ECE4803 **Nanoelectronics: Quantum and Statistical Mechanical Foundations** **Fall 2021**

DaysOfWeek	*Time*	*Building/Room*	*Section X*

Instructor: Dr. Douglas Yoder
Associate Professor
Electrical and Computer Engineering

Office: 219 Bunger-Henry building
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Office Hours:

To be announced. Please feel free to consult with me during office hours on issues that are academic, professional or otherwise.

Textbooks:

Griffiths and Schroeter, *Introduction to Quantum Mechanics* (3rd edition), Cambridge University Press, ISBN 9781107189638 (required)

Website: canvas.gatech.edu (Canvas)

Prerequisites: ECE 3040

Course Outcomes:

Upon successful completion of this course, students should be able to:

1. Demonstrate understanding of the relationships between wave functions, measurements, and probability theory in one, two and three spatial dimensions.
2. Compute single-particle eigenstates of Hermitian operators, and establish statistical properties of particles described by these states.
3. Demonstrate an understanding of the relationships between periodic potentials, electronic dispersion, and density of states in one, two and three spatial dimensions.
4. Compute the equilibrium occupation probabilities of total energy eigenstates, and elucidate statistical properties of many-particle systems for both fermions and bosons
5. Calculate near-equilibrium current flow in simple one-dimensional structures in both the classical and quantum limits

Course Content:

Students are responsible for all material presented in lectures, relevant chapters in the official textbooks, and lab assignments. The textbook and the lectures are designed to complement each other, and neither one alone is a substitute for the other. Class attendance is an important part of the educational experience.

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Grading Policy:

Evaluations:		**Final Grades:**	
Homework Assignments:	25%	>90%	A
Quiz 1	25%	80-90%	B
Quiz 2	25%	70-80%	C
Final Examination	25%	60-70%	D
		<60%	F

Although there is no "curve" for this course in the traditional sense, there will be bonus points on the final exam from which you can receive an "earned curve". To benefit from this curve, you must learn the material.

Homework Assignment Policy:

You will be have roughly one homework assignment every week. Homework assignments will typically be communicated through Canvas on or before Friday of a given week, and will be due no sooner than Friday of the following week. Please pay careful attention to the due dates for each homework assignment. Only those assignments submitted on time will be graded. Solutions to all assigned problems will be made available following the return of graded homework submissions.

Exam Policy:

There will be two in-class midterm exams, as indicated above. The final exam will be given at the scheduled time during exam week. The tentatively scheduled time is **[day,date,time].** Cell phones, laptops and other electronic items must be turned off and placed in a container such as a backpack or purse such that they are inaccessible to you during lectures, quizzes, and exams. Students registered with Disability Testing Services (DTS) may opt to take their exams at DTS rather than in the classroom, provided sufficient advance notice is given.

Office of Disability Statement:

Georgia Tech is committed to a climate of mutual respect and full participation. Our goal is to create learning environments that are usable, equitable, inclusive and welcoming. If there are aspects of this course that result in barriers to your learning or accurate assessment thereof, please notify me as soon as possible. Students with disabilities should contact the Office of Disability Services to discuss options for all relevant accommodations. ODS can be reached at 404 894 2563, **dsinfo@gatech.edu**, or disabilityservices.gatech.edu .

Academic Honor Code:

Students are expected to act according to the highest ethical standards. Academic misconduct is any act which does or could improperly distort student grades or other student academic records. Such acts include but are not limited to the following:

Academic Honor Code (continued):

- Unauthorized Access: Possessing, using, or exchanging improperly acquired written, verbal or digital information in the preparation of a problem set, laboratory report, essay, examination, or other academic assignment.
- Unauthorized Collaboration: Unauthorized interaction with another Student or Students in the fulfillment of academic requirements.
- Plagiarism: Submission of material that is wholly or substantially identical to that created or published by another person or persons, without adequate credit notations indicating the authorship.
- False Claims of Performance: False claims for work that has been submitted by a Student.
- Deliberate Falsification: Deliberate falsification of a written or verbal statement of fact to a Faculty member and/or Institute Official, so as to obtain unearned academic credit.
- Forgery: Forgery, alteration, or misuse of any Institute document relating to the academic status of the Student.
- Distortion: Any act that distorts or could distort grades or other academic records.

Institute Absence Policy:

All students are expected to attend announced quizzes, laboratory periods, and final examinations. Although it is recognized that occasionally it may be necessary for students to be absent from scheduled classes or laboratories for personal reasons, students are responsible for all material covered in their absences, and they are responsible for the academic consequences of their absences. Students should discuss planned absences with me as soon as possible after the beginning of an academic term. When prior notice of absence is given, or in cases of sickness-related absence, late work will be accepted for full credit if submitted within a reasonable time frame.

Communications:

Verbal notices may be given in class. It is your responsibility to obtain this information in class. If you are not present, you must get this information from other students. Notices and other communications may also be delivered via email or Canvas; read your email and check Canvas regularly.

Tips for Assignments and Exams:

- Always read the textbook and review lecture notes before attempting to solve assigned problems. Re-read as necessary for **a clear understanding**. Clarify any outstanding questions you have with me, the teaching assistant, or your fellow classmates.
- Homework assignments are not intended to be mechanical busywork. *The purpose of assignments is to provide students with immediate feedback about their level of understanding, after learning has already taken place. If you find you are not able to solve an assigned problem without referring back to the textbook, then you will likely have the same problem on exams*. What should you do? Read and review the weekly material in the textbook and your lecture notes again *in their entirety* (i.e. not in a patchwork fashion) before attempting any more homework problems.

ECE4803 **Nanoelectronics: Quantum and Statistical Mechanical Foundations** **Fall 2021**

Tips for Assignments and Exams (continued):

- Past experience shows that the keys to earning an "A" in this class are regular class attendance and working through all the assigned problems in the manner described above. If you choose to "cheat" by letting others do the homework for you, you are only hurting yourself.
- In order **to receive full credit**, you must
  - **Show all work.** It is important that you demonstrate to the grader that you understand the process of how to solve each problem.
  - **Label answers** with proper units, e.g. Volts, kg/m^3, etc. If your answer is a vector, the vector direction must be clearly indicated, e.g. $\vec{a}_x$, $\vec{a}_y$, $\vec{a}_z$, etc.
  - **Box your final answers.** This eliminates any ambiguity concerning what constitutes your final answer.

What is Expected of Students:

- Students are expected to adhere to the academic Honor Codes established by Georgia Tech.
- Students are expected to be respectful towards each other.
- Students are responsible for material covered or assigned during lectures, regardless of attendance.

How to Succeed in ECE 4803:

- Approach learning the material with commitment and determination, starting Day 1. Sometimes learning will come easily, and sometimes not. This is normal. Seek help from your instructor or teaching assistant for all issues that you have trouble resolving on your own. We are always happy to help!
- Stay synchronized with the class: read ahead the night before a lecture, attend all lectures and stay current with reading assignments. Your understanding of past and current material is the best predictor of how well you will understand future material, and how quickly you can learn it.
- Recognize that study time does not equate to learning. Learning happens during quality study time, when you are 100% focused and free from all distractions.
- On exams and homework assignments, be prepared to demonstrate your understanding of the concepts presented in the course through the solution of new problems (as an engineer does). Strive therefore to achieve a clear understanding of the concepts involved, rather than a "mechanical memorization" of solution techniques for previously-worked problems (as a technician would).
- Read the relevant book chapter(s) and review lecture notes before working on homework assignments. This is the best way to avoid gaps in your knowledge base that will come back to haunt you later.
- The purpose of end-of-chapter problems in the text is to provide students with instant feedback on their level of understanding; if after reading the problem statement and a couple minutes of thought it is still not clear how to go about solving the problem, this is a red flag telling you to go back and re-read the chapter before attempting to solve any more end-of-chapter problems.

How to Succeed in ECE 4803 (continued):

- Start each homework assignment well in advance of the due date: you will find that your quality of learning will improve the more time you have to think through each question (and make connections with the concepts you have learned through your readings).
- Read and review relevant book chapter(s) and lecture notes in advance of exams for mastery of the material. (Twice through is not uncommon.)

Instructor Commitment to the Student:

I will make every reasonable effort possible to ensure your success in this class. Students are strongly encouraged to seek help from this instructor with any problems they may have, academic, personal or otherwise. Students are also strongly encouraged to provide the instructor with feedback regarding all aspects of this course. Constructive criticism, especially that which might be considered "negative", is particularly welcome.

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Tentative Topical Outline

Please note that the following outline is subject to change. The best indicator of what will be covered in a given class is what is covered in the class previous. Attend lectures!

Normal Semester Week	Topics	Reading Material
	BASIC CONCEPTS	
1	Basic probability theory; conditional probability, correlation, probability mass and density.	Lecture notes
2	Wave functions and probability; fermions and bosons, scattering and double-slit experiments	Ch. 1, Ch. 5, Lecture notes
3	Properties of particles and their measurement	Ch. 12, Lecture notes
4	Operators, basic linear algebra, uncertainty principle, Dirac notation, matrix formulation	Ch. 3, Appendix, Lecture notes
	ONE DIMENSIONAL PROBLEMS	
5	Square wells, step barriers, multiple barriers	Ch. 2, Lecture notes
6	Harmonic Oscillator	Ch. 2, Lecture notes
7	Periodic potentials, Kronig-Penney model, Bloch functions, electronic dispersion	Lecture notes
	THREE DIMENSIONAL PROBLEMS	
8	Quantum dots, central force problems, angular momentum	Ch. 4, Lecture notes
9	The hydrogen atom	Ch. 4, Lecture notes
10	Spin angular momentum, electronic dispersion	Ch. 4, Lecture notes
	STATISTICAL MECHANICS	
11	States, properties and statistics of a simple model system	Lecture notes
12	Ensembles, thermal equilibrium, temperature and entropy	Lecture notes
13	Boltzmann distribution, Helmholz free energy, and particles in a box	Lecture notes
14	Chemical potential, the grand partition function and entropy	Lecture notes
15	Fermi-Dirac Bose-Einstein distribution functions, and the classical limit	Lecture notes
16	Near-equilibrium transport and electron devices	Lecture notes
	Final Exam: [day, date time]	