



**NATIONAL OPEN UNIVERSITY OF NIGERIA**  
**PLOT 91, CADASTRAL ZONE, NNAMDI AZIKIWE EXPRESSWAY, JABI - ABUJA**  
**FACULTY OF SCIENCES**

**DEPARTMENT OF PURE AND APPLIED SCIENCE**

**2021\_1 EXAMINATIONS...**

**COURSE CODE:** PHY 309  
**COURSE TITLE:** QUANTUM MECHANICS 1  
**CREDIT UNIT:** 3  
**TIME ALLOWED:** (2½ HRS)

**INSTRUCTION:** *Answer question 1 and any other four questions*

**QUESTION 1**

(a) Show that the following are vector spaces over the indicated field:

- (i) The set of real numbers over the field of real numbers. 4 marks
- (ii) The set of complex numbers over the field of real numbers. 4 marks
- (iii) The set of quadratic polynomials over the complex field. 4 marks

(b) Check whether the following vectors are linearly independent.

$$2i+3j-k, -i+j+3k \text{ and } -3i+2j+k \quad 4 \text{ marks}$$

(c) Find the coordinates of the vector  $\begin{bmatrix} 1 & 2 \\ -2 & i \end{bmatrix}$  with respect to the basis

$$\begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} \begin{bmatrix} 0 & 1 \\ 1 & 0 \end{bmatrix} \begin{bmatrix} 0 & -i \\ i & 0 \end{bmatrix} \begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix} \quad 6 \text{ marks}$$

**QUESTION 2**

- (a) What is this wave function  $\psi$ ? 3 marks
- (b) Mention the probability amplitude. 3 marks
- (c) Write the applications of  $\psi$ ? 3 marks
- (d) Explain the term wave packet 3mark

### QUESTION 3

- (a) Write the function  $h(x)e^{2x} \sin x$  as a sum of odd and even functions. 4marks
- (b) Evaluate the following integrals
- (i)  $\int_{-a}^a x^{2n+1} dx, n = 0, 1, 2, \dots$
- (ii)  $\int_{-a}^a x^{2n} dx, n = 0, 1, 2, \dots$  8 marks

### QUESTION 4

Discuss the following

- (a) Blackbody radiation 4 marks
- (b) Photoelectric effect 4 marks
- (c) Compton effect 4 marks

### QUESTION 5

A quantum-mechanical oscillator of mass  $m$  moves in one dimension such that its energy eigenstate is given as;

$$\psi(x) = (y^2/\pi)^{\frac{1}{4}} \exp(-y^2 x^2/2)$$

with energy

$$E = \hbar^2 y^2 / 2m$$

- (a) Find the mean position of the particle. 6 marks
- (a) Find the mean momentum of the particle. 6 marks

### QUESTION 6

What are the allowable eigenfunctions and energy eigenvalues of the infinite potential well?

$$V(x) = \begin{cases} 0, & -L \leq x \leq L \\ \infty, & \text{elsewhere} \end{cases}$$

12 marks