

Model Question Paper

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Course Code: 1BPHEC102

First Semester B.E. Degree Examination, January 2025 Quantum Physics and Electronic Sensors (EEE Stream)

TIME:3 hrs.

Max.Marks:100

- Note: 1. Answer any FIVE full questions, choosing ONE question from each MODULE*
2. VTU Formula Hand Books Permitted
3. M: Marks, L: Bloom's level, C: Course outcomes.

		Module-1	M	L	C
Q.1	a	State and explain de Broglie's hypothesis. Derive the expression for the de Broglie wavelength of a particle of mass m accelerated through a potential difference V .	8	L2	CO1
	b	Discuss Heisenberg's uncertainty principle and explain how it leads to the broadening of spectral lines.	8	L2	CO1
	c	Calculate the de Broglie wavelength of an electron having kinetic energy 100eV.	4	L3	CO1
		OR			
Q.2	a	Derive the time-independent Schrödinger wave equation for a free particle.	7	L2	CO1
	b	Explain the physical significance of a wave function and its square modulus.	8	L2	CO1
	c	Determine the first three energy eigen values for an electron in a one-dimensional infinite potential well of width 1 nm.	5	L3	CO1
		Module-2			
Q.3	a	Discuss the failures of classical free electron theory and assumptions of quantum free electron theory of metals.	8	L2	CO2
	b	Explain the concept of Fermi-Dirac distribution function and its temperature dependence.	8	L2	CO2
	c	Calculate the probability of an electron occupying an energy level 0.02eV below the Fermi level at 400K.	4	L3	CO2
		OR			
Q.4	a	Derive the expression for electron concentration in an intrinsic semiconductor.	7	L2	CO2
	b	Explain the working principle of the Hall effect and its applications.	8	L2	CO2
	c	A semiconductor sample 1 mm thick carries a current of 2 mA in a magnetic field of 0.1 T. If the Hall voltage is 1 mV, determine the Hall coefficient.	5	L3	CO2
		Module-3			
Q.5	a	Explain the Meissner effect and discuss its significance.	8	L2	CO3
	b	Derive the relation for the critical current in a cylindrical wire using Ampere's law (Silsbee effect).	8	L2	CO3
	c	A superconducting wire of radius 0.5 mm carries a persistent current in a magnetic field of 2×10^{-2} T. Calculate the critical current.	4	L3	CO3
		OR			
	a	Explain the concept of Cooper pair formation and the role of phonons.	7	L2	CO3

Q.6	b	Distinguish between Type I and Type II superconductors using M–H characteristics.	8	L2	CO3
	c	For a superconducting sample with critical temperature 7.2 K and critical field at 0K is $6.5 \times 10^{-4} \text{ Am}^{-1}$, find the critical field at 4 K.	5	L3	CO3
Module-4					
Q.7	a	Using the two level diagram, derive Einstein's relations between the A and B coefficients and explain the concept of stimulated emission.	8	L2	CO4
	b	Explain the working of a semiconductor diode laser with a neat diagram.	7	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.	5	L3	CO4
OR					
Q.8	a	Explain the principle and working of a Mach–Zehnder interferometer.	8	L2	CO4
	b	Describe the Pockel's effect and Kerr effect in electro-optic modulators.	7	L2	CO4
	c	Calculate the V-number and number of modes supported by an optical fiber of core radius 25 μm , operating at wavelength 1.3 μm , and $\text{NA} = 0.2$.	5	L3	CO4
Module-5					
Q.9	a	Differentiate between direct and indirect band-gap semiconductors with examples.	7	L2	CO5
	b	Explain the working principle of a photo-diode and phototransistor.	8	L2	CO5
	c	A Hall sensor is made from N-type silicon has a Hall coefficient $0.035 \text{ m}^3\text{C}^{-1}$. The active area of the sensor has a thickness 0.5 mm. Calculate the voltage sensitivity S_v of the hall sensor in $\text{V A}^{-1}\text{T}^{-1}$.	5	L3	CO5
OR					
Q.10	a	Explain the construction and working of a piezoelectric sensor and mention its applications.	8	L2	CO5
	b	Describe the working principle of a superconducting nanowire single-photon detector (SNSPD).	7	L2	CO5
	c	The resistance of a platinum RTD at 0°C is 100Ω , and its temperature coefficient $\alpha = 0.0039 / ^\circ\text{C}$. Find its resistance at 75°C .	5	L3	CO5
