The Hashemite University
Faculty of Science
Department of Physics

Course Title:	Condensed Matter Physics	**Course Number:**	2102771
Semester:	Spring	**Year:**	2025
Designation:	Elective	**Prerequisite(s):**	None
Instructor:	Dr. Gassem Alzoubi	**Instructor's e-mail:**	gassem@hu.edu.jo
		Webpage:	http://staff.hu.edu.jo/gassem
Office Hours:	Monday and Wednesday, 12:00 –1:30 Pm, Physics Building, Room # 107		

Course Description (catalog): Physics 771 is an elective graduate course that introduces students to basic principles of Condensed Matter Physics (CMP). The primary focus will be on structural and electronic properties of crystalline solids.

Textbook(s) and/or Other Supplementary Materials:

Textbook: Michael P Marder, Condensed Matter Physics, 2nd edition. John Wiley & sons 2015.

References:

(1) Neil W. Ashcroft and N. David Mermin, Solid State Physics, new edition, Brooks/Cole 1976.

(2) Charles Kittel, Introduction to Solid State Physics, 8th edition. Wiley 2004

Major Topics Covered:

Topics	No. of Weeks	Contact hours*	Chapter in Text	Sections
The Idea of Crystals: Two-Dimensional Lattices (Bravais Lattices), Lattices with Bases, Primitive Cells, Wigner-Seitz Cells, Symmetries (Translation and Point Groups)	2	6	1	All sections
Three-Dimensional Lattices: Monatomic Lattices(The Simple Cubic Lattice, The Face-Centered Cubic Lattice, The Body-Centered Cubic Lattice, The Hexagonal Lattice, The Hexagonal Close-Packed Lattice, The Diamond Lattice), Compounds (Rocksalt—Sodium Chloride, Cesium Chloride, Fluorite—Calcium Fluoride, Zincblende—Zinc Sulfide, Wurtzite—Zinc Oxide, Perovskite—Calcium Titanate),	2	6	2	2.1 – 2.4
Scattering and Structures: Theory of Scattering from Crystals, Special Conditions for Scattering, Elastic Scattering from Single Atom, Wave Scattering from Many Atoms, Lattice Sums, Reciprocal Lattice, Miller Indices, Scattering from a Lattice with a Basis, Experimental Methods (Laue Method and Powder Method), Production of X-Rays	2	6	3	3.1 – 3.4
The Free Fermi Gas and Single Electron Model: Densities of States, Results for Free Electrons, Statistical Mechanics of Noninteracting Electrons, Sommerfeld Expansion, Specific Heat of Noninteracting Electrons at Low Temperatures	2	6	6	All sections
Non-Interacting Electrons in a Periodic Potential: Translational Symmetry—Bloch's Theorem, Formal Demonstration of Bloch's Theorem, Additional mplications of Bloch's Theorem, Van Hove Singularities, Kronig-Penney Model	2	6	7	7.1 – 7.2
Nearly Free and Tightly Bound Electrons: Nearly Free Electrons, Degenerate Perturbation Theory, Tightly Bound Electrons, Linear Combinations of Atomic Orbitals, Wannier Functions, Tight Binding Model	2	6	8	8.1, 8.2, and 8.4
Cohesion of Solids: Noble Gases, Ionic Crystals, Ewald Sums	1	3	11	11.1–11.3
Phonons: Vibrations of a Classical Lattice, Classical Vibrations in	2	6	13	13.1 -

One Dimension, Classical Vibrations in Three Dimensions, Normal Modes, Lattice with a Basis, Vibrations of a Quantum-Mechanical Lattice, Phonon Specific Heat, Thermal Expansion				13.3
Total	**15**	**45**		

*Contact hours include lectures and exams

Specific Outcomes of Instruction (Course Learning Outcomes):
After completing the course, the student will be able to:

	Course Learning Outcomes (CLO)	(SO*)
CLO1.	Understand the fundamentals of crystal structure of lattices with bases, reciprocal lattice, First Brillouin zone, Lattice planes and Miller indices, X-ray diffraction, and how it can be used to identify crystal structure. Use VESTA to visualize some crystal structures	(a), (k), (i)
CLO2.	Understand Bloch's theorem in a periodic potential, energy bands and gap, Calculation of band structure using perturbation theory and Tight binding approximation. Write simple Mathematica codes to calculate band structures of simple systems	(a), (k)
CLO3.	Understand bonding in solid materials, Debye and Einstein models of lattice vibrations	(a), (e) (k)

(SO*) = Student Outcomes Addressed by the Course.

#	Outcomes Description Applied and Natural Sciences Student Outcomes	Contribution
(a)	**an ability to apply knowledge of mathematics, science, and applied sciences**	**H**
(b)	**an ability to design and conduct experiments, as well as to analyze and interpret data**	
(c)	**an ability to formulate or design a system, process or program to meet desired needs**	
(d)	**an ability to function on multidisciplinary teams**	
(e)	**an ability to identify and solve applied sciences problems**	**L**
(f)	**an understanding of professional and ethical responsibility**	
(g)	**an ability to communicate effectively**	
(h)	**the broad education necessary to understand the impact of solutions in a global and societal context**	
(i)	**a recognition of the need for, and an ability to engage in life-long learning**	
(j)	**a knowledge of contemporary issues**	
(k)	**an ability to use the techniques, skills, and modern scientific and technical tools necessary for professional practice.**	**M**
H = High, M = Medium, L = Low		

Grading Plan:

Homeworks	30 points	
Midterm exam	30 Points	**TBA**
Final exam	40 Points	**TBA**

General Notes: **Attendance Policy:** students are expected to attend every class and arrive on time in compliance with HU regulations. In case you find yourself in a situation that prevents you from attending class or exam, you have to inform your instructor. If you miss more than 6 classes for the (Sunday, Tuesday, and Thursday model) or 4 classes for the (Monday and Wednesday Model), you cannot pass the course.

Prepared by: Dr. Gassem Alzoubi **Date: Feb**, 24, 2025