Christ Church Grammar School

Science Department
Year 11 2021

# ATAR PHYSICS
# UNIT 2: WAVES
# TOPIC TEST - 2021

Student Name:

SOLUTIONS

Teacher: CJO JRM PCW
(Please circle)

**Time allowed for this paper**
Working time for paper: 50 minutes.

**Instructions to candidates:**

- You must include **all** working to be awarded full marks for a question.
- Answers should be expressed to three significant figures unless otherwise indicated.
- Marks may be deducted if diagrams are not drawn neatly with a ruler and to scale (if specified).
- Marks will be deducted for incorrect or absent units.
- **No** graphics calculators are permitted – scientific calculators only.

| Mark: | / 48 |
|---|---|
| = | % |

**Question 1** **(10 marks)**

Sounds travels through air at a speed of 341 m $s^{-1}$. An acoustic guitarist is plucking their string and making a note of middle C which has a frequency of 256 Hz.

(a) If the string is resonating at its second harmonic, and the length of the string is 1.12 m, calculate the speed of the wave on the string.

(4 marks)

| Description | Marks |
|---|---|
| λ = 1.12m – Must include some logic. | 1 |
| V = f λ | 1 |
| V = 256 x 1.12 | 1 |
| V = 287 $ms^{-1}$ | 1 |
| Total | 4 |

The guitarist realised that the note being played by the string is actually lower than middle C. They decide to alter the tension of the string to correct this issue.

(b) State which way the tension should be changed and explain your answer.

(3 marks)

| Description | Marks |
|---|---|
| Increase T | 1 |
| Increasing Tension, increases the restoring force of the pulse, accelerating it back to its equilibrium point, hence increasing the velocity along the string. | 1 |
| Increasing velocity will increase frequency as wavelength is constant | 1 |
| Total | 3 |

Later on, the guitarist is lost in thought about his guitar and decides to complete an experiment. They take a spare string and tie one end to the wall and pull the other end so it is tight. When they pluck the string, they note that pitch is the same as that from the guitar but they are unable to make a loud sound.

(c) Explain why the sound from the acoustic guitar is much louder.

(3 marks)

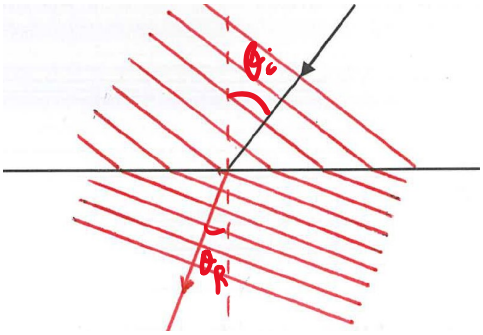
| Description | Marks |
|---|---|
| Vibration of string causes the rest of the guitar body to vibrate (forced vibration) | 1 |
| Vibration of guitar body causes more particles to vibrate and to a higher amplitude | 1 |
| This leads to a higher volume | 1 |
| Total | 3 |

**Question 2** **(11 marks)**

A student observes a ray of light traveling in air and approaching the surface of a body of water.

(a) Complete the diagram below, labelling all relevant aspects and angles and adding in wavefronts.

(4 marks)



| Description | Marks |
|---|---|
| Wavefronts in Air (perpendicular to rays) | 1 |
| Angles of incidence and refraction included | 1 |
| Normal drawn in | 1 |
| Ray correctly drawn and bends toward normal | 1 |
| Total | 4 |

(b) State the name of the phenomenon occurring in the diagram above and explain why this occurs.

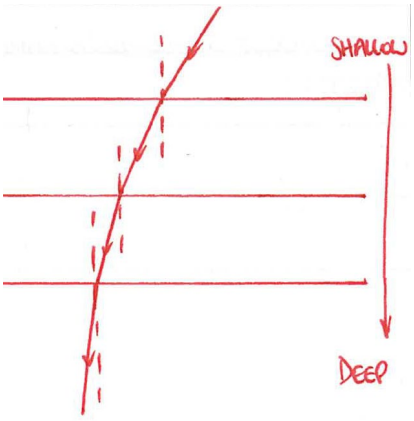
(3 marks)

| Description | Marks |
|---|---|
| Refraction | 1 |
| Speed of light is different in different materials (or discussion of Optical density) | 1 |
| Wave will bend because of the difference in speed | 1 |
| Total | 3 |

(c) When in deeper water, the temperature of the water decreases as depth increases. Light therefore travels more slowly the deeper it gets. With the aid of a ray diagram (not wave front), explain the shape of the light's trajectory as it moves from the surface into deeper water.

(4 marks)

| Description | Marks |
|---|---|
| Incident ray curves toward the normal | 1 |
| Overtime, ray bends more and more creating a curved trajectory | 1 |
| Diagram – Rays are shown, with arrows | 1 |
| Diagram – overall curve is shown | 1 |
| Total | 4 |



**Question 3** **(9 marks)**

A speaker is playing a consistent tone of 115 Hz. The audience listening were between 1.52 m and 6.24 m away from the speaker. The closest audience members were subject to a sound intensity of $8.86 \times 10^{-3}$ W m$^{-2}$. The temperature in the room is 25.0 ºC.

(a) Calculate the wavelength of the sound.

(2 marks)

| Description | Marks |
|---|---|
| V = f λ $\quad \lambda = \frac{v}{f}$ | 0.5 |
| $\lambda = \frac{346}{115}$ | 0.5 |
| λ = 3.01 m | 1 |
| Total | 2 |

(b) Calculate the minimum intensity of the sound for the audience members.

(4 marks)

| Description | Marks |
|---|---|
| $I = \frac{P}{A}$ or $I \propto \frac{1}{r^2}$ | 1 |
| $I_1 r_1^2 = I_2 r_2^2$ | 1 |
| $I_2 = \frac{8.86 \times 10^{-3} (1.52^2)}{6.24^2}$ | 1 |
| $5.26 \times 10^{-4}$ W m$^{-2}$ | 1 |
| Total | 4 |

(c) If a second speaker was included, playing the same note, state and explain where someone would need to stand to hear a quiet sound.

(3 marks)

| Description | Marks |
|---|---|
| Somewhere between the speakers where the path difference is half a wavelength | 1 |
| At this location, destructive interference occurs | 1 |
| This leads to a lower amplitude/ quiet sound | 1 |
| Total | 3 |

**Question 4** **(7 marks)**

A person is walking down a street and can hear a noisy truck but cannot see it as it is behind a building. Once the truck appears from behind the building, the pitch of the sound from the truck changes.

(a) State how the sound would change and explain why this occurs.

(4 marks)

| Description | Marks |
|---|---|
| Higher frequencies would be heard when it becomes visible | 1 |
| These frequencies do not diffract well as their wavelength is low | 1 |
| and would not have reached the observer from behind the building | 1 |
| Low frequencies remain the same as they diffract well | 1 |
| Total | 4 |

Simultaneously, the truck driver is concentrating on their rear-view mirror. They notice that when the truck's motor is at a particular rotational frequency, the mirror shakes violently.

(b) State this phenomenon and explain why this occurs.

(3 marks)

| Description | Marks |
|---|---|
| Resonance | 1 |
| The motor's driving frequency is the same as the natural frequency of the mirror | 1 |
| This results in favourable energy transfer and large amplitudes of oscillation | 1 |
| Total | |

**Question 5** **(4 marks)**

Geoff, a videographer, is reviewing some footage taken during a war. The camera was situated a large distance away from a cannon and filmed it firing. Geoff notes that there is a 4.38 second delay between the cannon firing and the sound reaching the camera. He uses the rule of thumb that the distance in kilometres is one third of the time taken in seconds.

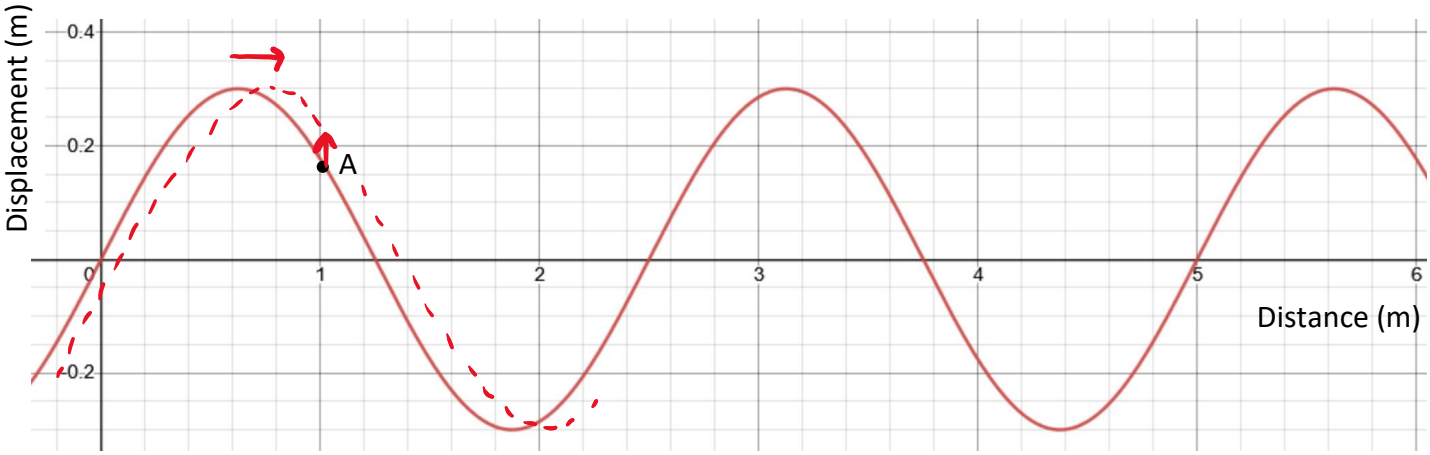
(a) Calculate the percentage error of Geoff's estimate. Assume speed of sound is 342 m $s^{-1}$.

(4 marks)

| Description | Marks |
|---|---|
| Estimated distance = $\frac{4.38}{3}$ = 1.46 km | 1 |
| Actual = vt = 342 x 4.38 = 1.50 km | 1 |
| Percentage error = $\frac{measured-accepted}{accepted} \times 100$ | 1 |
| Percentage error = $\frac{1.46-1.50}{1.50} \times 100$ = -2.67% | 1 |
| Total | 4 |

**Question 6** **(7 marks)**

The graph below shows a wave on the surface of the ocean, moving from left to right.




(a) State the amplitude and wavelength of the wave. State answers to 2 significant figures.

(2 marks)

| Description | Marks |
|---|---|
| Amplitude = 0.30 m | 1 |
| Wavelength = 2.5 m | 1 |
| Total | 2 |

(b) On the graph, indicate the direction of the particles velocity at point A.

(1 marks)

| Description | Marks |
|---|---|
| Arrow pointing upwards | 1 |
| Total | 1 |

An observer of this wave starts a timer when he notices the first crest goes past him and stops the timer at the 4th crest. The time shown is 10.2 seconds.

(c) Calculate the speed of the wave.

(4 marks)

| Description | Marks |
|---|---|
| 3T = 10.2 s, T = 3.4 s | 1 |
| $f = \frac{1}{T} = \frac{1}{3.4}$ = 0.294 Hz | 1 |
| V = f λ = 0.294 x 2.5 | 1 |
| V = 0.735 m $s^{-1}$ | 1 |
| Total | 4 |

**END OF TEST**