Blow-up of Applied Physics for EEE Stream (22PHYE12/22) Syllabus

Module 1 (8 Hours)
Quantum Mechanics: de Broglie Hypothesis and Matter Waves, de Broglie wavelength and derivation of expression by analogy, Phase Velocity and Group Velocity, Heisenberg's Uncertainty Principle and its application (Non existence of electron inside the nucleus - Non Relativistic), Principle of Complementarity, Wave Function, Time independent Schrödinger wave equation (Derivation), Physical Significance of a wave function and Born Interpretation, Expectation value, Eigen functions and Eigen Values, Particle inside one dimensional infinite potential well, Quantization of Energy States, Waveforms and Probabilities. Numerical Problems **Pre-requisite:Wave–Particle dualism** **Self-learning: de Broglie Hypothesis**

Sl.No.	Topics	Subtopics	Topics to be covered	Duration (hr)
1	**Quantum Mechanics**	de Broglie Hypothesis and Matter Waves, de Broglie wavelength and derivation of expression by analogy,	**Statement of de-Broglie Hypothesis,** Derivation of expression for de Broglie wavelength (λ) by analogy and different forms of expression for (λ)	1 Hour
		Phase Velocity and Group Velocity, Heisenberg's Uncertainty Principle and its application (Non existence of electron inside the nucleus-Non Relativistic),	Wave Packets, Wave Velocity and Group Velocity (Definitions and Mention of Expression) Heisenberg's Uncertainty Principle, Non existence of electron inside the nucleus (Non-relativistic),	1 Hour
		Principle of Complementarity, Wave Function,	Principle of Complementarity, Correlation between de Broglie Wavelength, Heisenberg's Uncertainty principle and wave packet, Wave Function, Explanation, General Mathematical Form (Exponential),	1 Hour
		Time independent Schrödinger wave equation (Derivation),	Schrödinger Time Independent wave definition, Setting up of Time independent Schrödinger wave equation in 1D (derivation) and extension to 3D (mention)	1 Hour
		Physical Significance of a wave function and Born Interpretation, Expectation value, Eigen functions and Eigen Values,	Physical Significance of a wave function (Probability Density) and Born Interpretation, Expectation value, Eigen functions and Eigen Values,	1 Hour
		Particle inside one dimensional infinite potential well, Quantization of Energy states, Waveforms and Probabilities.	One Dimensional Potential Well Explanation and Boundary conditions, Schrödinger Wave equation for a particle in 1 D infinite potential well, General Solution, Applying Boundary Conditions, Energy Eigen Values (Quantization of Energy States), Normalization and Eigen Function, Variation of wave functions and probability density distributions for n = 1, 2, 3 states	2 Hours

		Numerical Problems	Numerical Problems on de Broglie Hypothesis, Heisenberg's Uncertainty Principle, Energy Eigen Values for a particle in 1D infinite potential well	1 Hour

Module-2 (8 Hours)

Electrical Properties of Solids:
Quantum Free Electron Theory of Metals: Assumptions, Fermi-energy, Fermi factor, Variation of Fermi Factor with Temperature and Energy, Mention of expression for electrical conductivity.
Dielectric Properties: Polar and non-polar dielectrics, Electrical Polarization Mechanisms, Internal fields in solid, Clausius- Mossotti equation(Derivation), Solid, Liquid and Gaseous dielectrics. Application of dielectrics in transformers, Capacitors, Electrical Insulation. Numerical Problems.
Superconductivity :
Introduction to Superconductors, Temperature dependence of resistivity, Meissner's Effect, Critical Field, Temperature dependence of Critical field, Types of Super Conductors, BCS theory (Qualitative), High Temperature superconductivity, SQUID, MAGLEV, Numerical problems.

Pre-requisites: Classical Free Electron Theory
Self-learning: Dielectrics Basics

Sl. No.	Topics	Subtopics	Topics to be covered	Duration (hr)
1	**Conductors**	Quantum Free Electron Theory of Metals :Assumptions, Fermi-energy, Fermi factor, Variation of Fermi Factor with Temperature and Energy, mention of expression for electrical conductivity.	Assumptions of Quantum Free Electron Theory of Metals, l Fermi-energy, Fermi factor, Variation of Fermi Factor with Temperature and Energy. Mention of expression for electrical conductivity	1 ½ Hours
2	**Dielectric Properties**	Polar and non-polar dielectrics, Electrical Polarization Mechanisms, internal fields in solid, Clausius-Mossotti equation (Derivation), solid, liquid and gaseous dielectrics . Application of dielectrics in transformers, Capacitors, Electrical Insulation. Numerical Problems.	Fundamentals of dielectrics. Polar and non- polar dielectrics, Polarization, Mention of relation between dielectric constant and polarization. Electrical polarization Mechanisms (Electronic, Ionic, Orientation and Space charge).	½ Hour
			Definition of internal field in case of solids and mention of its expression for one dimensional case. Mention of expressions for internal field for three dimensional cases and Lorentz field. Derivation of Clausius-Mossotti equation.	1 Hours
			Description of solid, liquid and gaseous dielectrics with one example each. Qualitative explanation of applications of dielectrics in transformers, Capacitors, Electrical Insulation.	1 Hour

3	**Superconductivity**	Introduction to Superconductors, Temperature dependence of resistivity, Meissner's Effect, Critical Field, Temperature dependence of Critical field, Types of Super Conductors, BCS theory (Qualitative), High Temperature superconductivity, SQUID, MAGLEV, Numerical problems.	General Introduction about Superconductivity, Graphical approach of Temperature dependence of resistivity in metals, Mathiessen's rule [$\rho=\rho0+\rho(T)$], Temperature dependence of resistivity in superconductors, Definition of superconductivity & Critical temperature. Meissner's Effect,	½ Hours
			Critical field, Temperature dependence of Critical field, Detailed explanation of Type-1 & Type-II Superconductors. BCS Theory: Phonon & Phonon field, cooper pairs, High Temperature Superconductors(qualitative).	1 ½ Hours
			Brief explanation of SQUID & mention its applications, The construction and working of MAGLEV vehicle.	1 Hour
		Numerical Problems	Numerical Problems : Fermi factor, Electrical Conductivity, Polarization, Clausius-Mossotti relation, Variation critical field with temperature.	1 Hour

Module 3 (8 Hours)
Lasers and Optical Fibers: **Lasers**: Characteristics of LASER, Interaction of radiation with matter, Expression for Energy Density and its significance. Requisites of a Laser System. Conditions for Laser action. Principle, Construction and Working of Carbon Dioxide Laser. Application of Lasers in Defense (Laser range finder) and Laser Printing. Numerical Problems. **Optical Fibers:** Total Internal Reflection**,** Propagation mechanism, Angle of Acceptance, Numerical Aperture, Fractional Index Change, Modes of Propagation, Number of Modes and V Number, Types of Optical Fibers. Attenuation and Mention of Expression for Attenuation coefficient, Attenuation Spectrum of an Optical Fiber with Optical Windows. Discussion of Block Diagram of Point to Point Communication, Intensity based Fiber Optic Displacement Sensor, Merits and Demerits, Numerical problems. **Pre-requisite: Properties of light** **Self-learning: Total Internal Reflection**

Sl. No.	Topics	Subtopics	Topics to be covered	Duration (hr)
1	**LASER**	Characteristics of LASER, Interaction of radiation with matter, Expression for Energy Density and its significance. Requisites of a Laser System. Conditions for Laser action. Principle, Construction and Working of Carbon Dioxide Laser. Application of Lasers in Defense (Laser range finder) and Laser Printing.	Characteristics of LASER, Interaction of radiation with matter (induced absorption, spontaneous and stimulated emission in terms of Einstein Coefficients), Derivation of expression for energy density equation and its significance	1 ½Hour
			Requisites of a Laser system (Excitation source, Active media and laser cavity) and pumping, Conditions for laser action(population inversion & meta stable state)	
			Principle, Construction and working of CO_2 Laser with energy level diagram	1½ Hour
			Application of Lasers in Defense (Laser range finder) and Explanation of Laser printing.	
2	**Optical Fibers**	Total Internal Reflection, Propagation mechanism, Angle of Acceptance, Numerical Aperture, Fractional Index Change, Modes of Propagation, Number of Modes and V Number, Types of Optical Fibers. Attenuation and Mention of Expression for Attenuation coefficient, Attenuation Spectrum of an Optical Fiber with Optical Windows. Discussion of Block Diagram of Point to Point Communication, Intensity based Fiber Optic Displacement Sensor, Merits and Demerits	Total Internal Reflection**,** Propagation mechanism, Angle of Acceptance, Numerical Aperture |(NA), derivation of expression for NA, Fractional Index Change(Δ), Relation between NA & Δ. Modes of propagation , mention of expression for number of modes and V number. Types of optical fibers.	2 Hours
			Types of attenuation, Mention of Expression for Attenuation coefficient, and Attenuation spectrum of an optical fiber with communication windows. Mention of expression for attenuation coefficient, Discussion of block diagram of point to point communication. Optical fiber sensors- Intensity based displacement sensor Merits and demerits of optical fibers.	1 ½ Hours
3	**Numerical Problems**	Numerical Problems	Numerical Problems : Ratio of Population, Number of photons / sec in a LASER beam of certain power output, Numerical Aperture, Acceptance angle and Attenuation Co-efficient	1 ½ Hour

Module 4 (8 Hours)
Maxwell's Equations and EM waves: **Maxwell's Equations:** Fundamentals of Vector Calculus. Divergence and Curl of Electric field and Magnetic field (static), Gauss' divergence theorem and Stoke's theorem. Description of laws of Electrostatics, Magnetism, Faraday's laws of EMI, Current Density, Equation of Continuity, Displacement Current (with derivation), Maxwell's equations in vacuum, Numerical Problems **EM Waves**: The wave equation in differential form in free space (Derivation of the equation using Maxwell's

equations), Plane Electromagnetic Waves in vacuum, their transverse nature.

Pre-requisite:Electricity & Magnetism
Self-learning: Fundamentals of vector calculus.

Sl.No.	Topics	Subtopics	Topics to be covered	Duration (hr)
1	**Maxwell's equations**	Fundamentals of Vector Calculus. Divergence and Curl of Electric field and Magnetic field (static), Gauss' divergence theorem and Stoke's theorem. Description of laws of Electrostatics, Magnetism, Faraday's laws of EMI, Current Density, Equation of Continuity, Displacement Current (with derivation) Maxwell's equations in vacuum,	Fundamentals of vector calculus: Briefly explain scalar product, vector product, Concept of divergence, gradient and curl along with physical significance and examples like Div and curl of E and B	1 ½ Hour
			Discuss the three different types of integrations *viz* linear, surface and volume integrations. Derivation of Gauss divergence theorem, mention Stokes' theorem.	1 ½ Hour
			Explain briefly Gauss flux theorem in electrostatics and magnetism, Ampere's law, Biot-Savart's law and Faraday's laws of electromagnetic induction,	1 Hour
			Discuss continuity equation, definition of displacement current(I_d), expression for displacement current, Maxwell- Ampere's law, List four Maxwell's equations in differential form and in vacuum	1 Hour
	EM Waves:	The wave equation in differential form in free space (Derivation of the equation using Maxwell's equations), Plane Electromagnetic Waves in vacuum, their transverse nature.	Derive Wave equation for EM waves in vacuum in terms of electric field using Maxwell's Equations. Explanation of Plane electromagnetic waves in vacuum along with the equations for Electric Field and Magnetic field variations.	2 Hours
			Explain the transverse nature of electromagnetic waves (Linear, Circular, Elliptical Polarization) Numerical Problems on Divergence and Curl	1 Hour

Module 5

Semiconductors and Devices:
Fermi level in Intrinsic & Extrinsic Semiconductor, Expression for concentration of electrons in conduction band & holes concentration in valance band (only mention the expression),Relation between Fermi energy & Energy gap in intrinsic semiconductors(derivation), Law of mass action, Electrical conductivity of a semiconductor (derivation), Hall effect, Expression for Hall coefficient (derivation) and its application. Photo-diode and Power responsivity, Construction and working of Semiconducting Laser, Four probe method to determine resistivity, Phototransistor, Numerical problems.

Pre requisite: Basics of Semiconductors
Self-learning: Fermi level in Intrinsic & Extrinsic Semiconductor

Sl.No.	Topics	Subtopics	Topics to be covered	Duration (hr)
1	**Semiconductors**	Fermi level in Intrinsic & Extrinsic Semiconductor, Expression for concentration of electrons in conduction band & holes concentration in valance band (only mention the expression), Relation between Fermi energy & Energy gap in intrinsic semiconductors(derivation), Law of mass action, Electrical conductivity of a semiconductor (derivation), Hall effect, Expression for Hall coefficient (derivation) and its application.	Explanation of Fermi level in intrinsic semiconductor and Explanation of Fermi level in n-type & p-type semiconductors, Carrier concentration (only expression), Relation between Fermi energy & Energy gap in intrinsic semiconductors (derivation).. Law of mass action: to show N_e*N_h=a, Derivation of Electrical conductivity of a semiconductor and also Mention expression for intrinsic semiconductor	2 ½ Hours
			Explanation of Hall Effect, Hall Voltage, Hall field , Derivation of Expression for Hall coefficient and Hall Voltage. Applications.	1 Hour
2	**Devices**	Photo-diode and Power responsivity, Construction and working of Semiconducting Laser, Four probe method to determine resistivity, Phototransistor, Numerical problems.	Photo Diode : Construction, working & power responsivity by graphical approach and applications. phototransistor : Construction & working of phototransistor & its applications. Four probe : Resistivity measurement and Temperature dependence of resistivity of semiconductor using four probe & its applications.	2 Hours
			Semiconductor Laser Diode: Construction & working with energy level diagram, applications	1 Hour
3	**Numerical Problems**	Numerical Problems	Electrical conductivity, Hall Effect.	1 Hour