Lahore University of Management Sciences

PHY 538 – Special Topics in Condensed Matter Physics

Spring 2023

To understand how to navigate course outlines, consult: How to Use a Course Outline (http://surl.li/gpvuw)

Instructor	Muhammad Shahbaz
Room No.	
Office Hours	
Email	
Telephone	
Secretary/TA	
TA Office Hours	
Course URL (if any)	
Support Services	LUMS offers a range of academic and other services to support students. These are mentioned below, and you are encouraged to use these in addition to in-class assistance from course staff. For a complete list of campus support services available for you click here (https://advising.lums.edu.pk/#supportservices)

Course Basics				
Credit Hours	3			
Lecture(s)	Nbr of Lec(s) Per Week	2	Duration	75 min
Recitation (per week)	Nbr of Rec (s) Per Week		Duration	
Lab (if any) per week	Nbr of Session(s) Per Week		Duration	
Tutorial (per week)	Nbr of Tut(s) Per Week	1	Duration	60 min

Course Distribution	
Core	
Elective	
Open for Student Category	Juniors, Seniors & Grad
Closed for Student Category	

COURSE DESCRIPTION

The purpose of the course is to introduce students to the techniques of quantum field theory as applied to the study of condensed matter. Various systems from condensed matter physics such as metals, superconductors and graphene will be considered and they will be treated using quantum field theory techniques, in particular the use of real-time and imaginary-time Green's functions. Special emphasis will be put on the use of Feynman diagrams.

COURSE PREREQUISITE(S)

- PHY 332 Condensed Matter Physics or GRAD

COURSE OBJECTIVES

Lahore University of Management Sciences

• • •	To explore the use of quantum field theory techniques in condensed matter physics. To understand how to extract experimentally measurable and relevant information from complicated interacting many-body Hamiltonians

Learning Outcomes	
• • •	To apply quantum field theory techniques to be predict properties of condensed matter systems.

Grading Breakup and Policy
Homework (5 in total): 20% Quiz (Approximately 4 quizzes): 20% Mid-Term 25% Final Exam 35% The instructor has the liberty of varying these grade assignments by 5%.

Examination Detail	
Midterm Exam	Yes
Final Exam	Yes

COURSE OVERVIEW			
Week/ Lecture/ Module	Topics	Recommended Readings	Objectives/ Application
1	Basic ideas of many-body theory/Review of quantum mechanics	**Jishi, Chapter 1** **Taylor, Chapter 1** **Coleman, Chapter 1**	
2	Single particle states for many-body physics (examples: Bloch states, Wannier states)	**Jishi, Chapter 2** **Singleton, Chapters 2, 3 and 4**	
3	Second quantization	**Jishi, Chapter 3** **Stefanucci, Chapters 1 and 2**	
4	Second quantization/introduction to the electron gas/review of statistical mechanics	**Stefanucci, Chapters 1 and 2** **Jishi, Chapters 4 and 5**	

		Coleman, Chapter 3	
5	Real-time Green's functions/Correlation functions	**Jishi, Chapter 6** **Coleman, Chapter 5** **Stefanucci, Chapters 4, 5 and 6**	
6	Real-time Green's functions (applications such as quantum dots and tunneling)	**Jishi, Chapter 7**	
7	Imaginary time Green's functions/Correlation functions	**Jishi, Chapter 8** **Coleman, Chapter 8**	
8	Imaginary time Green's functions (with applications such as the two-dimensional electron gas)/Feynman diagram	**Jishi, Chapters 8 and 9** **Coleman, Chapters 7 and 8**	
9	Feynman diagrams	**Jishi, Chapter 9** **Coleman, Chapters 7 and 8**	
10	The electron gas	**Jishi, Chapter 10** **Coleman, Chapter 6**	
11	Introducing phonons and photons into the mix	**Jishi, Chapter 11**	
12	Superconductivity	**Jishi, Chapter 12** **Coleman, Chapter 14**	
13	Nonequilibrium Green's functions	**Stefanucci, Chapter 16** **Jishi, Chapter 13**	
14	**Review**		

Textbook(s)/Supplementary Readings

R. Jishi, Feynman diagram techniques in condensed matter physics (CUP, 2013)

P. Coleman, Introduction to Many-body physics (CUP, 2015)

G. Stefanucci and R. van Leeuwen, Non-equilibrium Many-Body Theory of Quantum Systems, A Modern Introduction (CUP, 2013)

P. Taylor and O. Heinonen, A quantum approach to condensed matter physics (CUP, 2002)

J. Singleton, Band Theory and electronic properties of solids (OUP, 2001)

T. Lancaster and S. J. Blundell, Quantum Field Theory for the gifted amateur (OUP, 2014)

Campus supports & Key university policies

Campus Supports

Students are strongly encouraged to meet course instructors and TA's during office hours for assistance in course-content, understand the course's expectations from enrolled students, etc. Beyond the course, students are also encouraged to use a variety of other resources. (Instructors are also encouraged to refer students to these resources when needed.) These resources include Counseling and Psychological Services/CAPS (for mental health), LUMS Medical Center/LMC (for physical health), Office of Accessibility & Inclusion/ OAI (for long-term

disabilities), advising staff dedicated to supporting and guiding students in each school, online resources (https://advising.lums.edu.pk/advising-resources), etc. To view all support services, their specific role as well as contact information click here (https://advising.lums.edu.pk/#supportservices).

Academic Honesty/Plagiarism

LUMS has zero tolerance for academic dishonesty. Students are responsible for upholding academic integrity. If unsure, refer to the student handbook and consult with instructors/teaching assistants. To check for plagiarism before essay submission, use similarity@lums.edu.pk. Consult the following resources: 1) Academic and Intellectual Integrity (http://surl.li/gpvwb), and 2) Understanding and Avoiding Plagiarism (http://surl.li/gpvwo).

LUMS Academic Accommodations/ Petitions policy

Long-term medical conditions are accommodated through the Office of Accessibility & Inclusion (OAI). Short-term emergencies that impact studies are either handled by the course instructor or Student Support Services (SSS). For more information, please see Missed Instrument or 'Petition' FAQs for students and faculty (https://rb.gy/8sj1h)

LUMS Sexual Harassment Policy

LUMS and this class are a harassment-free zone. No behavior that makes someone uncomfortable or negatively impacts the class or individual's potential will be tolerated.

To report sexual harassment experienced or observed in class, please contact me. For further support or to file a complaint, contact OAI at oai@lums.edu.pk or harassment@lums.edu.pk. You may choose to file an informal or formal complaint to put an end to the offending behavior. You can also call their Anti-Harassment helpline at 042-35608877 for advice or concerns. *For more information: Harassment, Bullying & Other Interpersonal Misconduct: Presentation (http://surl.li/gpvwt)*