# UNIVERSITY OF FORT HARE

**Waves and Optics PHY 124F**

**SUPPLEMENTARY EXAMINATIONS**

**OCTOBER/ NOVEMBER**

**2024**

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| | |
|---|---|
| **Time:** | **2 Hours** |
| **Subject:** | **PHY 124F** |
| **Marks:** | **100** |

**This paper consists of 5 pages, including the cover page**


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**Moderator**
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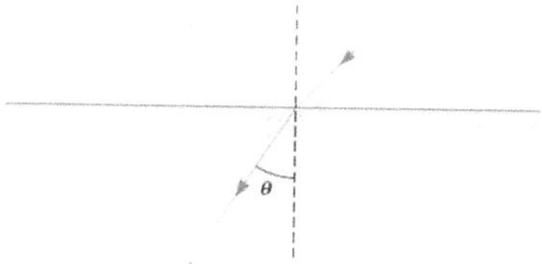
## INSTRUCTIONS

1. Answer **ALL** questions
2. Show all calculations of units

**Question 1 (10)**

1.1 (a) Find a critical angle for an air-water boundary. (The index of refraction of water is 1.33.) **(4)**




(b) Two mirrors are at right angles to one another. Alight ray is incident on the first at an angle of 35° with respect to the normal to the surface. What is the angle of reflection from the second surface? **(6)**

**Question 2 (30)**

2.1 Define the following terms:

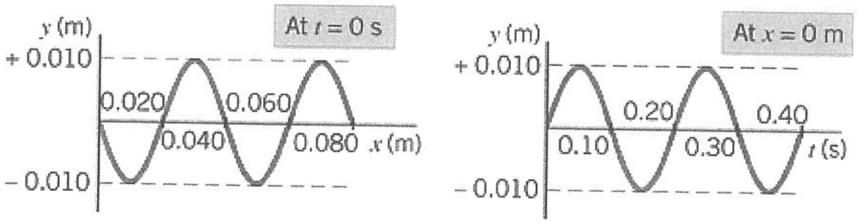
(a) Amplitude

(b) Wavelength

(c) Period

(d) Frequency **(8)**

2.2 The drawing shows two graphs representing a transverse wave on a string. The wave is moving in the - x direction. Using the information contained in these graphs, write the mathematical expression for the wave.




**(10)**

2.3 Tsunamis are fast-moving waves often generated by underwater earthquakes. In the deep ocean their amplitude is barely noticeable, but upon reaching shore, they can rise up to the astonishing height of a six-story building. One tsunami, generated off the islands in Alaska, had a wavelength of *750 km* and traveled a distance of *3700 km* in *5.3 h*.

(a) What was the speed (*in m/s*) of the wave?

(b) Find the wave's frequency and

(c) Find the wave's period. **(6)**

2.4 A wave has the following properties: A = 0.37m, period = 0.77s, wave speed = 12 m/s. The wave is traveling in the $+x$ direction. What is the mathematical expression for the wave? **(6)**

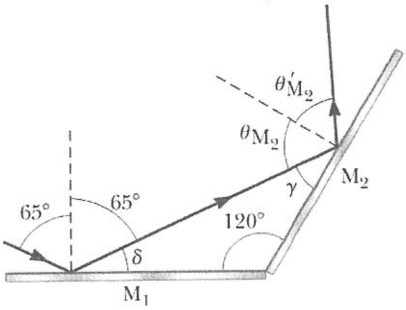
**Question 3 (20)**

3.1 State Law of Reflection **(2)**

3.2 A light ray strikes a reflective plane surface at an angle of 65° with the surface.

(a) Find the angle of incidence.
(b) Find the angle of reflection.
(c) Find the angle made by the reflected ray and the surface.
(d) Find the angle made by the incident and reflected rays. **(8)**

3.3 Two plane mirrors are separated by 120° as illustrated in the drawing. If a ray strikes mirror $M_1$ at a 65° **angle of incidence, at what angle $\theta$ does it leave mirror $M_2$? (10)**




**Question 4 (15)**

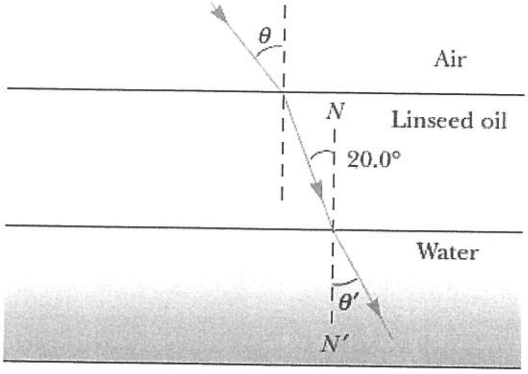
4.1 Derive the Lens maker's equation. **(7)**

4.2 Assume that a certain spherical mirror has a focal length of +10.0 cm. Locate and describe the image for the object distances of

(a) 25.0 cm **(3)**
(b) 10.0 cm **(2)**
(c) 5.00 cm **(3)**

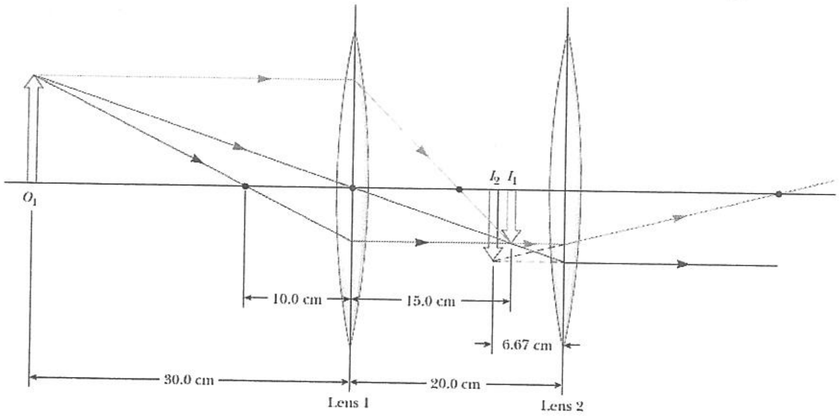
**Question 5 (25)**

5.1 Find $\theta$ and $\theta'$ if $n_{air} = 1$; $n_{water} = 1.33$ and $n_{Linsed} = 1.48$




**(10)**

5.2 Two thin converging lenses of focal lengths $f1$ =10.0 cm and $f2$ =20.0 cm are separated by 20.0 cm, as illustrated in the Figure illustrated below. An object is placed 30.0 cm to the left of the Lens. Find the position and the magnification of the final image.




**(10)**

5.3 The distance between an object and its image formed by a diverging lens is **45.0 cm**. The focal length of the lens is ***–23.0 cm***.

Find:

(a) the image distance

(b) the object distance. **(5)**

*Useful information*

$F_x = -kx$, $\quad a_x = -\frac{k}{m}x$, $\quad \omega = \sqrt{\frac{k}{m}}$, $\quad x(t) = A\cos(\omega t + \phi)$, $\quad v(t) = -A\omega\sin(wt + \phi)$,

$a(t) = -A\omega^2\cos(\omega t + \phi)$, $\quad v_{max} = A\omega$, $\quad a_{max} = A\omega^2$, $\quad KE = \frac{1}{2}mv^2$, $\quad U = \frac{1}{2}kx^2$, $\quad E_{tot} = \frac{1}{2}kA^2$,

$v^2 = \omega^2(A^2 - x^2)$, $\quad \theta = \theta_{max}\cos(\omega t + \phi)$, $\quad \omega = \sqrt{\frac{g}{L}}$, $\quad T = \frac{2\pi}{\omega}$, $\quad R = -bv$, $\quad \omega = \sqrt{\omega_0^2 - \left(\frac{b}{2m}\right)^2}$,

$x(t) = Ae^{-\frac{b}{2m}t}\cos(\omega t + \phi)$, $\quad y(x,t) = A\cos(kx \pm wt + \theta)$, $\quad \omega = 2\pi f$, $\quad f = \frac{1}{T}$, $\quad k = \frac{2\pi}{\lambda}$,

$v = \lambda f = \frac{\omega}{k}$, $\quad v = \frac{\lambda}{T}$, $\quad v = \sqrt{\frac{T}{\mu}}$, $\quad K_\lambda = U_\lambda = \frac{1}{4}\mu\omega^2A^2\lambda$, $\quad E_\lambda = \frac{1}{2}\mu\omega^2A^2\lambda$, $\quad v = \sqrt{\frac{B}{\rho}}$,

$P = \frac{1}{2}\mu\omega^2A^2v$, $\quad \Delta P(x,t) = \Delta P_{max}\sin(kx \pm \omega t)$, $\quad v = \sqrt{\frac{Y}{\rho}}$, $\quad v = (331\,m/s)\sqrt{1 + \frac{T_c}{273^\circ C}}$,

$\Delta P_{max} = \rho v\omega s_{max}$, $\quad K_\lambda = U_\lambda = \frac{1}{4}(\rho A)\omega^2 s_{max}^2\lambda$, $\quad I = \frac{P}{A}$, $\quad I = \frac{P}{4\pi r^2}$, $\quad E_\lambda = \frac{1}{2}(\rho A)\omega^2 s_{max}^2\lambda$,

$P = \frac{1}{2}(\rho A)v(\omega s_{max})^2$, $\quad I = \frac{1}{2}\rho v(\omega s_{max})^2$, $\quad I = \frac{(\Delta P_{max})^2}{2\rho v}$, $\quad x = \frac{n\lambda}{2}$, $\quad x = \frac{n\lambda}{4}$, $\quad f_n = \frac{nv}{2L}$, $\quad n = \frac{c}{v}$,

$f_n = \frac{nv}{4L}$, $\quad f_n = nf_1$, $\quad \beta = 10\log\left(\frac{I}{I_0}\right)$, $\quad f_o = \left(\frac{v - v_o}{v - v_s}\right)f_s$, $\quad y = y_1 + y_2 = (2A\sin kx)\cos\omega t$,

$y = y_1 + y_2 = 2A\cos\left(\frac{\phi}{2}\right)\sin\left(kx \pm \omega t - \frac{\phi}{2}\right)$, $\quad n_1\sin\theta_1 = n_2\sin\theta_2$, $\quad \sin\theta_c = \frac{n_2}{n_1}$,

$M = \frac{h'}{h} = -\frac{p}{q}$, $\quad \frac{1}{p} + \frac{1}{q} = \frac{2}{R}$, $\quad f = \frac{2}{R}$, $\quad \frac{n_1}{p} + \frac{n_2}{q} = \frac{n_2 - n_1}{R}$.