(2)

B Sc Eng. IPE/ME/2nd Semester

Date: 09 July 2025
Time: 10:00 -12:00

ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)
ORGANISATION OF ISLAMIC COOPERATION (OIC)
DEPARTMENT OF NATURAL SCIENCES

Semester Mid Examination — **Summer Semester: 2023-2024**
Course Number: PHY 4213 — **Full Marks: 120**
Course Title: Waves and Oscillations, Geometrical Optics and Wave mechanics — **Time: 2 Hours**

Answer all **4 (Four)** questions. Figures in the right margin indicate full marks of questions whereas corresponding CO and PO are written within parentheses

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1. (a) Define simple harmonic motion with its characteristics and give two examples. (6) (CO1) (PO1)

(b) With application point of view explain the difference among (i) free and forced oscillation, (ii) damped and undamped oscillation. (6) (CO1) (PO1)

(c) Define converging and diverging lenses with examples and ray diagrams. (6) (CO1) (PO1)

2. (a) (i) Demonstrate that the lens maker's formula for a real image by a convex lens is given by, $\frac{1}{f} = (\mu - 1)\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$, where the symbols have their usual meanings. (10+10) (CO2) (PO2)

(ii) A particle is subjected to two simple harmonic motions represented by the following equations

$$x = a\sin(\omega t + \delta)$$
$$y = b\sin\omega t$$

in a plane acting at right angles to each other. Discuss the formation of Lissajous figures due to the superposition of these two vibrations.

(b) A damped harmonic oscillator is described by the following linear differential equation (20) (CO2) (PO2)

$$\frac{d^2x}{dt^2} + 2\gamma\frac{dx}{dt} + \omega^2 x = 0; \text{ with } \gamma > 0$$

Assume a solution of the form $x(t) = Aexp(i\alpha t)$ with α allowed to be complex. Plug the solution into the differential equation and solve for α in terms of k, m, and γ. Use your answer to write down the most general solution to the differential equation that you can. Discuss all the cases of parameter space for: $\gamma > \omega$, $\gamma = \omega$ and $\gamma < \omega$ with the aid of sketch.

(c) Demonstrate that the approximate value of longitudinal spherical aberration caused by a spherical surface is given by, (20) (CO2) (PO2)

$$\Delta f_h = \frac{h^2}{2(\mu-1)^2 f_p}$$, where the symbols have their usual meanings.

3. (a) The midpoint of a guitar string executes simple harmonic motion with following form $x(t) = A\sin(\omega t + \phi)$. It has an angular frequency of $\omega = 2.76 \times 10^3 s^{-1}$ and an amplitude of $A = 1.60\ mm$. Take the phase constant to be $\phi = \pi/2$. (1 + 1 + 2 + 3) (CO3) (PO2)

(i) Calculate the period of oscillation of the string.
(ii) Obtain the maximum speed of the string during this motion.
(iii) Determine the maximum acceleration of the string.
(iv) Determine the initial displacement, velocity and acceleration of the midpoint of the string.

(b)	If the phase angle for a block-spring system in simple harmonic motion is $\pi/6$ and the block's position is given by $x = Asin(\omega t + \phi)$, determine the ratio of the kinetic energy to the potential energy at time $t = 0$.	(7) (CO3) (PO2)
(c)	A damped system has following elements: $m = 20\ kg; k = 30\ N/m; b = 0.9\ N.s/m$ Determine: (i) damping factor, (ii) undamped natural frequency, and (ii) natural frequency of damped oscillation.	(7) (CO3) (PO2)
4. (a)	Double convex lenses are to be manufactured from a glass of refractive index 1.50 with both faces of same radius of curvature. Calculate the radius of curvature if the focal length is to be 25 cm.	(7) (CO3) (PO2)
(b)	A convex lens of focal length 20 cm is in contact with a concave lens of focal length 25 cm. Calculate the focal length and power of the combination.	(7) (CO3) (PO2)
(c)	Suppose you have a convex lens of focal length f. Find the least possible distance between the object and a real image formed by the lens.	(7) (CO3) (PO2)