GWANDA STATE UNIVERSITY

FACULTY OF ENGINEERING AND THE ENVIRONMENT

DEPARTMENT OF GEOMATICS AND SURVEYING

WAVES AND OPTICS (ESG 1109)

Final Examination Paper

June 2026

EPOCH MINE CAMPUS

Time Allowed: **3 hours**
Total Marks: **100**
Examiner's Name: **Mr. V. Muzenda**

INSTRUCTIONS

1. Answer **ALL** question in SECTION A.
2. Answer any **THREE** questions from SECTION B.
3. Use of calculators is permissible.

MARK ALLOCATION

Section A	**40**
Question 1	20
Question 2	20
Section B	**60**
Question 3	20
Question 4	20
Question 5	20
Question 6	20
Total Attainable	**100**

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SECTION A
ANSWER ALL QUESTIONS IN THIS SECTION (40 Marks)

Question 1

(a) What is a mirror? **[2]**

(b) As a student studying Geomatics and Survey. What are the advantages of incorporating waves and optics into your field **[4]**

(c) With aid of a diagram state and explain the laws of reflection and refraction. **[6]**

(d) Suppose you have an unknown clear substance immersed in water, and you wish to identify it by finding its index of refraction. You arrange to have a beam of light enter it at an angle of $45,\ 0^0$, and you observe the angle of refraction to be $40,\ 3^0$. What is the index of refraction of the substance? The index of refraction of water is 1.33. **[4]**

(e) How far from the lens must the film in a camera be, if the lens has a 35.0 mm focal length and is being used to photograph a flower 75.0 cm away? **[4]**

Question 2

a) A wave traveling along a string is described by $\boldsymbol{y(x, t) = (0.00327m)Sin(72.1x - 2.72t),}$

Determine the following characteristics of the wave motion

i) Amplitude

ii) Wave constant k

iii) Wavelength

iv) Period

v) Frequency

vi) Speed of the wave **[6]**

b) With aid of a diagram explain how images are formed in a

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(i) Convex spherical mirror. [6]

(ii) Concave spherical mirror. [6]

c) State and explain two uses of concave mirrors. [2]

SECTION B (60 marks)

Answer ANY THREE questions from this section.

Question 3

(a) Describe and explain the Doppler effect and the Doppler shift in detail, include the equations involved **[10]**

(b) The siren of a police car at rest emits at a predominant frequency of 1600Hz.What frequency will you hear if you are at rest and the police car moves at 25.0 m/s

(i) towards you **[3]**

(ii) away from you **[3]**

(b) Briefly describe the dispersion of white light by a glass prism. **[4]**

Question 4

(a) With aid of a diagram differentiate between a concave and a convex mirror, taking into account the center of curvature (C), the field view, and distance of the image to the mirror and the height of the image. **[12]**

(b) With the aid of a diagram explain how a signal is transmitted in an optical fibre**.** **[3]**

(c) An optical fibre is manufactured using glass of refractive index of 1.5. Calculate the speed of light travelling through the optical fibre. Speed of light in air $=3 * 10^8\ m/s$ **[3]**

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(d) Give two reasons why the telecommunications industry uses optical fibres instead of copper conductors to transmit signals **[2]**

Question 5

a) State the principle of superposition for waves **[3]**

b) Two separate waves traveling along a stretched string superpose and their individual progressive wave equation are given below.

$y_1 = A \sin (kx - \omega t) \quad y_2 = A \sin (kx - \omega t + \phi)$

Show that the overall equation of the combined wave form is

$$y = 2A \cos\left(\frac{\phi}{2}\right) \sin\left(kx - \omega t + \frac{\phi}{2}\right)$$

[7]

c) The schematic diagrams below summarise the Fermat's principles. Use these diagrams to derive the laws of reflection and refraction **[10]**

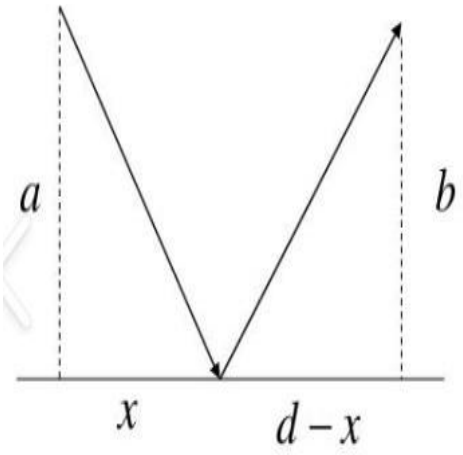


Figure B1

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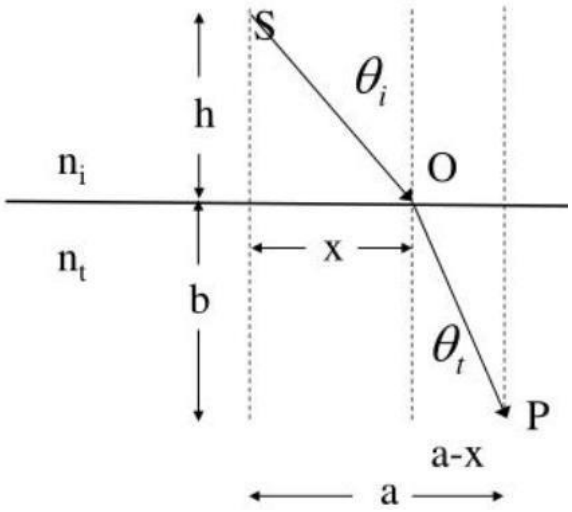


Figure B2

Question 6

a) Give the three main types of waves and give a brief description of each type **[6]**

b) A string has a linear **μ=525g/m** and is under tension **τ=45N.** We send a sinusoidal wave frequency *f*=120Hz and amplitude y= 8.5mm along the string.

i) At what average rate does the wave transport energy **[4]**

c) The general differential equation that governs the travel of waves of all types is

$$\frac{\partial^2 y}{\partial x^2} = \frac{1}{v^2}\frac{\partial^2 y}{\partial t^2}.$$

Derive the above wave equation and show all the necessary steps **[10]**

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End of Question Paper.

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