Minor Specialization Degree Scheme w.e.f: AY: 2025-2026

Quantum Technologies

Minor Degree : Quantum Technologies													
Sl. No.	Course and Course code		Course Title	Teaching Dept.	Teaching Hours/Week			Examination					Credits
					Theory Lecture	Tutorial	Practical /Drawing	Duration in hr	CIE Marks	SEE Marks	Total Marks		
					L	T	P						
1.	PCC	25PHY201	Foundations of Quantum Technologies	Physics	3	0	0	3	50	50	100		3
2.	PCC	25PHY202	Introduction to Quantum Technologies and Applications	Physics	3	0	0	3	50	50	100		3
3.	PCC	25PHY203	Basic Laboratory course for Quantum Technologies	Physics/ IT Streams/ECE	2	0	1	3	50	50	100		3
4.	PCC	25PHY204	Introduction to Quantum Computation	Physics/ IT Streams/ECE	3	0	0	3	50	50	100		3
5.	PCC	25PHY205	Introduction to Quantum Materials	Physics	3	0	0	3	50	50	100		3
6.	PCC	25PHY206	Solid State Physics for Quantum Technologies	Physics	3	0	0	3	50	50	100		3
				TOTAL	**17**	**0**	**1**	**18**	**300**	**300**	**600**		**18**

Foundations of Quantum Technologies

Course Code:	**PHY201**	**Course Type:**	**PCC**
Teaching Hours/Week (L: T: P: S):	**3:0:0:0**	**Credits:**	**03**
Total Teaching Hours:	**45**	**CIE + SEE Marks:**	**50+50**
Prerequisite: Basics of Engineering Mathematics and Physics - MAT102 and PHY102 or PHY104			

Teaching Department: Physics

Course Objectives:

1.	To understand the basics of quantum mechanics.
2.	To study the fundamentals of Linear Vector spaces.
3.	To study the postulates of quantum mechanics.
4.	To describe the basic ideas of statistical physics.
5.	To understand information science and basic concepts of computational complexity and their connection to quantum computing.

UNIT-I

Quantum Mechanics	**10 Hours**

Brief overview of classical physics (This segment is meant for the student to understand what a Hamiltonian is, which will feature later in quantum mechanics). Hamiltonian formalism: Generalized momenta, Hamiltonian function, Physical significance and the Hamilton's equations of motion, Examples of the simple harmonic oscillator. Principle of least action: derivation of equation of motion, variation and end points. Hamiltonian function and Hamilton's equations. – free particle, particle moving in a conservative potential, hydrogen atom. Historical evolution of quantum mechanics. Planck's quantum hypothesis. Photo electric effect. Atomic spectra Bohr's quantization principle. De Broglie's Wave particle duality.

Linear Vector spaces	**08 Hours**

Matrix formalism of quantum mechanics Linear vector spaces - orthogonality and linear independence, bases and dimensions, completeness, Hilbert's spaces. Hermitian operators. Bra and Ket notations for vectors. Representation theory. Schwartz's inequality theorem - proof of Heisenberg uncertainty relation.

UNIT-II

Postulates of Quantum Mechanics	**12 Hours**

Schrodinger Equation and Time evolution of quantum states. Measurement Postulate. Schrodinger, Heisenberg and Interaction pictures. Eigen values, Expectation values and Matrix elements. Density operator formalism of quantum mechanics – pure and mixed states.

Superposition and Entanglement in quantum mechanics. No cloning theorem. Applications of postulates –Particle in a box, Hydrogen atom, Harmonic Oscillator. Number states, ladder operators and Coherent states of a harmonic oscillator. Spin and Angular momentum – spin half particles. Rabi problem of a spin-half particle in a rotating magnetic field. Bosons and Fermions.

Statistical Physics	**06 Hours**

Quick review of first and second laws of thermodynamics. Thermal Equilibrium and Gibbs principle. Applying Gibbs principle to Classical and Quantum harmonic oscillators. Bosons and Fermions and Quantum statistics – Fermi-Dirac and Bose- Einstein distributions.

UNIT-III

Information Science and Brief overview of Computational Complexity	**09 Hours**

Digital communication and information. Quantifying information in terms of Shannon entropy. Basic ideas of quantum information. Decoherence and noise. Introductory ideas of Kraus operators.

Qualitative ideas of a Turing machine. Types of Turing machines. Time and Space complexity – P vs NP, PSPACE. Quantum complexity classes – Q, EQP, BQP, BPP, QMA. Post Quantum Cryptography (PQC).

Course Outcomes: At the end of the course students will be able to

1.	Understand and apply basic mathematical tools used in quantum science.
2.	To realize the basics of linear vector spaces.
3.	To understand the postulates of quantum mechanics.
4.	Describe the basic ideas of statistical physics and information science relevant to quantum systems.
5.	Understand basic concepts of Information science and Computational complexity and their connection to quantum computing.

Course Outcomes Mapping with Program Outcomes & PSO

Program Outcomes→	1	2	3	4	5	6	7	8	9	10	11	12	PSO↓		
↓ Course Outcomes															3
PHY202-1.1	3	2				2					1	2			3
PHY202-1.2	3	2				2					1	2			3
PHY202-1.3	3	2				2					1	2			3
PHY202-1.4	3	2				2					1	2			3
PHY202-1.5	3	2				2					1	2			3

1: Low, 2: Medium, 3: High

TEXTBOOKS:	
1.	Introduction to Quantum Mechanics, Griffiths D. J., 3rd Edition, Cambridge University Press (2024).
2.	Principles of Quantum Mechanics, Shankar, R., 2nd edition, Springer (2014).
3.	Quantum Information Science – Manenti R., Motta M., 1st Edition, Oxford University Press (2023).
REFERENCE BOOKS:	
1.	Quantum computation and quantum information – Nielsen M. A., and Chuang I. L., 10th Anniversary edition, Cambridge University Press (2010).
2.	A Pathak, Elements of Quantum Computation and Quantum Communication, Boca Raton, CRC Press (2015).
3.	Information Theory, Robert B. Ash, Dover Publications (2003).
4.	Introduction to the Theory of Computation, Michael Sipser, 3rd edition, Cengage India Pvt. Ltd. (2014).
5.	Statistical Mechanics, Pathria R. K., Paul D. Beale, 4th edition, Academic Press, (2021).
E Books / MOOCs/ NPTEL/ Web links	
1.	NPTEL - Foundations of Quantum Theory: Non-Relativistic Approach https://onlinecourses.nptel.ac.in/noc24_ph38/preview

Introduction to Quantum Technologies and Applications

Course Code:	**PHY202**	**Course Type:**	**PCC**
Teaching Hours/Week (L: T: P: S):	**3:0:0:0**	**Credits:**	**03**
Total Teaching Hours:	**45**	**CIE + SEE Marks:**	**50+50**
Prerequisite: Basics of Engineering Mathematics and Physics – MAT102 and PHY102 or PHY104			

Teaching Department: Physics

Course Objectives:

1.	To understand the basics of Quantum Mechanics.
2.	To explain the general physical principles involved in realizing qubits for quantum computation.
3.	Identify and compare various hardware implementations of qubits used in quantum computing.
4.	Describe the quantum gates and its practical relevance.
5.	Analyse real-world applications of quantum sensing and understand the implementation of quantum communication protocols in fibre-based and free-space systems.

UNIT - I

Quantum Technologies	**09 Hours**
Four verticals: A Brief Introduction. Motivation for Quantum Technologies. A qualitative overview of salient aspects of quantum physics - Quantum States, Wavefunctions, Probabilistic interpretation, Physical observables, Hermitian operators, expectation values. Heisenberg uncertainty principle, Schrodinger equation, Time evolution. distinction from classical physics, Heuristic description of Superposition, Tunnelling and entanglement, no cloning theorem, Simulating classical systems – Feynman's idea of a quantum simulator and the birth of the field.	
Quantum Computing	**09 Hours**
Basics of qubits -- what is a qubit? How is it different from a classical bit? – Review of classical logic gates. Introduction to Quantum Computing, Moore's law and and its end, Differences between Classical & and Quantum computing. Probability, and Quantum Superposition, normalization rule. Concept of qubit and its properties. Representation of qubit by Bloch sphere. Single and Two qubits. Extension to N qubits.	

UNIT - II

Quantum Computation, Overview of applications and recent achievements	**10 Hours**

Di Vincenzo criteria for realizing qubits. Physical implementation of qubits (very qualitative description) - Solid State Qubits, Semiconducting Qubits: quantum dots, spins, Superconducting Qubits: charge, flux and phase, Topological Qubits: proposals and advantages, Atoms and Ions: Trapped ions, Rydberg atoms, Neutral atoms, Photonic Qubits: Conventional linear optical setups, Integrated Photonics. NMR qubits. Conventional NMR qubits. NV centres.

Quantum gates	**08 Hours**

Quantum Gates: Single Qubit Gates: Quantum Not Gate, Pauli – X, Y and Z Gates, Hadamard Gate, Phase Gate (or S Gate). Multi-Qubit Gates (Qualitative).

UNIT - III

Quantum Sensing and Quantum Communications	**09 Hours**

Basics of quantum sensing. Basics of Photon (single and entangled) generation and detection. Gravimetry. Atomic clock. Magnetometry. State of the art in Quantum Sensing.

Basics of digital communication. Quantifying classical information – Shannon entropy. Basic ideas of quantum communication, security, eavesdropping. Overview of quantum communication achievements. Terrestrial – fibre-based Free space, Satellite-based.

Course Outcomes: At the end of the course students will be able to learn

1.	The general physical principles of realizing qubits for computation.
2.	The various hardware implementations of qubits for computation.
3.	The basic ideas of quantum gates.
4.	The applications of quantum sensing.
5.	The implementations of quantum communications protocols in fibre-based and free-space.

Course Outcomes Mapping with Program Outcomes & PSO

Program Outcomes→	1	2	3	4	5	6	7	8	9	10	11	12	PSO↓		
↓ Course Outcomes													1	2	3
PHY201-1.1	1					1			1	2	3	2	2		
PHY201-1.2	1					1			1	2	3	2	2		
PHY201-1.3	1					1			1	2	3	2	2		
PHY201-1.4	1					1			1	2	3	2	2		
PHY201-1.5	1					1			1	2	3	2	2		

1: Low 2: Medium 3: High

TEXTBOOKS:	
1.	Quantum Information Science – Manenti R., Motta M., 1st Edition, Oxford University Press (2023).
2.	Quantum computation and quantum information – Nielsen M. A., and Chuang I. L., 10th Anniversary edition, Cambridge University Press (2010).
REFERENCE BOOKS:	
1.	Elements of Quantum Computation and Quantum Communication, A. Pathak, Boca Raton, CRC Press (2015)
2.	An Introduction to Quantum Computing, Phillip Kaye, Raymond Laflamme, and Michele Mosca, Oxford University Press (2006)
3.	Quantum computing explained, David McMahon, Wiley (2008)
E Books / MOOCs/ NPTEL/ Web links	
1.	NPTEL - Quantum Technology and Quantum Phenomena in Macroscopic Systems https://onlinecourses.nptel.ac.in/noc22_ph15/preview

Basic Laboratory Course for Quantum Technologies

Course Code:	**PHY203**	**Course Type:**	**PCC**
Teaching Hours/Week (L: T: P: S):	**2:0:1:0**	**Credits:**	**03**
Total Teaching Hours:	**45**	**CIE + SEE Marks:**	**50+50**
Prerequisite: Basics of Engineering Mathematics and Physics - MAT102 and PHY102 or PHY104			

Teaching Department: Physics/IT Streams/ECE/EEE

Course Objectives:

1.	To understand the basics of optics.
2.	To study the basic experimental techniques in characterizing resonators and RLC circuits.
3.	To identify the fundamental principles and working of Radio Frequency Technology.
4.	To study the principles involved in Interfacing instruments with a computer.
5.	To understand the real-world applications of Quantum Simulators.

UNIT-I

Optics — **09 Hours**

Interferometry – wavelength measurements, intensity measurements. Diffraction – single slit, grating. Microscopy – magnification, aberration. Polarization optics – PBS, HWP, QWP.

RLC circuits — **09 Hours**

Series and parallel RLC circuits – Verifying the quality factor formulae. Extracting intrinsic losses. Digital circuits. Adder, Multiplier. Encoder, Decoder. D flipflop, shift registers. How to use common Integrated Circuit chips.

UNIT-II

Radio Frequency Technology: — **09 Hours**

Using Oscilloscope. Ring-up and ring-down time measurements of RLC circuits. Measurements of different pulse-shapes generated by a function generator. Using Vector Network Analyzer. Transmission and reflection measurements of coaxial cable in open, short and matched termination. Voltage standing wave ratio measurement. Amplitude and Phase quadrature, In-phase and Out-of-phase quadrature plots and Quality factor measurement of RLC circuits. Characterizing S-parameters, ABCD and Z matrices of common 2 port networks – coaxial cable, attenuator, low pass high pass bandpass filters etc.. Characterizing 3 port networks – directional couplers, circulators, isolators. Using a spectrum analyzer. Noise from a resistor at different temperatures.

Interfacing instruments with a computer — **09 Hours**

Data acquisition. Signal demodulation – heterodyne vs Homodyne, Mixing of signals. Sampling, digitization using ADCs – under-sampling and aliasing, oversampling and noise. Averaging and interpolation techniques.

Quantum Simulators

Running quantum protocols in a quantum simulator. Implementing simple quantum algorithms on cloud-based quantum computers (depending on availability of time on such machines). Running simple algorithms on cloud-based quantum processors (optional).

UNIT-III

Laboratory Experiments

(Any eight experiments from List 1 & List 2)

List of Experiments – I

1. Creating and Measuring Quantum Superposition States in Qubits.
2. Generating and Measuring Entangled Bell States Using Two Qubits
3. Simulating Classical System Behavior Using Quantum Circuits Based on Feynman's Quantum Simulator Concept
4. Understanding Qubits and Quantum Gates
5. Quantum Circuit with CNOT Gate for Entanglement
6. Simulating a Simple Quantum Algorithm (Shor's Algorithm)
7. Implementing Quantum Error Correction
8. Basic Quantum Magnetometry (Simulating a Magnetic Field Interaction)
9. Ramsey Interferometry: Measuring Quantum Phase Shifts and Coherence in Qubits Using Rotational Pulses Quantum Key Distribution (QKD) Using BB84 Protocol

List of Experiments – II

1. Diffraction Analysis with Single Slit and Diffraction Grating
2. Characterization of Polarization Optics
3. Resonance in Series and Parallel RLC Circuits
4. Measurement of Intrinsic Losses in RLC Circuits
5. Design and Testing of Basic Digital Circuits
6. Measurement of S-parameters for 2-port and 3-port RF Networks
7. Running Quantum Algorithms on Simulators

Course Outcomes: At the end of the course students will be able to

1.	Basic experimental techniques in optics.
2.	Basic experimental techniques in characterizing resonators and RLC circuits.
3.	Basic digital circuits.
4.	Fundamental techniques in RF engineering.
5.	Interfacing instruments with computers and carry out data acquisition.

Course Outcomes Mapping with Program Outcomes & PSO

Program Outcomes→	1	2	3	4	5	6	7	8	9	10	11	PSO↓		
↓ Course Outcomes														
PHY203-1.1	3	2	2					2			1			

PHY203-1.2	3	2	2					2			1			
PHY203-1.3	3	2	2					2			1			
PHY203-1.4	3	2	2					2			1			
PHY203-1.5	3	2	2					2			1			

1: Low 2: Medium 3: High

TEXTBOOKS:

1.	Optics, Eugene Hecht, A. R. Ganesan, 5th edition, Pearson (2019).
2.	Art of Electronics, Paul Horowitz and Winfield Hill, 3rd edition, Cambridge University Press (2015).
3.	Digital Design, Morris Mano, Michael D. Cilletti, 6th edition, Pearson Education (2018).

REFERENCE BOOKS:

1.	Discrete-time signal processing, Alan V. Oppenheim and Ronald W. Shaffer, 4th edition, Pearson (2009).
2.	Optical quantum information and quantum communication, A. Pathak and A. Banerjee, SPIE Spotlight Series, SPIE Press (2016).

E Books / MOOCs/ NPTEL/ Web links

1.	NPTEL - Optical Fiber Communication https://archive.nptel.ac.in/courses/108/106/108106167/
2.	NPTEL - Introduction to Electronic Circuits https://archive.nptel.ac.in/courses/108/102/108102097/
3.	NPTEL - Advanced Optical Communication https://archive.nptel.ac.in/courses/117/101/117101002/
4.	NPTEL – Electrical Measurement and Electronic Instruments https://archive.nptel.ac.in/courses/108/105/108105153/
5.	NPTEL – Introduction to Quantum Computing https://nptel.ac.in/courses/106106232.

Introduction to Quantum Computation

Course Code:	**PHY204**	**Course Type:**	**PCC**
Teaching Hours/Week (L: T: P: S):	**3:0:0:0**	**Credits:**	**03**
Total Teaching Hours:	**45**	**CIE + SEE Marks:**	**50+50**
Prerequisite: Basics of Engineering Mathematics and Physics - MAT102 and PHY102 or PHY104			

Teaching Department: Physics/IT Streams/ECE/EEE

Course Objectives:

1.	To understand qubit vs classical bits.
2.	To study the quantum correlations.
3.	To identify the fundamental principles of quantum algorithms.
4.	To study the principles involved in quantum complexity classes.
5.	To understand the quantum error corrections.

UNIT-I

Qubits versus classical bits	**09 Hours**
Spin-half systems and photon polarizations. Trapped atoms and ions. Artificial atoms using circuits. Semiconducting quantum dots. Single and Two qubit gates – Solovay - Kitaev Theorem.	
Quantum correlations	**09 Hours**
Entanglement and Bell's theorems. Review of Turing machines and classical computational complexity. Time and space complexity (P, NP, PSPACE). Reversible computation. Universal quantum logic gates and circuits.	

UNIT-II

Quantum algorithms	**09 Hours**
Deutsch algorithm. Deutsch Josza algorithm. Bernstein - Vazirani algorithm. Simon's algorithm. Database search. Grover's algorithm. Quantum Fourier Transform and prime factorization. Shor's Algorithm.	
Quantum complexity classes	**09 Hours**
Quantum complexity classes – Q, EQP, BQP, BPP, QMA. Additional Topics in Quantum Algorithms. Variational Quantum Eigen solver (VQE). HHL. QAOA.	

UNIT-III

Introduction to Error correction	**09 Hours**
Fault-tolerance. Simple error correcting codes. Survey of current status. NISQ era processors. Quantum advantage claims. Roadmap for future.	

Course Outcomes: At the end of the course students will be able to

1.	To realize qubits Vs classical bits
2.	Explain the theoretical basics of quantum correlations.
3.	To understand and explain the working of important quantum algorithms.
4.	Discuss the basic ideas of Quantum complexity classes.
5.	Learn the basics of quantum error correction

Course Outcomes Mapping with Program Outcomes & PSO

Program Outcomes→	1	2	3	4	5	6	7	8	9	10	11	PSO↓		
↓ Course Outcomes														
PHY204-1.1	3	2	2					2			1			
PHY204-1.2	3	2	2					2			1			
PHY204-1.3	3	2	2					2			1			
PHY204-1.4	3	2	2					2			1			
PHY204-1.5	3	2	2					2			1			

1: Low 2: Medium 3: High

TEXTBOOKS:

1.	Quantum Information Science – Manenti R., Motta M., 1st Edition, Oxford University Press (2023).
2.	Quantum computation and quantum information – Nielsen M. A., and Chuang I. L., 10th Anniversary edition, Cambridge University Press (2010).
3.	A Pathak, Elements of Quantum Computation and Quantum Communication, Boca Raton, CRC Press (2015).

REFERENCE BOOKS:

1.	Quantum error correction and Fault tolerant computing, Frank Gaitan, 1st edition, CRC Press (2008).
2.	Quantum computing explained, David McMahon, Wiley (2008).
3.	Introduction to Quantum Computing: From a lay person to a programmer in 30 steps, Hui Yung Wong, 1st edition, Springer-Nature Switzerland AG (2022).

E Books / MOOCs/ NPTEL/ Web links

1.	NPTEL - Introduction to Quantum Computing: Quantum Algorithms and Qiskit, IBM and IITM. https://nptel.ac.in/courses/106106232

Introduction to Quantum Materials

Course Code:	**PHY205**	**Course Type:**	**PCC**
Teaching Hours/Week (L: T: P: S):	**3:0:0:0**	**Credits:**	**03**
Total Teaching Hours:	**45**	**CIE + SEE Marks:**	**50+50**
Prerequisite: Basics of Engineering Mathematics and Physics - MAT102 and PHY102 or PHY104			

Teaching Department: Physics

Course Objectives:

1.	To understand the basics of band theory of solids.
2.	To study the characteristics and properties of magnetism.
3.	To study the fundamental principles and phenomenon of superconductivity.
4.	To study the principles involved in various techniques to fabricate semiconductors.
5.	To understand the real-world application of semiconductors in mechanical engineering.

UNIT-I

Elementary band theory — **10 Hours**

Band theory, in solid-state physics, theoretical model describing the states of electrons, in solid materials - Metals, Semiconductors and Insulators. Survey of semiconducting devices for quantum technologies (electronic, quantum optical devices and principle of operation). Correlated systems. Kronig-Penny model of band Gap, Conductor, Semiconductor (P and N-type) and insulator, Conductivity of Semiconductor, mobility, Hall Effect, Measurement of conductivity (four-probe method) and Hall Co efficient.

Magnetism — **06 Hours**

Magnetic Properties of Matter: Dia-, Para-, Ferri- and Ferromagnetic Materials, Classical Langevins theory of dia and Paramagnetic Domains, Curies law, Weiss Theory of Ferromagnetism and Ferromagnetic Domains, Discussion of B H Curve, Hysteresis and Energy Loss. Magnetic measurements, hall effect, magnetoresistance. Faraday and Kerr effects.

UNIT-II

Superconductivity — **10 Hours**

Experimental Results, Critical Temperature, Critical magnetic field, Meissner effect, Type- I and type-II Superconductors, Londons Equation and Penetration Depth, Isotope effect, Idea of BCS theory (No derivation). Flux quantization. High T_c superconductivity.

Josephson Effect – AC and DC Josephson effects. Survey of superconducting devices for quantum technologies.

2D materials — **06 Hours**

Graphene and its properties – single and few layers. Transition Metal Dichalcogenides – Electronic and Optical Properties. Topological Phases of matter. Basics of Topology. Geometric phases - Berry

Phase. Aharonov Bohm effect. Topological phases of matter.

UNIT-III

Survey of material growth techniques	**09 Hours**

Molecular Beam Epitaxy (MBE), Chemical vapor deposition, Metalorganic Vapour Phase Epitaxy (MOVPE), Pulsed laser deposition (PLD), Crystal growth techniques, Solution Growth Techniques - Hydrothermal Synthesis, Other Specialized Techniques: Spray Pyrolysis.

Course Outcomes: At the end of the course students will be able to

1.	The basics of band theory of solids
2.	The basics of magnetism
3.	The basics of superconductivity
4.	About new 2D materials like graphene, TMDCs
5.	About topology and topological phases of matter

Course Outcomes Mapping with Program Outcomes & PSO

Program Outcomes→	1	2	3	4	5	6	7	8	9	10	11	PSO↓		
↓ Course Outcomes														
PHY205-1.1	3	2	2					2			1			
PHY205-1.2	3	2	2					2			1			
PHY205-1.3	3	2	2					2			1			
PHY205-1.4	3	2	2					2			1			
PHY205-1.5	3	2	2					2			1			

1: Low 2: Medium 3: High

TEXTBOOKS:

1. Condensed Matter Physics, M P Marder, 2nd Edition, John Wiley and Sons, 2010.

REFERENCE BOOKS:

1. Introduction to Superconductivity, Michael Tinkham, standard ed., Medtech (2017).

E Books / MOOCs/ NPTEL/ Web links

1. Class Central Courses –
Topological Phases of Quantum Matter
https://www.classcentral.com/course/youtube-topological-phases-of-quantum- matter-by-sumathi-rao-168678
2. Youtube Channel: TAUVOD
Topological Superconductivity in Quantum Materials and Devices
https://www.youtube.com/watch?v=PGM-hAGV-f8
3. UC Berkeley
Quantum Materials
https://physics.berkeley.edu/research-faculty/lanzara-group/projects/quantum- materials.

Solid State Physics for Quantum Technologies

Course Code:	**PHY206**	**Course Type:**	**PCC**
Teaching Hours/Week (L: T: P: S):	**3:0:0:0**	**Credits:**	**03**
Total Teaching Hours:	**45**	**CIE + SEE Marks:**	**50+50**
Prerequisite: Basics of Engineering Mathematics and Physics - MAT102 and PHY102 or PHY104			

Teaching Department: Physics

Course Objectives:

1.	To understand the basics of Solids and its structure.
2.	To study the drude theory of metals.
3.	To study the fundamentals of phonons in solids.
4.	To study the principles involved in magnetism.
5.	To understand the phenomenon of superconductivity.

UNIT-I

Structure of solids — **09 Hours**

Introduction. Symmetry, Bravais lattices. Laue equations and Bragg's law. Brillouin Zones. Atomic scattering and structure factors. Characterization of crystal structures – XRD etc. Bonding in solids – van der Waals and Repulsive interactions, Lennard Jones potential, Madelung constant.

The Drude theory of metals — **09 Hours**

DC & AC electrical conductivity of a metal; Hall effect & magnetoresistance, Density of states, Fermi-Dirac distribution, Specific heat of degenerate electron gases. Free electron model. Beyond the Free electron model. Kronig-Penney Model. Periodic potential – Bloch Theorem. Band theory. Tight binding model.

UNIT-II

Elementary Lattice Dynamics: Phonons in Solids — **18 Hours**

One dimensional monoatomic and diatomic chains. Phonon spectrum. Long wavelength acoustic phonons and elastic constants. Vibrational Properties- normal modes, acoustic and optical phonons.

Lattice Vibrations and Phonons: Linear, Monoatomic and Diatomic Chains, Qualitative Description of the phonon spectrum in solids, Dulong and Petits Law, Einstein and Debye theories of specific heat of solids, T^3 Law.

UNIT-III

Dielectric Properties of Materials — **09 Hours**

Polarization Local Electrical Field at an Atom, Depolarization Field, Electric Susceptibility, Polarizability, Clausius Mosotti Equation, Classical theory of Electronic Polarizability.

LASERs: Properties, Einsteins A and B co-efficient, Metastable States, Spontaneous and

Stimulated emissions, Optical Pumping and population Inversion, Three Level and Four Level Lasers, Ruby LASER, He-Ne Laser and semiconductor (GaAs) Laser. Applications of Laser.

Course Outcomes: At the end of the course students will be able to

1.	Basics of solid states physics
2.	Various approximations for electronic states in matter
3.	The theory of phonons in solids
4.	Dielectric properties of materials
5.	LASERs and its applications

Course Outcomes Mapping with Program Outcomes & PSO

Program Outcomes→	1	2	3	4	5	6	7	8	9	10	11	PSO↓		
↓ Course Outcomes														
PHY206-1.1	3	2	2					2			1			
PHY206-1.2	3	2	2					2			1			
PHY206-1.3	3	2	2					2			1			
PHY206-1.4	3	2	2					2			1			
PHY206-1.5	3	2	2					2			1			

1: Low 2: Medium 3: High

TEXTBOOKS:

1.	Introduction to Solid State Physics, Charles Kittel, Wiley India Edition (2019)
2.	Condensed Matter Physics, M P Marder, 2nd Edition, John Wiley and Sons (2010)

REFERENCE BOOKS:

1.	Introduction to Superconductivity, Michael Tinkham, standard edition, Medtech (2017)

E Books / MOOCs/ NPTEL/ Web links

1.	NPTEL - Solid state physics https://nptel.ac.in/courses/115105099
2.	NPTEL - Introduction to Solid State Physics https://archive.nptel.ac.in/courses/115/104/115104109/
3.	NPTEL - Solid State Physics https://nptel.ac.in/courses/115106127
4.	NPTEL - Concepts of magnetism and superconductivity https://archive.nptel.ac.in/courses/115/105/115105131/
5.	NPTEL - Superconductivity https://archive.nptel.ac.in/courses/115/101/115101012/

Introduction to Quantum Mechanics
Bridge course: Mechanical, Civil and Biotechnology Engineering
Prerequisites for the Minor Degree on Quantum Technologies

Course Code:	**PHY200**	**Course Type:**	**PCC**
Teaching Hours/Week (L: T: P: S):	**---**	**Credits:**	**---**
Total Teaching Hours:	**18**	**CIE Marks:**	**50**
Prerequisite: Basics of Engineering Mathematics – MAT102			

Teaching Department: Physics

Course Objectives:

1.	To understand the Matrix formulation of quantum mechanics.
2.	To study the principles of quantum mechanics and its applications.

UNIT-I

Vector Spaces Basics — **9 Hours**

Definition and properties of vector spaces. Basis, dimension. Inner product definition and geometric interpretation. Orthogonality, orthonormal bases, and Gram-Schmidt orthogonalization. Representation of operators in vector spaces. Eigenvalues, eigenvectors, and diagonalization.

Dirac representation and matrix operations:

Matrix representation of 0 and 1 States, Identity Operator I, Applying I to$|0\rangle$and $|1\rangle$ states, Pauli Matrices and its operations on $|0\rangle$and $|1\rangle$states, Explanation of i) Conjugate of a matrix and ii) Transpose of a matrix. Unitary matrix U, Examples: Row and Column Matrices and their multiplication (Inner Product), Orthogonality and Orthonormality. Numerical Problems.

UNIT-II

Quantum Mechanics — **9 Hours**

Introduction to quantum mechanics, de Broglie Hypothesis and Matter Waves, de Broglie wavelength, Phase Velocity and Group Velocity, Relation between Phase Velocity and Group Velocity (Derivation), Relation between Particle Velocity and Group Velocity, Heisenberg's Uncertainty Principle - Application of Uncertainty Principle (nonexistence of electron inside the nucleus), Wave Function, Physical Significance of a wave function, Time independent Schrödinger wave equation (Derivation), Eigen functions and Eigen Values, Particle inside one dimensional infinite potential well, Numerical Problems.

Course Outcomes: At the end of the course students will be able to

1.	Apply the knowledge of vector space and Matrix formulation in quantum computation.

2.	Apply the knowledge of quantum mechanics to analyze the physical properties exhibited by particles at sub-atomic level.
TEXTBOOKS:	
1.	Arthur Beiser, "Concepts of Modern Physics", Tata McGraw Hill Education Private Limited, Special Indian Edition, 2009.
2.	Michael A. Nielsen & Isaac L. Chuang, "Quantum Computation and Quantum Information", Cambridge Universities Press, 2010 Edition.
3.	Parag K Lala, "Quantum Computing – A Beginner's Introduction", Indian Edition, McGraw Hill, Reprint 2020.
REFERENCE BOOKS:	
1.	Elements of Quantum Computation and Quantum Communication, A. Pathak, Boca Raton, CRC Press (2015)
2.	An Introduction to Quantum Computing, Phillip Kaye, Raymond Laflamme, and Michele Mosca, Oxford University Press (2006)
3.	Quantum computing explained, David McMahon, Wiley (2008)
E Books / MOOCs/ NPTEL/ Web links	
1.	NPTEL - Quantum Technology and Quantum Phenomena in Macroscopic Systems https://onlinecourses.nptel.ac.in/noc22_ph15/preview