

8. Exams

Both the midterm and final exams will be held at the same time and place as the usual class. Calculations and intermediate results should be clearly written to receive full credit. Grading criteria and results will be announced as soon as possible. Students will have one week to dispute their grades after receiving the results.

9. Course Grading

The course grade will be based on the following components:

Items	Contribution
Problem Sets	45%
Midterm Exam	20%
Final Exam	35%

Class Protocol

All electronic devices are to be turned off during class unless advance permission is given by the instructor. **No recording of lectures of any kind (including audio and video) is allowed.**

Class resources

Brightspace (https://it.stonybrook.edu/services/brightspace) will be used as the primary means of distribution for course materials.

If you have a physical, psychological, medical, or learning disability that may impact your coursework, please contact the Student Accessibility Support Center, ECC (Educational Communications Center) Building, Room 128, (631) 632-6748. They will determine with you what accommodations, if any, are necessary and appropriate. All information and documentation is confidential.

Students who require assistance during emergency evacuation are encouraged to discuss their needs with their professors and Disability Support Services. For procedures and information go to the following website: http://www.stonybrook.edu/ehs/fire/disabilities

Academic Honesty

Any academic dishonesty on a written homework will result in a zero grade for the assignment for all parties involved.

All exam work must be entirely your own with no collaboration or outside materials/information. Any academic dishonesty on the midterm exams or the final exam will result in failing the course. The case will be submitted to the College of Engineering's Committee on Academic Standing and Appeals.

Electronic Communication Statement

Email and especially email sent via Brightspace is one of the ways the faculty officially communicates with you for this course. It is your responsibility to make sure that you read your email in your official University email account. For most students that is Google Apps for Education (http://www.stonybrook.edu/mycloud), but you may verify your official Electronic Post Office (EPO) address at http://it.stonybrook.edu/help/kb/checking-or-changing-your-mail-forwarding-address-in-the-epo.

If you choose to forward your official University email to another off-campus account, faculty are not responsible for any undeliverable messages to your alternative personal accounts. You can set up Google Mail forwarding using these DoIT-provided instructions found at http://it.stonybrook.edu/help/kb/setting-up-mail-forwarding-in-google-mail.

If you need technical assistance, please contact Client Support at (631) 632-9800 or supportteam@stonybrook.edu.

Student Accessibility Support Statement

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Academic Integrity Statement

Each student must pursue their academic goals honestly and be personally accountable for all submitted work. Representing another person's work as your own is always wrong. Faculty is required to report any suspected instances of academic dishonesty to the Academic Judiciary. Faculty in the Health Sciences Center (School of Health Technology & Management, Nursing, Social Welfare, Dental Medicine) and School of Medicine are required to follow their school-specific procedures. For more comprehensive information on academic integrity, including categories of academic dishonesty, please refer to the academic judiciary website at http://www.stonybrook.edu/commcms/academic_integrity/index.html

Critical Incident Management Statement

Stony Brook University expects students to respect the rights, privileges, and property of other people. Faculty are required to report to the Office of University Community Standards any disruptive behavior that interrupts their ability to teach, compromises the safety of the learning environment, or inhibits students' ability to learn. Faculty in the HSC Schools and the School of Medicine are required to follow their school-specific procedures. Further information about most academic matters can be found in the Undergraduate Bulletin, the Undergraduate Class Schedule, and the Faculty-Employee Handbook.

Course Materials and Copyright Statement

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