B Sc Eng.ME/IPE/2nd Sem.

Date: 8 March 2024
Time: 02:30 pm - 4:00 pm

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)

ORGANISATION OF ISLAMIC COOPERATION (OIC)

DEPARTMENT OF NATURAL SCIENCES

Mid Semester Examination — **Summer Semester A. Y. 2022 - 2023**
Course Number: PHY 4213 — **Full Marks: 75**
Course Title: Waves and Oscillation, Geometrical Optics and wave mechanics — **Time: 1.5 Hours**

Please answer according to the order of the questions. There are 03 (Three) Questions. Answer all of them. Marks in the margin indicate full marks. Don't write on this question paper. Symbols carry their usual meanings. Assume reasonable values for any missing data. Programmable calculators are not allowed.

1.a) Describe graphically the mechanical, kinetic, and potential energies as a function of time and displacement for a linear harmonic oscillator. Identify the positions at where the total energy will be kinetic, and at where the total energy will be potential. (5) (CO1) (PO1)

b) i. List five differences between undamped and damped oscillations.
ii. Define the quantum mechanical operators. Name different types of quantum mechanical operators. (2.5+2.5) (CO1) (PO1)

c) Define the quantum mechanical operators for energy and momentum and describe how it is used to determine the eigen values from the eigen functions. (5) (CO1) (PO1)

2.a) Demonstrate the Lissajous figures formed due to the composition of two simple harmonic motions (SHMs), of different phase and amplitude and a frequency ratio of 2:1. (Consider the phase differences of 0° and 90° between two SHMs). (15) (CO2) (PO2)

b) i. Deduce the expression for the general equation of a damped harmonic oscillator.
ii. Describe your understanding about eigen functions and eigen values. An eigen function of the operator d^2/dx^2 is $\psi = e^{2x}$, find the corresponding eigen value. (7.5+7.5) (CO2) (PO2)

c) Derive the time dependent and time independent Schrödinger's equations. Explain, what you understand by orthogonal wave functions. Show that $\int_{-\infty}^{\infty} \psi_m \psi_n \, dV = 0;\ n \neq m$, and hence ψ_n and ψ_m are orthogonal to each other. (10+5) (CO2) (PO2)

3.a) In a CRO, the deflection of an electron beam by two mutually perpendicular electric fields is given by (5) (CO3) (PO2)

$$x = 4\cos 2\pi\nu t$$
$$y = 4\cos(2\pi\nu t + \pi/6).$$

Determine the path of the resultant electron beam.

b) i. A mass of 1 g vibrates through 1 mm on each side of the middle point of its path and makes 500 complete vibrations per second. Assuming its motion to be simple harmonic, show that the maximum force acting on the particle is π^2 N. (2.5+2.5) (CO3) (PO2)
ii Determine the expectation value of the position of a particle in quantum mechanics.

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c) Determine the normalized value of the one dimensional wave function, given by $\Psi(x) = A \sin(\pi x/a)$; $0<x<a$ and $\Psi(x) = 0$ outside . Illustrate the potential well according to the given boundary conditions. (5) (CO3) (PO2)