University of Tennessee at Knoxville, Spring 2023

MSE 350/357: Principles of Materials Physics

PHYS 342: Structure of Matter

Course Credit Hours: 3

Class: 10:20 am – 11:10 am, MWF, 1/23 – 5/8/2023, Ferris Hall 510

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Catalog Course Description:

MSE 350/357: Fundamental electronic, optical, and magnetic properties of solid-state materials. Basic bonding and crystallography correlations to electronic, optical, and magnetic properties of materials. Specific subjects that will be covered include wave properties of electrons, Schrodinger's equation, energy bands in crystals, electrical conduction in metals and semiconductors, classical and quantum mechanical treatments of optical properties, and magnetic phenomena.

PHYS 342: Elementary solid-state physics. Bonding in solids, free-electron-gas theory of metals, crystal structures, reciprocal lattice, energy bands, phonons, semiconductors and semiconductor devices, optical properties of solids, phenomenological description of superconductivity, magnetism, and other forms of broken symmetry.

Recommended Prerequisites: MSE 201/207, or PHYS 232/250/252

Course materials and resources

Textbook: There is no single book that the course is strictly following, but the major and additional reference books are listed below. References to each lecture will be provided in the lecture note.

Major reference books:

- Introduction to Solid State Physics, written by Charles Kittel, published by John Wiley & Sons, Inc. (Information page.)
- Introductory Solid State Physics, written by H. P. Myers, published by Taylor & Francis. (Information page.)

Additional references:

- The Oxford Solid State Basics, written by Steven H. Simon, published by Oxford University Press. (Information page. Online lectures.)
- Principles of Electronic Materials and Devices, written by S. O. Kasap, published by McGraw Hill. (Information page.)

Grading system: Assignment (30%) + Midterm-I (20%) + Midterm-II (20%) + Final (30%)

Course Outline and Schedule:

Date	Lecture	Topic	References			Due
			Kittel	*Myers*	Additional	
1/23	1	I. Introduction to Materials Physics		Ch1.1	*Simon*: Ch1	
1/25	2	II. Elementary Quantum Physics of Atoms		Ch1.2-1.3	*Simon*: Ch5 *Kasap*: Ch3	
1/27	3	III. Classical Theory of Solid-State Materials			*Simon*: Ch2-4 *Kasap*: Ch2	
1/30	4	IV. Crystallography: Atomic bonding and crystal structure	Ch1 and Ch3	Ch1.4	*Simon*: Ch6	
2/1	5	IV. Crystallography: Lattice and reciprocal lattice	Ch1	Ch2	*Simon*: Ch12-13	
2/3	6	IV. Crystallography: Wave diffraction	Ch2	Ch3	*Simon*: Ch14	HW 1
2/6	7	V. Phonons: Vibrations of a one-dimensional atomic chain	Ch4	Ch5.4 and 5.7	*Simon*: Ch9.1-9.2 and Ch10	
2/8	8	V. Phonons: Phonons as quanta of vibration and quasiparticles	Ch4	Ch5.3 and 5.9-5.10	*Simon*: Ch9.3-9.4	
2/10	9	V. Phonons: Experimental observation of phonons through inelastic scattering	Ch4	Ch5.11		HW 2
2/13	10	V. Phonons: Thermal properties	Ch5	Ch5.12		
2/15	11	VI. Electrons in Solids: Free electron Fermi gas	Ch6	Ch6		
2/17	12	VI. Electrons in Solids: Nearly free electron model and Bloch's Theorem	Ch7	Ch7.1-7.5	*Simon*: Ch15	HW 3
2/20	13	VI. Electrons in Solids: Wave equation of electron in a periodic potential	Ch7	Ch7.6	*Simon*: Ch16.1-16.2	
2/22	14	VI. Electrons in Solids: Band structure	Ch7	Ch7.7-7.8	*Simon*: Ch16.5	
2/24	15	VI. Electrons in Solids: Revisiting the periodic table from a solid-state perspective		Ch7.9-7.12		HW 4
2/27	**Midterm-I**		**Lecture 1-12, HW1-4**			
3/1	16	VII. Electronic Materials: Semiconductors	Ch8	Ch10.1-10.8	*Simon*: Ch17 *Kasap*: Ch5.1-5.3, 5.9	
3/3	17	VII. Electronic Materials: Semiconductor devices	Ch8	Ch10.9-10.10	*Simon*: Ch18 *Kasap*: Ch6.1-6.2, and 6.8-6.9	HW 5
3/6	18	VII. Electronic Materials: Fermi surface in metals and its experimental studies	Ch9	Ch9		
3/8	19	VII. Electronic Materials: Physical properties of metals	Ch9	Ch9		
3/10	20	VII. Electronic Materials: Magnetoresistance and Hall effects	Ch9, Ch17	Ch10.11		HW 6
Spring Break (3/13-3/17)						
3/20	21	VIII. Superconductivity: Experiments	Ch10	Ch13		
3/22	22	VIII. Superconductivity: Theories	Ch10	Ch13		
3/24	23	VIII. Superconductivity: Microscopic picture	Ch10	Ch13		HW 7
3/27	24	VIII. Superconductivity: Application	Ch10	Ch13		

3/29	25	IX. Magnetism: Magnetic properties of atoms, Hund's rule, Ising model			*Simon*: Ch19.1-19.5, Ch20.2	
3/31	26	IX. Magnetism: Paramagnetism and diamagnetism	Ch11	Ch11.1-11.4	*Simon*: Ch19.6	HW 8
4/3	**Midterm-II**		**Lecture 13-23, HW5-8**			
4/5	27	IX. Magnetism: Magnetic order and spontaneous symmetry breaking			*Simon*: Ch20	
Spring Recess (4/7)						
4/10	28	IX. Magnetism: Ferromagnetic order, magnons and hysteresis	Ch12	Ch11.9	*Simon*: Ch21	
4/12	29	IX. Magnetism: Antiferromagnetic and ferrimagnetic order	Ch12		*Simon*: Ch20	
4/14	30	IX. Magnetism: Experimental measure of magnetism (scattering and magnetic resonance)	Ch12-13	Ch11.8		HW 9
4/17	31	IX. Magnetism: Exchange interactions and Mott insulators	Ch14	Ch11.6-11.7	*Simon*: Ch23	
4/19	32	X. Optical Properties: Optical reflectance	Ch15			
4/21	33	X. Optical Properties: Optical techniques	Ch15		*Kasap*: Ch9	HW 10
4/24	34	XI. Nanostructures: Imaging techniques	Ch18			
4/26	35	XI. Nanostructures: Physical properties in one-dimension	Ch18			
4/28	36	XI. Nanostructures: Physical properties in zero-dimension	Ch18			HW 11
5/1	37	XII. Noncrystalline Solids	Ch19			
5/3	Students' presentation - I					
5/5	Students' presentation - II					HW 12
5/8	Review					
End of Classes (5/9)						
5/12	**Final Exam, 3:30-6:00 pm**		**Lecture 1-37, HW1-12**			