“Solid State Physics I” Course Syllabus

1、General information

Course Title	Solid State Physics I	**Course Code**	PHYS3110
Course Category	Major Core	**Majors**	Physics
Total Hours	4 credits	**Lecture Hours**	72 Hours
Instructor	Wang Xue Feng	**Date**	2021.9
Textbook	Charles Kittel, Introduction to Solid State Physics (Wiley: New York, 2004).		

2、Course Aim

(1) General Aim:

Solid State Physics I is a basic course of Applied Physics. The subject focuses on the relationship between the solid microstructure and particles and the law of their motion. The subject illustrates the solid properties and application, especially solid state theory and band theory. The topics include: Crystal structure, Binding of solid, Lattice vibration, Electronic energy band, Electron dynamics in solid.

(2) Specifications:

Course Aim 1: Be aware of the history and evolution of Solid State Physics; Important developments and applications in other science and technology communities, such as materials, nanotechnologies, and electronics; and the scope of application.

Course Aim 2: Grasp the fundamental principles and methods of Solid State Physics. Know well the Categories of crystals according to their geometry, atomic bindings and electronic structures. Be capable of estimating crystal properties according to their categories.

Course Aim 3: Master the analytical methods used in Solid State Physics, Master the method to calculate the binding energies, the phonon spectra, the electronic energy structures of typical crystals. Be capable of analyzing the transport properties of typical crystals and figuring out the electronic motion in electric field.

(3) Correspondence of the Course Aims to its Contents and the Graduation requirements

Table 1: Correspondence of Aims to Contents and graduation requirements

Course Aims	**The corresponding course contents**	**Graduation requirements**
Course Aim 1	Chapter 1: Crystal Structure; Chapter 3: Crystal Binding and Elastic Constant Chapter 5: Phonon II. Thermal Properties Chapter 8: Semiconductor crystals	Graduation requirement 3: Be aware of the frontier and development trends of physics, the physical ideas in new technologies, and be familiar with the impact of new discoveries, theories and technologies in physics on society. Graduation requirement 5: Proficient in a foreign language (English), with reading, writing, and communication skills. Graduation requirement 8: Inspire a passion of independent and lifelong learning, be adaptable to new environment.
Course Aim 2	Chapter 1: Crystal Structure; Chapter 2: Wave Diffraction and the Reciprocal Lattice; Chapter 3: Crystal Binding and Elastic Constant Chapter 4: Phonon 1. Crystal Vibration; Chapter 7: Energy Bands	Graduation requirement 2: Master the basic physical and mathematic knowledge, experimental methods and skills related. Develop the ability to analyze and solve problems using physical theories and methods. Graduation requirement 8: Inspire a passion of independent and lifelong learning, be adaptable to new environment.
Course Aim 3	Chapter 2: Wave Diffraction and the Reciprocal Lattice; Chapter 5: Phonon II. Thermal Properties Chapter 6: Free Electron Fermi Gas; Chapter 8: Semiconductor crystals Chapter 9: Fermi Surfaces and Metals.	Graduation requirement 2: Master the basic physical and mathematic knowledge, experimental methods and skills related. Develop the ability to analyze and solve problems using physical theories and methods. Graduation requirement 7: Be able to carry out project research, design, data processing, and academic communication. Graduation requirement 8: Inspire a passion of independent and lifelong learning, be adaptable to new environment.

3、Teaching Targets and Approaches

Chapter 1 Crystal Structure

1.Teaching Aim

In this chapter students study the basic concepts and methods to describe crystals. Students are required to be familiar with the concepts including Bravais Lattice and Primitive Vectors; Simple, Body-Centered, and Face-Centered Cubic Lattices; Primitive Unit Cell, Wigner-Seitz Cell, and Conventional Cell; Crystal Structures and Lattices with Bases; Symmetry Operations; Lattice Planes, and Miller Indices. Students should know how to Classify Bravais Lattices and understand the Seven Crystal Systems and Fourteen Bravais Lattices. Using the basic concepts, they can identify typical crystal structures such s Hexagonal Close-Packed and Diamond Structures; Sodium Chloride, Cesium Chloride, and Zincblende Structures.

2.Difficult Points

Bravais Lattice and Primitive Vectors; Symmetry Operations; Miller Indices

3. Teaching Contents

Section 1. Periodic Array of Atoms

(1) Lattice Translation Vectors

Key points: Understand translation symmetry and know how to find the lattice translation vectors of a crystal. Grasp the concepts basis and the crystal structure. Know how to find the primitive lattice cell of a crystal.

(2) Fundamental Type of Lattices

Key points: Know the two-dimensional lattice types and the three-dimensional lattice types.

(3) Index Systems for Crystal Planes

Key points: Know how to find out the Miller Indices of a given crystal lattice.

Section 2. Fundamental Types of Lattices

(1) Two-Dimensional Lattice types

Key points: Understand the classification of lattice types of two-dimensional crystals.

(2) Three-Dimensional Lattice types

Key points: Understand the classification of lattice types of three-dimensional crystals.

Section 3. Index Systems for Crystal Planes

Key points: Understand the index systems for crystal planes using primitive lattice vector coordination and conventional lattice vector coordination systems. Be familiar with the Miller Index system.

Section 4. Simple Crystal Structures

(1) Sodium Chloride Structure

Key points: Be familiar with the Sodium Chloride Structure. Know how to figure out the corresponding lattice structure, primitive cells, basis, and lattice type.

(2) Cesium Chloride Structure

Key points: Be familiar with the Cesium Chloride Structure. Know how to figure out the corresponding lattice structure, primitive cells, basis, and lattice type.

(3) Hexagonal Close-Packed Structure (hcp)

Key points: Understand the meaning of ‘Close-Packed Structures’. Be familiar with the difference between hcp and fcc structures.

(4) Diamond Structure

Key points: Be familiar with the Diamond Structure. Know how to figure out the corresponding lattice structure, primitive cells, basis, and lattice type.

(5) Cubic Zinc Sulfide Structure

Key points: Be familiar with the Cubic Zinc Sulfide Structure. Know how to figure out the corresponding lattice structure, primitive cells, basis, and lattice type.

4. Teaching method

PPT lectures, Handwritten derivation in class, discussion in class, tutorial after class, self-directed learning.

5. Evaluation

Via homework assignments, thinking questions in class, quizzes.

Chapter 2 Wave Diffraction and the Reciprocal Lattice

1. Teaching Aim

In this chapter students study the wave diffraction of crystal lattice and the concept of reciprocal lattice. Students are required to be familiar with the experiments of X-ray diffraction by crystals. Master the Bragg Law and Equation as well as Laue Equation or Formulation. Understand the equivalence of Bragg’s and Laue’s views of the X-ray diffraction in crystals. Understand the reason and the background for the introduction of reciprocal lattice. Master the relations between the direct and the reciprocal lattices.

2. Difficult Points

Establish a clear and full picture of crystal structure, crystal (direct) lattice, and reciprocal lattice.

3. Teaching Contents

Section 1. Diffraction of Waves by Crystals

(1) Bragg Law

Key points: Understand why the crystal planes can be treated as mirrors with specular reflection. Be able to derive the Bragg equation considering two neighbor crystal planes.

Section 2. Scattered Wave Amplitude

(1) Fourier Analysis

Key points: Understand the Fourier components of physical properties in crystals.

(2) Reciprocal Lattice Vectors

Key points: Master the method to obtain reciprocal lattice vectors.

(3) Diffraction Conditions

Key points: Understand the diffraction conditions of an incident wave in crystals.

(4) Laue Equations

Key points: Be able to derive the Laue Equations and understand their equivalence to the Bragg Law.

Section 3. Brillouin Zones

Key points: Be familiar with the reciprocal lattices to the sc, bcc, and fcc lattices. Grasp the method to find the Brillouin Zones of reciprocal lattice.

4. Teaching method

PPT lectures, Handwritten derivation in class, discussion in class, tutorial after class, self-directed learning.

5. Evaluation

Via homework assignments, thinking questions in class, quizzes.

Chapter 3 Crystal Binding and Elastic Constants

1. Teaching Aim

In this chapter students study the interatomic coupling for different elements. The energetic, mechanical, and geometric properties are discussed for typical binding types of atoms to construct crystal structures. Students are required to be familiar with the concept of binding energy and be able to estimate the binding energy, equilibrium lattice constant, and elastic constants for some simple cases.

2. Difficult Points

Estimate the energy versus the lattice constant of crystal from the interatomic coupling for an atom pair.

3. Teaching Contents

Section 1. Crystals of Inert Gases

(1) Van der Waals-London Interaction

Key points: Understand the physical mechanism of Van der Waals-London Interaction and be familiar with the simple model for the interaction.

(2) Repulsive Interaction

Key points: Understand the origins of the interatomic repulsive interaction.

(3) Equilibrium Lattice Constants

Key points: Estimate the equilibrium lattice constants for a known crystal structure from the interatomic coupling.

(4) Cohesive (Binding) energy

Key points: Be familiar with the definition of Binding energy and be able to apply it for analysis of crystal stability.

Section 2. Ionic Crystals

(1) Electrostatic or Madelung Energy

Key points: Understand the importance of direct Coulomb interaction in ionic crystals.

(2) Evaluation of the Madelung Constant

Key points: Be familiar with the calculation of Madelung constant for simple crystals.

Section 3. Covalent Crystals

Key points: Be familiar with the features of covalent crystals.

Section 4. Metals

Key points: Be familiar with the features of metallic crystals.

Section 5. Hydrogen Bonds

Key points: Be able to identify hydrogen bonds and typical materials with hydrogen bonds.

4. Teaching method

PPT lectures, handwritten derivation, discussion, tutorial after class, self-directed learning.

5. Evaluation

Via homework assignments, thinking questions in class, quizzes.

Chapter 4 Phonon I. Crystal Vibrations

1. Teaching Aim

In this chapter students study the dynamics of atoms in crystals and derive vibration modes of atoms in simple cases. Students are required to understand the physical origin of the adiabatic approximation and the harmonic approximation, be able to extract the Hook constant from the interatomic coupling, and be familiar with the derivation of vibration modes in one-dimensional crystals. Students should also establish the connection between the degree of freedom and the mode number and understand the reason why only the modes are distributed in the first Brillouin zone.

2. Difficult Points

Switch between real space and k-space when discussing atomic dynamics in crystals. Distinguish the group velocity from the phase velocity.

3. Teaching Contents

Section 1. Vibrations of Crystals with Monatomic Basis

(1) First Brillouin Zone

Key points: Establish the dynamic equation of atoms connected via spring to neighbors in the one-dimensional monatomic crystal chain, and derive the vibration modes in the first Brillouin zone.

(2) Group Velocity

Key points: Figure out the dispersion relation of vibration modes and derive the group velocity of each mode.

(3) Long Wavelength Limit

Key points: In the long wavelength limit estimate the sound velocity and compare it with the result of elastic wave.

Section 2. Two Atoms per Primitive Basis

Key points: Derive the phonon dispersion for one-dimensional diatomic chain.

Section 3. Quantization of Elastic Waves

Key points: Phonon is quasi-particle due to the quantization of vibration wave.

Section 4. Phonon Momentum

Key points: Understand the phonon momentum and know how to use it.

4. Teaching method

PPT lectures, Handwritten derivation in class, discussion in class, tutorial after class, self-directed learning.

5. Evaluation

Via homework assignments, thinking questions in class, quizzes.

Chapter 5 Phonon II. Thermal Properties

1. Teaching Aim

In this chapter students study the density of states and the thermal properties of phonons. Students are required to derive the heat capacities of phonons in the Einstein and the Debye models. Comparing the results with those obtained in classical gases, students should understand the quantum effects on thermal properties and the result of zero point energy.

2. Difficult Points

Understand the density of states and use it in the calculation of thermal properties. Obtain the total energy by integrating the energies of phonons and derive the limit at low and high temperatures.

3. Teaching Contents

Section 1. Phonon Heat capacity

(1) Bose-Einstein (Plank) Distribution

Key points: Be familiar with the Bose-Einstein (Plank) Distribution for phonons.

(2) Normal Mode Enumeration

Key points: Transfer the summation over states into integration with the density of states.

(3) Density of States in One Dimension

Key points: Density of states in energy space can be derived from the constant density of states in k-space. They are connected by the group velocity which can be obtained from the dispersion.

(4) Density of States in Three Dimension

Key points: Similarly, density of states in three dimension is obtained from the constant density of states in k-space and dispersion.

(5) Debye Model for Density of States

Key points: Density of states in obtained by assuming linear dispersion or constant sound velocity.

(6) Debye T^3 Law

Key points: Heat capacity is proportional to cubic power of temperature in the Debye model.

(7) Einstein Model of the Density of States

Key points: Density of states in obtained by assuming constant energy/frequency of phonon. The Heat capacity decreases exponentially at low temperature in the Einstein model.

4. Teaching method

PPT lectures, Handwritten derivation in class, discussion in class, tutorial after class, self-directed learning.

5. Evaluation

Via homework assignments, thinking questions in class, quizzes.

Chapter 6 Free Electron Fermi Gas

1. Teaching Aim

In this chapter students study the quantum description of free electrons with Coulomb interaction between electrons neglected. Students are required to derive the Fermi energy and understand the temperature dependence of the Fermi energy in systems of different dimensions. Thermal and electric properties of free electron Fermi gas are discussed.

2. Difficult Points

Connect the thermal & electric properties with the system parameters such as electron mass, density of states, density of electrons, dimensionality, and temperature, etc.

3. Teaching Contents

Section 1. Energy Levels in One dimension

Key points: Solve the Schrodinger equation to obtain the energy levels of standing electrons in one-dimensional square well. Energy levels of propagating electrons can be obtained using the periodic boundary condition.

Section 2. Effect of Temperature on the Fermi-Dirac Distribution

Key points: Be familiar with the variation of Fermi-Dirac distribution at different temperature.

Section 3. Free Electron Gas in Three Dimensions

Key points: Extend the one-dimensional results to three-dimensional cases. Notice the k-space difference between the standing and the propagating states and the difference in density of states between three- and one-dimensional systems.

Section 4. Heat Capacity of the Electron Gas

Key points: Calculate the energy of electron gas versus temperature with the temperature dependence of Fermi-Dirac distribution.

Section 5. Electrical Conductivity and Ohm’s Law

Key points: With the collision time known, electrical conductivity can be derived by estimating the momentum deviation under an electric field.

Section 6. Thermal Conductivity of Metals

Key points: Thermal conductivity can be estimated by assuming a temperature gradient.

4. Teaching method

PPT lectures, Handwritten derivation in class, discussion in class, tutorial after class, self-directed learning.

5. Evaluation

Via homework assignments, thinking questions in class, quizzes.

Chapter 7 Energy Bands

1. Teaching Aim

In this chapter students study the energy bands – the electronic structure of electron gas in periodic potential. Students should be familiar with the Bloch theorem and the Bloch functions. Students are required to understand well the physical mechanism behind the formation of energy bands.

2. Difficult Points

Prove and understand the Bloch theorem. Be familiar with the features of Bloch functions.

3. Teaching Contents

Section 1. Nearly Free Electron Model

(1) Origin of the Energy Gap

Key points: Understand the origin of the energy gap by considering redistribution of electrons in periodic potential.

(2) Magnitude of the Energy Gap

Key points: Estimate the energy difference of two standing waves in a periodic potential.

Section 2. Bloch Functions

Key points: Be familiar with the form of Bloch functions.

Section 3. Kronig-Penney Model

Key points: In the Kronig-Penney Model the energy bands can be solved exactly from the Schrodinger equation. This convinces us the existence of energy bands..

Section 4. Wave Equation of Electron in a Periodic Potential

(1) Restatement of the Bloch Theorem

Key points: Exact proof of the Bloch Theorem is given.

(2) Crystal Momentum of an Electron

Key points: Understand the crystal momentum of an electron in a periodic potential.

(1) Solution of the Central Equation

Key points: Understand the form of the central equation for energy bands and its solutions.

(2) Kronig-Penney Model in Reciprocal Space

Key points: Describe the KP model in k-space with the help of Fourier expansion.

(3) Empty Lattice Approximation

Key points: Reduce the energy band of free electron into the first Brillouin zone.

(4) Approximate Solution near a Zone Boundary

Key points: Consider only the coupling between states k and k+G near k=–G.

(5) Number of Orbitals in a Band

Key points: Each primitive cell contributes one independent value of k to each band.

(6) Metals and Insulators

Key points: Check the existence of overall energy gap near the Fermi energy.

4. Teaching method

PPT lectures, Handwritten derivation in class, discussion in class, tutorial after class, self-directed learning.

5. Evaluation

Via homework assignments, thinking questions in class, quizzes.

Chapter 8 Semiconductor Crystals

1. Teaching Aim

In this chapter students study the elementary properties of semiconductors – the gapped crystals. Students are required to understand the equation of motion for electrons in energy bands and be familiar with the widely used concepts in semiconductors such as hole and effective mass.

2. Difficult Points

Describe electronic dynamics in both the real space and the k-space.

3. Teaching Contents

Section 1. Band Gap

Key points: Understand the projection of energy bands in real space and be familiar with the conduction band, forbidden band and valence band.

Section 2. Equations of Motion

(1) Physical Derivation of the equations of motion

Key points: Establish the picture that the force on an object results in the change of momentum.

(2) Holes

Key points: Vacancies in valence band can conduct current as well electrons in conduction band.

(3) Effective Mass

Key points: Parabolic fitting of the bottom and the top of bands.

(4) Physical Interpretation of the Effective Mass

Key points: Understand the mass ‘change’ of electrons in a crystal.

(5) Effective Masses in Semiconductor

Key points: Be familiar with the usage of effective mass for electrons and holes.

(6) Silicon and Germanium

Key points: Be familiar with the typical element semiconductors.

(7) Intrinsic Carrier Concentration

Key points: Understand the difference between Intrinsic and extrinsic (doped) semiconductors.

(8) Intrinsic Mobility

Key points: Be able to evaluate the mobility of electrons.

(9) Impurity Conductivity

Key points: Understand the effects of impurities in semiconductors.

(10) Thermal Ionization of Donors and Acceptors

Key points: Be able to distinguish between donor and acceptor impurities.

Section 3. Thermoelectric Effects

Key points: Understand the thermoelectric phenomena in semiconductors..

4. Teaching method

PPT lectures, Handwritten derivation in class, discussion in class, tutorial after class, self-directed learning.

5. Evaluation

Via homework assignments, thinking questions in class, quizzes.

Chapter 9 Fermi Surfaces and Metals

1. Teaching Aim

In this chapter students study mainly the isoenergetic surface of energy bands at the Fermi energy and the tight-binding method for energy bands. Students are required to be familiar with the reduced, the extended, and the periodic schemes of Brillouin zones and be able to figure out briefly the shape of Fermi Surfaces in energy bands of metals. Students should be able to calculate the energy bands from a tight-binding Hamiltonian and derive the motions of electrons under a constant electric field.

2. Difficult Points

Establish the three-dimensional picture of energy bands in crystals. Be familiar with the solutions of eigen equations in matrix form.

3. Teaching Contents

Section 1. Schemes of Brillouin zones

Key points: Be familiar with the transform among the reduced, extended, and periodic zone schemes.

Section 2. Construction of Fermi Surfaces

Key points: Have a clear picture of the boundaries of Brillouin zones, the energy bands, and the Fermi Surfaces.

Section 3. Calculation of Energy Bands

Key points: Understand the physical origin of tight-binding method and be familiar with the method.

4. Teaching method

PPT lectures, Handwritten derivation in class, discussion in class, tutorial after class, self-directed learning.

5. Evaluation

Via homework assignments, thinking questions in class, quizzes.

Chapter 10 Superconductivity

1. Teaching Aim

In this chapter students study the phenomena of superconductivity and the corresponding theoretical description and understandings. Students are required to be familiar with the London Equation and the BCS description for superconductivity.

2. Difficult Points

Establish the picture of macroscopic quantum transport phenomena.

3. Teaching Contents

Section 1. Experimental Survey

Key points: Be familiar with the phenomena and features parameters for superconductivity.

Section 2. Theory Survey

Key points: Understand the London equation and the BCS ground state for superconductivity.

4. Teaching method

PPT lectures, Handwritten derivation in class, discussion in class, tutorial after class, self-directed learning.

5. Evaluation

Via homework assignments, thinking questions in class, quizzes.

Chapter 11 Diamagnetism and Paramagnetism

1. Teaching Aim

In this chapter students study briefly the diamagnetism and paramagnetism and the corresponding theoretical understandings.

2. Difficult Points

Understand the physical mechanisms of diamagnetism and paramagnetism.

3. Teaching Contents

Section 1. Langevin Diamagnetism Equation

Key points: Understand the Langevin equation for diamagnetism.

Section 2. Quantum Theory of Diamagnetism of Mononuclear Systems

Key points: Understand the quantum explanation of diamagnetism.

Section 3. Quantum Theory of Paramagnetism

Key points: Understand the quantum explanation of paramagnetism.

4. Teaching method

PPT lectures, Handwritten derivation in class, discussion in class, tutorial after class, self-directed learning.

5. Evaluation

Via homework assignments, thinking questions in class, quizzes.

Chapter 12 Ferromagnetism and Antiferromagnetism

1. Teaching Aim

In this chapter students study briefly the ferrognetism, the ferrimagnetism, and the antiferromagnetism plus the corresponding theoretical understandings.

2. Difficult Points

Understand the physical mechanisms of ferromagnetism and antiferromagnetism.

3. Teaching Contents

Section 1. Ferromagnetic Order

Key points: Understand the phenomena and physical mechanism of ferromagnetism.

Section 2. Ferrimagnetic Order

Key points: Understand the phenomena and physical mechanism of ferromagnetism.

Section 3. Antiferromagnetic Order

Key points: Understand the phenomena and physical mechanism of antiferromagnetism.

4. Teaching method

PPT lectures, Handwritten derivation in class, discussion in class, tutorial after class, self-directed learning.

5. Evaluation

Via homework assignments, thinking questions in class, quizzes.

4、Class Hour Allocation

Table 2: Contents and class hours per chapter

Chapter	contents	Class hours
Chapter 1	Crystal Structure	8
Chapter 2	Wave Diffraction and the Reciprocal Lattice	4
Chapter 3	Crystal Binding and Elastic Constants	8

Chapter 4	Phonon I. Crystal Vibrations	8
Chapter 5	Phonon II. Thermal Properties	6
Chapter 6	Free Electron Fermi Gas	6
Chapter 7	Energy Bands	6
Chapter 8	Semiconductor Crystals	8
Chapter 9	Fermi Surfaces and Metals	8
Chapter 10	Superconductivity	2
Chapter 11	Diamagnetism and Paramagnetism	2
Chapter 12	Ferromagnetism and Antiferromagnetism	2
Review and Final Exam		4

5、Course Schedule

Table 3: Course schedule

Week	Date	Chapter	Contents	Hours	Assignments and requirements
1	-	1	Introduction to the course, Lattice Translation Vectors; Bravais Lattice and Primitive Vectors; Simple, Body-Centered, and Face-Centered Cubic Lattices; Primitive Unit Cell, Wigner-Seitz Cell, and Conventional Cell; Crystal Structures and Lattices with Bases;	4	Problems 1,3
2	-	1	Symmetry Operations and the Classification of Bravais Lattices; The Seven Crystal Systems and Fourteen Bravais Lattices;Hexagonal Close-Packed and Diamond Structures; Sodium Chloride, Cesium Chloride, and Zincblende Structures; Lattice Planes, and Miller Indices;	4	Problem 5
3	-	2	Diffraction of Waves by Crystals; Formulation of Bragg and von Laue; The Laue Condition and Ewald's Construction; Definitions and Examples of Reciprocal Lattices; First Brillouin Zone	4	Problems 1, 4, 7

4	-	3	The Spatial Distribution of Valence Electrons Ionic Crystals, Covalent Crystals and Metals Molecular Crystals and Hydrogen-Bonded Solids; The Noble Gases: The Lennard-Jones Potential	4	Problems 1,2,3
5	-	3	Density, Cohesive Energy, and Bulk Modulus of the Solid Noble Gases; Ionic Crystals: The Madelung Constant Failures of the Static Lattice Model	4	Problems 4,5
6	-	4	The Harmonic Approximation; The Adiabatic Approximation; One-Dimensional Monatomic Bravais Lattice	4	Problems 1,4
7	-	4	One-Dimensional Lattice with a Basis; Relation to Theory of Elasticity	4	Problems 5,7
8	-	5	Normal Modes and Phonons; Models of Debye and Einstein; Comparison of Lattice and Electronic Specific Heats	4	Problems 1,3,4,
9	-	5, 6	Density of Normal Modes; Debye T^3 Law; Free Electron Fermi gases; Energy Levels in One dimension; Effect of Temperature on the Fermi-Dirac Distribution	4	Chapter 5, Problem 4; Chapter 6, Problem 1
10	-	6	The Periodic Potential and Bloch's Theorem Born-von Karman Boundary Condition Electrical Conductivity and Ohm's Law; Thermal Conductivity of Metals	4	Problems 5, 6,8
11	-	7	Nearly free electron model; Origin of the Energy Gap; Magnitude of the Energy Gap; Bloch Functions; Wave Equation of Electron in a Periodic Potential	4	Problems 1,2,6,8
12	-	7,8	Perturbation Theory and Weak Periodic Potentials; Energy Levels Near a Single Bragg Plane; Bnd Gap; Illustration of Extended-, Reduced-, and Repeated-Zone Schemes in One Dimension	4	Chapter 7, Problem 8
13	-	8	Equations of Motion; Static Electric Fields; The General Theory of Holes; Crystal Momentum, Band Index, and Velocity;	4	Problems 2,4
14	-	8,9	Intrinsic Carrier Concentration; Thermoelectric Effects; The Fermi Surface; Fermi Surface and Brillouin Zones; Linear Combinations of Atomic Orbitals; Schemes of Brillouin zones	4	Chapter 9, Problems 1
15	-	9	Wave Packets of Bloch Electrons; Semiclassical Mechanics; General Features of the Semiclassical Model; Calculation of Energy Bands; Application tight-binding method to Bands from s-Levels	4	Problems 2,3
16	-	9,10	General Features of Tight-Binding Levels; Superconductivity	4	Chapter 9, Problem 4; Chapter10, Problem 1
17	-	11,12	Diamagnetism and Paramagnetism; Ferromagnetism and Antiferromagnetism	4	Ch. 11, Problems 1, 2; Ch. 12, Problem 3
18	-		Review and Final Exam	4	

6、Textbook and References

1．Charles Kittel, Introduction to Solid State Physics (Wiley: New York, 2004).
2. 黄昆. 固体物理学. 北京：人民教育出版社，1988.
3. 中译本：基泰尔“固体物理导论”，项金钟、吴兴惠译，化学工业出版社
4. 胡安，章维益，“固体物理学”，高等教育出版社， 北京，2010.

7、Teaching Philosophy and Methods

1. All students are regarded as potential discoverers of new facts rather than as receptacles for memorizing previously developed knowledge. A teacher is a facilitator for this discovering process. It is the teacher’s responsibility to design the framework in which learning can take place, and then stimulate and nurture the students' development, giving help in terms of knowledge, techniques, and encouragement.

2. The students learn in different ways and all students in a class should be included in the learning process. Different teaching styles will be introduced to the class addressing different learning styles and students will be encouraged to participate in a mixture of lecture, discussion, and group activities.

3. PPT presentation, blackboard hand written derivation, and other teaching aid are used in the teaching practice.

7、Course Examination

7.1 The Correspondence between the Course Examination and the Course Aim

Table 4: Correspondence between Examination and Aim

Course Aim	**Examination Content**	**Exam method**
Course Aim 1	Corresponding Teaching Content	Usual Performance+ Quiz+Exam
Course Aim 2	Corresponding Teaching Content	Usual Performance+ Quiz+Exam
Course Aim 3	Corresponding Teaching Content	Usual Performance+ Quiz+Exam

7.2 Grading Method

(1) Grading

Multi-process evaluation: in class and off class assessment, processive and final exam.

Calculation: Overall Grade = (Attendance and Homeworks)*20% +(Quiz 1)*10%+(Midterm Exam)*20%+(Quiz 2)*10%+(Cumulative Final Exam)*40%

(2) Weight of Course Aims in Grading

Table 5: Weight of Course Aims and Grading Analysis

Weight / Course Aim	Usual performance	Processive Exams	Overall Grading
Aim 1	20%	20%	Aim1: Grade=0.2 x usual + 0.2 x quizs+0.8 x exams Aim2: Grade=0.2 x usual + 0.2 x quizs+0.8 x exams Aim3: Grade=0.2 x usual + 0.2 x quizs+0.8 x exams Overall Grade = 0.2 x Aim1 Grade + 0.4 x Aim1 Grade + 0.4 x Aim1 Grade
Aim 2	40%	40%	
Aim 3	40%	40%	

7.3 Grading Standard

Course Aim	**Grading Standard**				
	90-100	**80-89**	**70-79**	**60-69**	**＜60**
	Outstanding	**Excellent**	**Good**	**Passed**	**Failed**
	A	**B**	**C**	**D**	**F**
Aim 1	Masterly Achieved	Greatly Achieved	Progressively Achieved	Basically Achieved	No Enough Evidence of Achievement
Aim 2	Masterly Achieved	Greatly Achieved	Progressively Achieved	Basically Achieved	No Enough Evidence of Achievement
Aim 3	Masterly Achieved	Greatly Achieved	Progressively Achieved	Basically Achieved	No Enough Evidence of Achievement