Physics ATAR - Year 11

Waves
Unit Test
2019

Name: SOLUTIONS	Mark: / 51 = % 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 Formulae

Path Difference $n\lambda = |L_1 - L_2|$

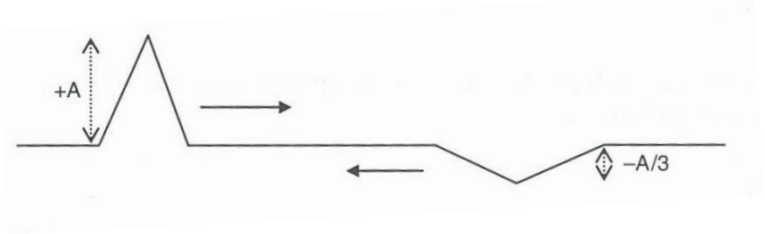
Speed of sound in air v(T) = 331 + 0.6T

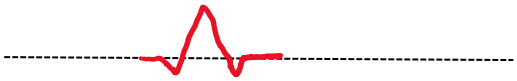
Intensity $\frac{I_1}{I_2} = \frac{{r_2}^2}{{r_1}^2}$

Question 1 **(3 marks)**

Two waves are travelling on a string. The directions and amplitude of each wave is shown in the figure below.

(a) On the line on the right, draw resulting wave when the two waves meet. (1 mark)





(1/2 mark if amplitude does not go below zero)

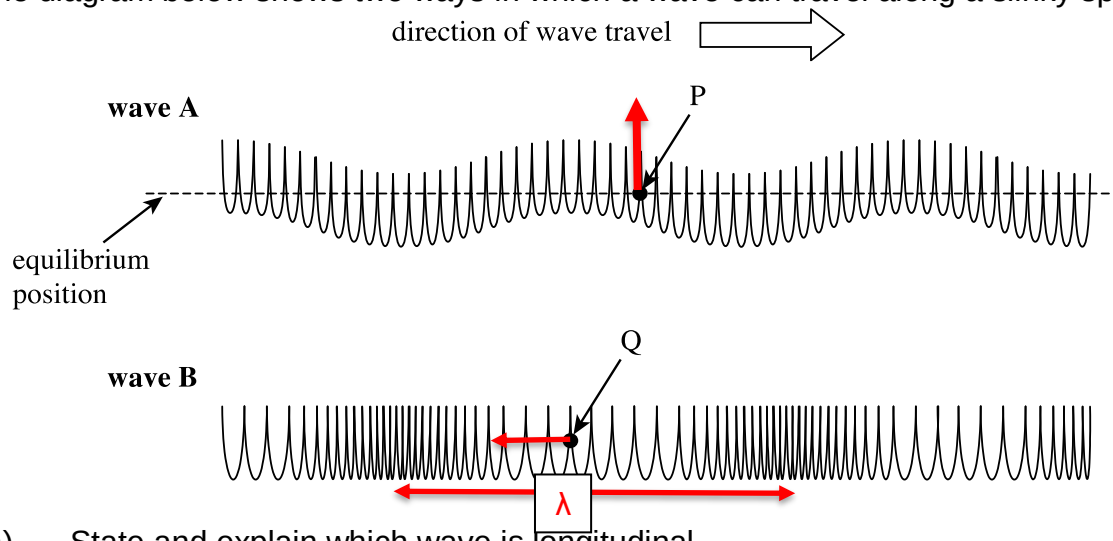
(b) When the two waves meet, calculate the amplitude of the resulting wave.

(2 marks)

Description	Marks
ΣA = +A + (-A/3)	1
= +2/3 A	1
Total	2

Question 2 **(5 marks)**

The diagram below shows two ways in which a wave can travel along a slinky spring.



(a) State and explain which wave is longitudinal.

(2 marks)

Description	Marks
B	1
Particle displacement is in the same direction as the wave propagation	1
Total	2

(b) On the diagram:

(3 marks)

i. clearly indicate and label the wavelength of wave B (between any two points on the diagram)

ii. use arrows to show the direction in which the points P and Q are about to move as each wave moves past these points.

Question 3 **(3 marks)**

Sound travels from air into a medium where it travels faster.

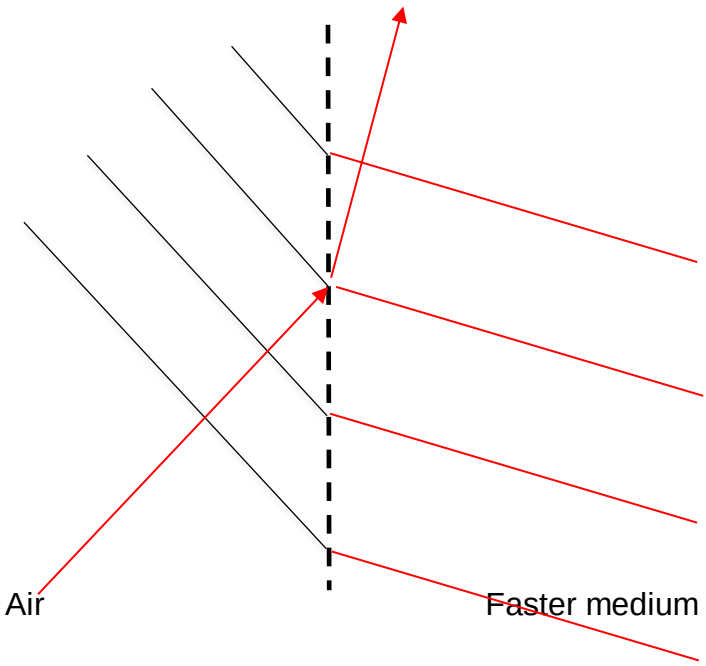
(a) Circle which of the following will occur

(1 mark)

A. The frequency will decrease, but the wavelength will increase.
B. The frequency will increase, but the wavelength will decrease.
C. The frequency will remain the same, but the wavelength will increase.
D. The frequency will remain the same, but the wavelength will decrease.

(b) Complete the following wave front diagram of the water waves as they enter the faster medium.

(2 marks)



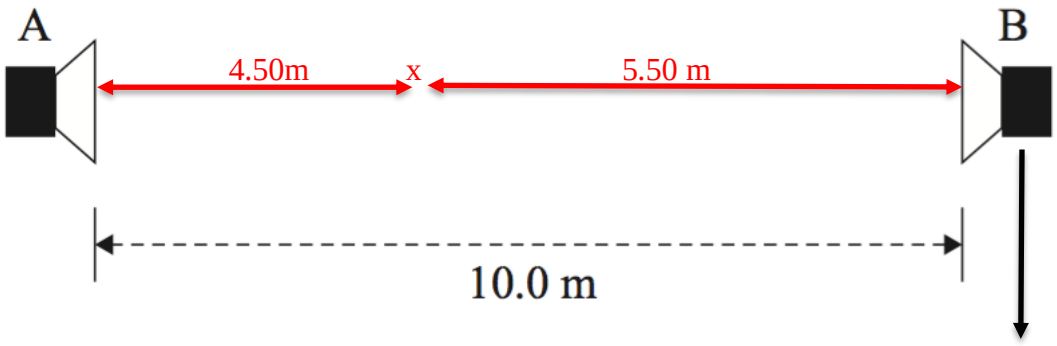
Question 4 **(3 marks)**

A 0.500 W speaker produces a sound intensity of 0.159 Wm^{-2} at a distance of 0.500 m. Calculate the distance required such that 1/10th of this intensity is heard.

Description	Marks
$\frac{I_1}{I_2} = \frac{r_2^2}{r_1^2}$ $I_2 = 0.0159 \times 10^{-2}$	1
$\frac{0.159}{0.0159} = \frac{r_2^2}{0.50^2}$ $r_2 = \sqrt{\frac{0.159}{0.0159} . 0.50^2}$	1
= 1.58 m	1
Total	3

Question 5 **(7 marks)**

Simon sets up the following experiment in a large open area. He connects two speakers that are facing each other, as shown below. Both speakers are connected 10.0 m apart to the same signal generator and amplifier, which is producing a sound with a wavelength of 1.00 m.



(a) On the diagram, indicate one region where the path difference produced by the two sources are 1λ.

(1 mark)

Simon then walks at right angles to the line separating the speakers (as shown in the diagram) a distance of 6.34 m.

(b) Determine via calculation, whether Simon would hear a loud or quiet sound at this position.

(3 marks)

Description	Marks
L_1 = 10.0 m $L_2 = \sqrt{10.0^2 + 6.34^2}$ = 11.84 m 6.34 m	1
$n\lambda = \lvert L_1 - L_2 \rvert$ $n = \frac{\lvert L_1 - L_2 \rvert}{\lambda} = \frac{11.84 - 6.34}{1} = 5.5$	1
Since n = half integer, he would hear a quiet region.	1
Total	3

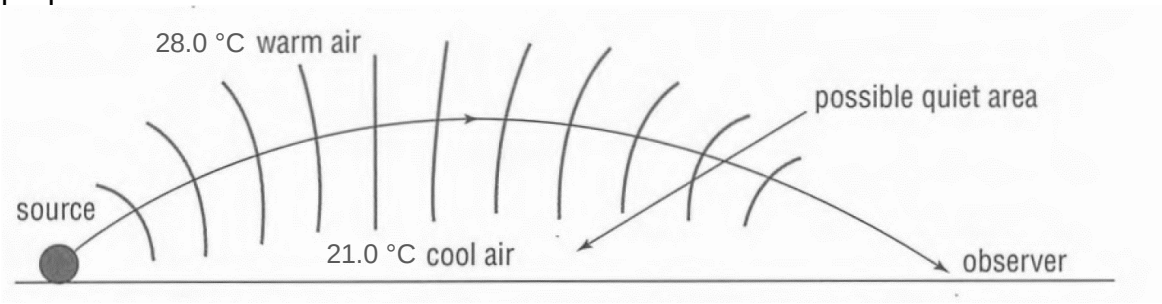
Simon finds that when he tries to conduct this experiment in a science classroom, the loud and quiet regions are very difficult to locate. Explain why this is so.

(3 marks)

Description	Marks
Wave interference,	1
Sound would reflect and diffract around objects in the classroom	1
Path difference will not be apparent/multiple paths introduced.	1
Total	3

Question 6 **(6 marks)**

A 'temperature inversion' is an atmospheric condition where the temperature near the ground is cooler than further above, this often occurs during the evening when the land cools quicker than the air. This can cause sound waves to bend as the medium they are travelling in changes its properties.



(a) State the two wave phenomena that are occurring in the diagram above and explain how **one** of them occurs.

(3 marks)

Phenomenon 1:Refraction Phenomenon 2: Total internal reflection

Explanation:

Description	Marks
1 mark for both phenomenon named.	1
Wave enters medium where it travels faster/slower. And bends away/towards normal to boundary	2
Wave approached boundary at angle > critical angle. Total internal reflection occurs and it travels back down to observe.	2
Total	3

(b) State what happens to the speed of sound as the air temperature decreases.

(1 marks)

v decreases

(c) Given that the speed of sound in air as a function of temperature is v(T) = 331 + 0.61T, calculate the difference in air speeds from the diagram above.

(2 marks)

Description	Marks
$v1 - v2 = 331 + 0.61(28) - 331 + 0.61(21)$	1
$= 4.27\ ms^{-1}$	1
Total	2

Question 7 **(3 marks)**

A 1.50 m long rope is stretched between two supports with a tension that makes the speed of transverse waves 48.0 ms^{-1}. Calculate the frequency of the third overtone.

Description	Marks
$f_n = \frac{nv}{2L}$, $f_4 = \frac{4v}{2L}$	1
$= \frac{4(48)}{2(1.5)}$	1
= 64.0 Hz	1
Total	3

Question 8 **(5 marks)**

A WiFi router transmits at 5.00 GHz frequency which emits EMR waves that travel at the speed of light.

(a) Calculate the wavelength of the waves that the router produces.

(3 marks)

Description	Marks
$v = f\lambda;\ \therefore\ \lambda = \frac{v}{f}$	1
$= \frac{3.00 \times 10^8}{5.00 \times 10^9}$	1
= 0.0600 m	1
Total	3

Some routers can transmit on 'dual-band' meaning they can send the signal over a 5 GHz or a 2.4 GHz. The company that produces the router will advertise to the consumer that:

- 5 GHz can send data at a faster rate but might not reach all regions in your house.
- 2.4 GHz sends data at a slower rate but will reach further regions in your house.

(b) Comment on one property of the WiFi signal to explain one of the differences between the bands mentioned above.

(2 marks)

Description	Marks
As f increases, λ decreases so the 5 GHz band will have a lower wavelength This will cause less diffraction and some regions in the house will be in shadows,	1 1
As f increases, T decreases, so period of 5 GHz wave will be lower More data per second can be sent per second in a smaller period.	1 1
Total	2

Question 9 **(16 marks)**

One of the 63.5 cm long strings of an ordinary acoustic guitar is tuned to produce the note B_3 (frequency 245 Hz) when vibrating in its fundamental mode.

(a) Calculate the speed of transverse waves on this string.

(3 marks)\

Description	Marks
$f_n = \frac{nv}{2L}$, $nv = 2Lf$	1
= 2(0.635)(245)	1
= 311 ms^{-1}	1
Total	3

(b) The velocity of a wave on a string is proportional to the square root of the tension of the string (ie $v \propto \sqrt{T}$). If the tension of the string in part (a) is increased by 3.00%, show that the new velocity of the wave is 316 ms^{-1}.

(2 marks)

Description	Marks
$v_2 = \sqrt{1.03}\, v_1$ $= \sqrt{1.03} \times 311$ $= 315.63$	1
= 316 ms^{-1}	1
Total	2

(c) Calculate the new frequency of the wave on the string.

(3 marks)

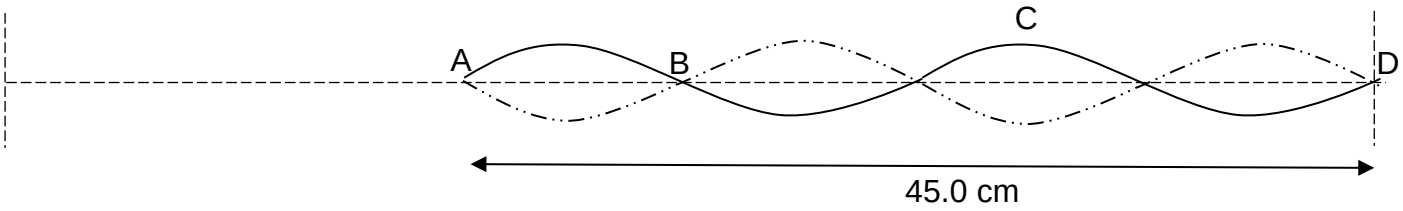
Description	Marks
$f_n = \frac{nv}{2L}$,	1
$= \frac{1(316)}{2(0.635)}$	1
= 249 Hz	1
Total	3

(d) The strings of a guitar are very narrow and only displace a small amount of air - this means they cannot produce a loud sound by themselves. To overcome this an acoustic guitar makes use of a sound box. Explain how the sound box of an acoustic guitar increases the volume of the sound produced.

(4 marks)

Description	Marks
String is attached to large acoustic box	1
Free vibration of the string causes forced vibration of the box	1
Box has a larger surface area and displaces more air particles.	1
Increasing the volume of the sound heard.	1
Total	4

The player then places their finger along the string, shortening the vibrating length of the string to 45.0 cm. They are able to set up the standing wave as shown below:



(e) With wave speed remaining at 316 ms^{-1}, Calculate the frequency of this wave.

(3 marks)

Description	Marks
$f_n = \frac{nv}{2L}$, $f_4 = \frac{4v}{2L}$	1
$=\frac{4(316)}{2(0.45)}$	1
= 1404 Hz = 1.40 kHz	1
Total	3

(f) State the name of the harmonic that has been set up on the standing wave.

(1 mark)

4th Harmonic

END OF TEST