

# 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.**

	<b>Module-1</b>	<b>M</b>	<b>L</b>	<b>C</b>
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
<b>OR</b>				
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
<b>Module-2</b>				
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
<b>OR</b>				
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
<b>Module-3</b>				
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 $2 \times 10^{-2}$ T. Calculate the critical current.	4	L3	CO3
<b>OR</b>				
	a Explain the concept of Cooper pair formation and the role of phonons.	7	L2	CO3

<b>Q.6</b>	<b>b</b> Distinguish between Type I and Type II superconductors using M-H characteristics.	8	L2	CO3
	<b>c</b> For a superconducting sample with critical temperature 7.2 K and critical field at 0K is $6.5 \times 10^{-4}$ Am <sup>-1</sup> , find the critical field at 4 K.	5	L3	CO3

#### Module-4

<b>Q.7</b>	<b>a</b> 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>b</b> Explain the working of a semiconductor diode laser with a neat diagram.	7	L2	CO4
	<b>c</b> 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

<b>Q.8</b>	<b>a</b> Explain the principle and working of a Mach-Zehnder interferometer.	8	L2	CO4
	<b>b</b> Describe the Pockel's effect and Kerr effect in electro-optic modulators.	7	L2	CO4
	<b>c</b> Calculate the V-number and number of modes supported by an optical fiber of core radius 25 $\mu\text{m}$ , operating at wavelength 1.3 $\mu\text{m}$ , and NA = 0.2.	5	L3	CO4

#### Module-5

<b>Q.9</b>	<b>a</b> Differentiate between direct and indirect band-gap semiconductors with examples.	7	L2	CO5
	<b>b</b> Explain the working principle of a photo-diode and phototransistor.	8	L2	CO5
	<b>c</b> 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

<b>Q.10</b>	<b>a</b> Explain the construction and working of a piezoelectric sensor and mention its applications.	8	L2	CO5
	<b>b</b> Describe the working principle of a superconducting nanowire single-photon detector (SNSPD).	7	L2	CO5
	<b>c</b> The resistance of a platinum RTD at 0°C is 100 $\Omega$ , and its temperature coefficient $\alpha = 0.0039 /^\circ\text{C}$ . Find its resistance at 75°C.	5	L3	CO5

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