Bachelor of Science in Computer Science

Copperbelt University

School of Information and Communication Technology

PH 212: PHYSICS II

Test 1

Date: Friday 20th May, 2022
Time: 14:00 hrs
Test duration: 2 hours

Total marks: 40

Instructions

- *There are FOUR (4) questions in this test.* ***Attempt ALL of them.***
- *Clearly number your answers.*
- *Bullet points are acceptable in answering descriptive questions.*

QUESTION 1

a) What is a wave? **(1 mark)**

A wave is a disturbance allows energy to be transferred from one point to another some distance away without any particles of the medium travelling between the two points.

b) A plane-progressive wave is represented by the equation

$y = 0.1\sin(50t - 0.8x)$

where y is the displacement in centimetres, t is in seconds and x is the distance from a fixed origin, O, in centimetres. Find

i. the frequency of the wave **(2 marks)**

$y = A\sin(\omega t - 2\pi x/\lambda)$ where $\omega = 2\pi f$

$\omega t = 2\pi f t = 50t$, thus $2\pi f = 50$, $f = 50/(2\pi) = 7.958$ Hz

ii. its wavelength **(2 marks)**

$2\pi x/\lambda = 0.8x$, thus $2\pi/\lambda = 0.8$, thus $\lambda = 2\pi/0.8$ thus $\lambda = 7.854$cm

iii. the displacement at the origin after 2 seconds have elapsed. **(2 marks)**

$y = 0.1\sin(50t)$ $y = 0.1\sin(50\times2) = y = 0.1\sin(100)$. Note 100 is in radians. $Y = -0.0506$ cm.

iv. the resultant wave formed when it meets another wave described by y = 0.1sin(50t + 0.8x) **(3 marks)**

$y = 0.1\sin(50t - 0.8x) + 0.1\sin(50t + 0.8x)$

$y = 0.1\sin(50t)\cos(0.8x) - 0.1\cos(50t)\sin(0.8x) + 0.1\sin(50t)\cos(0.8x) + 0.1\cos(50t)\sin(0.8x)$

$= 0.2\sin(50t)\cos(0.8x)$

QUESTION 2

a) A small loudspeaker in a concert emits sound waves with a power output of 64 W.

i. Find the intensity at 4 m from the source. **(3 marks)**

$I = P/(4\pi r^2) = 64/(4\pi\times16) = 0.3183\ W/m^2$

ii. At what distance would the intensity be four times as much as it is at 4 m from the source? **(3 marks)**

$I_1 = P/(4\pi r_1^2)$ and $I_2 = P/(4\pi r_2^2)$. $I_2 = 4\ I_1$

$I_2 = P/(4\pi r_2^2) = 4\ P/(4\pi r_1^2)$

Thus $1/r_2^2 = 4/r_1^2$. Thus $r_2 = r_1/2$. Thus $r_2 = 2$m

c) What are ultrasonics? Provide TWO(2) medical applications of ultrasonics. **(4 marks)**

- *Ultrasonics are sound waves of higher frequency than 20 000Hz cannot be heard by a human but a cat or dog may hear them.*

Medical

- *Ultrasonic techniques are used in clinical practice in hospitals.*
- *In diagnostic ultrasonics, the frequencies are very high and the waves reflected from inside the patient are amplified and displayed on the screen of a receiver.*
- *Ultrasonics are used to study development of a foetu. The waves are reflected back from the foetus.. In this way the birth can be monitored throughout the prenatal period to check on any abnormalities.*
- *In eye hospitals, ultrasonics are used to measure the eye-lens of a person with a cataract (eye) defect, which is replaced by an equivalent plastic lens.*
- *The chief advantage of diagnostic ultrasonics is the absence of danger to the patient.*
- *Radiography, i.e., the use of X-rays, could be very dangerous.*

QUESTION 3

a) Describe the principle behind recording and reproduction of sound. **(5 marks)**

- *To record sound a microphone captures sound waves and converts them into electrical energies to be encoded and then either stored or transmitted by a current.*
- *To reproduce the sounds playback devices read the encoded data and convert them back into electrical energy that when fed to a loudspeaker is recreated as the original sound waves.*

b) Explain the principle and operation of a microphone **(5 marks)**

- *A microphone has a thin, metal diaphragm that vibrates in response to frequency and amplitude of sound waves.*
- *As the diaphragm of an early microphone moved,carbon dust was compressed and decompressed and its resistance altered.*

- *The flow of an electric current passed through the carbon was affected by its changing resistance thereby creating a specific electrical signal.*
- *The carbon microphone was invented in 1878 by Welsh scientist and music professor David Hughes.*
- *In a modern microphone the diaphragm is suspended within a magnetic field which, when disturbed, creates electric signals that represent the pattern of the sound wave.*
- *Electromagnets, capacitors and crystals are all used for this purpose.*

QUESTION 4

a) What are coherent sources of light? **(2 marks)**

Coherent sources are those which emit light waves of the same wavelength or frequency which are always in phase with each other or have a constant phase difference.

b) Suppose light travels a distance t in a medium of refractive index n. if λ_0 is the wavelength in the vacuum. Derive an expression for the phase difference due to this path in the medium in terms of n, t and λ_0. **(3 marks)**

If λ is the wavelength in the medium, the phase difference due to this path is

$$\Delta = \frac{2\pi t}{\lambda} \quad \text{.....(1)}$$

If the wave travels from a vacuum (or air) to this medium, its frequency does not alter but its wavelength and speed become smaller.

Suppose λ_0 is the wavelength and c is the speed in a vacuum.

Then if c_m is the speed in the medium,

$$\text{frequency} = \frac{c}{\lambda_0} = \frac{c_m}{\lambda_m} \qquad \therefore \lambda = \frac{c_m}{c}\lambda_0 \quad \text{.....(2)}$$

Substituting for λ from (2) in (1),

$$\Delta = \frac{2\pi ct}{c_m\lambda_0} = \frac{2\pi mt}{\lambda_0} \quad \text{.....(3)}$$

since $n = c/c_m$.

c) A viewing screen is separated from a double-slit source by 1.2m. The distance between the two slits is 0.030 mm. The second-order bright fringe is 4.5 cm from the centre line.

i. Determine the wavelength of the light **(3 marks)**

$y_{bright} = m\lambda L/d$

thus $\lambda = dy_{bright}/(mL) = 0.030\times10^{-3}\times4.5\times10^{-2}/(2\times1.2) = 5.6\times10^{-7}m = 560$ nm

ii. Calculate the distance between adjacent bright fringes. **(2 marks)**

$y_{m+1} - y_m = \lambda L/d = 5.6\times10^{-7}\times1.2/0.030\times10^{-3} = 2.2\times10^{-2}m = 2.2$ cm