Faculty of Science

Bachelor of Science (B.Sc.)

SUBJECT: PHYSICS

B.Sc. VI Semester

Paper-CORE

SOLID STATE PHYSICS

Course Outcomes

	Course Learning Outcomes	Cognitive Level
CO -I	On completion of course Learner will be able to differentiate crystalline & amorphous solids and classify various crystal structures.	U, R
CO -II	On completion of course Learner will be able to build concepts of bonding in solids, lattice dynamics and various theories of specific heat of solids.	R, An, Ap
CO -III	On completion of course Learner will be able to learn free electron and band theory of solids and their consequences.	R, U, E
CO -IV	On completion of course Learner will be able to understand the origin of magnetic and dielectric properties in solids.	An, C
CO -V	On completion of course Learner will be able to define different nanostructures.	U, C, An

Credit and Marking Scheme

	Credits	Marks		Total Marks
		Internal	External	
Theory	4	40	60	**100**
Practical	2	40	60	**100**
Total	**6**	**200**		

Evaluation Scheme

	Marks	
	Internal	**External**
Theory	3 Internal Exams of 20 Marks (During the Semester) (Best 2 will be taken)	1 External Exams (At the End of Semester)
Practical	3 Internal Exams (During the Semester) (Best 2 will be taken)	1 External Exams (At the End of Semester)

Content of the Course

Theory

No. of Lectures (in hours per week): 4.5 Hrs. per week

Total No. of Lectures: 60 Hrs. **Maximum Marks:** 60

Units	Topics	No. of Lectures
I	**Crystal Structures** Premier Indian Institutes and their contribution: Bhabha Atomic Research Centre, Mumbai, Advanced Materials and Processes Research Institute (AMPRI), Bhopal; Defence and Research Development Organization, New Delhi; Indian Institute of Science. Bangalore: Bose Institute, Kolkata Raja Ramana Centre for Advance Technology, Indore. **Classification of solids and space lattice:** Crystalline and amorphous solids; Space lattice; Basis; Lattice translational vector: Unit cell; Primitive and non- primitive cells; Bravais lattice in two and three dimensions; Seven crystal systems; Fundamentals of elements of symmetry; Point groups and space groups; Lattice planes and miller indices; Relation between interplanar spacing and lattice constants. **Simple crystal structures:** Simple cubic; Face centred cubic (NaCI): Body centred cubic (CsCI); Hexagonal closed packed; Diamond and Zine sulfide structure; Coordination numbers and atomic packing fraction. ***Reciprocal lattice and its properties, Diffraction in crystal: Laue's and Bragg's equations;*** Determination of crystal ***structure by X rays*** (Powder method) **Keywords/Tags:** Crystal structure, Miller indices, Coordination number. Diffraction in crystal	12
II	**Physical properties of matter** **Bonding in solids:** Force between atoms, Lennard -Jones potential, classification of crystals on bonding basis, cohesive (binding) energy of ionic crystal, Madelung constant, covalent crystal.	12

	Specific heat: Specific heat of solid and its variation with temperature: Classical theory of Dulong and Petit: Einstein model assumptions and derivation for specific heat; Debye model assumptions and derivation for specific heat. Outcomes of different models. **Lattice Dynamics:** Mono-atomic lattice vibration and dispersion relation, Brillouin Zones, Concept of phonons. **Keywords/Tags:** Bonding, Specific heat, Lattice vibration, Phonon,	
III	**Free electron and Band Theory of Solids** **Free electron theory:** Free Electrons gas, Drude Lorentz Theory, electrical resistivity and electrical conductivity; Ohm's Law ($J = \sigma E$); Wiedemann Frenz law; Hall effect, Hall coefficients and experimental determination. Sommerfield Model; Density of States, **Band theory:** Wave functions in a periodic lattice and Bloch theorem, Kronig - Penney Model, E - K relation for free electron, number of states in a band, nearly free electron and tight binding models, crystal momentum, velocity and concepts of effective mass. Distinction between Conductors, Semiconductors and insulators. **Keywords/Tags:** Free electron theory, Hall effect, Energy Band	**12**
IV	**Magnetic Properties of Matter:** Dia-, Para- and Ferromagnetic Materials. Classical Langevin Theory of Dia– and Paramagnetic Domains. Quantum Mechanical Treatment of Paramagnetism. Curie's law, Discussion of B-H Curve. Hysteresis Loss. **Dielectric Properties of Materials:** Polarization. Local Electric Field at an Atom. Depolarization Field. Electric Susceptibility. Polarizability. Clausius Mosotti Equation. Classical Theory of Electric Polarizability. Normal and Anomalous Dispersion. Cauchy and Sellmeir relations. Langevin-Debye equation. Complex Dielectric Constant. **Keywords/Tags:** Magnetic Materials, Hysteresis, Polarizability	**12**

V	**Introduction to Nanotechnology** **Nanoscale systems**: Density of states (0-D, 1-D,2-D,3-D), Nanostructures: 0D, 1D, 2D and 3D nanostructures (nanodots, thin films, nanowires, nanorods), Band structure and density of states of materials at nanoscale, Size Effects in nano systems, quantum confinement of carriers in 3D, 2D, 1D, 0D nanostructures and its consequences. **Synthesis of Nanoparticles**: Top down and Bottom up approach, Ball milling, Nanolithography, Wet Chemical Method, Essential difference in structure and properties of bulk and nano materials (qualitative description), Applications of Nano materials. **Keywords/Tags:** Nano material, top down and Bottom up	**12**

References

Test/Reference Books:

1. Introduction to Solid State Physics, Charles Kittel, 8th Ed., 2004, Wiley India Pvt. Ltd.
2. Elements of Solid State Physics, J.P. Srivastava, 2nd Ed., 2006, Prentice-Hall of India
3. Introduction to Solids, Leonid V. Azaroff, 2004, Tata Mc-Graw Hill
4. Solid State Physics, Neil W. Ashcroft and N. David Mermin, 1976, Cengage Learning
5. Solid State Physics, Rita John, 2014, McGraw Hill
6. Solid State Physics, R. K Puri and V. K. Babbar, S.Chand & Company Pvt. Ltd.
7. Fundamental of Solid State Physics, Saxena Gupta, Pragati Prakashan
8. Applied Solid State Physics, Rajnikant, Wiley India
9. Solid State Physics, Gupta Kumar, K. Nath & Co.
10. Nanotechnology: Principles and Practices, Sulabha K. Kulkarni, Capital Publishing, 2016

Web Links:

1. Department of highereducation, Government of Madhya Pradesh (M.P.).
2. https://archive.nptel.ac.in/courses/115/106/115106127/ [solid state physics videos on youtube]
3. https://archive.nptel.ac.in/courses/115/105/115105131/ [Concepts in magnetism and superconductivityvideo]
4. https://www.classcentral.com/course/youtube-noc-jan-2020-electronic-theory-of-solids-prof-arghya- taraphder-47339

List of Practical

1. To design a switch (NOT gate) using a transistor.
2. To verify and design AND, OR, NOT and XOR gates using NAND gates.
3. To design a combinational logic system for a specified Truth Table.
4. To convert a Boolean expression into logic circuit and design it using logic gate ICs.
5. To minimize a given logic circuit.
6. Half Adder, Full Adder.
7. Half Subtractor, Full Subtractor, Adder-Subtractor using Full Adder I.C.
8. To study Flip-Flop (RS, Clocked RS, D-type and JK) circuits using NAND gates.
9. To study JK Master-slave flip-flop using Flip-Flop ICs
10. To study a 4-bit Counter using D-type/JK Flip-Flop ICs and study timing diagram.
11. To make a 4-bit Shift Register (serial and parallel) using D-type/JK Flip-Flop ICs.
12. Verification of Fresnel's Law of reflection.
13. Verification of Cauchy's formula using spectrometer.
14. To count the number of particles emitting from radioactive source with the help of G M counter.
15. To study characteristics curves of Junction field effect transistor.
16. To study thermal bias stability of transistor in common emitter mode.
17. To study frequency response curve of single stage RC amplifier in CE mode.
18. Measurement of h-parameters of a transistor.
19. Find out closed loop gain of feedback amplifier.
20. Study of wave form of Wein bridge oscillator and to measure frequency of oscillations.
21. Study of amplitude modulated wave and determination of modulation index using CRO.
22. Study of frequency modulated wave and determination of modulation index using CRO.
23. Study of characteristic curve of Photodiode.
24. Measurement of unknown capacitance by schering bridge.
25. To study the characteristic curve of Tunnel diode.

B.Sc. VI Semester

Paper- DSE (DISCIPLINE SPECIFIC ELECTIVE)

DIGITAL & ANALOG SYSTEMS AND APPLICATIONS

Course Outcomes

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	Course Learning Outcomes	PSOs Addressed	Cognitive Level
CO -I	On completion of course Learner will be able to number systems and their conversion	1,2,5,6	U, R, Ap
CO -II	On completion of course Learner will be able to learn the applications of Laws of Boolean Algebra	1,2,3	U, R,C, An,Ap
CO -III	On completion of course Learner will be able to understand different logic gates	1,2,4	U, R, An
CO -IV	On completion of course Learner will be able to understand the operation of flip flops	1,2,3,6	U, R, Ap, C
CO -V	On completion of course Learner will be able to understand Operational amplifiers and their various applications.	1,3,4,5,6	U, R, An, C, E

Credit and Marking Scheme

	Credits	Marks		Total Marks
		Internal	External	
Theory	4	40	60	**100**
Total	**4**	**100**		

Evaluation Scheme

	Marks	
	Internal	**External**
Theory	3 Internal Exams of 20 Marks (During the Semester) (Best 2 will be taken)	1 External Exams (At the End of Semester)

Content of the Course

Theory

No. of Lectures (in hours per week): 4.5 Hrs. per week

Total No. of Lectures: 60 Hrs. + Tutorials **Maximum Marks:** 60

Units	Topics	No. of Lectures
I	**Number System:** Introduction to decimal, binary, octal & hexadecimal number systems, BCD numbers, inter conversion of binary, octal and hexadecimal numbers. Binary addition, subtraction, 1's complement & 2's complement subtraction methods. BCD: BCD addition & subtraction. Codes: BCD code, Excess-3 code, Gray Code, Parity code, Hamming code, ASCII code and EBCDIC code. **Keywords:** Number System, BCD, Binary Operation.	12
II	**Boolean Algebra & Karnaughs Map:** Laws of Boolean algebra, De-Morgans's theorems, Minimization of Boolean expressions and logic diagrams, Sum of Product and Product of Sum, Karnaugh map for 2, 3 and 4 variables, Simplification of Karnaugh map and their truth tables. **Keywords:** Boolean Algebra, Karnaughs Map.	12
III	**Logic Gates and Arithmetic Logic Circuits:** Introduction to logic gates – AND, OR, NOT NAND, NOR and EXOR gates, realization of basic gates using Universal Gates, Half adder, Half subtractor, Full adder, Full subtractor. **Keywords:** logic gates, Adder and Subtractor.	12
IV	**Flip Flop Circuits:**	12

	Introduction, Types of Flip Flop Circuits: RS FF using NAND and NOR gates, clocked RS-FF, D-type FF, Concept of preset and clear, JK Flip-Flop, T- Flip- Flop, JK-MS-FF. **Keywords:** Flip Flop Circuits.	
V	**Operational Amplifier** Block diagram of OP-Amp, characteristics of the ideal OP-Amp. OP-Amp Parameters: Input offset voltage, input offset current, Input bias current, CMRR, SVRR, large signal voltage gain, slew rate, gain band width product.Output resistance. Open loop and closed loop OP-Amp configurations, differential. inverting andnon- inverting amplifiers. voltage series feedback amplifier, effect of feedbackon closed loop gain, Input and output resistance, bandwidth, total output voltage. Application of OP-Amp: Adder. Subtractor, Integrator and differentiator. **Keywords:** Operational amplifier. CMRR, inverting and non - inverting amplifiers, integrator.	12

References

Test/Reference Books:

1. Digital Computer Electronics, Malvino & Brown, Tata McGraw Hill, 1995
2. Digital Principles and Applications, Malvino & Leach, McGraw Hill, 1975
3. Digital Integrated Electronics, Taub & Shillings, McGraw Hill, 1977
4. Digital Electronics, R.L. Tokheim, McGraw Hill, 1990
5. Digital Fundamentals, B. Basavraj, Vikas Publishing Company, 1998
6. Digital Circuits & Design, S. Salivahanan, Vikas Publishing Company, 2012
7. Digital Electronics: An Introduction To Theory And Practice by W. H. Gothmann, Prentice Hall Of India Pvt. Ltd., New Delhi
8. Operational Amplifier and Linear integrated Circuit by R A Gayakwad, Pearson Education, New Delhi.
9. Operational Amplifier and their applications – Subir Kumar Sarkar, S.Chand & Sons, NewDelhi1999
10. Digital and Analogue Technique- Navneet Gokhale and Kale, Kitab Mahal
11. Hand Book of Electronics – Gupta and Kumar, Pragati Prakashan, Meerut, 2008
12. Digital Electronics & Microcomputer – R.K. Gaur, Dhanpat Rai Publications, 2016

Web Links:

https://nptel.ac.in/courses/117103063 (Basic Electronic Operational Amplifier)

https://nptel.ac.in/courses/122601025 (Introduction to Basic Electronics)

https://archive.nptel.ac.in/courses/108/105/108105132/ (Digital Electronics)

https://nptel.ac.in/courses/117106086 Digital Circuits and Systems)

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B.Sc. VI Semester

NUCLEAR AND PARTICLE PHYSICS

DSE (CREDITS 4)

	Course Learning Outcomes	Cognitive Level
CO -I	On completion of course Learner will be able to understand the ground state properties of a nucleus, process of radioactivity, the radioactive decay law, its uses .	U,R, An
CO -II	On completion of course Learner will be able to understand (a) nuclear models and their roles in explaining the ground state properties of the nucleus (b) mechanisms of alpha, beta and gamma rays emission.	U,Ap,An, E
CO -III	On completion of course Learner will be able to formulate the basic aspects of nuclear reactions, the Q- value of such reaction, fission and fusion reaction.	R , U , Ap ,C
CO -IV	On completion of course Learner will be able to understand the principles and basic constructions of particle (radiation) detectors and accelerators	U,An, C
CO -V	On completion of course Learner will Gain knowledge about the classifications of particles and various symmetry elements involved in particle physics.	U,Ap

Credit and Marking Scheme

	Credits	Marks		Total Marks
		Internal	External	
Theory	4	40	60	**100**
Total	**4**	**100**		

Evaluation Scheme

	Marks	
	Internal	**External**
Theory	3 Internal Exams of 20 Marks (During the Semester) (Best 2 will be taken)	1 External Exams (At the End of Semester)

Content of the Course

Theory

No. of Lectures (in hours per week): 4.5 Hrs. per week

Total No. of Lectures: 60 Hrs. + Tutorials **Maximum Marks:** 60

Units	Topics	No. of Lectures
I	**Nucleus, Nuclear Forces and Radioactivity** 1. Introduction to Bhabha Atomic Research Centre (BARC), Defence Research and Development Organization (DRDO) and Indian Space Research Organization (ISRO), Raja Ramanna Centre for Advanced Technology, (RRCAT) Indus-1 and Indus-2 synchrotron. 2. Composition, charge, size, shape, mass and density of the nucleus; Nuclear angular momentum; Nuclear magnetic dipole moment; Electric quadrupole moment; Mass defect; Packing fraction and Binding energy; Binding energy of Deuteron; Stability of nuclei (N vs Z curve), Binding energy curve. 3. Nuclear Forces: General concept of Nuclear force; Yukawa Meson field theory of Nuclear forces; Properties of Nuclear forces. 4. Radioactive disintegration; Properties of alpha, beta, gamma rays; law of radioactive decay; successive radioactive decay; radioactive equilibrium; Radioisotopes; application of radioactivity (Agriculture, Medicinal, Industrial and Archaeological). **Keywords:** Nuclear Forces, Binding energy, Deuteron, Radioactive disintegration.	18

II	**Nuclear models and Nuclear Decay** 1. Nuclear models: Shell model; magic number; Square well potential; Harmonic oscillator potential well; Spin-Orbit potential; Unified (collective) model; Liquid Drop model; Semi-empirical mass formula. 2. Two Body system: The ground state properties of the Deuteron; Deuteron in Central potential (Square well); Excited state of the deuteron; Neutron-Proton scattering at low energies; Scattering length. 3. Alpha decay: Alpha particles spectra; Gamow's theory of Alpha decay; Beta decay: Shape of Beta ray spectrum; Explanation of Beta decay on the basis of Neutrino and Antineutrino hypothesis; Fermi theory of Beta decay; Selection rules; Conservation of B-decay: Gamma ray emission: Multipole radiation. **Keywords:** Shell model, Liquid Drop model, Scattering, Alpha decay, Beta decay Radioisotopes	18
III	**Nuclear reactions and Nuclear Energy** 1. Nuclear reactions: Kinds of Nuclear reactions; Nuclear reaction kinematics; Q-value; Compound Nucleus and concept of direct reactions; Conservation laws; Nuclear reaction cross- sections 2. Nuclear energy: Nuclear Fission; Chain reaction and Critical Mass; Nuclear Reactors and its basic components; Nuclear Fusion; Condition for the maintained Fusion reactions; Energy production in stars; Fusion reaction in Sun, Principle of atomic bomb and hydrogen bomb. **Keywords:** Nuclear reactions, Nuclear Fission, Q-value.	18

IV	**Nuclear counters and detectors** 1. Ionization Chamber; Proportional counter; Geiger-Müller counte; Scintillation counter; semiconductor detectors; P-N junction detector; Lithium drifted; High purity Ge Detector; Gamma ray interactions NaI (TI) Scintillation. 2. Detector electronics and Pulse processing: Pulse counting systems; Pulse height analysis systems; Pulse timing; Pulse shape discrimination. 3. Accelerators: Cyclotron, Betatron, synchrotron.	**18**
V	**Fundamental particle** 1. Fundamental particles: Classification of prticles-antiparticles and their interactions; Conservation laws; Charges; Isospin; Baryon number; Strangeness; Parity; Charge conjugation; CPT theorem; CP violation and natural K-decay. 2. Fundamental particle symmetry: SU(2) and SU(3) symmetry and their application to Multiplet Meson and Baryon state; Quark as the building blocks of Hadrons; Quark Model; Colour degree of freedom, Ghost particles, Higgs Boson Particle (God particle), Large Hadron collider (LHC). **Keywords:** Fundamental particles, Isospin, Baryon. Quark.	**18**

REFERENCES

Test/Reference Books:

1. Waghmare Y. R., "Introductory Nuclear Physics", Oxford & IBH Oub.
2. Kapoor S. S., Ramamurthy V. S., "Nuclear Radiation Detectors", New Age International Publishers.
3. Cohen B. L., "Concepts of Nuclear Physics", McGraw Hill Education.
4. Tayal D. C., "Nuclear Physics", Himalaya Publishing House.
5. Patel S. B., "Nuclear Physics: An Introduction", New Age International Publishers.
6. Singh Jahan, "Fundamental of Nuclear Physics", Pragati Publications.
7. Books published by Madhya Pradesh Hindi Granth Academy, Bhopal.

Web links:

1. https://www.eshiksha.mp.gov.in/mpdhe

2. https://youtu.be/josqicH79PE?list=PLbMVogVj5nJRvq-w3zway7k3GzmUDte3a

Nuclear Physics: Fundamentals and Applications by Prof. H.C. Verma, Department of Physics, IIT Kanpur.

3 https://youtu.be/H7OipY8RzX0?list-PLOb6maW-5d1fvnUXykaaDOJPjEB0pTDF9

Lecture Series on Nuclear and Particle Physics by Prof. Poulose Poulose, Department of Physics, IIT Guwahati.