MAASAI MARA UNIVERSITY

REGULAR UNIVERSITY EXAMINATIONS 2023/2024

FOURTH YEAR SECOND SEMESTER

SCHOOL OF SCIENCE

UNIVERSITY EXAMINATIONS FOR THE DEGREE OF BACHELOR OF SCIENCE (PHYSICS)

COURSE CODE: PHY 4246-1

COURSE TITLE: COMPUTATIONAL PHYSICS

Question paper

DATE: 18th APRIL 2024 TIME: 0830-1030 HRS

INSTRUCTIONS

- Answer Question **ONE** and any other **TWO**.
- Use of sketch diagrams where necessary and brief illustrations are encouraged.
- Read the instructions on the answer booklet keenly and adhere to them.

This paper consists of _3_ printed pages.

QUESTION ONE: [20]

a) Suppose, a fruit-seller sold 20 mangoes and 10 oranges in one day for a total of Kshs 350. The next day he sold 17 mangoes and 22 oranges for Kshs 500. If the prices of the fruits remained unchanged on both the days, what was the price of one mango and one orange using the python code? [3]

b) Explain briefly 3 areas where Computational physics can be applied in practical solutions to problems. [3]

c) State two areas in physics where Monte-Carlo methods can be applied for numerical solutions. [2]

d) Why is Computer simulation important? [2]

e) Discuss two major errors associated with numerical integration schemes for ordinary differential equations (o.d.e.s). [2]

f) The wave equation, which in one dimension occurs so frequently in physics with x some sort of displacement or perturbation, whereas c is the (constant) wave speed. Write down a set of coupled first-order equations for solving the wave equation numerically. [4]

g) Write a computer program in python to Plot sine and cosine over the range $\{-\pi,\pi\}$. [4]

QUESTION TWO: [15]

a) Write a general Euler's-method routine that will calculate the next state of the system from the current state, the derivatives, and the desired time step. [5]

b) Write a program that plots the motion of a mass oscillating at the end of a spring. The force on the mass should be given by $F = mg + kx$. [10]

QUESTION THREE: [15]

a) Mesh analysis law is used to solve for the currents through loops in networks. Applying these laws gives us systems of linear equations, which can then be expressed as matrix equations, such as

$$\begin{pmatrix} -13 & 2 & 4 \\ 2 & -11 & 6 \\ 4 & 6 & -15 \end{pmatrix} \begin{pmatrix} I_A \\ I_B \\ I_C \end{pmatrix} = \begin{pmatrix} 5 \\ -10 \\ 5 \end{pmatrix}$$

Design a computer program in python that can be able to obtain the solutions for I_A, I_B and I_C commenting on each step within the code. [5]

B) Quantum theory is one area that requires computers for further Progress. The time-independent Schrodinger's equation,

$$-\frac{\hbar^2}{2m}\nabla^2\psi + V(\mathbf{r})\psi = -i\hbar\frac{\partial}{\partial t}\psi$$

describes the wave function for a quantum particle. Design a code to obtain normalized values of the eigenvalues of wave function. [10]

QUESTION FOUR: [15]

A) The table 1 is a lab experiment from another physics course in Maasai Mara University.

Table 1:File microphones.txt

#Frequency	Mic 1	Mic 2
10	0.654	0.192
11	0.127	0.032
12	0.120	0.030
13	0.146	0.031
14	0.155	0.033
15	0.175	0.036

Read the data file directly into python code. Design a program code to plot mic 1, mic 2 versus frequency for the microphones. [10]

B) Find the volume of a hemisphere of radius 1unit using the Monte Carlo integration. [5]

End and Good Luck.