Physics ATAR - Year 11

Waves Physics Unit Test 2015

Name: SOLUTIONS

Mark: / 57

= %

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.

Additional data and formulae:

Speed of sound in air at 25.0 °C = 340 ms^{-1}

Question 1 **(3 marks)**

The intensity of sound from a rather vocal magpie is measured at a distance of 15.0 m to be 5.01 x 10^{-6} Wm^{-2}. Calculate the sound intensity that would be measured at a distance of 7.50 m from the magpie.

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

$$\frac{15}{7.5} = 2$$ (½)

$$\left(5.01\times10^{-6}\right)\left(2^2\right) = 2.00\times10^{-5}\,Wm^{-2}$$ (1)

(½)

Award marks for working as long as calculation is shown that distance is half, and that must be squared.

Question 2 **(8 marks)**

A fishing boat is 115 m from a large flat cliff in Shark Bay on a 25.0°C day. The boat briefly sounds its foghorn and an echo of the sound is heard after a certain time.

(a) Explain why an echo is heard.

(2 marks)

- Sound is reflected off the cliffs
- The cliffs are a large, hard, flat surface so sound bounces straight back.

(b) Calculate the time delay Δt, between the originating sound and the echo.

(3 marks)

$$s = vt$$ (1)

$$(2)(115) = (340)\Delta t$$ (1)

$$\Delta t = 0.676s$$ (1)

(c) If the frequency of the foghorn is 75.0 Hz, calculate the wavelength of the sound wave.

(3 marks)

$v = f\lambda$ (1)

$\lambda = \frac{340}{75}$ (1)

$\lambda = 4.53m$ (1)

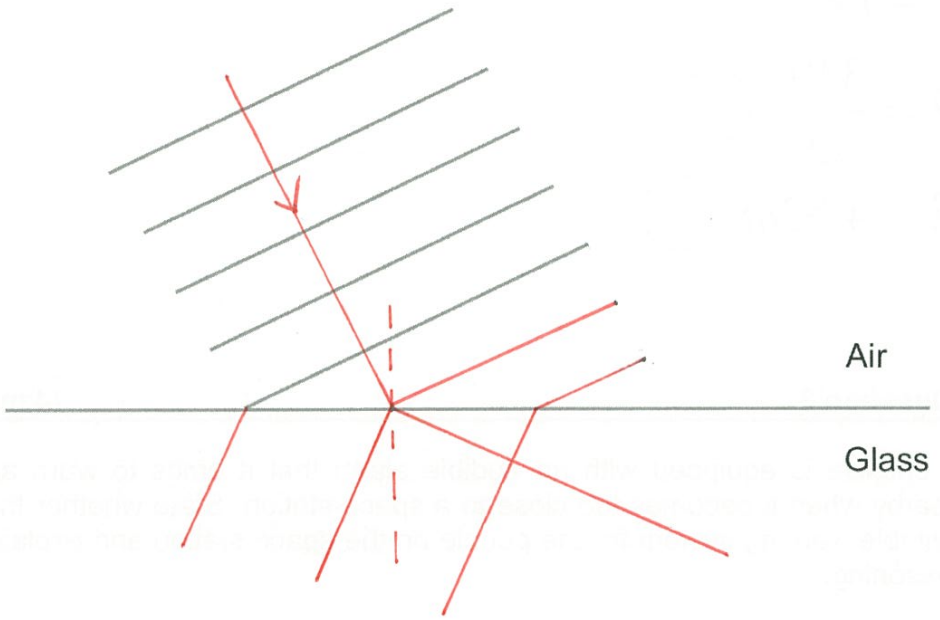
Question 3 **(4 marks)**

A satellite is equipped with an audible alarm that it emits to warn anyone nearby when it becomes too close to a space station. State whether this is a suitable warning system for the people on the space station and explain your reasoning.

- Sound is a mechanical wave
- And therefore requires the intermolecular forces between particles to travel through a medium
- Space is a vacuum and has no particles
- So no sound would be heard

Question 4 **(4 marks)**

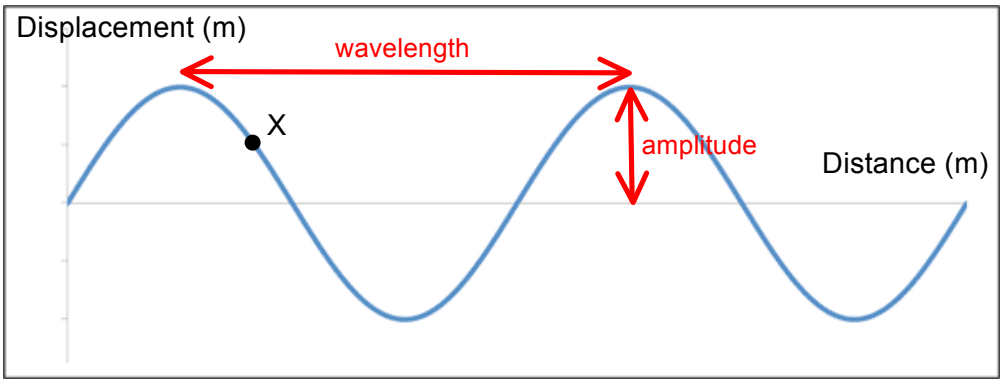
Complete the wavefront diagram below to show how the path of a sound wave changes as it moves from air to glass.



1 - Lines of propagation 90° to wave fronts
1 - Wave fronts evenly spaced, parallel and straight
1 - Refracted ray going correct way, with wave fronts spaced further out
½ - Normal line
½ - Arrow showing direction of propagation

Question 5 **(3 marks)**

The graph below shows the displacement of particles with respect to distance from an oscillating source.



(a) On the diagram clearly label the amplitude and wavelength of the wave. (2 marks)

(b) State the direction that a particle at position X is moving if the wave is propagating to the right. (1 mark)

Up

Question 6 **(4 marks)**

Ultrasound imaging is used to see within the human body by locating the boundaries between soft tissue and fluid or soft tissue and bone. Describe how an ultrasound locates these boundaries and uses their location to form an image.

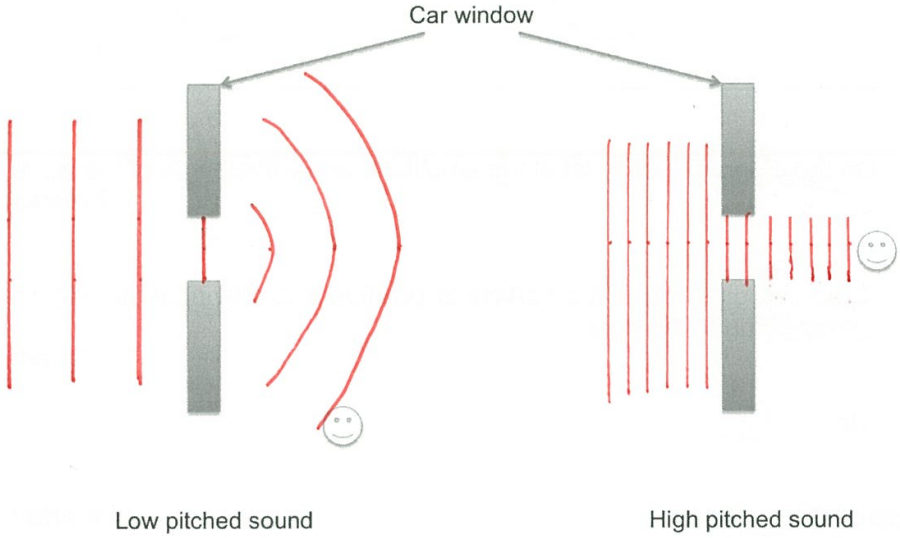
- Ultrasound wave goes through tissue until it reaches a boundary
- Some waves are reflected off the boundary
- The time taken for the reflection to reach the sensor is measured
- Distance to the boundary can be calculated using s = vt

Question 7 **(6 marks)**

A student is walking along a footpath and approaches a parked car. Music is being played in the car and the passenger window of the car is open. The student crouches down on the ground near the window and hears that only the low pitched bass notes are prominent. As he stands up again by the open window he also hears the high pitched notes clearly.

(a) Complete the two wave front diagrams below to show why this effect is observed.

(4 marks)



2 marks per diagram

Lines before the barrier should be evenly spaced, straight and parallel.

Lines for the high pitched sound should be significantly closer together than the low pitched sound.

The low pitched shape should be an even curve.

The high pitched should have a straight section, but may curve slightly at the edges.

If high pitched and low pitched swapped round but the shapes are correct –1.

(b) If a passenger in the car wound up the window so that the size of the gap is decreased, state the effect this would have on the frequencies of the sound heard when he is crouched down and explain your reasoning.

(2 marks)

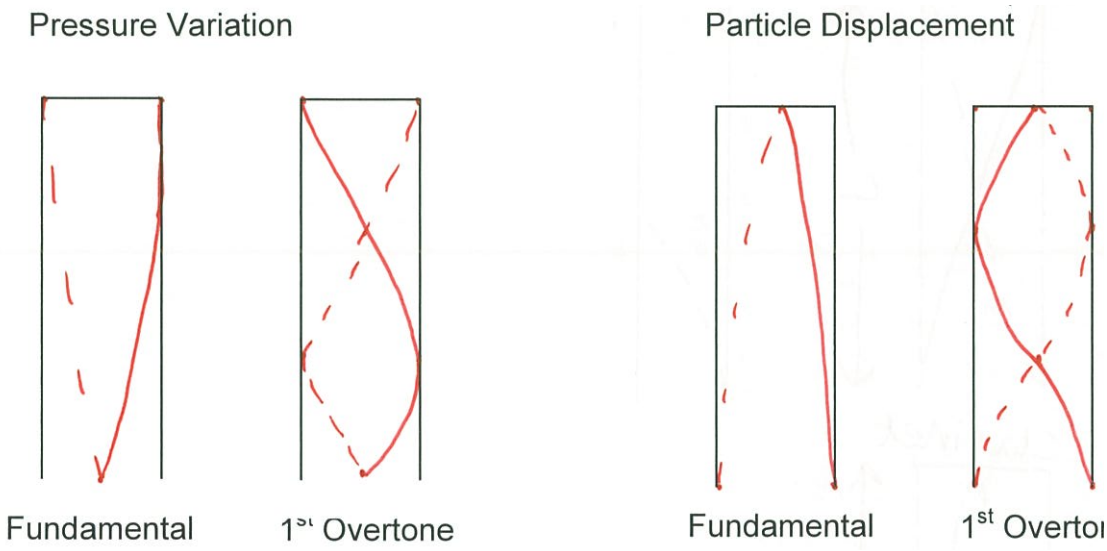
- Smaller gap would allow high frequency sound to diffract
- He would be able to hear high and low pitched sounds whilst he is crouched.

Question 8 **(14 marks)**

A clarinet is a musical instrument that can be considered to be an air column that is closed at one end. When the clarinet resonates a standing wave is formed.

(a) Complete the diagrams below to show the standing wave in terms of both pressure variation and particle displacement for the fundamental frequency and first overtone. Indicate nodes (N) and antinodes (A) on the sketches.

(4 marks)



1 mark for each diagram

2/4 if confused pressure with displacement but got shapes correct

(b) Calculate the fundamental frequency at a temperature of 25.0 ˚C if the clarinet has an effective length of 0.445 m (ignoring any end error).

(3 marks)

$L = 0.445m$

$Fundamental\ when\ L = \frac{\lambda}{4}$

$\lambda = (0.445)(4)$ ½

$\lambda = 1.78m$ ½

$v = f\lambda$ ½

$f = \frac{340}{1.78}$ ½

$f = 191\ Hz$ 1

OR

$f_n = \frac{nv}{4L}$ 1

$f = \frac{(1)(340)}{(4)(0.445)}$ 1

$f = 191\ Hz$ 1

(c) State which harmonic corresponds to the third overtone.

(1 mark)

7th

(d) Calculate the wavelength of the harmonic in part (c).

(3 marks)

$L = \frac{7\lambda}{4}$ 1

$\lambda = \frac{(4)(0.445)}{7}$ 1

$\lambda = 0.254\ m$ 1

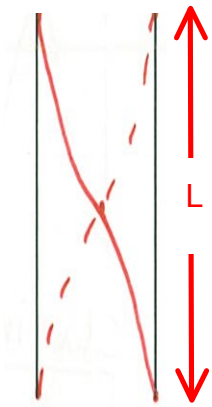
(e) A flute is a musical instrument that can be considered an open pipe at both ends. State how the fundamental frequency of a flute would be different to the fundamental frequency of a clarinet of the same effective length and justify your reasoning with the aid of a diagram and a calculation.

(3 marks)

Fundamental frequency of the flute will be higher than that of a clarinet.

Clarinet:

Flute:



Clarinet: $L = \lambda / 4$

Flute: $L = \lambda / 2$

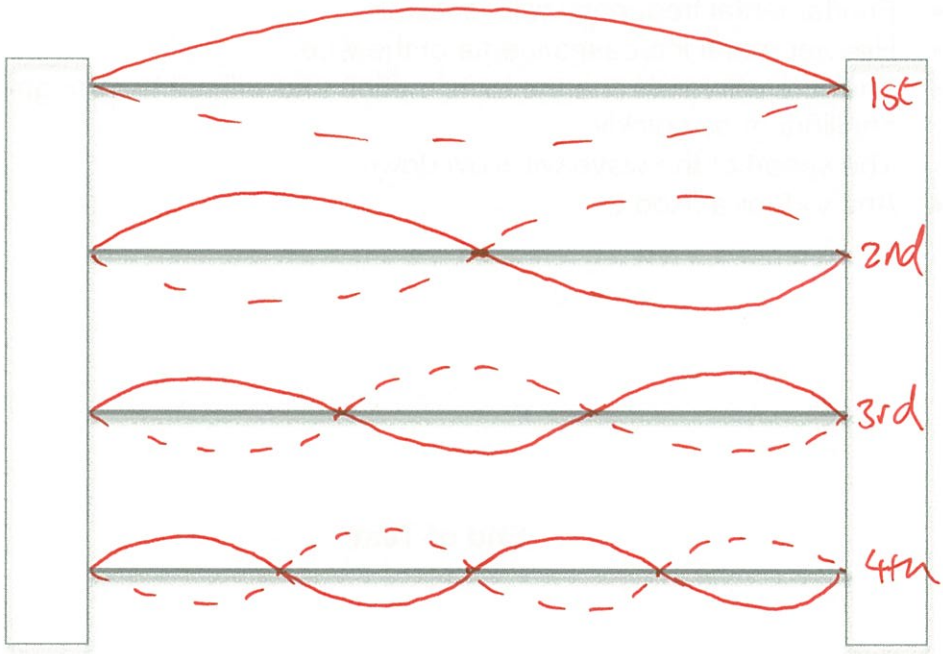
Wavelength is shorter in flute so frequency is higher as $f \propto 1/\lambda$

1 – appropriate diagrams
1 – link to formulae
1 – stating answer

Question 9 **(11 marks)**

A fence that is made by lengths of wire stretched between posts is shown below.

(a) On the diagram below draw and label the first four standing waves that could be set up by the wires on the fence between the two fence posts. (3 marks)



Each diagram 0.5 (must be neat, even spacing etc)

1 mark for labelling 1st, 2nd etc

Can write fundamental, 1st overtone etc as long as it's clear.

-1 mark if reflection isn't shown.

(b) The distance between the posts is 3.20 m. If the frequency of the 3rd harmonic is 24.0 Hz, calculate the speed of the wave in the wire.

(3 marks)

$f_n = \frac{nv}{2L}$ (1)

$24 = \frac{(3)(v)}{(2)(3.2)}$ (1)

$v = 51.2\ ms^{-1}$ (1)

OR

3rd harmonic when $L = \frac{3\lambda}{2}$

$\lambda = \frac{(3.2)(2)}{3}$ (½)

$\lambda = 2.13m$ (½)

$v = f\lambda$ (½)

$v = (2.13)(24)$ (½)

$v = 51.1\ ms^{-1}$ (1)

(c) The owner of the fence notices that one of the wires needs replacing. The only wire she has available is made from a significantly heavier metal than the original wire. State what effect this will have on the fundamental frequency of the wire and explain your reasoning.

(5 marks)

- Fundamental frequency will be lower
- Heavier metal increases inertia of the wire
- The wire will resist change to its motion and will not be brought back to equilibrium as quickly
- The speed of the wave will slow down
- And v∝f for a fixed L

End of Test