Physics ATAR - Year 11

Waves
Unit Test
2016

Name:

Mark: / 57

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Time Allowed: 50 minutes

Notes to Students:

- You must include **all** working to be awarded full marks for a question.
- Marks will be deducted for incorrect or absent units and answers stated to an incorrect number of significant figures.
- **No** graphics calculators are permitted – scientific calculators only.

Question 1 **(3 marks)**

The ear canal acts as a closed column of air 1.70 cm in length from the outer ear to the ear drum. Calculate the fundamental resonant frequency of the ear canal.

$v = f \times \lambda$ (1) As a closed tube, resonance occurs when $\lambda = 4 \times L$ (1/2)

$340 = f \times 0.017 \times 4$ (1/2)

$f = \frac{340}{0.017 \times 4} = 5.00\ kHz$ (1)

or other suitable answer using $f_n = nv/4L$

Question 2 **(5 marks)**

Students from the School are planning an entry for the World Robo Cup. One part of the competition requires the robots to play soccer. To 'see' the position of the 10.5 cm soccer ball used, each robot sends out a sonar signal.

(a) Calculate the lowest possible frequency of the sonar signal to 'see' the ball.

(3 marks)

$v = f \times \lambda$ (1)

$340 = f \times 0.105$ (1)

$f = \frac{340}{0.105} = 3.24\ kHz$ (1)

(b) Explain what would happen if a frequency lower than that calculated was used.

(2 marks)

- For frequencies less than this value the wavelength would be too large
- and the wave would diffract around the ball rather than being reflected by the ball back to the robot.

Question 3 **(3 marks)**

You are attending a concert night rehearsal and taking sound intensity measurements of Leo playing his saxophone. At the back of the concert hall 21.0 m from Leo you measure an intensity of 1.30 x 10^{-6} Wm^{-2}. Calculate the distance from Leo where the measurement would be 1.17 x 10^{-5} Wm^{-2}.

$\mathbf{I} \propto \frac{\mathbf{1}}{\mathbf{r^2}}$ (1)

$\frac{I_2}{I_1} = r^2$ (1/2) $= \frac{1.17 \times 10^{-5}}{1.30 \times 10^{-6}} = 9$ (1/2)

$\frac{21}{r} = \sqrt{9}$ $r = 7.00\ m$ (1)

or may use $I_1 \times {r_1}^2 = I_2 \times {r_2}^2$ to arrive at same answer

Question 4 **(10 marks)**

Before starting to rehearse Jack is tuning a string on his guitar using a 450 Hz tuning fork. He notices that as he gets closer to 450 Hz he hears a pulsating loudness and softness of sound equivalent to a frequency of 4.00 Hz.

(a) Determine the possible frequencies of his guitar string.

(2 marks)

Beat frequency = $| f_2 - f_1 |$ so f_B 450 +/- 4.00 Hz
String is vibrating at either 446 Hz or 454 Hz

(b) As he tightens the string he notices the pulsating sound increases in frequency. Which of the possible frequencies in part (a) was correct? Explain your reasoning.

(4 marks)

- 454 Hz
- Increasing tension by tightening increases the speed of the wave on the string.
- As the wavelength must stay the same, the frequency must be increasing.
- As the string is tightened the beat frequency increases, thus increasing the difference between the tuning fork and the string frequency. If the note were 446 Hz it would move closer to the frequency of the tuning fork and the beat frequency would decrease, not increase.

If answer does not explain relationship between tension and velocity can only achieve a maximum of 3 marks

(c) During the rehearsal Jack notices that when he plays a particular note on his base guitar the snare drum begins to vibrate. How would Jack, a competent physics student, explain this?

(4 marks)

- Jack explains that this is due to resonance.
- As Jack plays the note on his guitar it is is amplified and played through the speakers causing the air in the room to vibrate at the same frequency as the sound wave produced by his guitar.
- The snare drum has a natural frequency, which matches the driving frequency of the guitar note.
- The sound wave due to his guitar hits the snare drum forcing it to vibrate in sympathy and as this vibration is at its natural frequency, its amplitude of vibration increases.

Question 5 **(9 marks)**

An instrument maker understands that he can use either a closed or an open pipe to produce a note of the same frequency.

(a) Calculate the ratio of the length of a closed pipe to an open pipe if they are to produce the same frequency.

(3 marks)

$f_n = nv/4L$ for a closed pipe, $f_n = nv/2L$ for an open pipe

$$f_n = \frac{nv}{4L} = \frac{nv}{2L} \text{ so } f_n = \frac{1}{4} L : \frac{1}{2} L$$

a closed pipe has the same frequency in half the length of an open pipe

The ratio is 1 to 2

The instrument maker manufactures a 2.46 m pipe that can be used to create standing waves in either an open or closed mode by a pedal that opens or closes an aperture at the bottom of the pipe.

(b) Determine the frequencies of the first three harmonics of the pipe if it is left open at both ends.

(3 marks)

$f_n = nv/2L$ (1) $f_1 = 340/(2 \times 2.46)$ = 69.1 Hz (1)

$f_2 = 2 \times f_1 = 138$ Hz (1/2)

$f_3 = 3 \times f_1 = 207$ Hz (1/2)

or individual calculations for each frequency

(c) Determine the frequencies of the first three harmonics of the pipe if it is closed at one end.

(3 marks)

$f_n = nv/4L$ (1) $f_1 = 340/(4 \times 2.46) = 34.6$ Hz (1)

$f_2 = 3 \times f_1 = 103.7 = 104$ Hz (1/2)

$f_3 = 5 \times f_1 = 173$ Hz (1/2)

or individual calculations for each frequency

Question 6 **(6 marks)**

Jeff is sitting on his surfboard in the ocean at Trigg Beach waiting to pick up a good wave to surf in on. While he is sitting in one position he starts to make some observations. He counts 30 waves passing beneath his board in a time of 3 minutes, with 9.0 metres between each crest and trough.

(a) Calculate the period of the water waves he has observed.

(3 marks)

T = time/number of waves (1)

T = (3 x 60)/30 (1)

T = 6 s (1)

(b) Calculate the wave speed of the waves observed.

(3 marks)

$v = f \times \lambda$ where $f = 1/T$ (1)

$v = (1/6) \times (9 \times 2)$ (1)

$v = 3$ ms^{-1} (1)

Question 7 **(7 marks)**

An alarm clock that incorporates a ringing bell (a hammer that strikes the bell to make it ring) and a flashing light, is placed in a large sealed glass jar. An observer hears that the bell is ringing and sees that the light is flashing.

(a) Describe what an observer would notice when the air is totally removed from the jar by a vacuum pump.

(3 marks)

- They would see the hammer hitting the bell
- But not hear it
- They would see the light continue to flash

(b) Explain the observations made in part (a).

(4 marks)

You can see the hammer hitting the bell and the light flashing because

- Light is an electromagnetic wave
- that can travel through a vacuum

You can no longer hear the bell ringing because

- Sound is a mechanical wave
- that requires a medium to propagate through

Question 8 **(7 marks)**

Two loud speakers as shown in the diagram below are connected in phase with both emitting sounds of 360 Hz. The speakers are 2.50 m apart on a day the speed of sound in air is measured at 340 ms^{-1}.

(a) Describe and explain what a student would hear when walking from point A towards point B along the midpoint between the two speakers.

(2 marks)

- Walking from A towards B the intensity of the sound would decrease because intensity is proportional to the inverse of distance squared
- Path difference from each speaker to the mid point is the same, so waves arrive in phase and undergo constructive interference. A loud spot is heard.

(b) (i) Describe what a student would hear when walking from point B towards point D, 6.40 m in front of the speakers.

(2 marks)

- D is a soft spot as difference in path length = $\lambda/2$ (destructive interference).
- Student would hear the amplitude of the sound decrease to no sound.

(ii) Explain what is happening to the sound waves between points B and point D.

(3 marks)

- The path difference between the waves is changing.
- The waves arrive out of phase, but not 180 degrees out of phase, the waves experience partial destructive interference.
- The amplitude of the waves decreases until they are 180 degrees out of phase at point D.

Question 9 **(7 marks)**

A loudspeaker produces a 500 Hz sound at point A and a listener is located at point B.

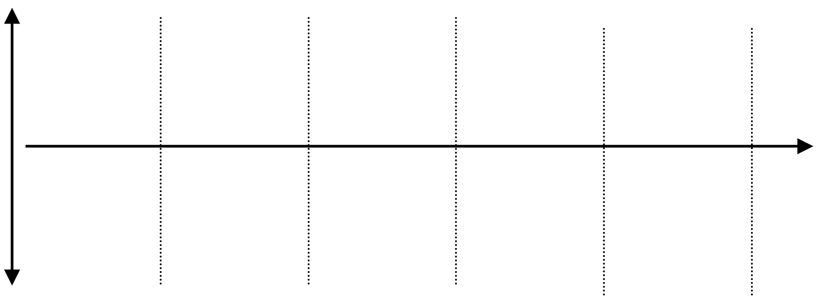
(a) Describe the motion of the particles in the air between A and B.

(2 marks)

- The particles of air vibrate (oscillate) parallel
- to the direction of the transfer of energy

(b) **Sketch** an appropriate displacement v time graph for a particle experiencing the wave travelling between points A and B, labelling the axes and indicating units for two complete oscillations.

(3 marks)



1 mark labelling displacement with m, 1 mark labelling time in ms, 1 mark wave shape (sinusoidal),
-1/2 mark if not two complete waves

(c) Indicate which of the following quantities can be established directly from your graph by labelling them on the sketch graph above.

wavelength – amplitude – period - frequency. Indicate them on your graph.

(2 marks)

Amplitude and period identified.

End of Test