PHYSICS 672: Advanced Solid State Physics II - Spring 2024

CONTACT INFORMATION & COURSE PARTICULARS

Credit Hours: Three

Class Time: Tuesday & Thursday, 9:45 AM – 11:00 AM.

Class Location: Nielsen Physics Building, Room 306.

Instructor: Dr. Steven Johnston,
Professor, Department of Physics and Astronomy.
He, Him, His.

Website: https://volweb.utk.edu/~sjohn145/

Office: Nielson 502 / IAMM 330

Office Phone: (865) 974-7837

Office Hours: Tuesdays & Thursdays, 11:00 AM – 12:00 PM.
Office hours will be held in person in my office in Nielson. If you cannot attend at that time, you can set an appointment at another time via email.

Email: sjohn145@utk.edu or via the Canvas message system.

Communications: I will primarily make announcements about the courses during class and electronically via the Canvas system. I will distribute hard copies of all assignments in class and post electronic documents on Canvas. Please ensure that your canvas notifications are enabled.

COURSE DESCRIPTION & GOALS

Overview: This course is a graduate-level course in solid state physics and many-body theory. It is the second course in a two-semester sequence and builds directly on the topics discussed in the previous course (PHYS671). Our focus this semester will be on advanced concepts in modern condensed matter physics, including diagrammatic methods and other approaches to many body systems. A tentative list of topics for this course provided at the end of this document.

Format: This course will be delivered in lecture format with in-class discussions and exercises. If the instructor or a significant fraction of the class becomes ill, we will move online temporarily and conduct classes over Zoom. In this event, you will be provided with the relevant zoom information.

Prerequisites: I will assume you are already familiar with the basic concepts in solid state theory that are covered in PHYS555 as well as more advanced topics covered in PHYS671. The former includes Bravais lattices, lattices with a basis, reciprocal space, Bragg scattering, classical models for lattice vibrations, noninteracting electron gases, band structure for weak periodic potentials, and Fermi surfaces. The latter includes electron-phonon interactions, Hartree-Fock mean-field theory, and linear spin-wave theory.

Textbook: We will be covering a range of topics in this course, and I will provide lecture notes on the material presented in class. These notes are my attempt to synthesize information from several textbooks that I have found helpful over the years (listed below).

1. "Many-Particle Physics" by G. D. Mahan. (2nd edition, Plenum)

2. "Introduction to Many-Body Physics" by Piers Coleman. (Cambridge)
3. "Feynman Diagram Techniques in Condensed Matter Physics" by Radi A. Jishi (Cambridge)
4. "Concepts in Solids" by P. Anderson. (Available as an Advanced Book Classics)
5. "A Guide to Feynman Diagrams and the Many-Body Problem" by R. D. Mattock. (Dover)

You do not need to purchase these books! But if you are going to buy one, I recommend the books by Coleman or Jishi and the book by Mattock.

Other graduate-level reference books include:

6. "Solid State Physics" by Ashcroft & Mermin. (Cengage Learning)
7. "A Quantum Approach to Condensed Matter Physics" by P. L. Taylor and O. Heinonen. (Cambridge)
8. "Advanced Solid State Physics" by P. Phillips (Cambridge)
9. "Fundamentals of Condensed Matter Physics" by M. L. Cohen and S. G. Louie. (Cambridge)
10. "Electrons and Phonons: The Theory of Transport Phenomena in Solids" by J. M. Ziman. (Oxford)

GRADING AND EVALUATION

Evaluation: I will calculate your overall grade from your performance on the problem sets, which will be assigned regularly throughout the semester. Note that not all assignments will be equally weighted. Your final numerical grade will be calculated as the sum of points earned on each assignment, divided by the total points available.

Grading: I will compute your letter grade using the conversion below.

A	90-100	C	64-66
A-	83-89	C-	60-63
B+	79-82	D+	57-59
B	74-78	D	54-56
B-	70-73	D-	50-53
C+	67-69	F	0-49

Appeals: You are welcome to discuss any issues you might have with the grading of an assignment; however, you must raise the objections with me no later than one week after I have returned the graded material.

OTHER INFORMATION

Group work policy: I encourage students to work together and discuss the homework with each other. Such discussions are one of the most effective ways of assimilating the material and often how one operates in a research setting. **But** the work you submit must be written up by you and not be a copy of your peers' work or some other source such as solutions found on the Internet. Any homework assignment that is a direct copy of another person's work without attribution will count as plagiarism and be dealt with accordingly. Do not take advantage of other people's work, and do not let anybody benefit from yours.

Health & Safety Concerns: Students are always encouraged to wear face masks and maintain social distancing (6 feet between individuals in traditional classrooms or, in instructional laboratories and similar settings, only a few minutes in closer proximity when necessary to achieve learning objectives). Students who are feeling ill or experiencing symptoms such as sneezing, coughing, or a higher-than-normal temperature will be excused from class and should stay home.

Students with disabilities: The University of Tennessee, Knoxville, is committed to providing an inclusive learning environment for all students. If you anticipate or experience a barrier in this course due to a chronic health condition, a learning, hearing, neurological, mental health, vision, physical, or other kinds of disability, or a temporary injury, you are encouraged to contact Student Disability Services (SDS) at 865-974-6087 or sds@utk.edu. An SDS Coordinator will meet with you to develop a plan to ensure you have equitable access to this course. If you are already registered with SDS, please get in touch with me to discuss implementing accommodations in your course access letter.

Academic Honesty & Integrity: By taking this course, you agree to the following statement: "An essential feature of the University of Tennessee, Knoxville is a commitment to maintaining an atmosphere of intellectual integrity and academic honesty. As a university student, I pledge that I will neither knowingly give nor receive any inappropriate assistance in academic work, thus affirming my personal commitment to honor and integrity."

All work submitted by a student is expected to represent their work. Students are expected to complete their homework without assistance from others. Students are expected to perform all work in conformance with the University policies regarding Academic Honesty. **I will pursue any cases of academic dishonesty that arise during the course.**

University Civility Statement: Civility is genuine respect and regard for others: politeness, consideration, tact, good manners, graciousness, friendliness, affability, amiability, and courteousness. Civility enhances academic freedom and integrity and is a prerequisite to the free exchange of ideas and knowledge in the learning community. Our community comprises students, faculty, staff, alums, and campus visitors. Community members affect each other's well-being and have a shared interest in creating and sustaining an environment where all community members and their points of view are valued and respected. Affirming the value of each member of the university community, the campus asks that all its members adhere to the principles of civility and community adopted by the campus: http://civility.utk.edu/.

This is a tentative list of the topics we'll discuss in this course.

1. BCS Theory of superconductivity (carried over from last semester).
2. Zero temperature Green's functions and the equation of motion method for calculating them.
3. Introduction to Feynman diagram and many-body perturbation theory.
4. Extensions to finite temperature and the Matsubara formalism.
5. One- and two-particle correlation functions, their connection to experiments, fluctuation-dissipation theorem, and linear response theory.
6. Applications: Migdal-Eliashberg theory, the Kondo problem, Anderson impurity model. high-T_c superconductivity, etc..