UNIVERSITY OF FORT HARE

SUPPLEMENTARY EXAMINATIONS

JANUARY/FEBRUARY 2019

University of Fort Hare
Together in Excellence

WAVE & OPTICS

(PHY122)

DURATION: 3Hours

MARKS: 100

INTERNAL EXAMINER

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MODERATOR

Dr. L. Nwokolo

INSTRUCTIONS

Answer any five(5) questions

Question 1[20 marks]

(a) A train is moving parallel to a highway with a constant speed of 20.0 m/s. A car is traveling in the same direction as the train with a speed of 40.0 m/s. The car horn sounds at a frequency of 510 Hz, and the train whistle sounds at a frequency of 320 Hz.

(i) When the car is behind the train, what frequency does an occupant of the car observe for the train whistle?

(ii) After the car passes and is in front of the train, what frequency does a train passenger observe for the car horn?

(b) Expectant parents are thrilled to hear their unborn baby's heartbeat, revealed by an ultrasonic motion detector. Suppose the fetus's ventricular wall moves in simple harmonic motion with an amplitude of 1.80 mm and a frequency of 115 per minute.

(i) Find the maximum linear speed of the heart wall.

(ii) Suppose the motion detector in contact with the mother's abdomen produces sound at 2 000 000.0 Hz, which travels through tissue at 1.50 km/s. Find the maximum frequency at which sound arrives at the wall of the baby's heart.

(iii) Find the maximum frequency at which reflected sound is received by the motion detector.

(c) Standing at a crosswalk, you hear a frequency of 560 Hz from the siren of an approaching ambulance. After the ambulance passes, the observed frequency of the siren is 480 Hz. Determine the ambulance's speed from these observations.

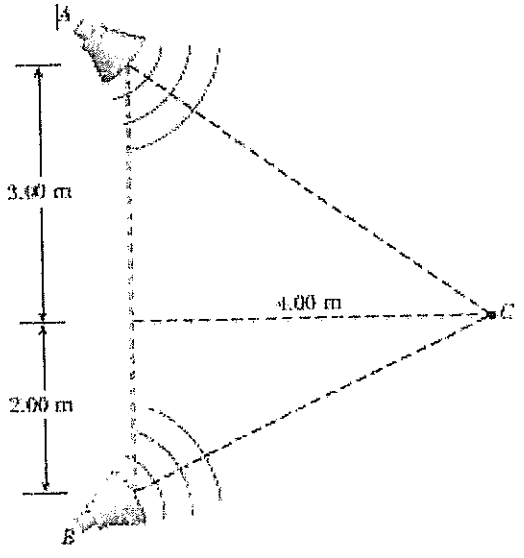
(d) Two small speakers emit sound waves of different frequencies. Speaker *A* has an output of 1.00 mW, and speaker *B* has an output of 1.50 mW. Determine the sound level (in dB) at point *C* (Fig.below) if

(i) only speaker *A* emits sound,

(ii) only speaker *B* emits sound, and

(iii) both speakers emit sound.

(e)



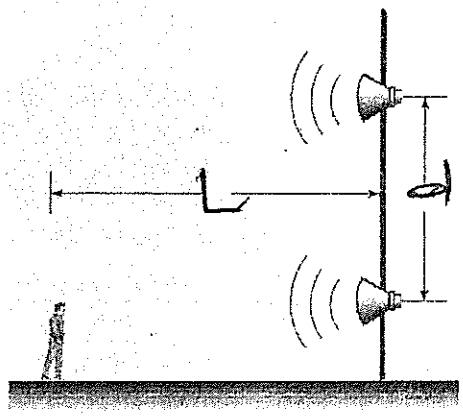
(f)

Question 2[20 marks]

(a) Two speakers are driven by the same oscillator whose frequency is 200 Hz. They are located on a vertical pole a distance of 4.00 m from each other. A man walks straight toward the lower speaker in a direction perpendicular to the pole as shown in Figure below.

(i) How many times will he hear a minimum in sound intensity, and

(ii) How far is he from the pole at these moments? Take the speed of sound to be 330 m/s and ignore any sound reflections coming off the ground.



(b) Show that the difference between decibel levels β_1 and β_2 of sound is related to the ratio of the distances $r1$ and $r2$ from the sound source by $\beta_2 - \beta_1 = 20 \log\left(\frac{r_1}{r_2}\right)$

(c) A loudspeaker is placed between two observers who are 110 m apart, along the line connecting them. If one observer records a sound level of 60.0 dB and the other records a sound level of 80.0 dB, how far is the speaker from each observer?

(d)The intensity of a sound wave at a fixed distance from a speaker vibrating at 1.00 kHz is 0.600 W/m^2.

(i) Determine the intensity if the frequency is increased to 2.50 kHz while a constant displacement amplitude is maintained.

(ii) Calculate the intensity if the frequency is reduced to 0.500 kHz and the displacement amplitude is doubled.

Question 3[20 marks]

(a) Two waves in a long string have wave functions given by

$y_1 = (0.015m)\cos(\frac{x}{2} - 40t)$ and

$y_2 = (0.015m)\cos(\frac{x}{2} + 40t)$

where $y1$, $y2$, and x are in meters and t is in seconds.

(i) Determine the positions of the nodes of the resulting standing wave.

(ii) What is the maximum transverse position of an element of the string at the position x = 0.400 m?

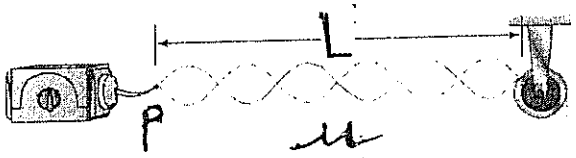
(b) Two speakers are driven in phase by a common oscillator at 800 Hz and face each other at a distance of 1.25 m. Locate the points along a line joining the two speakers where relative minima of sound pressure amplitude would be expected. (Use v = 343 m/s.)

(c) Find the fundamental frequency and the next three frequencies that could cause standing-wave patterns on a string that is 30.0 m long, has a mass per length of 9.00 x 10^{-3} kg/m, and is stretched to a tension of 20.0 N.

(d) In the arrangement shown in Figure below, an object can be hung from a string (with linear mass density μ = 0.002 00 kg/m) that passes over a light pulley. The string is connected to a vibrator (of constant frequency f), and the length of the string between point P and the pulley is L = 2.00 m. When the mass m of the object is either 16.0 kg or 25.0 kg, standing waves are observed; however, no standing waves are observed with any mass between these values.

(I) What is the frequency of the vibrator? (*Note:* The greater the tension in the string, the smaller the number of nodes in the standing wave.)

(iii) What is the largest object mass for which standing waves could be observed?



Question 4[20 marks]

(a) The overall length of a piccolo is 32.0 cm. The resonating air column vibrates as in a pipe open at both ends.

(i) Find the frequency of the lowest note that a piccolo can play, assuming that the speed of sound in air is 340 m/s.

(ii) Opening holes in the side effectively shortens the length of the resonant column. If the highest note a piccolo can sound is 4 000 Hz, find the distance between adjacent antinodes for this mode of vibration.

(b) Calculate the length of a pipe that has a fundamental frequency of 240 Hz if the pipe is

(i) closed at one end and
(ii) open at both ends.

(c) The fundamental frequency of an open organ pipe corresponds to middle C (261.6 Hz on the chromatic musical scale). The third resonance of a closed organ pipe has the same frequency. What are the lengths of the two pipes?

Question 5[20 marks]

(a) The *Apollo 11* astronauts set up a panel of efficient cornercube retroreflectors on the Moon's surface. The speed of light can be found by measuring the time interval required for a laser beam to travel from Earth, reflect from the panel, and return to Earth. If this interval is measured to be 2.51 s, what is the measured speed of light? Take the center-to center distance from Earth to Moon to be 3.84 " 108 m, and
do not ignore the sizes of the Earth and Moon.

(b) A dance hall is built without pillars and with a horizontal ceiling 7.20 m above the floor. A mirror is fastened flat against one section of the ceiling. Following an earthquake, the mirror is in place and unbroken. An engineer makes a quick check of whether the ceiling is sagging by directing a vertical beam of laser light up at the mirror and observing its reflection on the floor.

(i) Show that if the mirror has rotated to make an angle φ with the horizontal, the normal to the mirror makes an angle φ with the vertical.

(ii) Show that the reflected laser light makes an angle 2φ with the vertical.

(iii) If the reflected laser light makes a spot on the floor 1.40 cm away from the point vertically below the laser, find the angle φ.

END