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QUESTION PAPER

DEGREE AND DIPLOMA EXAMINATIONS: ☒ MAIN ☐ SUPP ☐ SPECIAL

EXAM MONTH AND YEAR : OCTOBER 2025

FACULTY	:	Science and Agriculture
DEPARTMENT	:	Physics
QUALIFICATION	:	Bsc
SUBJECT NAME	:	Waves, Vibrations & Optics
SUBJECT CODE	:	PHY123F
EXAMINER(S)	:	MTHIMUNYE TV
MODERATOR	:	MAPANTSELA Y
INSTRUCTIONS	:	Answer all five (5) questions • Read th
ANNEXURES/ADDENDA	:	2 pages
DURATION	:	3 HOURS
MARKS	:	100
NUMBER OF PAGES	:	6 (INCLUDING COVER PAGE).
ASSESSMENT WEIGHTING	:	50

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UNIVERSITY OF FORT HARE

PHY123F

EXAMINATIONS

OCT / NOV 2025

Time: 3 HOURS

Subject: Oscillations, Mechanical Waves, and Optics

Marks: 100



This paper consists of 11 pages, including a cover page.

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Internal Examiner
Mr. T.V. MTHIMUNYE

Moderator
MS MAPANTSELA

Instructions

- Answer all questions
- Read the question more than once and write down your data.
- When solving problems, specify applicable definitions and draw clearly labeled diagrams.

SECTION A (50)

Choose the **correct** answer from the possible answers given and mark it on the response card supplied.

A simple pendulum of length L swings with an amplitude θ and a frequency f as shown in Figure 1 below:

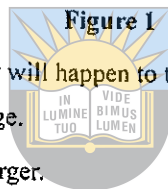
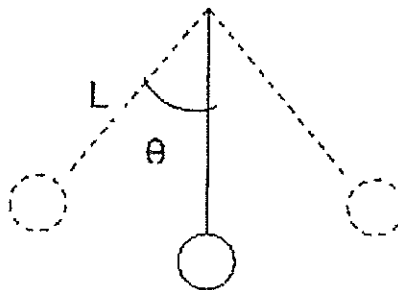


Figure 1

1. If the length is quadrupled, what will happen to the period of a simple pendulum?
 - A. It becomes twice as large.
 - B. It becomes $\sqrt{2}$ times larger.
 - C. It is unchanged.
 - D. It becomes $\frac{1}{\sqrt{2}}$ times as large.
 - E. It becomes one-half as large.
2. If the mass and the length of the pendulum are both doubled, the frequency of vibration will be:
 - A. It becomes twice as large.
 - B. It becomes $\sqrt{2}$ times larger.
 - C. It is unchanged.
 - D. It becomes $\frac{1}{\sqrt{2}}$ times as large.
 - E. It becomes one-half as large.
3. Which of the following statements is true about the swinging pendulum?
 - i. The greatest restoring force and the greatest potential energy occur at the same point

- ii. The greatest restoring force and the greatest kinetic energy occur at the same point
- iii. The greatest acceleration and the greatest kinetic energy occur at the same point

- A. I only
- B. I and II only
- C. II only
- D. II and III only
- E. I, and III

4. If the pendulum is length is taken to another planet where the gravitational acceleration is one fourth that of the earth, what will happen to the period of a simple pendulum?

- A. It becomes twice as large.
- B. It becomes $\sqrt{2}$ times larger.
- C. It becomes four times larger.
- D. It becomes $\frac{1}{\sqrt{2}}$ times as large.
- E. It becomes one-half as large.



5. A pendulum is timed as it swings back and forth. A stopwatch is started when the bob is at the left end of its swing. When the bob returns to the left end for the 60th return, the clock reads 80 s. What is the period of vibration?

- A. 80s
- B. 0.079 s
- C. 1.33 s
- D. 0.75 s
- E. None of these.

6. What is the frequency of the pendulum in question 39 above?

- A. 0.0167 Hz
- B. 0.0125 Hz
- C. 12.66 Hz
- D. 0.75 Hz
- E. None of these.

7. A string of length L , mass per unit length μ , and tension T is vibrating at its fundamental frequency. If the mass per unit length is doubled, with all other factors held constant, what is the effect on the fundamental frequency?

A. It becomes twice as large.
 B. It becomes $\sqrt{2}$ times larger.
 C. It is unchanged.
 D. It becomes $\frac{1}{\sqrt{2}}$ times as large.
 E. It becomes one-half as large.

8. Four wave functions are given below. Rank them in order of the magnitude of the phase constant, from least to greatest.

I. $y(x,t) = 5 \sin(4x - 20t + 4)$

II. $y(x,t) = 5 \sin(3x - 12t + 5)$

III. $y(x,t) = 5 \cos(4x + 24t + 6)$

IV. $y(x,t) = 14 \cos(2x - 8t + 3)$

A. IV, II, I, III
 B. IV, II, I, III
 C. III, I, II, IV
 D. IV, I, II, III
 E. III, IV, II, I



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9. Four wave functions are given below. Rank them in order of the magnitude of the frequency, from least to most significant.

I. $y(x,t) = 5 \sin(4x - 20t + 4)$

II. $y(x,t) = 5 \sin(3x - 12t + 5)$

III. $y(x,t) = 5 \cos(4x + 24t + 6)$

IV. $y(x,t) = 14 \cos(2x - 8t + 3)$

- A. IV, II, I, III
- B. IV = II, I, III
- C. III, I, II, IV
- D. IV, I, II, III
- E. III, IV, II, I

10. Two sound waves have intensities of 100 and 3000 milliwatts/m². How many decibels is the Louder sound above the other?

- A. -5.23 dB
- B. 24.77 dB
- C. 4.77 dB
- D. 14.77dB
- E. None of these.

11. A friend hands you an equation sheet with the following equation for the Doppler effect:

$$f' = \frac{(v + v_o)}{(v + v_s)} f$$

. This version of the equation is correct with signs as given only if:

- A. The observer and source are approaching each other.
- B. The observer approaches the source while the source moves away from the observer.
- C. The observer is moving away from the source while the source is approaching the observer.
- D. The observer and source are moving away from each other.
- E. The observer and source are moving in perpendicular directions.

12. Malose is listening to music at the bash, and the emitted sound waves from the source have the power of 70.0 W. If he is standing 150 cm from the source, what will be the intensity?

- A. 2.48 W/m²
- B. 2.48 x 10⁻⁴ W/m²
- C. 2.48 W/cm²
- D. 3.71 W/m²
- E. None of these.

13. At which distance will he (Malose in question 46 above) be able to hear the intensity level of 20 dB?
- A. 2.48 m
 - B. 2.36×10^5 m
 - C. 2.48 cm
 - D. 3.71 m
 - E. None of these
14. An object is 2 m in front of a plane mirror. Its image is:
- A. Virtual, inverted, and 2m behind the mirror.
 - B. Virtual, inverted, and 2m in front of the mirror.
 - C. Virtual, erect, and 2m in front of the mirror.
 - D. Real, erect, and 2m behind the mirror.
 - E. None of these.
15. A man stands with his nose 8 cm from a concave shaving mirror of radius 16 cm. The distance from the mirror to the image of his nose is:
- A. 8 cm
 - B. 12 cm
 - C. 16 cm
 - D. 24 cm
 - E. None of these.
16. The image produced by a convex mirror of an erect object in front of the mirror is always:
- A. Virtual, erect, and larger than the object.
 - B. Virtual, erect, and smaller than the object.
 - C. Real, erect, and larger than the object.
 - D. Real, erect, and smaller than the object.
 - E. None of these.
17. A 4.5 cm tall object is placed 28 cm in front of a spherical mirror. It is desired to produce a virtual image that is upright and 3.5 cm tall. What is the focal length of the mirror?
- A. -38 cm



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- B. -68 cm
 - C. -98 cm
 - D. 68 cm
 - E. 98 cm
18. A concave spherical mirror has a focal length of 12 cm. If an erect object is placed 6 cm in front of it:
- A. The magnification is 2, and the image is erect.
 - B. The magnification is 2, and the image is inverted.
 - C. The magnification is 0.67, and the image is erect.
 - D. The magnification is 0.67, and the image is inverted.
 - E. The magnification is 0.5, and the image is erect.
19. An erect object is placed on the central axis of a thin lens, further from the lens than the magnitude of its focal length. The magnification is -0.4. This means:
- A. The image is real and erect, and the lens is a converging lens.
 - B. The image is real and inverted, and the lens is a converging lens.
 - C. The image is virtual and erect, and the lens is a diverging lens.
 - D. The image is virtual and erect, and the lens is a converging lens.
 - E. The image is virtual and inverted, and the lens is a diverging lens.
20. Under what conditions will the total internal reflection occur?
- A. Light must move from a medium with a low index of refraction to a medium with a high index of refraction.
 - B. Light must move from a medium with a high index of refraction to a medium with a low index of refraction.
 - C. Light must move from a medium where it has a low speed to a medium where it has a high speed.
 - D. A and B.
 - E. B and C.
21. Which statement is wrong?
- A. The far point is the farthest distance at which an object can be seen clearly
 - B. Normal far point is about 25 cm
 - C. Near-sightedness means that the far point is too close

- D. Near point is the closest distance at which the eye can focus clearly
- E. Farsightedness means the near point is too far away
22. A Physics student has a near point located at 25 cm from his eyes. Which of these statements is correct?
- A. The student is near-sighted.
- B. The student is farsighted.
- C. The student is suffering from glaucoma.
- D. None of these statements is correct.
23. The normal far point of a healthy person is:
- A. At infinity.
- B. 50 cm
- C. 25 cm
- D. None of these.
24. A Physics student has a near point located at 50 cm from his eyes. Which of these statements is correct?
- A. The student is nearsighted.
- B. The student is farsighted.
- C. The student is suffering from glaucoma.
- D. The student has a cataract condition.
- E. None of these.
25. Accommodation of the human eye is:
- A. The ability of the lens to change the index of refraction.
- B. The ability of the lens to change its optical thickness depends on the change of the curvature diameter.
- C. The ability of the eye lens to transmit better some wavelength.
- D. The ability of the eye lens to change the diameter of curvature.
- E. None of these.



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SECTION B (50)

QUESTION 1

1. A 2.00 kg mass vibrates according to the equation $x(t) = (0.650\text{ m})\cos(8.40t)$ where x is in meters and t is in seconds. Determine

1.1.1. the frequency, and (2)

1.1.2. the total energy (4)

2.1. Write the expression for y as a function of x and t for a sinusoidal wave travelling along a rope in the negative x direction with the following characteristics: $A = 8.00\text{ cm}$, $\lambda = 80.0\text{ cm}$, $f = 3.00\text{ Hz}$, and $y(x,0) = 0$ at the point $x = 10.0\text{ cm}$. (4)

2.2. With what tension must a rope with length 2.50 m and mass 0.120 kg be stretched for transverse waves of frequency 40.0 Hz to have a wavelength of 0.750 m? (4)

2.3. Show that the wave function $y = e^{b(x-vt)}$ is a solution of the linear wave equation

$$\frac{\partial^2 y}{\partial x^2} - \frac{1}{v^2} \frac{\partial^2 y}{\partial t^2} = 0 \quad \text{where } b \text{ is a constant} \quad (5)$$

3.1 Find the speed of sound in mercury, which has a bulk modulus of approximately $2.80 \times 10^{10}\text{ N/m}^2$ and density of 13600 kg/m^3 . (2)

3.2. A sound wave in air has a pressure amplitude equal to $4.0 \times 10^{-3}\text{ N/m}^2$. Calculate the displacement amplitude of the wave at a frequency of 10 kHz. (3)

3.3. Write an expression that describes the pressure variation as a function of position and time for a sinusoidal sound wave in air. Assume $\lambda = 0.100\text{ m}$ and $\Delta P = 0.200\text{ N/m}^2$. (5)

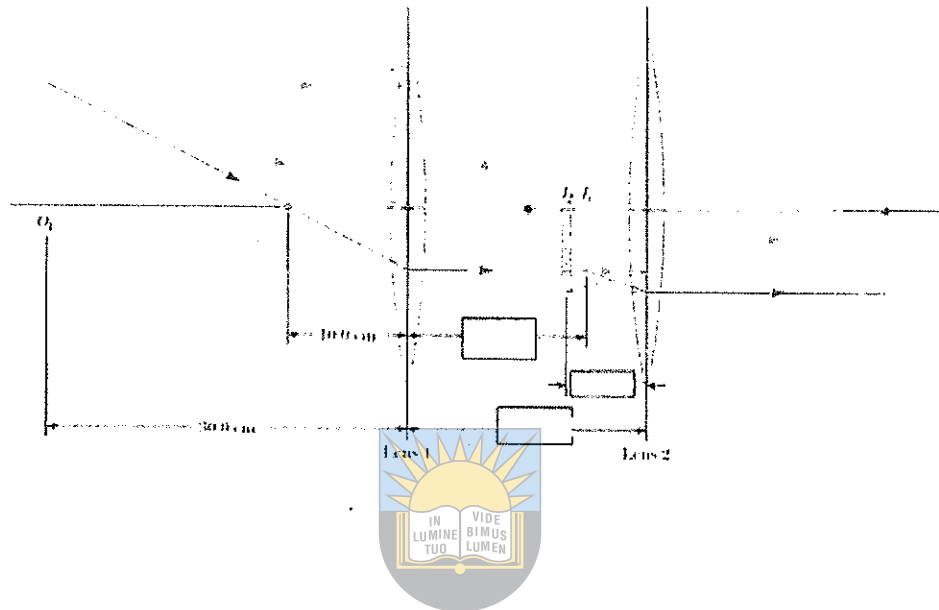
4. Two waves are travelling in the same direction along a stretched string. The waves are 90.0° out of phase. Each wave has an amplitude of 4.00 cm. Find the amplitude of the resultant wave. (5)

5. Calculate the length of a pipe that has a fundamental frequency of 240 Hz, assuming the pipe is

5.1 closed at one end (3)

5.2. open at both ends. (3)

6. Two thin converging lenses of focal lengths $f_1 = 10.0$ cm and $f_2 = 20.0$ cm are separated by 20.0 cm as illustrated in the figure below. An object is placed 30.0 cm to the left of lens 1. Find the position and the magnification of the final image. (10)





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Formula sheet (PHY123F)

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

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

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

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

$$v = \lambda f = \frac{\omega}{k}, \quad v = \frac{\lambda}{T}, \quad v = \sqrt{\frac{T}{\mu}}, \quad K = U = \frac{1}{4}\mu\omega^2 A^2 \lambda, \quad E = \frac{1}{2}\mu\omega^2 A^2 \lambda, \quad v = \sqrt{\frac{B}{\rho}}.$$

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

$$\Delta P_{\max} = \rho v \omega s_{\max}, \quad K = U = \frac{1}{4}(\rho A)\omega^2 s_{\max}^2 \lambda, \quad I = \frac{P}{A}, \quad I = \frac{P}{4\pi r^2}, \quad E = \frac{1}{2}(\rho A)\omega^2 s_{\max}^2 \lambda.$$

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

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

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

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

Constants (PHY123F)

$$v_{\text{cutoff}} = 345 \text{ nm/s}, \quad I_0 = 1.00 \times 10^{-12} \text{ W/m}^2$$

TABLE 35.1 *Indices of Refraction*

Substance	Index of Refraction	Substance	Index of Refraction
<i>Solids at 20°C</i>		<i>Liquids at 20°C</i>	
Cubic zirconia	2.20	Benzene	1.501
Diamond (C)	2.419	Carbon disulfide	1.628
Fluorite (CaF ₂)	1.434	Carbon tetrachloride	1.461
Fused quartz (SiO ₂)	1.458	Ethyl alcohol	1.361
Gallium phosphide	3.50	Glycerin	1.473
Glass, crown	1.52	Water	1.333
Glass, flint	1.66		
Ice (H ₂ O)	1.309	<i>Gases at 0°C, 1 atm</i>	
Polystyrene	1.49	Air	1.000 293
Sodium chloride (NaCl)	1.544	Carbon dioxide	1.000 45

Note: All values are for light having a wavelength of 589 nm in vacuum.

TABLE 14.1

Densities of Some Common Substances at Standard Temperature (0°C) and Pressure (Atmospheric)

Substance	ρ (kg/m ³)	Substance	ρ (kg/m ³)
Air	1.29	Ice	0.917×10^3
Aluminum	2.70×10^3	Iron	7.86×10^3
Benzene	0.879×10^3	Lead	11.3×10^3
Copper	8.92×10^3	Mercury	13.6×10^3
Ethyl alcohol	0.806×10^3	Oak	0.710×10^3
Fresh water	1.00×10^3	Oxygen gas	1.43
Glycerin	1.26×10^3	Pine	0.373×10^3
Gold	19.3×10^3	Platinum	21.4×10^3
Helium gas	1.79×10^{-1}	Seawater	1.03×10^3
Hydrogen gas	8.99×10^{-2}	Silver	10.5×10^3

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Constants (PHY123F)

$$v_{\text{sound}} = 343.0 \text{ m/s}, \quad I_o = 1.00 \times 10^{-12} \text{ W/m}^2,$$

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Substance	Index of Refraction	Substance	Index of Refraction
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Helium gas	1.79×10^{-1}	Seawater	1.03×10^3
Hydrogen gas	8.99×10^{-2}	Silver	10.5×10^3



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Formula sheet (PHY123F)

$$\begin{aligned}
 F_s &= -kx, & a_x &= -\frac{k}{m}x, & \omega &= \sqrt{\frac{k}{m}}, & x(t) &= A \cos(\omega t + \phi), & v(t) &= -A\omega \sin(\omega t + \phi), \\
 a(t) &= -A\omega^2 \cos(\omega t + \phi), & v_{\max} &= A\omega, & a_{\max} &= A\omega^2, & KE &= \frac{1}{2}mv^2, & U &= \frac{1}{2}kx^2, & E_{\text{tot}} &= \frac{1}{2}kA^2, \\
 v^2 &= \omega^2(A^2 - x^2), & \theta &= \theta_{\max} \cos(\omega t + \phi), & \omega &= \sqrt{\frac{g}{L}}, & T &= \frac{2\pi}{\omega}, & R &= -bv, & \omega &= \sqrt{\omega_0^2 - \left(\frac{b}{2m}\right)^2}, \\
 x(t) &= Ae^{-(b/2m)t} \cos(\omega t + \phi), & y(x, t) &= A \cos(kx \pm \omega t + \theta), & \omega &= 2\pi f, & f &= \frac{1}{T}, & k &= \frac{2\pi}{\lambda}, \\
 v &= \lambda f = \frac{\omega}{k}, & v &= \frac{\lambda}{T}, & v &= \sqrt{\frac{T}{\mu}}, & K_\lambda &= U_\lambda = \frac{1}{4}\mu\omega^2 A^2 \lambda, & E_\lambda &= \frac{1}{2}\mu\omega^2 A^2 \lambda, & v &= \sqrt{\frac{B}{\rho}}, \\
 P &= \frac{1}{2}\mu\omega^2 A^2 v, & \Delta P(x, t) &= \Delta P_{\max} \sin(kx \pm \omega t), & v &= \sqrt{\frac{Y}{\rho}}, & v &= (331 \text{ m/s}) \sqrt{1 + \frac{T_c}{273^\circ \text{C}}}, \\
 \Delta P_{\max} &= \rho v \omega s_{\max}, & K_\lambda &= U_\lambda = \frac{1}{4}(\rho A)\omega^2 s_{\max}^2 \lambda, & I &= \frac{P}{A}, & I &= \frac{P}{4\pi r^2}, & E_\lambda &= \frac{1}{2}(\rho A)\omega^2 s_{\max}^2 \lambda, \\
 P &= \frac{1}{2}(\rho A)v(\omega s_{\max})^2, & I &= \frac{1}{2}\rho v(\omega s_{\max})^2, & I &= \frac{(\Delta P_{\max})^2}{2\rho v}, & x &= \frac{n\lambda}{2}, & x &= \frac{n\lambda}{4}, & f_n &= \frac{nv}{2L}, & n &= \frac{c}{v}, \\
 f_n &= \frac{nv}{4L}, & f_n &= nf_1, & \beta &= 10 \log\left(\frac{I}{I_0}\right), & f_o &= \left(\frac{v + v_o}{v - v_s}\right) f_s, & 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), & n_1 \sin \theta_1 &= n_2 \sin \theta_2, & \sin \theta_c &= \frac{n_2}{n_1}, \\
 M &= \frac{h'}{h} = -\frac{p}{q}, & \frac{1}{p} + \frac{1}{q} &= \frac{2}{R}, & f &= \frac{2}{R}, & \frac{n_1}{p} + \frac{n_2}{q} &= \frac{n_2 - n_1}{R},
 \end{aligned}$$



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