CBCS SCHEME

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1BPHYS102

First Semester B.E./B.Tech. Degree Examination, Dec.2025/Jan.2026
Quantum Physics and Applications

Time: 3 hrs. Max. Marks: 100

Note: 1. Answer any FIVE full questions, choosing ONE full question from each module.
2. M : Marks , L: Bloom's level , C: Course outcomes.
3. VTU formula handbook is permitted.

		Module – 1	M	L	C
Q.1	a.	Set up one dimensional time-independent Schrodinger's wave equation.	8	L2	CO1
	b.	Write a brief note on- Physical significance of wave function, Principle of complementarily, Expectation value& Quantum tunneling.	8	L2	CO1
	c.	Calculate the de-Broglie wavelength associated with an electron having a kinetic energy of 100 eV.	4	L3	CO1
		OR			
Q.2	a.	Derive a normalized wave function for a particle inside one dimensional infinite potential well.	8	L2	CO1
	b.	State and explain Heisenberg Uncertainty principle with three relationships. Use the energy-time uncertainty to explain the broadening of spectral lines.	8	L2	CO1
	c.	An electron is bound in a 1-dimensional potential well of width 1 Å & of infinite height. Find its energy values in eV for the ground state & the first two excited states.	4	L3	CO1
		Module – 2			
Q.3	a.	Define Fermi energy and Fermi factor. Discuss the variation of Fermi factor with temperature and energy.	8	L2	CO2
	b.	What is Hall effect? Derive an expression for Hall voltage in terms of Hall-coefficient with all necessary diagrams.	8	L2	CO2
	c.	Find the temperature at which there is 1% probability that a state with an energy 0.5 eV above Fermi energy is occupied.	4	L3	CO2
		OR			
Q.4	a.	Explain the failure of Classical free electron theory of metals and list assumptions of quantum free electron theory.	8	L2	CO2
	b.	Derive the expression for Fermi energy in terms of energy gap of intrinsic semiconductor.	8	L2	CO2
	c.	A semiconductor sample 0.5 mm thick carries a current of 5 mA in a magnetic field of 0.2 T. If the Hall voltage is 1 mV, determine the Hall coefficient.	4	L3	CO2

		Module – 3			
Q.5	**a.**	What are phonons? Explain the role of phonons in Cooper pair formation.	**8**	**L2**	**CO3**
	b.	Explain flux quantization with neat diagram. Discuss DC & AC Josephson effect.	**8**	**L2**	**CO3**
	c.	For a superconducting sample with critical temperature 7.2 K and critical field at 0K is 6.5×10^{4} Am^{-1}, find the critical field at 4 K.	**4**	**L3**	**CO3**
		OR			
Q.6	**a.**	Explain Silsbee effect and hence derive an expression for the critical current for a superconducting cylindrical wire.	**8**	**L2**	**CO3**
	b.	Define Meissner's effect. Differentiate between Type I and Type II superconductors.	**8**	**L2**	**CO3**
	c.	A long thin superconducting wire has a radius of 0.5 mm and a critical field of 8 kA m^{-1}. Determine its critical current.	**4**	**L3**	**CO3**
		Module – 4			
Q.7	**a.**	Discuss stimulated emission process. Derive energy density of radiation in thermal equilibrium using Einstein coefficients.	**8**	**L2**	**CO4**
	b.	Explain the construction & working of superconducting nano wire single photon detectors (SNSPDs). Write it's any two advantages.	**8**	**L2**	**CO4**
	c.	The attenuation of light in an optical fiber is estimated at 2.2 dB/km. What fractional initial intensity remains after 2 km and after 6 km?	**4**	**L3**	**CO4**
		OR			
Q.8	**a.**	Define acceptance angle for an optical fiber. Hence, derive the expression for its Numerical Aperture (NA)and arrive at the condition for propagation.	**8**	**L2**	**CO4**
	b.	Describe the construction and working of a semiconductor laser based on energy band diagram.	**8**	**L2**	**CO4**
	c.	A fiber has a core refractive index of 1.48 and a cladding index of 1.46. Calculate its numerical aperture (NA) and acceptance angle in air.	**4**	**L3**	**CO4**
		Module – 5			
Q.9	**a.**	State Moore's law. Distinguish between classical and Quantum computing.	**8**	**L2**	**CO5**
	b.	Outline the operation of the CNOT gate and define its standard matrix and logical truth table.	**8**	**L2**	**CO5**
	c.	Given $\lvert\psi\rangle = \begin{pmatrix}\alpha_1\\ \alpha_2\end{pmatrix}$ and $\lvert\phi\rangle = \begin{pmatrix}\beta_1\\ \beta_2\end{pmatrix}$. Prove that $\langle\psi\vert\phi\rangle = \langle\phi\vert\psi\rangle^*$	**4**	**L3**	**CO5**
		OR			

Q.10	a.	Define bit and qubit. Mention four properties of a qubit. Explain the representation of qubit using Bloch sphere.	8	L2	CO5
	b.	Mention the Pauli X and Y gate and apply these on the state $\|0>$ and $\|1>$ mention the truth table along with circuit symbol.	8	L2	CO5
	c.	Prove, using matrix algebra, that two consecutive T gates are equivalent to a single S gate in quantum circuit.	4	L3	CO5

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