



MACHAKOS UNIVERSITY

University Examinations 2020/2021 Academic Year

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

FOURTH YEAR FIRST SEMESTER EXAMINATION FOR

BACHELOR OF EDUCATION (SCIENCE)

SPH 402: QUANTUM MECHANICS 11

DATE: 16/8/2021

TIME: 8.30-10.30 AM

INSTRUCTIONS:

The paper consists of **two** sections.

Section **A** is **compulsory** (30 marks)

Answer any **two** questions from section **B** (each 20 marks)

SECTION A

QUESTION ONE (30 MARKS)

- a) Distinguish between fermions and bosons as used in quantum mechanics (4 marks)
- b) What is the physical interpretation of $[L_x, L_y] \neq 0$ (3 marks)
- c) Show that angular momentum (L) is self adjoint (5 marks)
- d) Prove that $s_x s_y s_x s_y s_z s_x = s_x s_y s_x s_y \left(\frac{i\hbar}{2} \right) s_y = -\frac{i\hbar^5}{32} s_y$ (5 marks)
- e) Find the values of $\begin{bmatrix} L_y, z \end{bmatrix}$ (4 marks)
- f) Prove that $\begin{bmatrix} L^2, L_y \end{bmatrix} = 0$ (4 marks)
- g) Show that (i) $J_x = \frac{1}{2}\hbar \begin{bmatrix} 0 & 1 \\ 1 & 0 \end{bmatrix}$ (ii) $J_y = \frac{1}{2}\hbar \begin{bmatrix} 0 & -i \\ i & 0 \end{bmatrix}$ (5 marks)

SECTION B (20 MARKS EACH)

QUESTION TWO (20 MARKS)

Find the first order correction to the energy of the n^{th} state

QUESTION THREE (20 MARKS)

Derive the associated Legendre equation

QUESTION FOUR (20 MARKS)

Prove the equations below

i. $J_- J_+ = J^2 - J_z^2 - \hbar J_z$ (8 marks)

ii. $J_\pm J_\mp = J^2 - J_z^2 \pm \hbar J_z$ (8 marks)

iii. $[J_z, J_\pm] = \pm \hbar J_\pm$ (6 marks)

QUESTION FIVE (20 MARKS)

Show that given a state $|jm\rangle$, the state $|j, m+1\rangle$ must exist unless C_{jm}^+ vanishes for that particular m .