Solid state fundamentals for engineering

Academic Year: (2023 / 2024) **Review date: 12/02/2024 13:04:40**

Department assigned to the subject: Physics Department

Coordinating teacher: MUÑOZ CASTELLANOS, ANGEL

Type: Compulsory ECTS Credits : 6.0

Year : 2 Semester : 2

REQUIREMENTS (SUBJECTS THAT ARE ASSUMED TO BE KNOWN)

It is expected the students have taken the following courses in Engineering Physics: Physics I and II, Calculus I and II, Linear Algebra, Chemistry I and II, Probability and Statistic, Materials science and engineering, Differential equations, Quantum Physics, Mechanics and relativity, Complex variables and transforms.

LEARNING OUTCOMES

CB1. Students have demonstrated possession and understanding of knowledge in an area of study that builds on the foundation of general secondary education, and is usually at a level that, while relying on advanced textbooks, also includes some aspects that involve knowledge from the cutting edge of their field of study.
CB2. Students are able to apply their knowledge to their work or vocation in a professional manner and possess the competences usually demonstrated through the development and defence of arguments and problem solving within their field of study.
CB3. Students have the ability to gather and interpret relevant data (usually within their field of study) in order to make judgements which include reflection on relevant social, scientific or ethical issues.
CB4. Students should be able to communicate information, ideas, problems and solutions to both specialist and non-specialist audiences.
CB5. Students will have developed the learning skills necessary to undertake further study with a high degree of autonomy.
CG1. Analyze and synthesize basic problems related to physics and engineering, solve them and communicate them efficiently.
CG2. Learn new methods and technologies from basic scientific and technical knowledge, and being able to adapt to new situations.
CG3. Solve problems with initiative, decision making, creativity, and communicate and transmit knowledge, skills and abilities, understanding the ethical, social and professional responsibility of the engineering activity. Capacity for leadership, innovation and entrepreneurial spirit.
CG4. Solve mathematical, physical, chemical, biological and technological problems that may arise within the framework of the applications of quantum technologies, nanotechnology, biology, micro- and nano-electronics and photonics in various fields of engineering.
CG5. Use the theoretical and practical knowledge acquired in the definition, approach and resolution of problems in the framework of the exercise of their profession.
CG6. Develop new products and services based on the use and exploitation of new technologies related to physical engineering.
CE9. Understand and handle the fundamentals of materials science, technology and chemistry, as well as the relationship between microstructure, synthesis or processing and the properties of materials.
CE13. Understand and handle solid state physical principles relevant to engineering and, in particular, semiconductors for application in electronic and photonic components, as well as the fundamentals and applications of analog and digital electronics and microprocessors.
CT1. Work in multidisciplinary and international teams as well as organize and plan work making the right decisions based on available information, gathering and interpreting relevant data to make judgments and critical thinking within the area of study.

RA1. To have acquired sufficient knowledge and proved a sufficiently deep comprehension of the basic principles, both theoretical and practical, and methodology of the more important fields in science and technology as to be able to work successfully in them.

RA2. To be able, using arguments, strategies and procedures developed by themselves, to apply their knowledge and abilities to the successful solution of complex technological problems that require creating and innovative thinking.
RA3. To be able to search for, collect and interpret relevant information and data to back up their conclusions including, whenever needed, the consideration of any social, scientific and ethical aspects relevant in their field of study.
RA6. To be aware of their own shortcomings and formative needs in their field of specialty, and to be able to plan and organize their own training with a high degree of independence.

OBJECTIVES

CB1. Students have demonstrated knowledge and understanding in a field of study that builds upon their general secondary education, and is typically at a level that, whilst supported by advanced textbooks, includes some aspects that will be informed by knowledge of the forefront of their field of study
CB2. Students can apply their knowledge and understanding in a manner that indicates a professional approach to their work or vocation, and have competences typically demonstrated through devising and sustaining arguments and solving problems within their field of study
CB3. Students have the ability to gather and interpret relevant data (usually within their field of study) to inform judgments that include reflection on relevant social, scientific or ethical issues
CB4. Students can communicate information, ideas, problems and solutions to both specialist and non-specialist audiences
CB5. Students have developed those learning skills that are necessary for them to continue to undertake further study with a high degree of autonomy
CG1. Analyze and synthesize basic problems related to physics and engineering, solve them and communicate them efficiently.
CG2. Learn new methods and technologies from basic scientific and technical knowledge, and being able to adapt to new situations.
CG3. Solve problems with initiative, decision making, creativity, and communicate and transmit knowledge, skills and abilities, understanding the ethical, social and professional responsibility of the engineering activity. Capacity for leadership, innovation and entrepreneurial spirit.
CG4. Solve mathematical, physical, chemical, biological and technological problems that may arise within the framework of the applications of quantum technologies, nanotechnology, biology, micro- and nano-electronics and photonics in various fields of engineering.
CG5. Use the theoretical and practical knowledge acquired in the definition, approach and resolution of problems in the framework of the exercise of their profession.
CG6. Develop new products and services based on the use and exploitation of new technologies related to physical engineering.
CE9. Understand and handle the fundamentals of materials science, technology and chemistry, as well as the relationship between microstructure, synthesis or processing and the properties of materials.
CE13. Understand and handle solid state physical principles relevant to engineering and, in particular, semiconductors for application in electronic and photonic components, as well as the fundamentals and applications of analog and digital electronics and microprocessors.
CT1. Work in multidisciplinary and international teams as well as organize and plan work making the right decisions based on available information, gathering and interpreting relevant data to make judgments and critical thinking within the area of study.
RA1. To have acquired sufficient knowledge and proved a sufficiently deep comprehension of the basic principles, both theoretical and practical, and methodology of the more important fields in science and technology as to be able to work successfully in them;
RA2. To be able, using arguments, strategies and procedures developed by themselves, to apply their knowledge and abilities to the successful solution of complex technological problems that require creating and innovative thinking;
RA3. To be able to search for, collect and interpret relevant information and data to back up their conclusions including, whenever needed, the consideration of any social, scientific and ethical aspects relevant in their field of study;
RA6. To be aware of their own shortcomings and formative needs in their field of specialty, and to be able to plan and organize their own training with a high degree of independence.

DESCRIPTION OF CONTENTS: PROGRAMME

1.BONDING IN SOLIDS
1.1 General considerations
1.2 Ionic bonds

1.3 Covalent bonds
1.4 Van der Waals bonds
1.5 Metallic bonds
1.6 Hydrogen bonds

2. LATTICE VIBRATIONS. PHONONS- HEAT CAPACITY
2 1 Introduction
2.2 Interaction of atoms in the crystal
2.3 Vibrations of an one dimensional monoatomic chain
2.4 Vibration of an one dimensional diatomic chain
2.5 Three-dimensional lattice
2.6 Phonons
2.7 Heat capacity

3.THE THEORY OF FREE ELECTRONS IN METALS
3.1 Classical theory of metals: The Drude model
3.2 Electrical and thermal conductivity in metals
3.3 Quantum theory of metals: The Sommerfeld model
3.4 Work function
3.5 Thermionic emission
3.6 Photoelectric effect

4.THE BAND THEORY OF SOLIDS
4.1 Introduction: Band theory
4.2 Bloch theorem
4.3 The Kronig-Penny model
4.4 Some remarks about the Bloch theorem
4.5 Electrons affective mass
4.6 Metals and insulators
4.7 Holes and electrons

5.SEMICONDUCTORS
5.1 Introduction
5.2 Band Gap
5.3 Pure or intrinsic semiconductors
5.4 Extrinsic semiconductors
5.5 P-n junctions
5.6 Diodes, Transistors: Bipolar junctions transistor

6. DIELECTRIC MATERIALS
6.1 Introduction
6.2 Dielectric materials
6.3 Mechanisms of polarization
6.4 The complex dielectric constant. Frequency response
6.5 Piezoelectricity
6.6 Ferroelectricity

7.MAGNETIC MATERIALS
7.1 Introduction
7.2 Microscopic overview
7.3 Diamagnetism
7.4 Paramagnetism
7.5 Ferromagnetism and antiferromagnetism
7.6 Magnetic resonance

8.OPTICAL PROPERTIES OF MATERIALS
8,1 Basic concepts
8.2 Optical properties of metals
8.3 Optical properties of non-metals
8.4 Applications of optical phenomena

9. SUPERCONDUCTIVITY
9.1 Overview

9.2 Electrical rsistivity
9.3 The effects of a magnetic field
9.4 Microscopic theory
9.5 High Tc superconductors
9.6 Applications

LEARNING ACTIVITIES AND METHODOLOGY

AF1. THEORETICAL-PRACTICAL CLASSES. Knowledge and concepts students must acquire. Receive course notes and will have basic reference texts. Students partake in exercises to resolve practical problems
AF2. TUTORING SESSIONS. Individualized attendance (individual tutoring) or in-group (group tutoring) for students with a teacher. Subjects with 6 credits have 4 hours of tutoring/ 100% on- site attendance.
AF3. STUDENT INDIVIDUAL WORK OR GROUP WORK. Subjects with 6 credits have 98 hours/0% on-site.
AF8. WORKSHOPS AND LABORATORY SESSIONS. Subjects with 3 credits have 4 hours with 100% on-site instruction. Subjects with 6 credits have 8 hours/100% on-site instruction.
AF9. FINAL EXAM. Global assessment of knowledge, skills and capacities acquired throughout the course. It entails 4 hours/100% on-site
AF8. WORKSHOPS AND LABORATORY SESSIONS. Subjects with 3 credits have 4 hours with 100% on-site instruction. Subjects with 6 credits have 8 hours/100% on-site instruction (4 laboratory sessions).
MD1. THEORY CLASS. Classroom presentations by the teacher with IT and audiovisual support in which the subject`s main concepts are developed, while providing material and bibliography to complement student learning
MD2. PRACTICAL CLASS. Resolution of practical cases and problem, posed by the teacher, and carried out individually or in a group
MD3. TUTORING SESSIONS. Individualized attendance (individual tutoring sessions) or in-group (group tutoring sessions) for students with teacher as tutor. Subjects with 6 credits have 4 hours of tutoring/100% on-site.
MD6. LABORATORY PRACTICAL SESSIONS. Applied/experimental learning/teaching in workshops and laboratories under the tutor's supervision.

ASSESSMENT SYSTEM

% end-of-term-examination/test:	60
% of continuous assessment (assigments, laboratory, practicals…):	40

Throughout the course there will be continuous assessment tests. These tests will consist of several exams. They will allow to evaluate the degree of understanding of the different theoretical concepts explained in the lectures. The result of this evaluation will be the 25% of the final grade.
Laboratory practical sessions of the course will be structured in 4 sessions of 1.5 hours. Assistance and preparation of reports for each of the practices is compulsory. The laboratory final grade will be evaluated on the following two aspects of each of the practical sessions:
a) Student participation. It will be checked by questions made to the students by the teacher after the delivery of each report.
b) Correction of the report prepared for each practical session.

The lab grade will be 15% of the final grade.
It is compulsory to deliver the lab reports in order to pass the course.

There will be a final exam, which may consist of theoretical and practical (problems solving) questions. Its score will represent 60% of the final grade. In order to pass the course, a minimum grade of 3 (out of 10) must be obtained in the final exam.

BASIC BIBLIOGRAPHY

- Charles Kittel Introduction to solid state physics, 8th ed. Hoboken, NJ : John Wiley & Sons , 2005

- L. Solymar, D. Walsh Electrical properties of materials, Oxford Universitary Press, 2010

- Neil W. Ashcroft Solid state physics, [International ed.]. Fort Worth etc. : Sanders College Publishing , 1976

- Steven H. Simon The oxford solid state basics, Ed: Oxford : Oxford University Press , 2013

ADDITIONAL BIBLIOGRAPHY

- H. P. Myers , Introductory solid state physics, 2nd ed. London : Taylor & Franci.

- John R. Hook H.E Hall Solid State Physics, 2nd ed. Chichester : John Wiley & Sons.

- Manijeh Razeghi Fundamentals of solid state engineering, Kluver Acacemidc Publishers 2002.

- R. K. Puri, V.K. Babbar Solid state physics, , S. Chand&Company, LTD, Ramnagar New Delhi.