B.N.M. Institute of Technology

An Autonomous Institution under VTU

Semester: I/II		
COURSE: Applied Physics for CSE stream		
Course Code: 23PHC112/122	**L:T:P:J: 2:2:2:0**	**CIA Marks:** 50
Credits:	4	**SEA Marks:** 50
Hours:	40 L &13 P	**SEA Duration:** 03 Hours

Course Learning Objectives: The students will be able to

1	Understand and apply the concepts of Quantum Mechanics and its applications in various fields of engineering by gaining practical knowledge to correlate with the theoretical concepts.
2	Demonstrate the engineering applications of Photonics (Lasers and Optical Fibres) by applying basic principles and their realization through experimental approach.
3	Understand and apply electrical properties of Metals and Superconductors using quantum mechanical concepts by gaining practical knowledge to correlate with the theoretical concepts.
4	Understand the basic properties of Nanomaterials and explore their applications in modern engineering fields by gaining practical knowledge to correlate with the theoretical concepts.
5	Understand and apply the basic concepts of Quantum computing in engineering applications.

Module 1 – Quantum Mechanics	**RBT**	**Hrs**
Pre-requisite: Particle nature of Light radiations – Photo electric effect, Black Body Radiation Spectrum and Planck's law of radiation. **Teaching Component:** Need for Quantum mechanics, de-Broglie's hypothesis of Matter Waves and their properties, Heisenberg Uncertainty Principle and its application (Non-existence of electrons inside nucleus). Wave function, properties and its physical significance: probability density and Normalization, Time independent one-dimensional Schrodinger equation (derivation), time dependent (qualitative), Particle in a potential well of infinite height (Eigen values and Eigen functions), Finite well potential and Quantum Tunneling (qualitative), Numerical problems. **Applications to mention:** Quantum Computers and Quantum entanglement.	**Applying**	**08**
Module 2 – Photonics	**RBT**	**Hrs**
Pre-requisite: Concepts of Absorption and Emission, Reflection, Refraction and total Internal Reflection. **Teaching Component: 2.1: LASER:** Interaction of radiation with matter and characteristic properties of laser, Energy density of a photon at equilibrium in terms of Einstein's coefficients (derivation), Conditions for Laser action, Requisites of a Laser system, Construction and working of CO_2 Laser. Engineering Applications of Lasers: Holography in Data Storage – Recording using Wave front division technique and reconstruction of Holograms, Numerical Problems. **Applications to mention**: LIDAR, Laser welding, drilling & cutting. **2.2: Optical fibers:** Introduction to optical fibers, Propagation mechanism in optical fibers, Acceptance angle and Numerical Aperture (derivation), Types	**Applying**	**08**

<table>
<tr><td>of Optical fibers, Attenuation in optical fibers (no derivation) and its mechanisms, Engineering Applications of optical fibers – Point to point communication, Numerical problems.
Applications to mention: Endoscopy, Broad band Internet connection.</td><td></td><td></td></tr>
<tr><td>Module 3 – Electrical Properties of Materials</td><td>RBT</td><td>Hrs</td></tr>
<tr><td>Pre-requisite: Free electron theory of metals, Ohm’s Law in terms of current density.
Teaching Component: 3.1 Metals: Quantum free electron theory – Assumptions, Density of states (qualitative), Fermi energy and Fermi factor, Effect of temperature on fermi factor, Expression for Fermi energy (derivation) at absolute zero temperature and at certain higher temperature (qualitative), effective mass (qualitative). Merits of quantum free electron theory, Numerical Problems.
3.2 Superconductors: Temperature dependence of resistivity in metals (Matthiessen’s rule) and superconducting materials. Effect of magnetic field (Meissner effect). Critical magnetic field and its temperature dependence, Type-I and Type-II superconductors, BCS theory (qualitative). High-temperature superconductors (qualitative). Applications of superconductors – SQUID, Numerical problems.
Applications to mention: Maglev vehicles, Superconducting magnets, Loss less power transmission, Nuclear Reactors.</td><td>Applying</td><td>08</td></tr>
<tr><td>Module 4 – Modern Engineering Materials</td><td>RBT</td><td>Hrs</td></tr>
<tr><td>Teaching Component: 4.1 Nano Materials: Introduction to Nano science and Nano materials, Surface to volume ratio, Quantum confinement – Quantum well, Quantum wire, Quantum dot. Synthesis of Nano materials – Top-down approach (Ball milling method) and bottom-up approach (Sol gel method). Carbon Nano tubes - synthesis of CNTs using Arc Discharge Method, types, properties and Applications. Scanning Electron Microscope (SEM), Application of SEM in analysis of Molecular size, Numerical problems.
4.2 Composite Materials: Introduction to composite materials, Classification of composites based on reinforcement materials and matrix. Advantages and disadvantages of composite materials, Engineering Applications – MEMS (qualitative).
Applications to mention: Targeted drug delivery system, Nanocomposites and Shape Memory Alloys (SMA).</td><td>Applying</td><td>08</td></tr>
<tr><td>Module 5 – Quantum Computing</td><td>RBT</td><td>Hrs</td></tr>
<tr><td>Teaching Component: Introduction to quantum computing- Matrix form of wave function, Identity Operator, Determination of I|0> and I|1>, classical information and quantum information, Moore’s law, Superposition in quantum computation, concept of Qubit, properties- mathematical representation, representation of qubit by Bloch sphere, Quantum Gates –Single qubit gates (Pauli’s X, Y, Z & Hadamard gate), Two qubit gate (CNOT gate), Three qubit gate (CCNOT or Toffoli gate) and difference between classical computing and quantum computing.
Applications to mention: Quantum simulation, Cryptography, Optimization and Quantum machine learning.</td><td>Applying</td><td>08</td></tr>
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Lab Experiments (2 Demo + 8 Lab sessions + 1 Experimental Demo +1 Repetition class + 1 Lab Test)	
Sl. No	**List of Experiments**
1	Determination of Planck's constant
2	Verification of Stefan's law
3	Determination of radius of curvature of a Plano convex lens using Newton's Rings
4	Determination of wavelength of Laser using Diffraction
5	Determination of Acceptance angle and Numerical Aperture of an Optical fiber
6	Determination of Fermi energy of copper
7	Determination of Resistivity of a metal
8	Determination of size of a Nano particle using diffraction pattern
9	Experimental demonstration on Magnetic levitation (Maglev Vehicle)

Course Outcomes: After completing the course, the students will be able to	
23PHC112/122.1	Apply the concepts of Quantum Mechanics to physical situations and determine parameter related to the concepts.
23PHC112/122.2	Apply principles of Photonics (Lasers and Optical Fibers) to determine optical parameters in the field of engineering.
23PHC112/122.3	Apply the quantum concepts and determine parameters related to electrical properties materials.
23PHC112/122.4	Apply the Concepts of Nano Science and determine parameters related to nano materials.
23PHC112/122.5	Apply the principles of Quantum Mechanics and their applications in Quantum Computing.

Reference Books

1. Principle of Quantum Mechanics: Concepts & Applications, Nouredine Zettili, Wiley, 2nd Edition, 2009.
2. Quantum Computation and Quantum Information, Michael A. Nielsen & Isaac L. Chuang, Cambridge Universities Press, 2010 Edition.
3. Lasers and Non-linear optics, B.B. Laud, New Age International Publishers, 3rd Edition, 2011.
4. Lasers and Optical Instrumentation, S. Nagabhushana and B. Sathyanarayana, I.K. International Publishing House Pvt. Ltd, 2013.
5. Solid State Physics, S.O. Pillai, New Age International Publishers, 9th Edition, 2020.
6. Introduction to Nanoscience and Nanotechnology, Chris Binns, Wiley, 2010.
7. An Introduction to Composite Materials, T.W. Clyne and D. Hull, Cambridge University Press, 3rd Edition, 2019.
8. University Practical Physics by D.C. Tayal, Edited by ILA Agarwal, 2000, Himalaya Publishing House, Mumbai.
9. Engineering Physics Laboratory Manual (BNMIT).

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2	Demonstrate the engineering applications of Photonics (Lasers and Optical Fibres) by applying basic principles and their realization through experimental approach.
3	Understand and apply electrical properties of Metals using quantum mechanical concepts and Dielectrics by gaining practical knowledge to correlate with the theoretical concepts.
4	Understand the basic properties of Nanomaterials and explore their applications in modern engineering fields by gaining practical knowledge to correlate with the theoretical concepts.
5	Understand and apply the concepts of Semiconductors in engineering applications and their realization through experimental approach.

Module 1 – Quantum Mechanics	**RBT**	**Hrs**
Pre-requisite: Particle nature of Light radiations – Photo electric effect, Black Body Radiation Spectrum and Planck's law of radiation. **Teaching Component:** Need for Quantum mechanics, de-Broglie's hypothesis of Matter Waves and their properties, Heisenberg Uncertainty Principle and its application (Non-existence of electrons inside nucleus). Wave function, properties and its physical significance: probability density and Normalization, Time independent one-dimensional Schrodinger equation (derivation), time dependent (qualitative), Particle in a potential well of infinite height (Eigen values and Eigen functions), Finite well potential and Quantum Tunneling (qualitative), Numerical problems. **Applications to mention:** Quantum Computers and Quantum entanglement.	**Applying**	**08**
Module 2 – Photonics	**RBT**	**Hrs**
Pre-requisite: Concepts of Absorption and Emission, Reflection, Refraction & Total Internal Reflection. **Teaching Component: 2.1: LASER:** Interaction of radiation with matter and characteristic properties of laser, Energy density of a photon at equilibrium in terms of Einstein's coefficients (derivation), Conditions for Laser action, Requisites of a Laser system, Construction and working of CO_2 Laser. Engineering Applications of Lasers: Holography in Data storage – Recording using Wave front division technique and reconstruction of Holograms, Numerical Problems. **Applications to mention**: LIDAR, Laser welding, drilling &cutting. **2.2: Optical fibers:** Introduction to optical fibers, Propagation mechanism in optical fibers, Acceptance angle and Numerical Aperture	**Applying**	**08**

(derivation), Types of Optical fibers, Attenuation in optical fibers (no derivation) and its mechanisms, Engineering Applications of optical fibers – Point to point communication, Numerical problems. **Applications to mention**: Endoscopy, Broad band Internet connection.		
Module 3 – Electrical properties of materials	**RBT**	**Hrs**
Pre-requisite: Free electron theory of metals, Ohm's Law in terms of current density. **Teaching Component: 3.1 Metals:** Quantum free electron theory – Assumptions, Density of states (qualitative), Fermi energy and Fermi factor, Effect of temperature on fermi factor, Expression for Fermi energy (derivation) at absolute zero temperature and at certain higher temperature (qualitative), effective mass (qualitative). Merits of quantum free electron theory, Numerical Problems. **3.2 Dielectric Materials:** Polarization and its types, Relation between dielectric constant and polarization (qualitative). Internal field and expression for internal filed in solids for one- dimensional (derivation) and three-dimensional cases (qualitative). Clausius- Mossotti equation (derivation). Application of dielectrics in transformers. Numerical Problems. **Applications to mention:** Fabricating capacitors, Energy storage devices, Heat sink in PCB. Coolant in thermal plants, Sensors & Actuators.	**Applying**	**08**
Module 4 – Modern Engineering Materials	**RBT**	**Hrs**
Teaching Component: 4.1 Nano Materials: Introduction to Nano science and Nano materials, Surface to volume ratio, Quantum confinement – Quantum well, Quantum wire, Quantum dot. Synthesis of Nano materials – Top-down approach (Ball milling method) and bottom-up approach (Sol gel method). Carbon Nano tubes - synthesis of CNTs using Arc Discharge Method, types, properties and Applications. Scanning Electron Microscope (SEM), Application of SEM in analysis of Molecular size, Numerical problems. **4.2 Composite Materials:** Introduction to composite materials, Classification of composites based on reinforcement materials and matrix. Advantages and disadvantages of composite materials, Engineering Applications - MEMS (qualitative) **Applications to mention:** Targeted drug delivery system and Nanocomposites.	**Applying**	**08**
Module 5 – Semiconductors and Semiconductor Devices	**RBT**	**Hrs**
Pre-requisite: Types of semiconductors. And P-n junction diode **Teaching Component: 5.1 Semiconductors:** Fermi energy and Fermi level, Fermi level in intrinsic semiconductors, Expression for concentration of electrons in conduction band & holes concentration in valance band (only mention the expression), Law of mass action, Electrical conductivity of a semiconductor (derivation), Hall effect, Expression for Hall coefficient (derivation) and its application. **5.2 Semiconductor Devices:** Photodiode and Power responsivity, Construction and working of Semiconducting Laser and Numerical problems. **Applications to mention:** Phototransistor and Solar cell.	**Applying**	**08**

Lab Experiments (2 Demo + 8 Lab sessions + 1 Experimental demo+ 1 Repetition class + 1 Lab Test)	
Sl. No	**List of Experiments**
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2	Determination of Radius of curvature of a Plano-convex lens using Newton's Rings
3	Determination of wavelength of Laser using Diffraction
4	Determination of Acceptance angle and Numerical Aperture of an Optical fiber
5	Determination of Fermi energy of copper
6	Determination of Dielectric constant by RC charging and discharging method
7	Determination of Size of a Nano particle using diffraction pattern
8	Photo Diode Characteristics
9	Experimental demonstration on magnetic levitation (Maglev vehicle)

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23PHE112/122.5	Apply the concepts of Semiconductors to determine parameters related to engineering applications.

Reference Books

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