Blow-up of Applied Physics for CSE Stream (22PHYS12/22) Syllabus

Module-1 (8 Hours)
LASER : Characteristic properties of a LASER beam, Interaction of Radiation with Matter, Einstein's A and B Coefficients and Expression for Energy Density (Derivation), Laser Action, Population Inversion, Metastable State, Requisites of a laser system, Semiconductor Diode Laser, Applications: Bar code scanner, Laser Printer, Laser Cooling(Qualitative), Numerical Problems. **Optical Fiber** : Principle and structure, Propagation of Light, Acceptance angle and Numerical Aperture (NA), Derivation of Expression for NA, Modes of Propagation, RI Profile, Classification of Optical Fibers, Attenuation and Fiber Losses, Applications: Fiber Optic networking, Fiber Optic Communication. Numerical Problems **Pre requisite:Properties of light** **Self-learning: Total Internal Reflection**

Sl.No	Topics	Subtopics	Topics to be covered	Duration
1	**LASER**	Basic properties of a LASER beam, Interaction of Radiation with Matter, Einstein's A and B Coefficients and Expression for Energy Density.	Basic properties of a LASER beam, Interaction of Radiation with Matter : Induced Absorption, Spontaneous Emission and Stimulated Emission, Einstein's A and B Coefficients : Rates of Absorption and emissions, Thermal Equilibrium, Boltzmann Relation, Derivation of Expression for Energy Density. $U_v = \frac{A}{B\left(e^{\frac{hc}{\lambda kT}} - 1\right)}$ Conclusion on $B_{12}=B_{21}$.	1 Hour
		Laser Action, Population Inversion, Metastable State, Requisites of a laser system, Numerical Problems.	Laser Action Explanation, Population Inversion explanation, Metastable State: Description using 3 level system, Requisites of a laser system : Energy Source, Active Medium, Laser Cavity,	1 Hour
		Semiconductor Diode Laser, Applications: Bar code scanner, Laser Printer, Laser Cooling,	Semiconductor Diode Laser: Principle, Construction, Working, Wavelength, Applications, Applications of LASER: Bar code scanner, Laser Printer, Laser Cooling	1 Hour
		Numerical Problems	Numerical Problems : Ratio of Population, Number of photons / sec in a LASER beam of certain power output.	1 Hour
2	**Optical Fibers**	Principle and structure, Acceptance angle and Numerical Aperture (NA)	**Principle : Total Internal Reflection,** Structure: Core, Clad, Sheath and corresponding Refractive Index, Propagation of Light Through the Optical fiber (Ray Diagram), Acceptance angle and Numerical Aperture (NA) Explanation	1 Hour

		Derivation of Expression for NA, Classification of Optical Fibers,	derivation of Expression for NA, Modes of Propagation Definition, RI Profile : Graph, Classification of Optical Fibers: Single Mode Step Index and Multi Mode Step and Graded Index Fibers,	1 Hour
		Attenuation and Fiber Losses, Applications: Fiber Optic networking, Fiber Optic Communication.	Attenuation, Attenuation Coefficient, Types of Fiber Losses: Absorption, Scattering and Geometrical Losses, Applications: Fiber optic Networking, Communication	1 Hour
		Numerical Problems	Numerical Problems : Numerical Aperture, Acceptance angle and Attenuation Co-efficient.	1 Hour

Module 2 (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 Schrodinger 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 3 (8 Hours)
Principles of Quantum Information & Quantum Computing: Introduction to Quantum Computing, Moore's law & its end, Differences between Classical & Quantum computing. Concept of qubit and its properties. Representation of qubit by Bloch sphere. Single and Two qubits. Extension to N qubits. **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), Probability, and Quantum Superposition, normalization rule. Orthogonality, Orthonormality. Numerical Problems **Quantum Gates**: **Single Qubit Gates:** Quantum Not Gate, Pauli – X, Y and Z Gates, Hadamard Gate, Phase Gate (or S Gate), T Gate **Multiple Qubit Gates:** Controlled gate, CNOT Gate, (Discussion for 4 different input states). Representation of Swap gate, Controlled -Z gate, Toffoli gate. **Pre requisites: Matrices** **Self-learning: Moore's law**

Sl.No	Topics	Subtopics	Topics to be covered	Duration (hr)
1	**Principles of Quantum Information & Quantum Computing:**	Introduction to Quantum Computing, Moore's law & its end, Differences between Classical & Quantum computing. Concept of qubit and its properties. Representation of qubit by Bloch sphere. Single and Two qubits. Extension to N qubits.	Introduction to Quantum Computing, **Moore's law** & its end. Differences between classical & quantum computing.	1 Hour
			Concept of qubit and its properties. representation of qubit by Bloch sphere. single and two qubits. Extension to N qubits.	1 Hour
2	**Dirac**	Matrix representation of 0	Matrix representation of 0 and 1 States,	2 ½ Hours

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<tr><td></td><td>representation and matrix operations:</td><td>and 1 States, Identity Operator I, Applying I to |0> and |1> states to show there is no change, Pauli Matrices and its operations on 0 and 1 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), Probability, and Quantum Superposition, normalization rule. Orthogonality, Orthonormality.</td><td>Identity Operator I, Applying I to |0> and |1> states to show there is no change, Pauli Matrices and its operations on 0 and 1 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), Probability, and Quantum Superposition, normalization rule. Orthogonality, Orthonormality.</td><td></td></tr>
<tr><td rowspan="2">3</td><td rowspan="2">Quantum Gates:</td><td rowspan="2">Single Qubit Gates: Quantum Not Gate, Pauli – X, Y and Z Gates, Hadamard Gate, Phase Gate (or S Gate), T Gate
Multiple Qubit Gates: Controlled gate, CNOT Gate, (Discussion for 4 different input states). Representation of Swap gate, Controlled -Z gate, Toffoli gate.</td><td>Quantum Not Gate, Pauli – X, Y and Z Gates, Hadamard Gate, Phase Gate (or S Gate), T Gate</td><td>1 Hour</td></tr>
<tr><td>Controlled gate, CNOT Gate, (Discussion for 4 different input states). Representation of Swap gate, Controlled -Z gate, Toffoli gate.</td><td>2 Hours</td></tr>
<tr><td>4</td><td>Numerical Problems</td><td>Standard Form Numerical Problems</td><td>Identity, Unitary, Inner Product, Orthogonality, Gates: X Gates, Hadamard Gate, CNOT Gate, Relating T and S gates (Standard Forms),</td><td>½ Hour</td></tr>
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Module 4 (8 Hours)

Electrical Conductivity in metals

Resistivity and Mobility, Concept of Phonon, Matheissen's rule, Failures of Classical Free Electron Theory, Assumptions of Quantum Free Electron Theory, Fermi Energy, Density of States, Fermi Factor, Variation of Fermi Factor With Temperature and Energy. Numerical Problems.

Superconductivity

Introduction to Super Conductors, Temperature dependence of resistivity, Meissner Effect, Critical Field, Temperature dependence of Critical field, Types of Super Conductors, BCS theory (Qualitative), Quantum Tunneling, High Temperature superconductivity, Josephson Junctions (Qualitative), DC and RF SQUIDs (Qualitative), Applications in Quantum Computing : Charge, Phase and Flux qubits . Numerical Problems.

Pre requisites:Basics of Electrical conductivity

Self-learning: Resistivity and Mobility

Sl.No.	Topic	Subtopics	Topics to be covered	Duration (hr)
1	**Electrical Conductivity in Metals**	Resistivity and Mobility, Concept of Phonon, Matheissen's rule, Failures of Classical Free Electron Theory, Assumptions of Quantum Free Electron Theory, Fermi Energy, Density of States, Fermi Factor, Variation of Fermi Factor With Temperature and Energy. Numerical Problems.	**(Electrical Conductivity in metals, Resistivity and Mobility)** Concept of Phonon, Variation of resistivity with temperature and impurity. Matheissen's rule. Mention of Failures of Classical Free Electron Theory of Metals,	1 Hour
			Quantum Free Electron Theory of Metals: Assumptions, Fermi Energy, Definition of Density of states and Fermi Factor. Variation of Fermi Factor with Temperature	1 Hour
2	**Superconductivity**	Introduction to Super Conductors, Temperature dependence of resistivity, Meissner Effect, Critical Field, Temperature dependence of Critical field, Types of Super Conductors, BCS theory (Qualitative), Quantum Tunneling, High Temperature superconductivity, Josephson Junctions (Qualitative), DC and RF SQUIDs (Qualitative), Applications in Quantum Computing : Charge, Phase and Flux qubits . Numerical Problems.	Introduction to Super Conductors, Temperature dependence of resistivity mentioning the critical temperature. Meissner's Effect and Explanation. Critical Field, Temperature dependence of Critical field.	2 Hours
			Types of Super Conductors (Soft-Type1 and Hard-Type2) superconductors explanation with graphs and examples, BCS theory of Superconductivity explanation with the formation of cooper-pairs , High Temperature superconductivity, Quantum Tunneling, Josephson Junctions, DC and AC Josephson Effects (Qualitative)	2 Hour
			DC and RF Squids (Qualitative), Applications in Quantum Computing : Charge qubit, Phase qubit and Flux qubit (Very brief explanation).	1 Hour
			Numerical Problems : Fermi Factor, Critical Field.	1 Hour

Module-5 (8 Hours)

Applications of Physics in computing:

Physics of Animation :

Taxonomy of physics based animation methods, Frames, Frames per Second, Size and Scale, Weight and Strength, Motion and Timing in Animations, Constant Force and Acceleration, The Odd rule, Oddrule Scenarios, Motion Graphs, Examples of Character Animation : Jumping, Parts of Jump, Jump Magnification, Stop Time, Walking: Strides and Steps, Walk Timing. Numerical Problems

Statistical Physics for Computing : Descriptive statistics and inferential statistics, Poisson distribution and modeling the probability of proton decay, Normal Distributions (Bell Curves), Monte Carlo Method : Determination of Value of π. Numerical Problems.

Pre requisites: Motion in one dimension, Probability

Self-learning: Frames, Frames per Second

Sl.No.	Topics	Subtopics	Topics to be covered	Duration (hr)
1	**Physics of Animation :**	Taxonomy of physics based animation methods, Frames, Frames per Second, Size and Scale, Weight and Strength, Motion and Timing in Animations, Constant Force and Acceleration, The Odd rule, Odd rule Scenarios, Motion Graphs, Examples of Character Animation : Jumping, Parts of Jump, Jump Magnification, Stop Time, Walking: Strides and Steps, Walk Timing, Numerical Problems	Introduction, Taxonomy of physics based animation methods, **Frames, Frames per Second,** Size and Scale, weight and strength,	1 Hour
			Motion and Timing in Animations : Motion Lines and Paths, Introduction to Motion, Timing Tools, Linear Motion Timing, Uniform Motion Timing, Slow in and Slow out, Constant Force and Acceleration, Forces Exerted by characters, The Odd rule: Odd rule multipliers, Odd rule scenarios (Four Different Scenarios), Motion Graphs,	2 Hour
			Examples of Character Animation : Jumping, Parts of Jump, Calculating Jump Actions, Jump Magnification (JM), Jump Acceleration, Landing, Stop time,Walking: Strides and Steps, Walk Timing.	2 Hour
			Numerical Problems : Odd rule multipliers and Odd rule Scenarios, Jump magnification (JM), Stop time	1 Hour
2	**Statistical Physics for Computing**	Descriptive statistics and inferential statistics, Poisson distribution and Normal Distributions (Bell Curves), Monte Carlo Method. Numerical Problems.	Descriptive statistics and inferential statistics, Poisson distribution, Modeling the probability for Proton Decay. Normal Distributions (Bell Curves) with an example, Monte Carlo Method : Determination of Value of π.	1 ½ Hour
			Numerical Problems on Poisson Distribution : Calculating the number of occurrences of an event in a given duration.	½ Hour