JIMMA UNIVERSITY

COLLEGE OF NATURAL SCIENCE

Department of physics

Solid State Physics I (Phys 2062) course outline

Course Title and Code: **Solid State Physics I (Phys 2062)**

Credits 3 Cr.hrs = Lecture (3 hrs) + Tutor (1 hrs)

Prerequisite(s): Modern physics (Phys **342**) Co - requisite(s): _____

Academic Year: 2012E.C / Semester [ ] / [√]

College: Natural Science Department: Physics

Program: Undergraduate Enrollment: Regular

Instructor's Name: GIZACHEW DIGA

Address: block № _____ room №_____

Course Rationale

The aims of this course are to introduce students to the basic ideas that underline solid-state physics, with emphasis on the behavior of electrons in crystalline structures, particularly in materials that are metallic. Students will appreciate solid-state physics as one branch of physics, which plays a fundamental role in the electronic industry.

Learning Outcomes

Upon completion of this course, students should be able to:

- examine the behavior of solid state systems and, their application with physical laws, make quantitative predictions of future behavior based upon their properties,
- describe crystal structure of solids in terms of a space lattice + unit cell, and relate structures in real space to those in reciprocal space,
- explain the concepts of the reciprocal lattice and the Brillouin zone,
- discuss the electrical, thermal and optical properties of solids in terms of the free electron model,
- describe how crystalline structures vibrate and the associated theories of heat capacity,
- discuss the factors that control the electrical conductivity of metals,
- explain the relation between XRD and reciprocal lattice.

Course Description: This course describes phenomena associated with the solid state: Topics to be treated include the classification of solids and crystal structure, X-ray diffraction, classification of crystals, binding energy, and an introduction to their electronic, vibrational, thermal, optical, magnetic, dielectric properties and the quantum mechanical description of electrons in crystals.

Course Outline

1) Crystal Structure (6 hrs)

1.1) Introduction- atomic models

1.2) Lattice points and space lattice

1.3) Fundamental types of lattices

1.4) Index system for crystal planes

1.5) Classification of crystals

2) X-Ray Diffraction (4 hrs)

2.1) Reciprocal lattices

2.2) Diffraction of waves by crystals: Bragg's law

2.3) Brillouin zones in one and two dimensions

3) Binding Energy in Crystals (5 hrs)

3.1) Bonding in solids

3.2) Ionic bonding

3.3) Covalent bonding

3.4) Metallic bond

3.5) Properties of metallic crystals

3.6) Cohesive energy and Madelung constant

4) **Thermal properties of solids (7 hrs)**

4.1) Crystal vibration

4.2) Lattice Specific heat

4.3) Classical theory (Dulong and Petit law)

4.4) Einstein's theory of specific heat

4.5) Debye's theory

4.6) Thermal conductivity

5) Dielectric properties of solids (9 hrs)

5.1) Review of basic formulae

5.2) The microscopic concept of polarization

5.3) Langevins theory of polarization in polar dielectrics

5.4) Clausius - Mosotti relation

5.5) The static dielectric constant of solids and liquids (Polarization of ionic crystals)

5.6) Ferroelectricity

5.7) Piezoelectricity

6) **Magnetic properties of solids** (8 hrs)

6.1) Magnetic permeability

6.2) Magnetization

6.3) Diamagnetism

6.4) Paramagnetism

6.5) Ferromagnetism

6.6) Quantum theory of paramagnetism and ferromagnetism

6.7) The magnetic domain model and domain wall

7) **The free electron Fermi gas** (**6 hrs**)

7.1) Energy levels in one dimension

7.2) Effect of temperature on the Fermi- Dirac distribution

7.3) Free electron gas in three dimensions

7.4) Heat capacity of the electron gas

Method of Teaching

Lecture, discussion (group works), home assignments, presentation, demonstration, and online learning resources.

Assessment

- Assignments and term projects, 15%
- Quizzes and tests 10%
- Midterm exam (25 %) and Semester final examination (50%)

Recommended References

1.C. Kittel, Introduction to Solid State Physics, Wiley, 8 ed., (2004).

2.M. Ali Omar, Elementary Solid state Physics: Principles and Applications, Addison Wesley, (1993).

3. S. O. Pillai, Solid State Physics, New Age Int. 6^{th} ed., (2008).

4. Ashcroft N.W., and Mermin N.D., Solid State Physics, Holt Saunders, (1976).

5. Burns G., Solid State Physics, Academic Press, (1985).

6. Hook J.R. and Hall H.E., Solid State Physics 2 ed., Wiley, (1991).

7. L. Mihly and M.C. Martin, Solid State Physics; problems and Solutions, Wiley- VCH, (2009).