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

DEPARTMENT OF PURE AND APPLIED SCIENCE

2021_2 EXAMINATIONS

COURSE CODE: **PHY309**
COURSE TITLE: **QUANTUM MECHANICS 1**
CREDIT UNIT: **3**
TIME ALLOWED: **(2½ HRS)**

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

QUESTION 1

. You are given the set $S_1 = \left\{\begin{pmatrix}1\\1\end{pmatrix}, \begin{pmatrix}1\\-1\end{pmatrix}\right\}$,

(a) Are they linearly independent? 3 marks
(b) Are they orthogonal? 3 marks
(c) Are they normalized? If not, normalize them. 4 marks
(d) Write the vector $\begin{pmatrix}3\\4\end{pmatrix}$
  (i) In terms of the usual basis in the Euclidean plane, 4 marks
  (ii) In terms of the basis $S_U = \left\{\begin{pmatrix}1\\1\end{pmatrix}, \begin{pmatrix}1\\-1\end{pmatrix}\right\}$, 4 marks
(e) Write the matrix of transformation from basis S_U to basis S_1 4 marks

QUESTION 2

(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 $3.2\times10^{-39} J$. 4 marks

(b) What value does Rayleigh-Jeans formula predict for the radiation of frequency $6\times10^{13} Hz$ emitted by a blackbody per unit time, per unit area at 2500 ^{0}K. Compare this value with that predicted by Planck. 8 marks

QUESTION 4

(a) Normalize each vector in the set $\left\{\begin{pmatrix}1\\2\\3\end{pmatrix}, \begin{pmatrix}-2\\0\\4\end{pmatrix}, \begin{pmatrix}1\\2\\1\end{pmatrix}\right\}$, 6 marks

(b)Write the function $h(x)=e^{2x}\sin x$ as a sum of odd and even functions. 6 marks

QUESTION 5

You are provided witha ladder operators$\alpha = \sqrt{\frac{m\omega}{2\hbar}}\left(x + \frac{ip}{m\omega}\right), \alpha^{+} = \sqrt{\frac{m\omega}{2\hbar}}\left(x - \frac{ip}{m\omega}\right)$. Also, the position and momentum operators are given by $\hat{x} = \sqrt{\frac{m\omega}{\hbar}}x$and $\hat{p} = \sqrt{\frac{1}{m\hbar\omega}}p$,

(i) Obtain the value of the commutator $[\hat{x}, \hat{p}]$. 2 marks

(ii) Show that$\hat{x} = \frac{1}{\sqrt{2}}(\alpha + \alpha^{+}), \hat{p} = \frac{-i}{\sqrt{2}}(\alpha + \alpha^{+})$. 2 marks

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

(b) Given that the expectation of the position and the momentum operators under consideration are zero in the ground state of the oscillator, prove that the following expression holds: $< x^2 >< p^2 >= \frac{1}{4}|< [x, p] >|^2$

$\alpha = \sqrt{\frac{m\omega}{2\hbar}}\left(x + \frac{ip}{m\omega}\right),\ \alpha^{+} = \sqrt{\frac{m\omega}{2\hbar}}\left(x - \frac{ip}{m\omega}\right)$ 6 marks

QUESTION 6

Given the matrix $\begin{bmatrix} 3 & -2 \\ 1 & 2 \end{bmatrix}$ find the corresponding eigenvectors and the eigenvalues. 12 marks