M.Sc. Course					Solid State Physics					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- To correlate the crystal structure to symmetry, recognize the correspondence between real and reciprocal lattice.
- To determine the crystal structure using various crystallographic parameters.
- To get the of knowledge of the behaviour of electrons in solids based on classical and quantum theories.
- To understand the origin of the energy bands in solids and basic notions on their calculation.
- To become familiar with the different types of magnetism and magnetism based phenomenon and familiarize with theory of superconuctivity
- To develop an understanding of the dielectric properties and ordering of dipoles in ferroelectrics.

9 Hrs.

UNIT 1: Crystal Diffraction and Reciprocal Lattice

Introduction, Crystalline and amorphous materials – crystal systems – Bravais lattices – Miller Indices – Symmetric elements – symmetric groups – reciprocal lattice – Braggs' law, reciprocal lattice to SC, BCC, FCC, Laue's equation and Bragg's law in terms of reciprocal lattice vector, diffraction and the structure factor, Ewald's construction, structure determination using Laue's method, powder crystal diffraction, rotating crystal method, scattered wave amplitude, Fourier analysis of the basis, structure factor of lattices (sc, bcc, fcc), atomic form factor.

UNIT 2: ENERGY BAND THEORY **9 Hrs.**

Classical free electron theory, wave mechanical treatment of electron in 1D and 3D well, Wiedemann-Franz law, quantum theory of solids, failure of free electron theory, density of states, Fermi-Dirac statistics, effect of temperature on Fermi distribution function, electrons in a periodic potential, Bloch's theorem, Kronig Penney Model, construction of Brillouin zone, reduced zone scheme, concept of energy band, energy band structure of conductors, semiconductors and insulators.

UNIT 3: MAGNETISM AND SUPECONDUCTIVITY **14 Hrs.**

Magnetic Susceptibility, diamagnetism, paramagnetism, the ground state of an ion and Hund's rules, adiabatic demagnetization, crystal fields, orbital quenching, Jahn-Teller effect, nuclear magnetic resonance, electron spin resonance, Mossbauer spectroscopy, magnetic dipolar interaction, exchange interaction, ferromagnetism, antiferromagnetism, ferrimagnetism, spin glasses. Basic properties of superconductors, phenomenological thermodynamic treatment, London equation, penetration depth, superconducting transitions, order parameter, Ginzburg-Landau theory, Cooper pair, electron-phonon interaction, BCS theory, coherence length, flux quantization, Josephson junction, high Tc superconductors, mixed state

UNIT 4: DIELECTRICS AND FERROELECTRICS **8 Hrs.**

Macroscopic Maxwell equation of electrostatics, theory of local field, theory of polarisability, dielectric constant, Claussius-Mosotti relation, dielectric breakdown, dielectric losses, ferroelectric, anti-ferroelectric, piezoelectric, pyroelectric, frequency dependence of dielectric properties, classification of ferroelectric crystal, ferroelectric phase transitions, relaxor ferroelectrics.

Max. <40> Hrs.

COURSE OUTCOMES

After completion of this course students will be able to;

CO1: relate crystal structure to symmetry, recognize the correspondence between real and reciprocal space..

CO2: analyze the crystal structures by applying crystallographic parameters and determine crystal structure by XRD data.

CO3: Studentswill be able to analyze the behaviour of electrons in solids based on classical and quantum theories.

CO4: understand various magnetic phenomena and analyze the magnetic ordering based on the exchange interaction of materials

CO5: explain superconductivity, its properties, important parameters related to possible applications.

CO6: differentiate between ferroelectric, anti-ferroelectric, piezoelectric and pyroelectric materials and develope application based on it.

TEXT/REFERENCE BOOK

1. Elements of Solid State Physics, By J.P. SRIVASATAVA, PHI Learning PVT. LTD., 2014.
2. Introduction to Solid State Physics, Charles Kittel, John Wiley & Sons, 2019.
3. Solid State Physics, S. O. Pillai, Wiley Eastern Ltd., 2006.
4. Magnetism in condensed matter, Stephen Blundell, Oxford University Press , 2011.

5. Condensed Matter Physics, Michael P. Marder, Wiley, 2010
6. Solid-State Physics: Introduction to the Theory, James D. Patterson, Bernard C. Bailey, Springer International Publishing, 2018.

Course Delivery Methods	
Lecture by use of boards/LCD projectors/OHP projectors	Yes
Tutorials/Assignments	Yes
Seminars	Yes
Mini projects/Projects	No
Laboratory experiments/teaching aids	No
Industrial/guest lectures	Yes
Industrial visits/in-plant training	No
Self- learning such as use of NPTEL materials and internets	Yes
Simulation	No

Course Outcome (CO) Attainment Assessment tools & Evaluation procedure

Direct Assessment:

Assessment Tool		% Contribution during CO Assessment	Maximum Marks	Exam Duration
Internal Assessment Examiantion	Assignment	10 %	-	-
	Quiz	15%	-	-
	Mid Semester Examination	25%	50	2 hours
	End Semester Examination	50%	100	3 hours

Assessment Components	CO1	CO2	CO3	CO4	CO5	CO6
Mid Sem Examination Marks	YES	YES	YES	NO	NO	NO
End Sem Examination Marks	YES	YES	YES	YES	YES	YES
Assignment	YES	YES	YES	YES	YES	YES

Indirect Assessment :
1. Student Feedback on Faculty
2. Student Feedback on Course Outcome

Mapping of Course Outcomes onto Program Outcomes

Course Outcome	Programme Outcome				
	PO1	PO2	PO3	PO4	PO5
CO1: Students will be able to relate crystal structure to symmetry, recognize the correspondence between real and reciprocal space.	H	H	M	M	L
CO2: Students will be able analyze the crystal structures by applying crystallographic parameters and determine crystal structure by XRD data.	M	H	H	H	M
CO3: Studentswill be able to understand the behaviour of electrons in solids based on classical and quantum theories.	H	H	M	M	L
CO4: Student will be able to understand various magnetic phenomena and analyze the magnetic ordering based on the exchange interaction of materials.	H	H	H	H	L
CO5: Students will be able to explain superconductivity, its properties, important parameters related to possible applications.	H	H	M	H	H
CO6: Student will be able to differentiate between ferroelectric, anti-ferroelectric, piezoelectric and pyroelectric materials and develope application based on it.	H	M	M	M	H

Lecture wise Lesson planning Details:

Weak No.	Lect. No.	Unit No.	Topics To be covered	CO Mapped	Remarks by Faculty
1	1	1	Revision of concepts, crystal structure, Bravais Lattice,	CO1, CO2	

	2		lattice translation vector, symmetry operations, simple crystal structures, Miller indices, lattice planes, Braggs' law,	CO1, CO2	
	3		reciprocal lattice to SC, BCC, FCC,	CO1, CO2	
2	4		Laue's equation and Bragg's law in terms of reciprocal lattice vector,	CO1, CO2	
	5		diffraction and the structure factor,	CO1, CO2	
	6		Ewald's construction,	CO1, CO2	
3	7		structure determination using Laue's method,	CO1, CO2	
	8		powder crystal diffraction, rotating crystal method,	CO1, CO2	
	9		scattered wave amplitude, Fourier analysis of the basis, structure factor of lattices (sc, bcc,fcc), atomic form factor.	CO1, CO2	
4	10	2	Revision and problem solving		
	11-12		Classical free electron theory, wave mechanical treatment of electron in 1D and 3D well Wiedemann-Franz law, quantum theory of Solids, failure of free electron theory	CO3	
5	13		density of states, Fermi-Dirac statistics,	CO3	
	14-15		effect of temperature on Fermi distribution function, electrons in a periodic potential, Bloch's theorem,	CO3	
6	16-17		Kronig Penney Model, construction of Brillouin zone, reduced zone scheme, concept of energy band,	CO3	
	18		Energy band structure of conductors, semiconductors and insulators.	CO3	
7	19	3	Revision and problem solving	CO3	
	20		Classical free electron theory, wave mechanical treatment of electron in 1D and 3D well Wiedemann-Franz law, quantum theory of thermal conductivity, failure of free electron theory.	CO4, CO5	
	21		density of states, Fermi-Dirac statistics,	CO4, CO5	
8	22		effect of temperature on Fermi distribution function	CO4, CO5	
	23-24		electrons in a periodic potential, Bloch's theorem, Kronig Penney Model, construction of Brillouin zone, reduced zone scheme, concept of energy band,	CO4, CO5	
9	25		Energy band structure of conductors, semiconductors and insulators.	CO4, CO5	
	26-27		Basic properties of Superconductors, London equation, penetration depth	CO4, CO5	
10	28		Superconducting transitions, order parameter, Ginzburg-Landau theory	CO4, CO5	
	29		Cooper pair, electron-phonon interaction, BCS theory	CO4, CO5	
	30		Josephson junction, Coherence length, Flux quantization,	CO4, CO5	
11	31		High Tc superconductors, mixed state.	CO4, CO5	
	32		Revision		
	33	4	Macroscopic Maxwell equation of electrostatics	CO6	
12	34		Theory of local field, theory of Polarisability, dielectric constant,	CO6	
	35		Claussius-Mosotti relation	CO6	
	36		Dielectric breakdown, dielectric losses,	CO6	
13	37-38		Ferroelectricz anti-ferroelectric, Piezoelectric, Pyroelectric, frequency dependence of dielectric properties.	CO6	
	39		Classification of ferroelectric crystal, ferroelectric phase transitions, relaxor ferroelectrics.	CO6	

14	40		Revision		