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

DEPARTMENT OF PURE AND APPLIED SCIENCE

OCT/NOV 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) Differentiate between Odd and Even function (4marks)

(b) What is inverse matrix? (2marks)

(c) Given a function h(x) = $e^{2x} sinx$. Find the Odd and even functions. (5marks)

(d) What is Blackbody radiation? (2marks)

(e) Mention the properties of inner product of a vector space V. (9marks)

QUESTION 2

(a) Prove that the function f(x) = secx is an even function (3marks)

(b) Differentiate between a vector space and norm of a vector (5marks)

(c) Given the radiation of frequency 6 x $10^{13}H_Z$ emitted by a blackbody per unit time, per unit area at 2500^0k. What is the value of Rayleigh-jeans formula? (4marks)

QUESTION 3

(a) Find the change in wavelength of a proton scattered at an angle of 23^0 after its collision with an electron initially at rest. (Take h= 6.626x10^{-34} m_e = 9.1 x 10^{-31} and C = 3 x 10^8m/s) (4 marks)

(b) Prove that the set

$$\left\{\begin{pmatrix}1\\0\\1\end{pmatrix},\begin{pmatrix}1\\1\\0\end{pmatrix},\begin{pmatrix}1\\2\\1\end{pmatrix}\right\}$$ is linearly independent (5 marks)

(c) State Heisenberg Uncertainty principle (3marks)

QUESTION 4

(a) Differentiate between orthogonal and orthonorrmal set (4marks)

(b) Sketch a diagram of Odd and Even functions (4marks)

(c) Normalize each vector in the set below (4marks)

$$\left\{\begin{pmatrix}-2\\0\\4\end{pmatrix}, \begin{pmatrix}1\\2\\1\end{pmatrix}\right\}$$

QUESTION 5

(a) What is Hermitian matrix? (2marks)

(b) Show that Sinmx and Sinnx are orthogonal $m \neq n$, $-\pi \leq x \leq \pi$ (4marks)

(c) If the matrix below is a proper orthogonal matrix. Find x. (2marks)

$$\begin{bmatrix}3 & x\\1 & 2\end{bmatrix}$$

(d) What is linear operator? (4marks)

QUESTION 6

(a) Given that the ladder operators

$$a = \sqrt{\frac{mw}{2\hbar}}\left(x + \frac{ip}{mw}\right) \quad a^{+} = \sqrt{\frac{mw}{2\hbar}}\left(x - \frac{ip}{mw}\right)$$

Show that $aa^{+} - a^{+}a = 1$ (4marks)

(b) Given that

$a = \sqrt{\frac{mw}{2\hbar}}\left(x + \frac{ip}{mw}\right)$ $a^{+} = \sqrt{\frac{mw}{2\hbar}}\left(x - \frac{ip}{mw}\right)$, position and momentum operator are given by

$$\hat{x} = \sqrt{\frac{mw}{\hbar}}x \quad \hat{p} = \sqrt{\frac{1}{m\hbar w}}\,p$$

Find the value of commutator $[\hat{x},\hat{p}]$ (2.5marks)

(ii) For the ground state find $<\hat{x}^2>$ and $<\hat{p}^2>$ (2.5marks)

(c) Show whether or not the set $\left\{\begin{pmatrix}1\\1\end{pmatrix}, \begin{pmatrix}-1\\-1\end{pmatrix}\right\}$ is a basis for two-dimensional Euclidean space.

(3marks)