GWANDA STATE UNIVERSITY

FACULTY OF ENGINEERING AND THE ENVIRONMENT

DEPARTMENT OF GEOMATICS AND SURVEYING

WAVES AND OPTICS (EGS 1109)

Final Examination Paper

November 2024

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**

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

Question 1

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

(b) With aid of a diagram differentiate between a converging and a diverging lens. **[4]**

(c) Define a critical angle. **[2]**

(d) State and explain the Brewster Law. **[3]**

(e) Explain the phenomena of dispersion of white light through a prism? **[4]**

(f) With an aid of a diagram escribe the working principle of an optical fiber **[5]**

Question 2

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

$$\frac{d^2y}{dx^2} = \frac{1}{v^2}\frac{d^2y}{dt^2}$$

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

b) A wave displacement is given by ***y= 200 Sin (30πt+45x)m***

i) Find the amplitude of the wave
ii) The wave constant k
iii) The wave length
iv) The period
v) The frequency
vi) The wave speed **[10]**

SECTION B (60 marks)

Answer ANY THREE questions from this section.

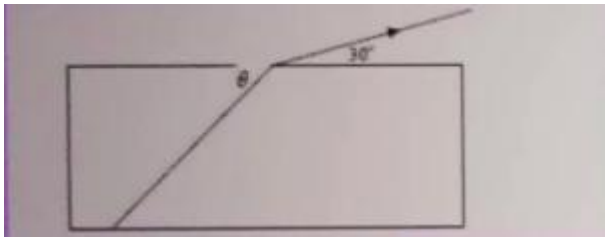
Question 3

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

(i) Convex spherical mirror. **[5]**

(ii) Concave spherical mirror. **[5]**

(b) The diagram below shows a ray of light as it leaves a rectangular block of glas, it makes an angle θ the inside surface of the glass block and an angle 30° when it is in the air as shown.



(i) If the refractive index of glass is 1.5 calculate the value of θ. **[4]**

(ii) What would be the value of the angle θ so that the ray of light emerges parallel to the side of the glass block? **[4]**

(iii) Calculate the speed of light as it passes through the glas**.** **[2]**

Question 4

(a) Use Fermat's principle to derive the law of reflection. **[6]**

(b) Use Fermat's principle to derive the law of refraction. **[6]**

(c) With aid of a diagram explain total internal reflection. **[4]**

(d) A converging lens of focal length 20 cm and a diverging lens of focal length 8 cm are placed in contact. Calculate the power of the combination. **[4]**

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.

$$y_1(x,t) = y_m sin(kx - wt)$$

$$y_2(x,t) = y_m sin(kx - wt + \alpha)$$

Show that the overall equation of the combined wave form is

$$y'(x,t) = [2y_m cos\frac{1}{2}\alpha]sin(kx - wt + \frac{1}{2}\alpha) \quad \textbf{[7]}$$

c) State and explain four features of a sound waves. **[8]**

d) Define a mirror and also give the difference between a real image and a virtual image **[2]**

Question 6

a) Describe the Doppler effect. **[3]**

b) Derive the Doppler equations

i $f' = (\frac{v+v_0}{v})f$ (observer in motion towards motion)

ii) $f' = (\frac{v-v_0}{v})$ **(** observer in motion away from the source) **[4]**

iii) A 5000-Hz sound wave is emitted by a stationary source. This sound wave reflects from an object moving toward the source. What is the frequency of the wave reflected by the moving object as detected by a detector at rest near the source? [4]

c) 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]**

di) Why is a solid substance able to transport both longitudinal waves and transverse waves, but a homogeneous fluid is able to transport only longitudinal waves? **[2]**

ii)In mechanics, massless strings are often assumed. Why is that not a good assumption when discussing waves on strings? **[3]**

End of Question Paper.

