NE 303 SOLID STATE PHYSICS

Course Code	Course Name	Semester	
NE 303	SOLID STATE PHYSICS	Fall ☒ Spring ☐ Summer ☐	
Hours		**Credit**	**ECTS**
Theory	**Practice** / **Lab**	3	5
3	0 / 0		

Course Details	
Department	Nanotechnology
Course Language	English
Course Level	Undergraduate ☒ Graduate ☐
Mode of Delivery	Face to Face ☒ Online ☐ Hybrid ☐
Course Type	Compulsory ☒ Elective ☐
Lecturer(s)	
Course Objectives	• Understand the crystal structures and symmetries in solids. • Analyze bonding mechanisms and interatomic forces. • Learn about electron behavior in periodic potentials and energy band structures. • Gain insight into phonons and thermal properties of solids. • Explore electrical, thermal, and magnetic properties of solids with applications to nanomaterials. • Connect quantum phenomena to the physical behavior of nanostructures.
Course Content	• **Introduction to solid state physics and its relevance to nanotechnology:** Basic concepts, history, and the role of solid state physics in understanding material properties at the nanoscale. • **Crystal structure and symmetry:** Crystal systems, Bravais lattices, unit cells, lattice directions and planes (Miller indices), symmetry operations. • **X-ray diffraction and reciprocal lattice:** Bragg's law, reciprocal space, Ewald construction, and structure factor. • **Bonding in solids:** Types of interatomic bonding (ionic, covalent, metallic, van der Waals, hydrogen bonding), cohesive energy, potential energy curves. • **Lattice dynamics and phonons:** Vibrations of monoatomic and diatomic chains, phonon dispersion, density of states, specific heat (Einstein and Debye models). • **Thermal properties of solids:** Thermal expansion, thermal conductivity, phonon-phonon scattering, thermal resistance. • **Free electron theory of metals:** Drude and Sommerfeld models,

	electrical and thermal conductivity, limitations of classical models. • **Band theory of solids:** Bloch's theorem, Kronig-Penney model, energy bands, Brillouin zones, effective mass of electrons and holes. • **Semiconductors:** Intrinsic and extrinsic semiconductors, Fermi level, carrier concentration, conductivity, doping. • **Nanostructured semiconductors:** Quantum wells, quantum wires, quantum dots, size effects on electronic and optical properties**.** • **Dielectric properties:** Polarization mechanisms, dielectric constant, ferroelectric materials, applications in nanodevices. • **Magnetic properties of solids:** Diamagnetism, paramagnetism, ferromagnetism, nanomagnetism, and magnetic storage technologies. • **Superconductivity:** Basic properties, Meissner effect, Cooper pairs, types of superconductors, superconductivity in nanoscale systems. • **Low-dimensional systems:** 2D materials (e.g., graphene), 1D nanowires, and their unique physical properties and applications.
Course Method/ Techniques	Lecture ☒ Question & Answer ☒ Presentation ☐ Discussion ☐
Prerequisites/ Corequisites	
Work Placement(s)	

Textbook/References/Materials

1. **Charles Kittel**, *Introduction to Solid State Physics*, Wiley, 8th Edition.
2. **N. W. Ashcroft & N. D. Mermin**, *Solid State Physics*, Cengage.
3. **S. O. Kasap**, *Principles of Electronic Materials and Devices*, McGraw-Hill.

Course Category				
Mathematics and Basic Sciences	☒		Education	☐
Engineering	☒		Science	☒
Engineering Design	☐		Health	☐
Social Sciences	☐		Profession	☐

Weekly Schedule

No	Topics	Materials/Notes
1	Introduction to Solid State Physics and Overview of Nanotechnology Applications	Lecture notes
2	Crystal Structures: Lattices, Basis, Unit Cells, Bravais Lattices	Lecture notes
3	X-ray Diffraction and Reciprocal Lattice	Lecture notes
4	Bonding in Solids: Ionic, Covalent, Metallic, van der Waals	Lecture notes
5	Elastic Properties and Crystal Binding	Lecture notes

6	Phonons and Lattice Vibrations	Lecture notes
7	Thermal Properties: Specific Heat and Thermal Conductivity	Lecture notes
8	Midterm Exam	
9	Free Electron Theory and Electrical Conductivity	Lecture notes
10	Band Theory of Solids: Bloch's Theorem and Brillouin Zones	Lecture notes
11	Semiconductors: Intrinsic and Extrinsic	Lecture notes
12	Nanostructured Semiconductors and Quantum Confinement	Lecture notes
13	Dielectric Properties and Ferroelectrics	Lecture notes
14	Magnetic Properties and Applications in Nanomagnetism	Lecture notes
15	Superconductivity and Low-Dimensional Systems	Lecture notes
16	Final Exam	

Assessment Methods and Criteria		
In-term studies	**Quantity**	**Percentage**
Attendance	14	10
Lab		
Practice		
Fieldwork		
Course-specific internship		
Quiz/Studio/Criticize		
Homework	2	10
Presentation / Seminar	1	5
Project		
Report		
Seminar		
Midterm Exam	1	25
Final Exam	1	50
	Total	**100%**
Contribution of Midterm Studies to Success Grade		50
Contribution of End of Semester Studies to Success Grade		50
	Total	**100%**

ECTS Allocated Based on Student Workload			
Activities	**Quantity**	**Duration (Hrs)**	**Total Workload**
Course Hours	14	3	42
Lab			
Practice			
Fieldwork			
Course-specific Work Placement			
Out-of-class study time	14	2	28
Quiz/Studio/Criticize			
Homework	2	5	10
Presentation / Seminar	1	5	5
Project			
Report			
Midterm Exam and Preparation for Midterm	1	25	25
Final Exam and Preparation for Final Exam	1	30	30
Total Workload			**125**
Total Workload / 25			**5**
ECTS Credit			**5**

Course Learning Outcomes	
No	**Outcome**
L1	Identify and describe the basic crystal structures, unit cells, and symmetry operations in solids.
L2	Analyze diffraction patterns and calculate interplanar distances using X-ray diffraction principles.
L3	Explain the origin of bonding in solids and relate it to mechanical and thermal properties.
L4	Describe and interpret lattice vibrations and phonons, and their influence on thermal conductivity and heat capacity.
L5	Apply band theory to distinguish between conductors, semiconductors, and insulators, and analyze carrier behavior in semiconductors.
L6	Evaluate how nanoscale effects modify electrical, thermal, and magnetic properties of materials in comparison to bulk materials.

Contribution of Course Learning Outcomes to Program Competencies/Outcomes

Contribution Level: 1: Very Slight, 2: Slight, 3: Moderate, 4: Significant, 5: Very Significant

	PO-1		PO-2		PO-3		PO-4		PO-5			PO-6			PO-7						PO-8		PO-9		PO-10			PO-11		Total
#	1.1	1.2	2.1	2.2	3.1	3.2	4.1	4.2	5.1	5.2	5.3	6.1	6.2	6.3	7.1	7.2	7.3	7.4	7.5	7.6	8.1	8.2	9.1	9.2	10.1	10.2	10.3	11.1	11.2	#
L1	X	X												X																-
L2		X	X				X							X																-
L3	X	X	X											X																-
L4	X	X		X							X			X																-
L5	X	X	X					X						X																-
L6	X	X	X								X			X														X		-
																														Total= -

1.1. Adequate knowledge in mathematics, natural sciences, and subjects specific to the relevant engineering discipline.

1.2. Ability to apply theoretical and practical knowledge in these areas to solve complex engineering problems.

2.1. Ability to identify, formulate, and solve complex engineering problems.

2.2. Ability to select and apply appropriate analysis and modeling methods for this purpose.

3.1. Ability to design a complex system, process, device, or product to meet specific requirements under realistic constraints and conditions.

3.2. Ability to apply modern design methodologies for this purpose.

4.1. Ability to select and use modern techniques and tools necessary for analyzing and solving complex problems encountered in engineering practice.

4.2. Ability to effectively utilize information technologies.

5.1. Ability to design experiments to investigate complex engineering problems or discipline-specific research topics.

5.2. Ability to conduct experiments.

5.3. Ability to collect data, analyze results, and interpret findings.

6.1. Ability to work effectively in intra-disciplinary teams.

6.2. Ability to work effectively in multi-disciplinary teams.

6.3. Ability to work independently.

7.1. Ability to communicate effectively both orally and in writing.

7.2. Knowledge of at least one foreign language.

7.3. Ability to write and comprehend effective reports, and to prepare design and production documentation.

7.4. Ability to deliver effective presentations.

7.5. Ability to give and receive clear and understandable instructions.

8.1. Awareness of the necessity for lifelong learning.

8.2. Ability to access information, follow developments in science and technology, and continuously renew oneself.

9.1. Acting in accordance with ethical principles and having professional and ethical responsibility.

9.2. Knowledge about standards used in engineering practices.

10.1. Knowledge of business practices such as project management, risk management, and change management.

10.2. Awareness of entrepreneurship and innovation.

10.3. Knowledge about sustainable development.

11.1. Knowledge of the global and societal impacts of engineering practices on health, environment, and safety, and understanding of contemporary issues reflected in the field of engineering.

11.2. Awareness of the legal consequences of engineering solutions.