EMBU UNIVERSITY COLLEGE

(A CONSTITUENT COLLEGE OF THE UNIVERSITY OF NAIROBI)

SECOND SEMESTER EXAMINATIONS 2013/2014

SECOND SEMESTER EXAMINATION FOR THE DEGREE OF BACHELOR OF SCIENCE

SPH 103: WAVES AND OPTICS

DATE: APRIL 10, 2014 **TIME: 11.00AM - 1.00PM**

INSTRUCTIONS:

ANSWER QUESTION ONE AND ANY OTHER TWO QUESTIONS

CONSTANTS

Electronic charge, e	=	1.602×10^{-19} C
Velocity of light, c	=	3.0×10^{8} m/s
Velocity of sound	=	330 m/s
Acceleration due to gravity, g	=	10 m/s^2

QUESTION ONE (30 MARKS)

a) Differentiate between transverse wave and longitudinal wave giving one example of each. (3 marks)

b) An oscillating mass requires 1.6s before it begins to repeat its motion. Find the frequency and angular frequency of the mass's motion. (3 marks)

c) A particle displaying SHM moves in a straight line between extreme positions A & B. If the distance AB=10 m and the maximum speed of the particle is 15 ms^{-1}, find the period of the motion.

(3 marks)

d) A radio station broadcasts at a frequency of 1.5×10^{7} Hz. Calculate the wavelength of the radio waves.

(2 marks)

e) A block has mass of 4.37kg and it is designed to oscillate at f=63.7Hz with amplitude of 37.2cm. What is the blocks speed and kinetic energy as it passes through the equilibrium point. (4 marks)

f) State the laws of reflection

(2 Marks)

g) A light wave having a free space wavelength of λ_0=500mm passes from vacuum into diamond (n_d=2.4). Find its wave speed and its wavelength in diamond.

(3 marks)

h) Determine the position of image of an object placed 30cm in front of a converging lens of focal length 10cm. Find its linear magnification.

(3 marks)

i) Determine the angle of minimum deviation for a glass prism whose prism angle is A = 60° and the refractive index of the glass material is η = 1.52

(3 Marks)

j) A car is approaching a zebra- crossing with a speed of 72 km/hr. A policeman standing near the crossing hears the frequency of its horn as 220 Hz. What is the real frequency of the horn?

(4 marks)

QUESTION TWO (20 Marks)

a) What do you understand by simple harmonic motion? Give two examples. (2 Marks)

b) Show that for particle executing simple harmonic motion, the instantaneous velocity v and acceleration, a, are given by $v = \omega\sqrt{A^2 - y^2}$ and $a=-\omega^2 y$, where ω=angular frequency, a= instantaneous acceleration.

(6 marks)

c) For a particle vibrating with SHM, the displacement is 15cm when velocity is 15cm/s and the displacement is 8cm when velocity is 18cm/s. calculate

i.) Amplitude (4 marks)

ii.) frequency (2 marks)

d) Determine the average kinetic energy for a vibrating particle of mass m and whose displacement is given by $y = A\sin(\omega t + \phi)$ where symbols have usual meaning. (6 marks)

QUESTION THREE (20 Marks)

a) Give any four distinctions between progressive waves and stationary waves. (4 marks)

b) When a block of mass 0.77kg is fastened to a spring, it extends by 2.2cm. The block is then pulled down a further distance x=7cm from equilibrium. What is the angular frequency, and hence the maximum speed of the oscillating block. (5 marks)

c) i.) A 60cm guitar string has a mass of 1.4g. If it is to play with a frequency of 396Hz, find the tension in the string? (Assume λ=1.2m) (4 marks)

ii.) If the tension in the question (a) above was 450N, would the guitar play a note flat or sharp? (3 marks)

d) A train moving at 25m/s emits a whistle of frequency 200Hz. Find the frequency observed by a stationary observer:

i.) In front of the train. (2 marks)

ii.) Behind the train (2 marks)

QUESTION FOUR (20 Marks)

a) State the Snell's law (1 Mark)

b) Define critical angle and briefly explain one application of total internal reflection (3 marks)

c) A ray of light passes from crown glass (n_c=2.4) to water (n_w=1.54).

i.) Obtain the critical angle of incidence (4 marks)

ii.) What happens if the angle of incidence in glass is 55°? (1 mark)

d) State Fermat's principle and using a diagram, show that Snell's law is a consequence of Fermat's principle. (6 marks)

e) A particle is placed at the bottom of a tub of water whose depth below the water surface is d. Derive the expression relating the displacement of a particle from the bottom of the tub in terms of the real depth and the refractive index of water. (5 marks)

QUESTION FIVE (20 Marks)

a) Explain hyperopia and myopia eye defects. (2 Marks)

b) A light from a hydrogen source is normally incident on a 30° crown glass prism. Find the angle of separation of the emerging ray of light, assuming λ_{red}=656nm and λ_{violet}=434mm. The refractive index of glass at these two wavelengths is 1.514 (red) and 1.528 (violet). (5 marks)

c) State three laws for location of images on a convex lens. (3 marks)

d) Consider a thin convex lens of refractive index n placed in air. Let R_1 and R_2 be the radii of curvature of the two coaxial spherical surfaces. Show that the focal length f is given by:

$$\frac{1}{f} = (n-1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$ (7 marks)

e) A lens has one radius of curvature 30cm and the other double of it. If its focal length is 40cm, calculate its refractive index. (3 marks)

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