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

DEPARTMENT OF PURE AND APPLIED SCIENCE

APRIL/MAY, 2019 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) Define the term vector space (2 marks)
b) List the properties of the inner product of a vector space V. (6 marks)
c) (i) Determine if the function $f(x) = \sec x$ is even or odd (2.5 marks)
(ii) Express the function $h(x) = e^{-x}\cosh x$ as a sum of odd and even functions. (2.5 marks)
d) Find: (i) the change in wavelength if a proton is scattered at an angle of $23°$ after its collision with an electron initially at rest (2.5 marks)
(ii) the wavelength of the wave associated with an electron moving at $10^6\ m/s$. (2.5 marks)
e) Discuss the following: Photoelectric effect (2 marks)
f) Compton effect (2 marks)

QUESTION 2

a Write the function $h(x) = e^{2x}\sin x$ as a sum of odd and even functions. (4 marks)
b Evaluate the following integrals

(i) $\int_{-a}^{a} x^{2n+1}dx,\ n = 0,1,2,....$ (4 marks)
(j) (ii) $\int_{-a}^{a} x^{2n}\,dx,\ n = 0,1,2,....$ (4 marks)

QUESTION 3

a Find the maximum kinetic energy with which an electron is emitted from a metal of work function 3.2×10^{-39} J when a radiation of energy $E = 3.313\times10^{-39}\ J$ falls on it, given that the work function is $3.2\times10^{-39}\ J$. (5 marks)

b What value does Rayleigh-Jeans formula predict for the radiation of

frequency 6×10^{13} *Hz* emitted by a blackbody per unit time, per unit area at 2500 ^{0}K. Compare this value with that predicted by Planck. (4 marks)

c Discuss Compton effect (3 marks)

QUESTION 4

a) If the matrix $\begin{bmatrix} 3 & x \\ 1 & 2 \end{bmatrix}$ is a proper orthogonal matrix, find x. (4 marks)

b) Find the eigenvalues of the given matrices: (i) $\begin{bmatrix} 3 & -2 \\ 1 & 2 \end{bmatrix}$ (4marks)

(ii) $\begin{bmatrix} 0 & 0 & 1 \\ 0 & 0 & 0 \\ 1 & 0 & 0 \end{bmatrix}$ (4 marks)

QUESTION 5

Normalize the eigenfunction $\psi(x) = A \exp\left(-\frac{m\omega}{2\hbar}x^2\right)$. Hence, find the probability that the particle subjected to harmonic oscillation lies in the range $0 \leq x \leq \frac{1}{2}$. (12 marks)

QUESTION 6

A quantum-mechanical oscillator of mass m moves in one dimension such that its energy eigenstate $\psi(x) = (y^2/\pi)^{1/4} \exp(-y^2x^2/2)$ with $E = \hbar^2y^2/2m$.

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

(b) Find the mean momentum of the particle. (6 marks)