RV College of Engineering®

Department of Physics

Date: 10/07/2025	Test – Improvement CIE	Max. Marks:	50
Semester: 2	UG	Duration:	90 minutes
Course Title: Quantum Physics for Engineers		Course Code:	PY221IC

Physical Constants: Constants: Planck's Constant: 6.625×10^{-34}Js. Mass of electron: 9.1×10^{-31}kg, Mass of neutron: 1.67×10^{-27}kg, Charge on electron: 1.6×10^{-19}C.

Sl No		Questions	M	BT	CO
1.	a)	Explain Meissner effect with suitable diagrams. How does the formation of Cooper pairs enable a superconductor to exhibit Meissner effect? Also prove that for a superconductor susceptibility (χ) = -1.	7	2	1
	b)	Compare the behaviour of a conductor and a superconductor with the help of a resistivity vs. temperature graph.	3	1	1
2.	a)	Explain with relevant graphs type I and type II superconductors based on their magnetic behaviour, critical magnetic field, and material examples.	7	2	2
	b)	The critical temperature of lead is 7.2 K, and the critical magnetic field at 5 K is measured to be 0.04 T. (a) Calculate the critical magnetic field at 0 K. (b) What is the magnetic field required to destroy superconductivity at 6 K?	3	2	3
3.	a)	Explain DC and AC Josephson effect with relevant diagram. Find out the frequency of the ac signal generated in AC Josephson junction for an applied voltage of 1μV.	7	3	2
	b)	Find the kinetic energy and velocity of an electron with de-Broglie wavelength of 0.2 nm.	3	1	3
4.	a)	For an electron in one dimensional infinite potential well, apply the one-dimensional time independent Schondinger wave equation, and show that the electron energy is quantized. Also obtain the normalized wave function.	8	2	2
	b)	Assuming the nucleus to be a cubical box of size 10^{-14} m, compute the lowest energy of a neutron confined to the nucleus.	2	1	3
5.	a)	With the relevant circuit diagram, formulae, model graphs and tabular columns, explain the procedure to determine the capacitance of a given capacitor and the dielectric constant of the medium in it by charging and discharging the capacitor through a resistor.	7	2	4
	b)	In a laser diffraction experiment, the grating is kept at a distance of 87 cm from the screen. Using the relevant formula calculate the wavelength of the laser. Given: grating constant = 5.08×10^{-3}m.	3	2	4

Diffraction order (n)	Distance $2X_n$ (cm)
2	4.8
4	9.7
6	14.5

Course outcomes	CO1	CO2	CO3	CO4
Maximum marks	10	22	08	10

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R V College of Engineering

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II Semester B.E. Regular/ Supplementary Examinations- July/August - 2025.
Common to CS/IS/AIML/CD/CY/BT.
Course : Quantum Physics for Engineers-PY221IC

Time : 3 Hours **Maximum Marks : 100**

Instructions to the students

1. Answer all questions from Part A. Part A questions should be answered in first three pages of the answer book only.
2. Answer FIVE full questions from Part B. In Part B question number 2 and 11 are compulsory. Answer any one full question from 3 and 4, 5 and 6, 7 and 8, 9 and 10.
3. Handbook of Physics will be provided.

Part A

Question No	Question	M	CO	BT
1.1	Compute the de Broglie wavelength of a smoke particle of mass 10^{-6} g moving at 1 cm/s.	01	3	3
1.2	What is normalization condition of a wave function?	02	2	2
1.3	What is the basic unit of quantum information?	01	1	1
1.4	Given a general quantum state $\|\psi\rangle=\alpha\|0\rangle+\beta\|1\rangle$, express ket and bra ψ in matrix form, given that α and β are complex.	02	2	2
1.5	Which pumping mechanism is used in semiconductor lasers?	01	1	1
1.6	What is the principle of intensity modulated temperature sensor?	01	2	2
1.7	What is the the Fermi factor for $E=E_F$ at room temperature in metals?	01	1	1
1.8	What is transition temperature in super conductors?	01	1	1

Part B

Question No	Question	M	CO	BT
2a	Show that in a dispersive medium, group velocity is less than phase velocity of matter waves.	04	2	2
2b	Solve the time independent Schorndinger wave equation, for a particle in one dimensional potential well of infinite height. Hence obtain the normalized wave function. Sketch the wave functions and probability density graphs for first two excited quantum states.	10	2	3
3a	Verify if the matrix $\frac{1}{\sqrt{2}}\begin{bmatrix} 1 & i \\ -i & 1 \end{bmatrix}$ is unitary.	04	2	2
3b	Represent a general Qubit state with the help of a Bloch sphere. Explain the action of the following gates on an arbitrary point on the Bloch sphere: a) Pauli X gate, b) Hadamard gate	10	3	3

OR

4a	Explain five differences between classical and quantum computing .	10	2	2
4b	Calculate the action of Pauli X gate followed by Hadamard gate on the state |1⟩	04	2	3
5a	With energy level diagram, explain the three fundamental interactions of electromagnetic radiation with matter. Write the principle and construction of intensity modulated temperature sensor using optical fiber.	10	2	2
5b	The angle of acceptance of an optical fibre is 30° when kept in air. Find the angle of acceptance when it is in kept in water of refractive index 1.33.	04	3	4
	OR			
6a	Define refractive index profile. Explain three basic types of optical fibers based on geometry, refractive index profile and propogation mechanism. Sketch the necessary diagrams.	10	1	1
6b	A laser system has an optical resonator of length 5μm operating in fundamental mode (m=1). If the operating temperature is 300K, find the ratio of population between two energy levels and also find the ratio of Einstein Coefficients A and B.	04	3	5
7a	Arrive at an expression for carrier concentration in metals at zero Kelvin. What is Fermi factor? Explain the variation of Fermi factor for energy levels below and above Fermi energy at zero kelvin.	10	2	3
7b	Compute the concentration of charge carriers in germanium at 340K whose energy gap is 0.75 eV. Assume that the effective mass of electrons and holes are equal to the rest mass of electron.	04	3	5
	OR			
8a	Prove that the Fermi level of an intrinsic semiconductor lies in the middle of the band gap. Sketch and explain the variation of Fermi level in a p-type semiconductor with increasing dopant concentration.	10	2	3
8b	Find the temperature at which there is 1% probability that a state with an energy 0.5eV above fermi energy is occupied.	04	3	5
9a	Explain Type-I and Type-II superconductors. Write a note on high temperature superconductors.	10	2	1
9b	The critical temperature for lead is 7.2K, when the external magnetic field is zero. At 5K temperature, it looses its superconductivity when a magnetic field of 33000 A/m is applied. Find the maximum value of magnetic field intensity which will allow the material to retain its superconductivity at zero kelvin.	04	3	5
	OR			
10a	With a schematic diagram, explain the construction and working of DC squid. What is critical current ? How does the critical current vary with temperature in BCS theory ? Plot the variation graphically. State two applications of the DC squid.	10	2	3
10b	What are critical magnetic field and critical temperature in superconductivity? With a neat graph, explain how one is dependent on the other.	04	2	2
11a	Draw the conventional and Expeyes circuits used to study the V-I characteristics of the zener diode. Plot the V-I characteristics of a zener diode for forward and reverse bias conditions using the given data and	10	4	4

determine the knee voltage, zener breakdown voltage, forward and reverse dynamic resistance. (Note: Use the graph sheet provided in the answer booklet.)

V_f(V)	I_f (mA)	V_r(V)	I_r(mA)
0.01	0	-3.14	-3.39
0.2	0.01	-3.07	-2.79
0.4	0.01	-2.98	-2.23
0.59	0.02	-2.87	-1.69
0.71	0.54	-2.58	-0.76
0.73	1.22	-2.11	-0.16
0.74	1.93	-1.39	-0.01
0.76	3.35	-0.6	-0.01
0.77	4.79	-0.2	-0.01

11b Define grating constant and find out the same for a diffraction grating containing 500 lines per inch. In a Laser diffraction experiment, the grating is kept at a distance of 158 cm from the screen. Consider the following table containing the diffraction data to find out the wavelength of the laser used in the experiment. Find out the average fractional error in the measurement. The least count of the graph is 1 mm. 10 4 4

Diffraction order (n)	Distance $2X_n$ (cm)
1	4.2
2	6.5
3	8.5
4	12.5
5	18.5