



VIT[®]

Vellore Institute of Technology
(Deemed to be University under section 3 of UGC Act, 1956)
CHENNAI

Reg. No

25BCE

Final Assessment Test(FAT) - NOV/DEC 2025

Programme	B.Tech.	Semester	Fall Semester 2025-26
Course Code	BAPHY105	Faculty Name	Prof. M Daniel Ranjan
Course Title	Engineering Physics	Slot	D1+TD1
		Class Nbr	CH2025260103704
Time	3 hours	Max. Marks	100

Instructions To Candidates

- Write only your registration number in the designated box on the question paper. Writing anything elsewhere on the question paper will be considered a violation.

Course Outcomes

- CO1: Identify limitations of classical physics through experimental observations.
 CO2: Apply matrix algebra and Dirac notation for the understanding of quantum mechanical problems involving linear operators, eigenvalues and eigenvectors.
 CO3: Solve the particle in 1-D and 3-D potential box problem using the principles of quantum mechanics.
 CO4: Apply fundamental concepts of quantum states and operators to understand the principles of quantum computing.
 CO5: Demonstrate quantum and optical phenomena through experiments and quantum operations through simulations.

Section - I

Answer all Questions (4 × 10 Marks)

01. a) How does Planck's radiation law fundamentally differ from Rayleigh-Jeans law, and how did this difference help resolve the ultraviolet catastrophe that puzzled physicists? [5 Marks]
 b) How does Young's double-slit experiment demonstrate the principle of superposition? [5 Marks]

[10] (CO1/K1)

02. Find the eigenvalue & eigen function of the matrix $A = \begin{bmatrix} 1 & -2 \\ 2 & 1 \end{bmatrix}$; also determine whether A is Hermitian? [10 Marks]

(OR)

- i. If $A = 2|\psi\rangle\langle\phi| - i|\chi\rangle\langle\psi|$ and the vectors are as shown below, then find A.

$$|\psi\rangle = \begin{bmatrix} 1 \\ 0 \\ 0 \end{bmatrix}, |\phi\rangle = \begin{bmatrix} 0 \\ 1 \\ 0 \end{bmatrix}, |\chi\rangle = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} \quad [5 \text{ Marks}]$$

- ii. An operator \hat{Q} is given by the matrix representation $\hat{Q} = \begin{pmatrix} 1 & i \\ -i & 2 \end{pmatrix}$. Find the adjoint of \hat{Q} . [2 Marks]

- iii. Find the inner product $\langle\psi|\phi\rangle$ for the following vectors.

$$|\psi\rangle = \begin{bmatrix} 1+i \\ 2 \\ -i \end{bmatrix}, |\phi\rangle = \begin{bmatrix} i \\ 1-i \\ 2 \end{bmatrix} \quad [3 \text{ Marks}]$$

[10] (CO2/K2)

03. a) Explain the factors influencing the probability of quantum tunnelling through a potential barrier, highlighting their significance and including the relevant equation. [5 Marks]
 b) Two electrons approach potential barriers of the same height but different widths. One barrier has a width of 0.5 nm, and the other has a width of 1.0 nm. If the tunnelling probability for the first barrier is 10%, calculate the tunnelling probability for the second, assuming both electrons have the same energy. [5 Marks]

[10] (CO3/K3)

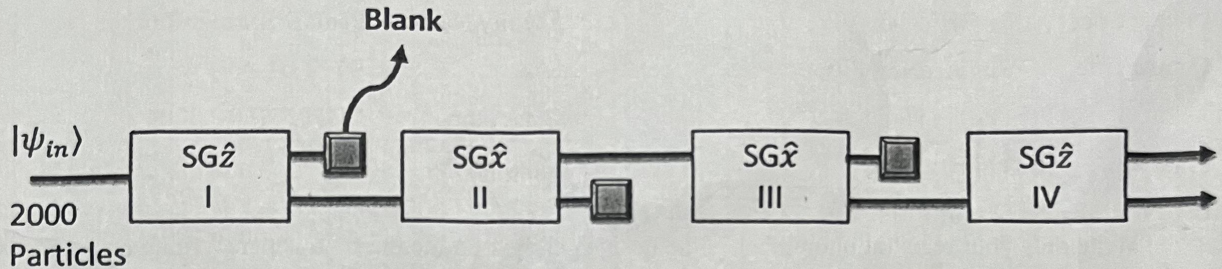
04. a) List and explain at least five key differences between classical bits and quantum bits (qubits). [5 Marks]
 b) A qubit is initially in the state $|\psi\rangle = \frac{1}{\sqrt{2}}(|0\rangle + |1\rangle)$, Find the new state after applying the Pauli-Z gate. [5 Marks]

[10] (CO4/K2)

Section - II

Answer all Questions (4 × 15 Marks)

05. a) Describe the construction and working principle and outcome of the Stern–Gerlach experiment. [9 Marks]
 b) Write down clearly what happens at every stage and describe the output of each section of the Stern–Gerlach components given in the following figure. Let's assume that initial beam contains 2000 particles. (Note: direction of motion of particles is along y axis). [6 Marks]



[15] (CO1/K3)

06. a) Given the Pauli matrices:

$$\sigma_x = \begin{bmatrix} 0 & 1 \\ 1 & 0 \end{bmatrix}, \sigma_y = \begin{bmatrix} 0 & -i \\ i & 0 \end{bmatrix}, \sigma_z = \begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix}$$

- i. Prove that $[\sigma_x, \sigma_y] = 2i\sigma_z$. [3 Marks]
 ii. Compute $[\sigma_x, \sigma_z]$. [3 Marks]
 iii. Is σ_z Hermitian? [3 Marks]

- b) Define projection and unitary operators, and explain their significance in quantum mechanics. [6 Marks]

[15] (CO2/K2)

07. Consider a particle of mass ' m ' confined in a 1-dimensional box of length ' L '. Derive the relations for the energy eigenvalues and associated wave functions of the particle. Draw the wave functions and their corresponding probability density for the particles in the 4th and 5th excited states. [15 Marks]

[15] (CO3/K2)

08. a) Define superposition and entanglement in qubits. [3 Marks]

b) Explain how measurement of one qubit in a Bell state ($|\beta_{00}\rangle$) affects the state of the other qubit. [3 Marks]

c) If a qubit is in state $|\psi\rangle = \alpha|0\rangle + \beta|1\rangle$, find the resulting state after applying a Pauli-Y gate. [3 Marks]

d) Show that $H|0\rangle = |+\rangle$ and $H|1\rangle = |-\rangle$ where, H refers to Hadamard gate. [6 Marks]

[15] (CO4/K3)

BL-Bloom's Taxonomy Levels - (K1-Remembering, K2-Understanding, K3-Appling, K4-Analysing, K5-Evaluating, K6-Creating)

