MACHAKOS UNIVERSITY

University Examinations for 2019/2020 Academic Year

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

FIRST YEAR SECOND SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE (TELECOMMUNICATION AND INFORMATION TECHNOLOGY)

BACHELOR OF EDUCATION (SCIENCE)

BACHELOR OF SCIENCE (MATHEMATICS)

BACHELOR OF SCIENCE (APPLIED TECHNOLOGY)

SPH 102: WAVES AND OPTICS

DATE: 12/8/2021 **TIME: 11:00 – 1:00 PM**

INSTRUCTIONS

Answer QUESTION ONE (Compulsory) and any other TWO QUESTIONS

QUESTION ONE (30 MARKS)

a) A string under tension produces sound waves when plucked. State three factors that determine the frequency of the emitted note. (3 marks)

b) Define lateral magnification 2 marks)

c) An object 3 cm high is placed 20 cm from (a) a convex and (b) a concave spherical mirror, each of 10 cm focal length. Determine the position and nature of the image in each case. (6 marks)

d) Distinguish between;

(i) Traveling and standing waves (2 marks)

(ii) Diffraction and interference (2 marks)

(iii) Longitudinal and transverse waves (2 marks)

e) Show that the equation $y = A(x + vt)^2$ represents a traveling wave (5 marks)

f) Light from a distant galaxy shows the characteristic lines of oxygen spectrum, except that the wavelengths are shifted from their values as measured using laboratory sources. In particular, the line expected at 513 nm shows up at 525 nm. What is the speed of the galaxy relative to the earth? (Assuming v << c) (4 marks)

g) A tuning fork of frequency 440 Hz is sounded at the top of a tube initially filled with water, which is allowed to run out slowly, and the position of resonance noted. Calculate the length of the air column corresponding to the first overtone assuming negligible errors. (Take speed of sound in air as 330 m/s) (4 marks)

QUESTION TWO (20 MARKS)

a) State **FOUR** factors that determines the intensity of a wave (4 marks)

b) Define the following terms as used in the superposition of waves

i. Resonance (2 marks)

ii. Beat (2 marks)

c) Given that the speed of sound in air is 330 m/s, calculate the frequency of the fundamental and first three overtones of an organ pipe 3 m long when the tube operates as a closed pipe. (8 marks)

d) A concave mirror forms an image on a screen twice as large as the object. Both object and screen are then moved to produce an image on the screen that is three times the size of the object. If the screen is moved 75 cm in the process, how far is the object moved? What is the focal length of the mirror? (4 marks)

QUESTION THREE (20 MARKS)

a) State three characteristics of sound or a note. (3 marks)

b) By applying the Fermat's principle to refraction, derive the Snell's Law (5 marks)

c) State two defects of the eye and explain with an aid of a diagram how each can be corrected. (6 marks)

d) Laser light passes through two identical parallel slits, 0.2 mm apart. Interference fringes are seen on a screen 1 m away with the Interference maxima separated by 3.29 mm.

i. Calculate the wavelength of the light? (3 marks)

ii. Describe how the intensity at the screen vary, if the contribution of each slit alone is I_0? (3 marks)

QUESTION FOUR (20 MARKS)

a) State the Huygens' Principle (2 marks)

b) Define the following terms as applied in waves

(i) Wavefront (2 marks)

(ii) Node (2 marks)

(iii) Resonance (2 marks)

c) A traveling wave in a string has a displacement from equilibrium given as a function of distance along the string *x* and time *t* as $y(x,t) = (0.45m)\sin[(5\pi/m)x + (20\pi/s)t + \pi/2]$.Determine the;

(i) Amplitude (2 mark)

(ii) Wavelength (2 marks)

(iii) Frequency (2 marks)

(iv) Velocity (2 mark)

(v) Initial phase angle (2 marks)

(vi) Displacement at $x = 10cm$ and $t = 0$. (2 marks)

QUESTION FIVE (20 MARKS)

e) State the **two** factors which determines the intensity of a wave (2 marks)

f) Describe the Doppler's Effect (2 marks)

g) Distinguish between

i. Classical and Relativistic Doppler effect (2 marks)

ii. Ultrasonic and infrasonic frequencies as used in waves (2 marks)

h) Show that $\frac{\lambda}{\lambda_o} = 1 - \frac{u}{c}$ for the Doppler Effect follows from $\lambda = \lambda_o\left[\frac{1-\frac{u}{c}}{1+\frac{u}{c}}\right]^{\frac{1}{2}}$ when $u << c$ (3 marks)

i) Calculate the speed at which one would approach a red traffic light to see a green signal? (Take the wavelength of red as 640 nm and a green as 540 nm.) (3 marks)

j) A double convex lens has a diameter of 5 cm and zero thickness at its edges. A point object on an axis through the center of the lens produces a real image on the opposite side. Both object and image distances are 30 cm, measured from a plane bisecting the lens. The lens has a refractive index of 1.52. Using the equivalence of optical paths

through the center and edge of the lens, determine the thickness of the lens at its center.

(6 marks)