Hong Kong Baptist University
Faculty of Science – Department of Physics

Title (Units): **PHYS 3015 STRUCTURE AND PROPERTIES OF MATTER (3,3,1)**

Course Aims: By using the framework of quantum physics, this course examines the structural, chemical, and electronic properties of matter, which form the basis for energy device applications.

Pre-requisite: PHYS 3005 Atomic and Nuclear Physics or consent of instructor.

Course Reviewed by: Dr. Zhifeng Huang and Dr. Alex Mok

Course Intended Learning Outcomes (CILOs):

No.	Upon successful completion of this course, students should be able to:
1	Describe the concept of crystal lattice and the nature of chemical bonding.
2	Outline the formation of energy bands and energy gaps in solids, and explain the dynamics of charge carriers in semiconductors using the energy band theory.
3	Analyze the structural, chemical and electronic properties of a material.
4	Examine the behavior of semiconductor devices.
5	Discuss how different properties of a material can be exploited in the design of energy devices.

Teaching & Learning Activities (TLAs)

CILOs	TLAs will include the following:
1-5	The theories will be introduced through lectures. Students will be presented with realistic examples related to energy science applications in order to demonstrate how the theories work.
1, 2, 5	The lectures will be augmented with recent articles, videos, and in-class discussion of popular devices related to energy. These can deepen their understanding as well as their interest in the subject.
3-4	Students will train their ability to analyze the property of a material in tutorial classes and homework assignments.

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Assessment Methods (AMs):

Type of Assessment Methods	Weighting	CILOs to be addressed	Description of Assessment Tasks
Continuous Assessment (tutorial assignments, homework assignments, quizzes, midterm examination)	50%	1-5	Tests and assignments are designed to measure and guide the learning process of students.
Final Examination	50%	1-5	Final Examination questions are designed to see how far students have achieved their intended learning outcomes.

Learning Outcomes and Weighting:

Content	CILO No.	Teaching (in hours)
I. Structure of solids	1, 3, 5	10
II. Atomic bonding	1, 3, 5	6
III. Electronic structure in solids	2, 3, 5	10
IV. Semiconductors	2, 4, 5	10

Textbook: None

References:

1. A. Beiser, Concepts of Modern Physics, 6th Ed., McGraw Hill, 2002.
2. C. Kittel, Introduction to Solid State Physics, 8th Ed., John Wiley and Sons, 2005.
3. B. G. Streetman and S. Banerjee, Solid State Electronic Devices, 6th Ed., Prentice Hall, 2005.
4. R. Eisberg and R. Resnick, Quantum Physics of Atoms, Molecules, Solids, Nuclei, and Particles, 2nd Ed., Wiley, 1985.
5. S. M. Sze and K. K. Ng, Physics of Semiconductor Devices, 3rd Ed., Wiley-Interscience, 2006.
6. R. A. Serway, C. J. Moses and C. A. Moyer, Modern Physics, 3rd Ed., Thomson Brooks/Cole, 2005.
7. K. Krane, Modern Physics, 2nd Ed., John Wiley & Sons, 1996.
8. S. T. Thornton and A. Rex, Modern Physics for Scientists and Engineers, 4th Ed., Cengage Learning, 2013.

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Course Content in Outline:

	Topic	**Hours**
I.	Structure of solids	10
	A. Crystal lattice	
	B. Symmetry	
	C. Common crystal structures	
	D. Diffraction from crystal structures	
	E. Brillouin zone and reciprocal lattice	
II.	Atomic bonding	6
	A. Interatomic interactions and cohesive energy	
	B. Chemical bonding (covalent crystals)	
	C. Electrostatic energy (ionic crystals)	
	D. Metallic bonds	
III.	Electronic structure in solids	10
	A. Nearly free electron model (energy bands, energy gap)	
	B. Periodic potentials and Bloch functions	
	C. Kronig-Penney model	
	D. Metals, semiconductors and insulators	
IV.	Semiconductors	10
	A. Effective mass and crystal momentum	
	B. Electronic inter-band transitions (optical processes, direct and indirect semiconductors)	
	C. Intrinsic and extrinsic semiconductors	
	D. Temperature dependence of charge carrier concentrations (Fermi-Dirac distribution)	
	E. Semiconductor junctions	