KENYATTA UNIVERSITY

UNIVERSITY EXAMINATIONS 2011/2012

SECOND SEMESTER EXAMINATION FOR THE DEGREE OF BACHELOR OF SCIENCE AND BACHELOR OF EDCATION (SCIENCE)

SPH 102: WAVES AND OPTICS

DATE: TUESDAY, 3RD APRIL 2012 **TIME:** 8.00 A.M – 10.00 A.M

INSTRUCTIONS

Answer question **ONE** and any other **TWO.**. Question **ONE** carries **30** marks while the other questions carry **20** marks each.

Use the following constants where necessary
Velocity of light $c = 3 \times 10^8$ m/s

Q1.

a) The displacement equation of a transverse progressive wave on a string is given as

$$y = 0.2 \sin \pi \left(\frac{x}{0.5} + \frac{t}{0.005} \right)$$ Where y and x are in cm while t is in seconds

Determine the following

i). Direction of the wave
ii). Wavelength
iii). Frequency and
iv). Velocity of the wave

(5 marks)

b) Name and discuss briefly two factors that influence the speed of propagation of a transverse wave on a string. (3 marks)

c) Describe the formation of a standing wave and describe three of its important features (3 marks)

d). A sound source is moving in a given direction with a velocity of 40m/s, following a listener in front moving at 20m/s. Taking the velocity of sound in air to be 340 m/s.

i) Describe how the sound frequency detected by the listener compares to that of the source. (3 marks)

ii) Calculate the frequency of the source if the listener detects a frequency of 600Hz. (2marks)

e).i).Using illustration diagram, describe the formation and nature of the image of an object placed between the focal point and the mirror, for a concave mirror. (2 marks)

ii). An object is placed 15 cm from a convex mirror of radius of curvature of 20 cm. Calculate

I) the position of the image formed and
II) the magnification

(3 marks)

f).Define the following terms and state the conditions that lead to each (6 marks)

i). Critical angle
ii). Myopia
iii) Hypermetropia

g) Describe how the Young's double slit experiment demonstrates the wave nature of light (3 marks)

Q2.

a). i). State Huygen's principle (2 marks)

ii). What is the theory of light advanced by the Huygen's principle? (1 mark)

iii). Using the principle explain how a plane waves appear when reflected on a concave. (2 marks)

iv). Show how the principle works to prove the Law of reflection of light. (3 marks)

b) The equation of a wave on a string is $y = 0.4 \text{ Cos } \pi x \text{ Sin } 80\pi t$. Where y and x are in cm and time in seconds. Determine

i). the amplitude and frequency of the progressive waves leading to this wave equation. (2 marks)

ii). positions of the first three successive antinodes. (3marks)

iii). If equation of a mechanical wave is $y = a \text{ Sin } (\omega t - kx)$. If $a = 1.0 \times 10^{-7}$ m, $\omega = 6.6 \times 10^{3}$ s^{-1} and $k = 20$ m^{-1}. Calculate the maximum speed of particles displaced by this wave. (2 marks)

c). i). The wavelength of a yellow light in air is 6.0×10^{-5} cm , what would be its wavelength in a glass of refractive index of 1.5? (2 marks)

ii). Calculate the critical angle this light would have when traveling from a liquid in which its wavelength is 4.5×10^{-5} cm into the air. (3 marks)

Q3.

a) i).State the Fermat's principle. (3marks)

ii).Use it to derive the law of refraction (6 marks)

iii).Explain meanings of the following terms;

(I) interference

(II) Resolution (2 marks)

iv).Describe what polarization demonstrates about light? (2 marks)

b) i).Describe how a thin film works to make a glass window appear non-reflecting (2 marks)

ii). State factors which determine the thickness of the film to be used. (2 marks)

iii). If light of wavelength 600nm is used, calculate the refractive index of a material of thickness 2.5×10^{-4}mm used to produce non-reflection at near normal view, for m =1. (3 marks)

Q4. a)

i). State the superposition principle. (2 marks)

ii) With an illustrative diagram explain the phenomenon called beats and state the conditions leading to its occurrence. (3 marks)

iii)Two waves whose equations are given below interact in space. Determine expression for the resultant wave formed

$y_1 = A \text{ Sin } 2\pi f_1 t$ and $y_2 = A \text{ Sin } 2\pi f_2 t$ (4 marks)

iv). Describe the amplitude of the wave formed in (iii) (1 marks)

b) .i). Explain Doppler Effect. (2 marks)

ii).Derive expression for the frequency of sound wave as detected by a stationary listener when the source is moving away at a velocity u, taking the velocity of sound in air as c and frequency of source as f_o. (4 marks)

iii).What frequency would be detected by the listener in b(ii) if the source frequency is 800Hz and moving at 25m/s.Take velocity of sound in air to be 340m/s. (2 marks)

iv).Describe any two possible areas of application of the Doppler effect. (2 marks)

Q5.

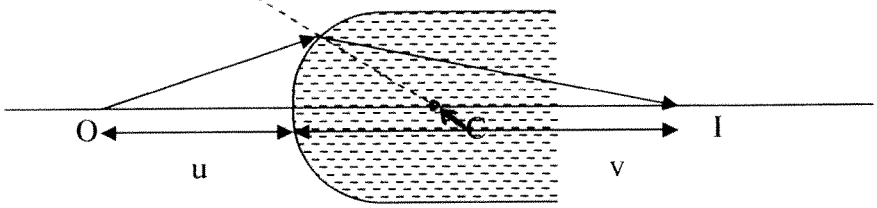
a) (i) Explain the concept of resonance with respect to a vibrating string . (3 marks)

ii). Describe the characteristics of resonance state in a string. (2 marks)

iii). A string of mass *m* and length *l* is fixed at both ends under tension *F*. If it is set into vibration by external force. Draw the first three harmonics (modes of oscillation) and obtain expression for the frequency of any mode n, in terms of the length, tension and mass. (4 marks)

b). i). Show that the refraction of light at a curved spherical surface of radius of curvature r and refractive index n_2 from a medium of refractive index n_1, such as figure 1,would lead to the expression (5 marks)

$$\frac{n_1}{u} + \frac{n_2}{v} = \frac{n_2 - n_1}{r}$$ where u and v are object and image distances



ii). A small insect is on the principal axis, 10 cm from the curved surface of the glass. If the radius of curvature of the glass is 15 cm and its refractive index is 1.5, find the location of the image and describe it fully. Take the refractive index of air to be 1.0. (4 marks)

iii) Describe the difference between diffraction gratings and Young's double slit experiments. (2 marks)