UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2017/2018

COURSE NAME	:	QUANTUM PHYSICS
COURSE CODE	:	BWC 20803
PROGRAMME CODE	:	BWC
EXAMINATION DATE	:	JUNE / JULY 2018
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWERS **ALL** QUESTIONS

THIS QUESTION PAPER CONSISTS OF **THREE (3)** PAGES

Q1 (a) Discuss a wave packet.

(5 marks)

(b) In this problem, consider a particle confined to the region $0 \le x \le L$ with wavefunction

$$\psi(x,t) = A\sin(\frac{2\pi x}{L})e^{-iEt}, \quad E = \frac{2\hbar^2}{mL^2}$$

(i) Determine the value for N that normalizes $\psi(x,t)$.

(ii) Sketch the probability density $P(x,t)$ for finding the particle at point x. Label your axes. What is the probability density $P(\frac{L}{2},t)$ for the particle to be $x = \frac{L}{2}$ at time t.

(iii) Calculate the expectation value for the position, $\langle x \rangle$.

(iv) Calculate the expectation value of the square of the momentum, $\langle p^2 \rangle$.

(15 marks)

Q2 (a) Explain a tunneling effect.

(5 marks)

(b) A beam of particles of energy E is fired from the left towards the symmetric potential shown in **Figure Q2(b)**. Assume that regions II and IV have a width sufficient for the particles to tunnel through, and that the width of region III is equal to a half-integer number of wavelengths $L_3 = \frac{n\lambda_3}{2}$.

(i) Sketch the form of the wavefunction expected in each of the 5 regions and give the functional forms of these wavefunctions.

(ii) Explain your choice of wavefunction for each region.

(iii) Explain how would you attempt to determine the various constants appearing in these wavefunctions.

(iv) Assume you can gradually change the width L_3 or potential V_3, what will happen?

(15 marks)

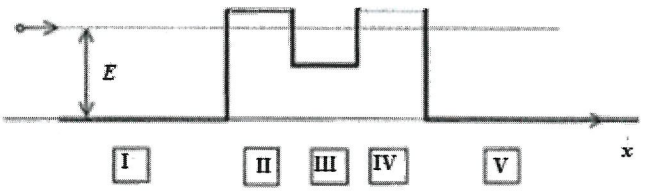

Figure Q2(b)

Q3 (a) List down the properties of the inner product.

(4 marks)

(b) Distinguish the terms orthogonal and orthonormal.

(4 marks)

(c) In describing photon polarization at 45° angle, how do you get $|/\rangle = \begin{pmatrix} \frac{1}{\sqrt{2}} \\ \frac{1}{\sqrt{2}} \end{pmatrix}$ given that $|x\rangle = \begin{pmatrix} 1 \\ 0 \end{pmatrix}$ and $|y\rangle = \begin{pmatrix} 0 \\ 1 \end{pmatrix}$?

(12 marks)

Q4 (a) Transform the harmonic oscillator in classical physics into quantum physics.

(5 marks)

(b) Show that $\psi(u) = (8u^2 - 12u)e^{-u^2/2}$ is an eigenfunction of the dimensionless equation $\frac{d^2\psi}{du^2} + (\varepsilon - u^2)\psi = 0$ and find the corresponding eigenvalue. Use the relationships used to derive the dimensionless parameters to find the energy that this represents for a particle in the harmonic oscillator potential, and find the energy level.

(15 marks)

Q5 (a) What is a Stern-Gerlach experiment?

(5 marks)

(b) Show that $[L_x, L_z] = -i\hbar L_y$.

(5 marks)

(c) A particle is in the state $|\psi\rangle = \frac{1}{\sqrt{5}}\begin{pmatrix} 2 \\ i \end{pmatrix}$. Find the probabilities of

(i) measuring spin-up or spin-down in the z direction.
(ii) measuring spin-up or spin-down in the y direction.

(10 marks)

-END OF QUESTIONS -