LAIKIPIA UNIVERSITY

UNIVERSITY EXAMINATIONS

FIRST SEMESTER 2025/2026 ACADEMIC YEAR

THIRD YEAR EXAMINATION FOR THE DEGREES OF BACHELOR OF EDUCATION (SCIENCE) AND BACHELOR OF SCIENCE (GENERAL)

PHYS 312: QUANTUM MECHANICS

STREAMS: REGULAR ***TIME: 2 HRS***

DAY: MONDAY [11.30 -1.30 P.M] ***DATE: 02/02/2026***

THIS QUESTION PAPER CONSISTS OF THREE (3) PAGES

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INSTRUCTIONS

*Read the question paper and questions carefully then answer question **ONE (40 marks –compulsory)** and any other **TWO** questions **(15 marks each)***

Where necessary, take speed of light c =3.8×10^{8}m/s

h=6.626×10^{-34}Js

e=1.6×10^{-19}J

QUESTION ONE (40 MARKS)

(a) Define the following terms as used in quantum mechanics

i) Hamiltonian operator **(1 Mark)**

ii) Complimentarity **(1 Mark)**

iii) Scrodinger equation **(1 Mark)**

iv) Harmonic oscillator **(1 Mark)**

v) Matrix mechanics **(1 Mark)**

(b) Given that A = d/dx and B = X^2, show that,

i) $A^2f_{(x)} = Af(x)$ **(2 Marks)**

ii) $ABf_{(x)} = BAf(x)$ **(2 Marks)**

(c) Determine whether the following are linear or non-linear,

i) A SQRT (square root operator). **(2 Marks)**

ii) A = X^2 (multiply by X^2 operator) **(2 Marks)**

(d) Differentiate between time dependent and time independent Schrodinger equation **(2 Marks)**

(e) In order to represent a physically observable wave, it must satisfy certain constraints. Explain any four. **(4 Marks)**

(f) Determine the electrons de Broglie wavelength, momentum, kinetic energy and speed when k=50nm. **(4 Marks)**

(g) Consider a system with a real Hamiltonian that occupies a state having a real wave function both at time t = 0 and at later time t = t_1. **(4 Marks)**

(h) Light of wavelength 200A falls on a metallic surface. If the work function of the surface is 4.2eV,

i) What is the kinetic energy of the fastest photoelectrons emitted? **(2 Marks)**

ii) Calculate the stopping potential and the threshold wavelength of the metal **(3 Marks)**

(i) Calculate the de Broglie wavelength of an electron having the kinetic energy of 1000eV. Compare the result with the wavelength of x- rays having the same energy. **(3 Marks)**

(j) Determine the de Broglie wavelength of an electron that has been accelerated through a potential difference of,

i) 100V **(2 Marks)**

ii) 200V **(2 Marks)**

(k) An electron has a speed of 500m/s with an accuracy of $0.004^{0}/_{0}$. Calculate the certainity with which we can locate the position of the electron. **(3 Marks)**

QUESTION TWO (15 MARKS)

In classical mechanics, the angular momentum, L, of a particle of position vector r and linear momentum P. Show that,

(a) $[Lx, Ly] = i\hbar Lz$ **(3 Marks)**

(b) $[Ly, Lz] = i\hbar Lx$ **(3 Marks)**

(c) $[Lz, Lx] = i\hbar Ly$ **(3 Marks)**

(d) $[L^2, L_X] = [L^2, L_Y] = [L^2, L_Z] = 0$ **(3 Marks)**

(e) $[L_+, L_Z] = i\hbar L_+$] **(3 Marks)**

QUESTION THREE (15 MARKS)

(a) Schrodinger Equation is an eigen value problem. Explain **(4 Marks)**

(b) Discuss three interpretative postulates and energy eigen functions **(6 Marks)**

(c) Find α^{+} (Hermitian adjoint) if α is a differential operator **(5 Marks)**

QUESTION FOUR (15 MARKS)

(a) Discuss in detail any five postulates in quantum mechanics **(10 Marks)**

(b) Explain two wave like and three particle like properties in quantum mechanics **(5 Marks)**