Physics ATAR - Year 11

Waves
Unit Test
2018

Name: SOLUTIONS	Mark: / 50 = %

Time Allowed: 50 minutes

Notes to Students:

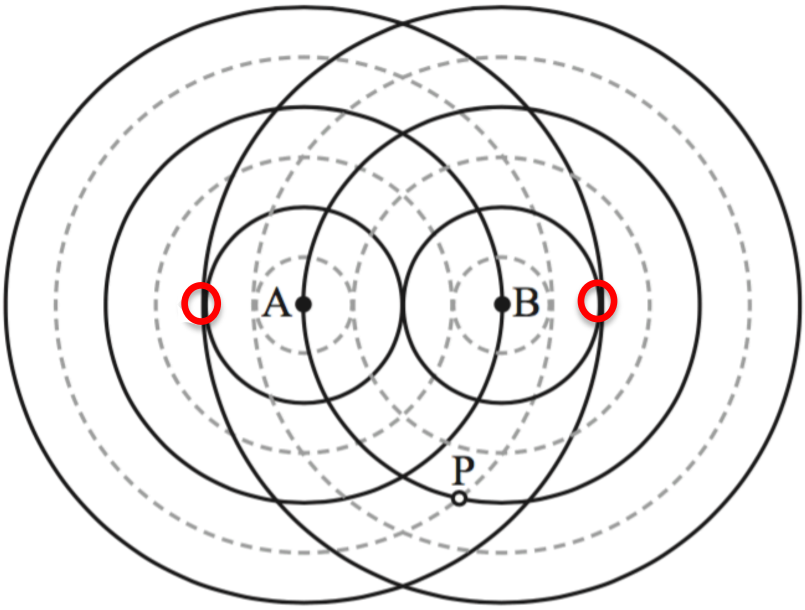
- You must include **all** working to be awarded full marks for a question.
- Marks will be deducted for incorrect or absent units and answers stated to an incorrect number of significant figures.
- **No** graphics calculators are permitted – scientific calculators only.

Additional Formulae

Path Difference	$n\lambda = \lvert L_1 - L_2 \rvert$
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 **(4 marks)**

Two in-phase point sources, A and B, generate waves as indicated in the diagram, in which the bold lines indicate crests and the dotted lines indicate troughs.



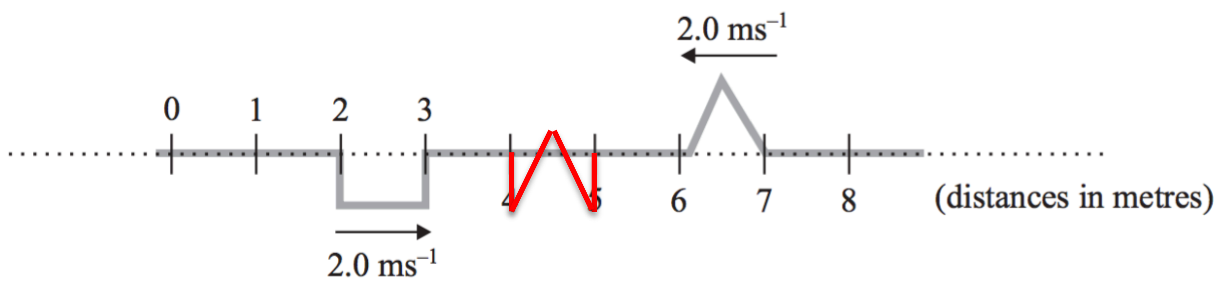
(a) Comment on the difference in path length between the lines AP and BP with reference to the wavelength of the waves and state the type of interference produced at point P.
(3 marks)

- The path length AP and BP are different
- by ½ a wavelength (AP = 2.5λ, BP = 2 λ)
- This will cause destructive interference to occur.

(b) On the diagram above, circle one region where constructive interference is produced due to a path difference of two wavelengths.
(1 mark)

Question 2 **(2 marks)**

The diagram below shows two wave forms with the same maximum amplitude travelling in opposite directions with speeds as indicated.

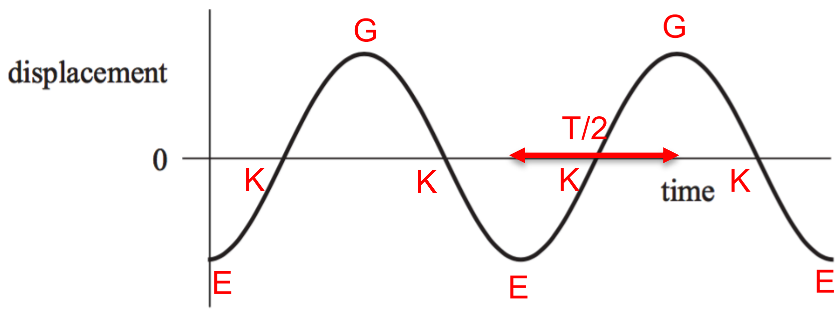


Use the principle of superposition to sketch the wave shapes 1.0 seconds after the time indicated on the graph.

1 mark: wave forms meeting in between 4 and 5 seconds
1 mark: correct superposition (4.5 cm peak **must be above** zero amplitude)

Question 3 **(4 marks)**

The diagram represents the vertical displacement for a mass on a spring as it moves through various displacements from its equilibrium position. Assume that vertical displacement from the rest position is positive.



(a) Indicate on the graph a point of maximum gravitational potential. Label this "**G**".

(b) Indicate on the graph a point of maximum elastic potential energy. Label this "**E**".

(c) Indicate on the graph a point of maximum kinetic energy. Label this "**K**".

(c) Indicate on the graph a point of half a period of oscillation by drawing an appropriate horizontal line labelled "**T/2**"

Question 4 **(4 marks)**

Water waves enter a shallower region where the wave speed slows down.

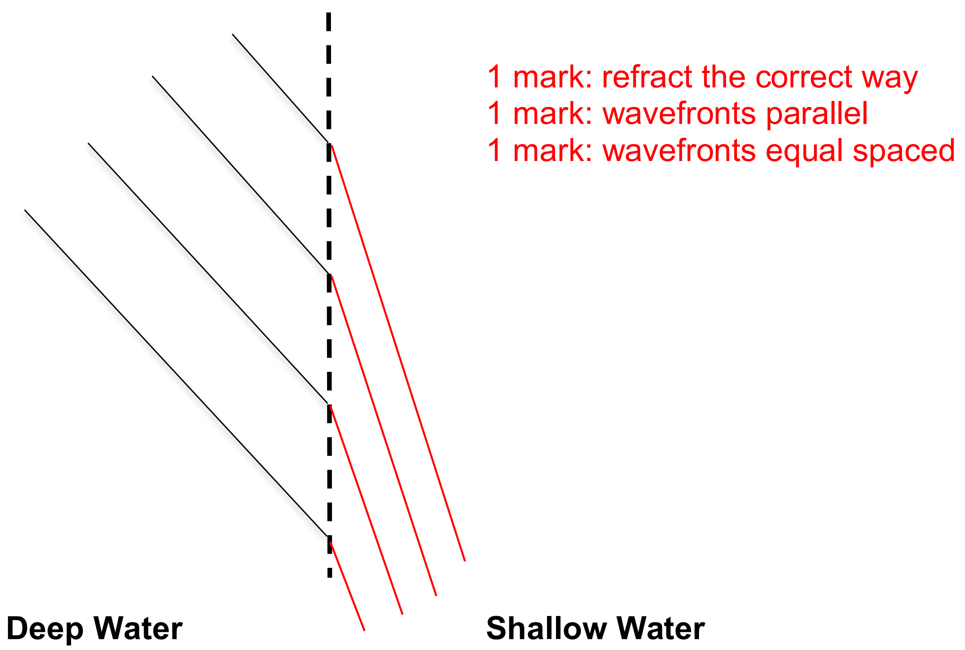
(a) Circle which of the following will occur

(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.

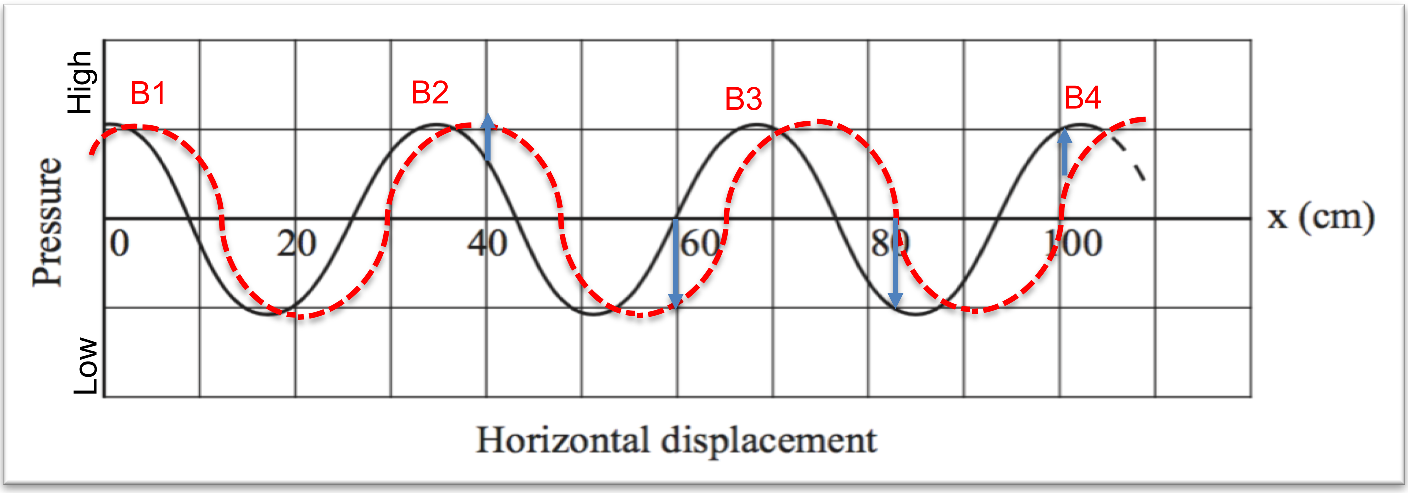
(b) Complete the following wave front diagram of the water waves as they enter shallow water.

(3 marks)



Question 5 **(7 marks)**

The diagram below represents a longitudinal pressure wave moving from left to right through air at a particular moment in time. The vertical axis shows pressure and the horizontal axis represents horizontal displacement from the source of the wave.



(a) For the displacements of 20, 40, 60, 80 and 100 cm, state at which points the pressure **is increasing**.

(2 marks)

40 cm and 80 cm

(b) On the graph, clearly identify three points where the pressure wave is in phase. Label these points as B1 B2 and B3.

(1 mark)

(b) If the wave speed is 342 ms^{-1}, calculate the frequency of the source. Show all working required.

(4 marks)

λ = 0.94 - 0.60
= 0.34 m
1

v = f λ
1

f = v/ λ

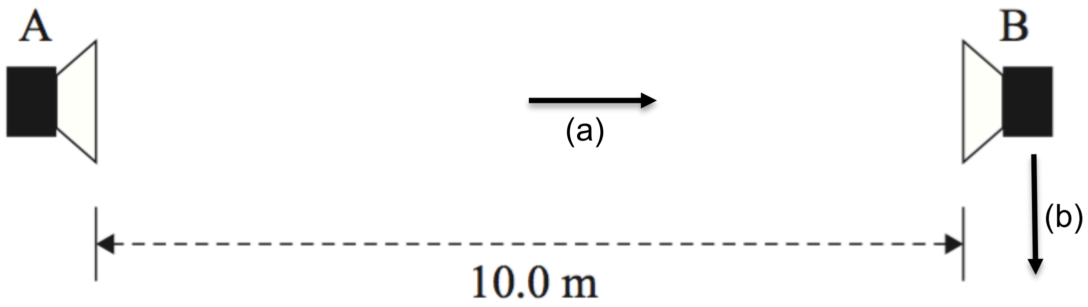
= 342 / 0.34
1

= 1005.8

= 1.0 x10^3 Hz
1

Question 6 **(8 marks)**

Holly sets up the following experiment in a large open area. She 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.



Holly stands in the centre, **equidistant** to speakers A and B as shown in the diagram. She then moves towards Speaker B and experiences a sequence of loud and quiet regions. She stops at the second region of quietness.

(a) Show, through an appropriate calculation, how far she is from speaker B at this second region of quietness.

(4 marks)

second region of destructive interference = $1.5\,\lambda$ 1

$LB + LA = 10$
$LA = 10 - LB$ 1

$1.5\,\lambda = LA - LB$

$= 10 - LB - LB$ 1

$1.50 = 10 - 2LB$ ½ $LB = 4.25$ m ½

Holly now stands at speaker B as shown by the arrow labelled (b) and begins to walk perpendicular to the two speakers.

(b) Calculate how far she must walk to hear the 3rd loud region.

(4 marks)

At B, n = 10
3rd region of interference from B = $2\,\lambda$, so n = 8 1

$L_1 - L_2 = 8$ $L_1 = 8 + L_2$ 1

$(8 + L_2)^2 - L_2^2 = 10^2$

$\cancel{L_2^2} + 16L_2 - \cancel{L_2^2} + 64 = 100$ 1

$16\,L_2 = 36$

$L_2 = 2.25$ m 1

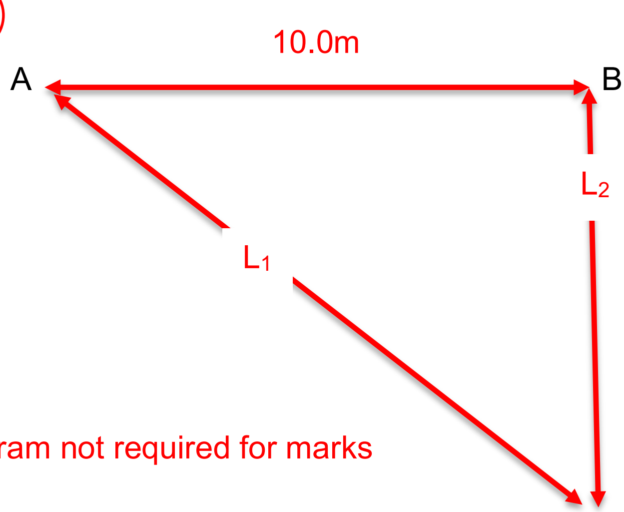


Diagram not required for marks

Question 7 **(8 marks)**

Roger is constructing and testing pipes for a pipe organ. The pipes can be considered to be uniform tubes open at one end and closed at the other. He needs to design a pipe to produce a fundamental frequency of 148 Hz.

(a) If the speed of sound in air is 342 ms^{-1}, calculate the length of pipe Roger needs to make. (3 marks)

$f_1 = 148$ Hz $\qquad f(n) = \frac{nv}{4L}$ 1

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

$= \frac{1(342)}{4(148)}$

$= 0.578$ m 1

Roger takes a speaker attached to a signal generator and notices that the pipe produces a loud tone when set at 148 Hz, confirming that he has constructed the correct length. He gradually increases the frequency produced by the speaker and observers another loud tone from the pipe at a certain frequency.

(b) Calculate this frequency. (2 marks)

Closed pipe – resonant frequencies at f_1, $3f_1$, $5f_1$, etc

$3f_1 = 3(148)$ 1

$= 444$ Hz 1

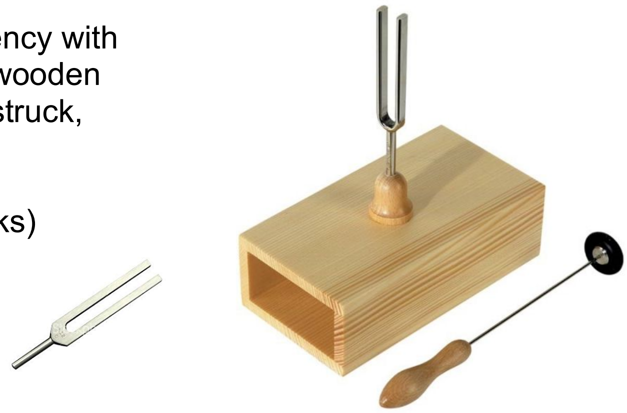
Alan comes along a week later and test the frequency of the pipe that Roger has made and finds that, even though the dimensions of the pipe have not changed, it is not producing the required frequency of 148 Hz.

(c) Provide a possible reason for this observation including an explanation. (3 mark)

- the temperature/pressure on the day could be different to when roger tested it
- the speed of sound increases as a function of temperature
- and since $f \propto v$, a change in v would cause a change in the fundamental frequency.

Question 8 **(8 marks)**

When a tuning fork is struck it oscillates at a set frequency with a low volume. When the tuning fork is connected to a wooden box similar to the one shown in the diagram and then struck, the same frequency is heard at a much louder volume.



(a) Explain this observation (3 marks)

- The tuning fork oscillates (driving frequency) at the same natural frequency of the wooden box.
- which causes the box to resonate.
- the larger surface area of the box displaces more are particles, hence a louder volume.

(b) State one other scenario where this phenomenon can be observed. (1 mark)

voice/throat, guitar, rubbing wine glass, acoustic guitar

(c) If the box has a length that corresponds to the first harmonic, calculate the optimum length of the box if the frequency of the tuning fork is 512 Hz and the speed of sound in air is measured to be 338 ms^{-1}

(3 marks)

$f_1 = 512$ Hz

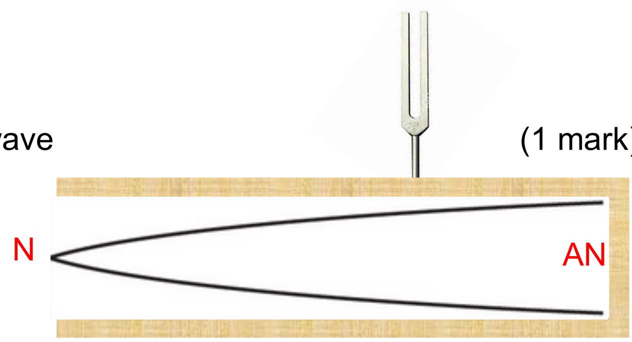
$$f(n) = \frac{nv}{4L} \quad 1$$

$$L = \frac{nv}{4f} \quad 1$$

$$= \frac{1(338)}{4(512)}$$

$$= 0.165 \text{ m} \quad 1$$

(d) On the diagram, draw in a **labelled** pressure wave envelope for the first harmonic. (1 mark)



Question 9 **(5 marks)**

A speaker is set up in an open area where the energy is allowed to spread out evenly and spherically. When a student is 2.50 m from the source, the intensity is measured to be 4.50×10^{-4} Wm^{-2}.

(a) Calculate the distance the student must be to measure an intensity of 17.0×10^{-4} Wm^{2}.

(3 marks)

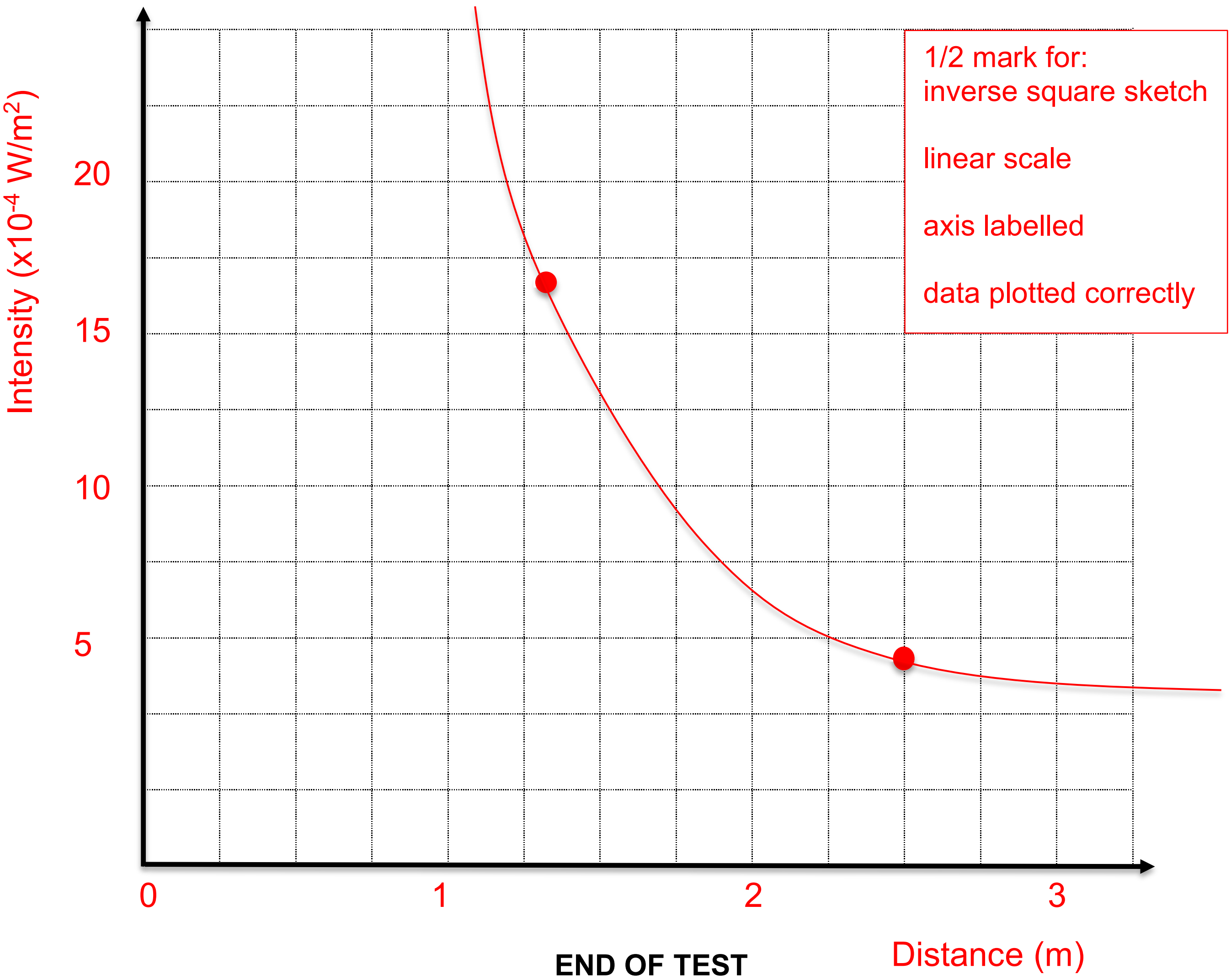
$$\frac{I_1}{I_2} = \frac{{r_2}^2}{{r_1}^2} \qquad {r_2}^2 = \frac{I_1 . {r_1}^2}{I_2} \quad 1$$

$${r_2}^2 = \frac{4.50 \times 10^{-4}(2.5^2)}{17.0 \times 10^{-4}} \quad 1$$

$${r_2}^2 = 1.65 \qquad r^2 = 1.29 \text{ m} \quad 1$$

(b) On the axis below, sketch the intensity of sound as a function of the student's distance from his initial position to final position.

(2 marks)



END OF TEST