KENYATTA UNIVERSITY

UNIVERSITY EXAMINATIONS 2011/2012

INSTITUTE OF OPEN LEARNING (IOL)

EXAMINATION FOR THE DEGREE OF BACHELOR OF EDUCATION AND BACHELOR OF SCIENCE

SPH 102: WAVE & OPTICS

DATE: Friday, 16th December, 2011 TIME: 11.00 a.m. – 1.00 p.m.

INSTRUCTIONS

1. Answer questions ONE and any other TWO questions.
2. The following constants and table may be useful:
   Speed of light in air $c = 3 \times 10^8$ m/s

Q1. (a) (i) What is polarization of a wave? (1 mark)

(ii) Give three examples of polarized waves. (3 marks)

(b) (i) What is Brewster angle? (1 mark)

(ii) What is the refractive index o a material with a Brewster angle of 23 °. (3 marks)

(c) (i) What are beats? (1 mark)

(ii) When two notes are sounded a beat frequency of 3 Hz is heard. If one is note is 600 Hz what are the possible frequencies of the other? (3 marks)

(d) (i) What is glaucoma? (1 mark)

(ii) A nearsighted person cannot see objects clearly beyond 25 cm (the far point). If the patient has no astigmatism and contact lenses are prescribed, what are the power and type of lens required to correct the patient's vision? (3 marks)

(e) (i) What is diffraction of light? (1 mark)

(ii) Coherent light of wavelength 580 nm is incident on a slit of width 0.3 mm. The observing screen is placed 2 m from the slit. Find the position of the first dark fringe. (3 marks)

(f) (i) What is Doppler effect? (1 mark)

(ii) A train moving at 40 m/s sounds its whistle of frequency 500 Hz. Determine the frequency heard by a stationary observer as the train approaches. (Sound speed = 343 m/s) (3 marks)

(g) (i) What is Huygen's principle? (1 mark)

(ii) Show how the law of refration can be derived using Huygen's principle. (3 marks)

(h) What is Fermats' principle. (2 marks)

Q2. (a) Use Fermat's principle to show that the critical angle for total internal reflection is given by $\sin\theta_c = 1/n$, where n is the index of refraction of the medium in which the light ray originates. The outside medium is air. (7 marks)

(b) Use Fermat's principle to show that a beam of light that enters a plate of glass of uniform thickness emerges parallel to its initial direction. (7 marks)

(c) By using Fermat's principle, show that if two media have exactly the same index of refraction, then a beam of light travels in a straight line when it crosses the boundary between them. (6 marks)

Q3. (a) (i) Show that the time required for light to travel from point source A in air, a distance h_1 above a water surface, to point B at a height h_2 below the water surface is

$$t = \left(\frac{h_1 \sec\theta_1}{c}\right) + \left(\frac{h_2 n \sec\theta_2}{c}\right)$$

where n is the index of refraction of water, θ_1 and θ_2 are angles of incidence and refraction, respectively. (4 marks)

(ii) A tube, open at only one end, is cut into two shorter (unequal) lengths. The piece open only at both ends has a fundamental frequency of 425 Hz, while the piece open at one end has a fundamental frequency of 675 Hz. What is the fundamental frequency of the original tube? (8 marks)

(iii) A whistle of frequency 540 Hz rotates in a circle of 60 cm at an angular speed of 10 rad/s. What is the lowest and the highest heard by a listener a long distance away at rest with respect to the centre of the circle? (Take speed of sound 340 m/s) (4 marks)

(b) Use Fermat's principle to derive law reflection. (4 marks)

Q4. (a) A source of sound waves of frequency 1080 Hz moves to the right with a speed of 32.9 m/s relative to the ground. To its right is a reflecting surface moving to the left with a speed of 65.9 m/s relative to the ground. Taking the speed of sound in air to be 330 m/s, find the

(i) wavelength emitted in air by the source. (3 marks)

(ii) number of waves per second arriving at the reflecting surface. (3 marks)

(iii) speed of the reflected waves. (3 marks)

(iv) wavelength of the reflected waves. (3 marks)

(b) Standing at a crosswalk, you hear a frequency of 560 Hz from the sirens of an approaching police car. After the police car passes, the observed frequency of the siren is 480 Hz. Assuming that the speed of sound in air is 330 m/s, determine the car's speed from these observations. (8 marks)

Q5. (a) A fish is at a depth of d under water. Show that when viewed from an angle of incidence, θ_1, the apparent depth, z, of the fish is

$$z = d\tan\theta_2\cot\theta_2$$

where θ_2 is the angle of refraction. (10 marks)

(b) Use Huygen's construction to prove Snell's law by working out the geometrical details in the figure 1

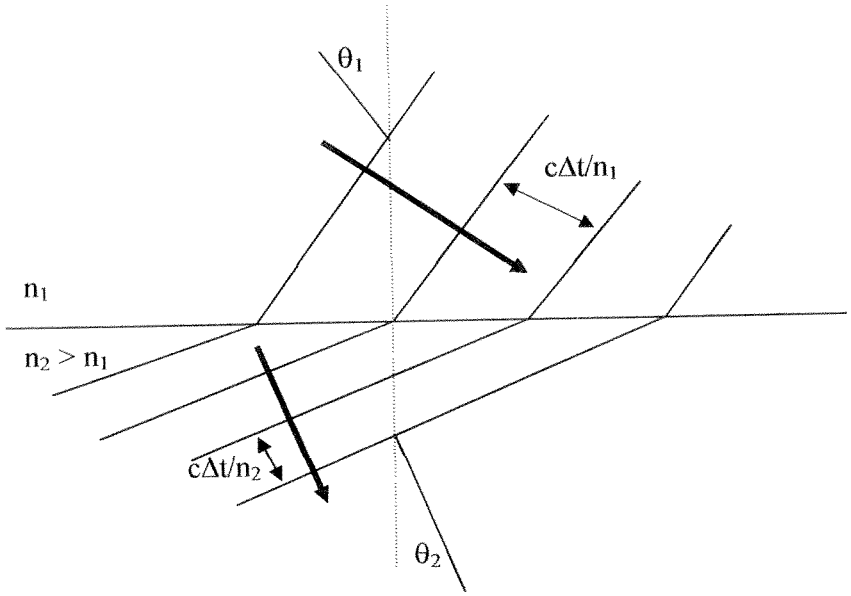

Fig. 1

(10 marks)

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