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RV COLLEGE OF ENGINEERING
Autonomous Institution affiliated to VTU
II Semester B.E. 2023 Examinations
DEPARTMEN OF PHYSICS
COURSE TITLE: Quantum Mechanics for Engineers.
(2022 SCHEME)
(Integrated Course – Lab + Theory)

Time: 03 Hours ***Maximum Marks: 100***

Instructions to candidates:

Answer all questions from Part A. Part A questions should be answered in first three pages of the answer book only.

Answer FIVE full questions from Part B. In Part B question number 2 is compulsory. Answer any one full question from 3 and 4, 5 and 6, 7 and 8, and 9 and 10, and 11 lab components (compulsory).

Physical constants: h = 6.625 x 10^{-34}Js, m_e = 9.1 x 10^{-31}kg, k_b= 1.38 x 10^{-23}J/K,

PART-A (Objective type for one or two marks)

(True & false and match the following questions are not permitted)

1	1.1	Discuss one property of wave function?	10
	1.2	Why can we not achieve population inversion under natural conditions?	
	1.3	Which type of attenuation is dependent on the wavelength?	
	1.4	What is Mathiesen's rule?	
	1.5	Discuss any one difference between type-I and II superconductor?	
	1.6	What is Josephson's effect?	
	1.7	Determine if the matrix given by A= $\begin{bmatrix} 1 & i \\ -i & 1 \end{bmatrix}$ a.) Is it Hermitian? b.) Is it Unitary?	
	1.8	For Silicon at 30°C, calculate the number of states per unit energy per unit volume at an energy 26 meV above the bottom of the conduction band (m_e*=1.18 m_e)	

PART-B (Maximum subdivisions is limited to 2 in each question)

		UNIT-I	
2	a	Starting with the classical wave equation derive an expression for Time Independent Schrodinger equation? Write the energy operator using the TISE equation.	
	b	For a particle trapped in an infinite potential well, with a neat figure derive the energy eigenvalue and sketch the probability density for the second excited states, clearly stating the maximum and minimum.	7+7
		UNIT-II	
3	a	What are Qubits? With a neat figure describe single particle quantum interference.	
	b	If $a = \begin{bmatrix} 2i \\ 3+3i \\ -i \end{bmatrix}$, compute $\langle a, a \rangle$	

		The Pauli matrices are given as $A = \begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix}, \quad B = \begin{pmatrix} 0 & -i \\ i & 0 \end{pmatrix}, \quad C = \begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix}$ i) Show that $A^2=B^2=C^2=I$ ii) Show that any of the two matrices anti-commute.	7+7
		OR	
4	a	Discuss the various single qubit gates in detail.	
	b	With a neat figure explain the principle, construction and result of the single photon experiment	

		UNIT-III	
5	a	A rectangular plate of semiconductor is subjected to a current of 4 mA along the X-direction, a magnetic field of 2 Tesla along the Z-direction. This result in a potential difference of 2 mV being developed parallel to the XZ- plane. If the plate has dimensions of 4 cm along X- direction, 2.0 cm along Y-direction, and 2.0 mm along Z-direction. Calculate the Hall coefficient of the material and its charge carrier concentration. Sketch the variation of Fermi energy level with respect to concentration for an n-type semiconductor.	7+7
	b	Derive an expression for the concentration of electrons in the conduction band for an intrinsic semiconductor.	
		OR	
6	a	Sketch the variation of Fermi factor for zero and non-zero temperature. Define the definition of Fermi energy valid at all temperatures. The Fermi energy for copper is 7.0 eV. For copper at 827°C, determine the energy of the electron level for which the probability of occupation is 0.95	7+7
	b	What is carrier concentration? Derive an expression for the carrier concentration in a p-type semiconductor under the influence of a mutually perpendicular EXB fields.	

		UNIT-IV	
7	A	What is an optical fiber? Explain the propagation of light in an optical condition. Obtain an expression for the numerical aperture of an optical fiber. The acceptance angle of an optical fiber is 30^0 and the fractional index change is 0.0505. Calculate the refractive indices of the core and cladding.	7+7
	B	What are the requisites of laser? Explain the working with a neat energy diagram for Semiconductor laser.	
		OR	
8	a	Discuss the Graded refractive index fiber with the help of neat figure and specifically explain the variation of R.I with respect to radial distances. An optic fiber of RI 1.50 is to be clad to ensure TIR that will contain light travelling within 5^o of the fiber axis. What minimum RI is allowed for the cladding? If the core diameter is 40 µm and the wavelength of light	7+7

		propagating is 1400 nm. Calculate its V-number and number of modes?	
	b	Explain the three types of interactions between the radiation and matter. Obtain an expression for the energy density of radiation in terms of Einstein's coefficients.	

		UNIT-V	
9	a	Discuss AC and DC Josephson effect in detail	7+7
	b	Discuss in detail DC Squids. How are Squids useful in quantum computing?	
		OR	
10	a	Explain BCS theory in detail.	7+7
	b	Define Meissner effect and discuss its application of Meissner effect in Maglev trains. Discuss in brief about critical current.	

		LAB COMPONENT	
11	a	What is a transistor? Draw a neat labeled diagram of a transistor circuit and the model graph(s). Explain the procedure to obtain the output characteristics of the transistor. From the model graph(s) show that the transistor can be used as a voltage and current regulator.	10+10
	b	With a neat figure, describe the apparatus required and procedure for conduction of the wavelength of laser experiment. If the distance between the grating and screen is 1 meter and the diffraction order is given below. The grating constant is 5.08×10^{-5}m. What is the wavelength and color of the laser generated?	

Diffraction order	1	2	3	4	5	6
Distance ($2X_n$)	3	5.8	8.7	11.5	14.4	17.2