هيئة تقويم التعليم والتدريب
Education & Training Evaluation Commission

T-104
2022

# Course Specification

| | |
|---|---|
| Course Title: | Solid State Physics |
| Course Code: | PHYS 371 |
| Program: | B.Sc. in Physics |
| Department: | Department of Physics and astronomy |
| College: | College of Science |
| Institution: | King Saud University |
| Version: | 2.0.0 |
| Last Revision Date: | Sep 2023 |

# Table of Contents:

# A. General information about the course:

| Course Identification | | | | | |
|---|---|---|---|---|---|
| **1. Credit hours:** | 4(3+0+2) | | | | |
| **2. Course type** | | | | | |
| a. | University ☐ | College ☐ | Department☒ | Track☐ | Others☐ |
| b. | Required ☒ | Elective☐ | | | |
| **3. Level/year at which this course is offered:** | sixth level /third year. | | | | |
| **4. Course general Description**<br><br>The course aims to introduce students to the physics of the solid state. The first part considers crystal structure and bonds in solid matter. Emphasis is put on cubic and hexagonal crystals. The interference pattern obtained by diffraction of waves by crystals reveals the lattice structure of the solid state. Concepts such as the reciprocal lattice vector and the Brillouin zone are introduced. In the second part, lattice vibrations are analyzed, and the dispersion relationship is introduced to understand how the lattice vibrates. The Debye and Einstein models for heat capacity are covered to explain how the lattice energy changes with temperature. Free electron Fermi gas model is introduced to explain electronic heat capacity and other electrical properties. | | | | | |
| **5. Pre-requirements for this course (if any):** 353phys | | | | | |
| **6. Co- requirements for this course (if any):** | | | | | |
| **7. Course Main Objective(s)**<br>1. explain the basic concepts of the structural and physical properties of materials.<br>2. recognize the main theories and laws of solid-state physics.<br>3. outline the crystal structure, reciprocal lattice and Brillouin zones, bonds in Crystals, free electron theory, phonons and lattice vibrations, thermal properties of insulators. | | | | | |

## 1. Teaching mode (mark all that apply)

| No | Mode of Instruction | Contact Hours | Percentage |
|---|---|---|---|
| 1. | Traditional classroom | 45 | 100% |
| 2. | E-learning | 0 | 0 |
| 3. | Hybrid<br>• Traditional classroom<br>• E-learning | 0 | 0 |
| 4. | Distance learning | 0 | 0 |

## 2. Contact Hours (based on the academic semester)

| No | Activity | Contact Hours |
|---|---|---|
| 1. | Lectures | 42 |
| 2. | Laboratory/Studio | 0 |
| 3. | Field | 0 |
| 4. | Tutorial | 0 |
| 5. | Others (specify) | 0 |
| | Total | 42 |

# B. Course Learning Outcomes (CLOs), Teaching Strategies and Assessment Methods

| Code | Course Learning Outcomes | Code of CLOs aligned with program | Teaching Strategies | Assessment Methods |
|---|---|---|---|---|
| 1.0 | Knowledge and understanding | | | |
| 1.1 | demonstrate a knowledge and broad understanding for solid state concepts in crystal structure, direct and reciprocal space and crystal binding. | K1 | • Give extensive examples during lecture.<br>• Give problem sheets to be discussed during lecture.. | • Hold Class discussion, tutorial sessions.<br>• Give quizzes, mid-term exam and final exam. |
| 1.2 | Explain thermal properties of phonons, heat capacity of phonons, Density of states and electrical and thermal conductivity. | K2 | | |
| 2.0 | Skills | | | |
| 2.1 | do quantitative calculations based on established theoretical models to describe the thermal properties of materials. | S1 | • Give extensive examples during lecture<br>• Give problem sheets to be discussed during lecture and labs.<br>• assignments.<br>• Discussions in the classes | • Hold Class discussion.<br>• Give Homework, mid-term exam and final exam. |
| 2.2 | demonstrate solving problems related to solid state physics. | S2 | | |
| 3.0 | Values, autonomy, and responsibility | | | |
| 3.1 | Write and present a short scientific paper on a published research work in solid state physics. | V1 | • Assignment | Group discussion and Presentation |

## C. Course Content

| No | List of Topics | Contact Hours |
|---|---|---|
| 1. | **Crystal Structure:**<br>• Definitions: lattice, basis, crystal structure, primitive lattice cell, volume of cell; Bravais lattice.<br>• Fundamental types of lattices (2D and 3D types).<br>• index systems for crystal planes, Lattice Planes and Miller indices.<br>• Simple crystal structures, Hexagonal close-packed (hcp) | 9 |
| 2. | **Determination of crystal structure, reciprocal, and Bravais lattice:**<br>• Determination of crystal structure: Bragg law, diffraction condition, Lau condition.<br>• Bravais lattice, reciprocal lattice vectors, Lattice Planes and Miller indices, Brillouin zone | 8 |
| 3. | **Crystal binding and elastic constants:**<br>• Energy calculations, the potential of energy function.<br>• Covalent binding.<br>• Ionic binding<br>• Metallic bonds<br>• Hydrogen Bonds | 7 |
| 4. | **Phonon I:**<br>• Vibrations of Crystals with Monatomic Basis<br>• First Brillouin Zone<br>• Group Velocity, Long Wavelength Limit, normal modes<br>**Phonon II: Thermal properties:**<br>• Phonon Heat Capacity<br>• Planck Distribution<br>• Density of States in One Dimension<br>• Density of States in Three Dimensions<br>• Debye Model for Density of States<br>• Debye T3 Law<br>• Einstein Model of the Density of States.<br>• Thermal conductivity. | 7 |
| 5. | **Energy bands:**<br>• Bloch theorem<br>• Kronig-Penney model<br>• Metal and insulator. | 2 |
| 6. | **Semiconductor:**<br>• Band gap, holes and electrons, effective mass.<br>• Homogenous and inhomogenous seminconductor. | 2 |
| 7. | **Free electron Fermi Gas:**<br>• Fermi-Dirac distribution,<br>• Energy levels, Heat capacity.<br>• Electrical Conductivity and Ohm's Law.<br>• Thermal conductivity of metals. | 7 |

| Total | 42 |
|---|---|

## D. Students Assessment Activities

| No | Assessment Activities * | Assessment timing (in week no) | Percentage of Total Assessment Score |
|---|---|---|---|
| 1. | First Midterm examination | Approx. 7 | 20% |
| 2. | Second Midterm examination | Approx. 11 | 20% |
| 3. | project | Approx.10 | 10% |
| 4. | Homework | 3-4 times | 10% |
| 4. | Final examination | From 16 to 18 | 40% |

*Assessment Activities (i.e., Written test, oral test, oral presentation, group project, essay, etc.)

## E. Learning Resources and Facilities

### 1. References and Learning Resources

| | |
|---|---|
| Essential References | 1- "An Introduction to Solid States Physics", C. Kittle, 8th Edition, John Wiley & Son Inc (2005).<br>2- The Oxford solid state basics, Steven H. and Simon, Oxford university press 2016 |
| Supportive References | 1- "Solid State Physics, Ashcroft & Mermin", 1st Edition, Harcourt Asia Pte Ltd (1976).<br>2- "Introduction to condensed matter Physics." Feng Duan & Jin Guojun, (World Scientific, 2005). |
| Electronic Materials | None |
| Other Learning Materials | Internet sites relevant to the course |

### 2. Required Facilities and equipment

| Items | Resources |
|---|---|
| facilities (Classrooms, laboratories, exhibition rooms, simulation rooms, etc.) | A classroom which accommodates 25 students. |
| Technology equipment (projector, smart board, software) | Whiteboard and Smart board |
| Other equipment (depending on the nature of the specialty) | Not applicable |

## F. Assessment of Course Quality

| Assessment Areas/Issues | Assessor | Assessment Methods |
|---|---|---|
| Effectiveness of teaching | Students\ Peer Reviewer | Indirect \ direct |
| Effectiveness of students assessment | Students- Faculty | Direct |
| Quality of learning resources | students | Indirect |
| The extent to which CLOs have been achieved | Faculty | Indirect |
| Other | None | None |

**Assessor** (Students, Faculty, Program Leaders, Peer Reviewer, Others (specify)

**Assessment Methods** (Direct, Indirect)

## G. Specification Approval Data

| | |
|---|---|
| **COUNCIL /COMMITTEE** | Physics Department's council |
| **REFERENCE NO.** | 8th (1st term/1445) |
| **DATE** | 06/06/1445 |