PHYSICS

Stage 6

Module 3: Waves and Thermodynamics

Wave Properties and Behaviour

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Exam Equivalent Time: 46.5 minutes *(based on allocation of 1.5 minutes per mark)*

Questions

1. PHYSICS, M3 2022 VCE 11 MC

Which one of the following statements best describes transverse and longitudinal waves?

A. Both transverse waves and longitudinal waves travel in a direction parallel to their vibrations.

B. Both transverse waves and longitudinal waves travel in a direction perpendicular to their vibrations.

C. Transverse waves travel in a direction perpendicular to their vibrations; longitudinal waves travel parallel to their vibrations.

D. Transverse waves travel in a direction parallel to their vibrations; longitudinal waves travel perpendicular to their vibrations.

2. PHYSICS, M3 2023 VCE 13 MC

A physics student hears a clap of thunder shortly after observing a flash of lightning.

Which one of the following statements best describes the sound associated with the clap of thunder and the visible light associated with the flash of lightning?

A. Both the sound and the visible light are examples of transverse waves.

B. Both the sound and the visible light are examples of longitudinal waves.

C. Sound is an example of a transverse wave and visible light is an example of a longitudinal wave.

D. Sound is an example of a longitudinal wave and visible light is an example of a transverse wave.

3. PHYSICS, M3 2023 VCE 16 MC

Water waves travelling at constant speed and hitting a barrier can change direction, as shown in the diagram below.

Which one of the following best identifies this phenomenon?

A. diffraction

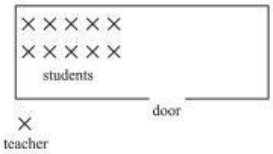
B. dispersion

C. refraction

D. resonance

4. PHYSICS, M3 2017 VCE 14 MC

A teacher stands in the corridor at a short distance from the open door of her classroom, as shown in the diagram below. She can hear her students. but cannot see them.



Which one of the following best explains why the teacher can hear her students?

A. The speed of sound is much greater than the speed of light.

B. The speed of sound is comparable with the speed of light.

C. Sound diffracts because the wavelength of sound is much smaller than the width of the door.

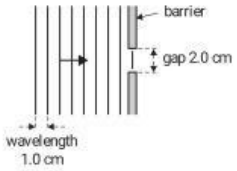
D. Sound diffracts because the wavelength of sound is comparable with the width of the door.

5. PHYSICS, M3 2020 VCE 14 MC

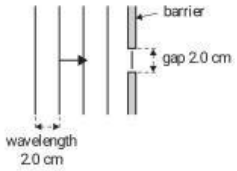
Students are investigating the diffraction of waves using a ripple tank. Water waves are directed towards barriers with gaps of different sizes, as shown below.

In which one of the following would the greatest diffraction effects be observed?

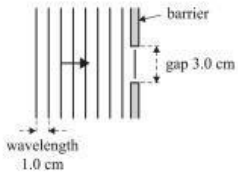
A.



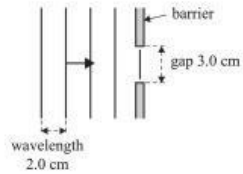
B.



C.



D.



6. PHYSICS, M3 2017 HSC 21a

A laser emits light of wavelength 550 nm. ($v = 3 \times 10^8$ ms^{-1})

Calculate the frequency of this light. ***(2 marks)***

7. PHYSICS, M3 2022 VCE 16

A small sodium lamp, emitting light of wavelength 589 nm, is viewed at night through two windows from across a street. The glass of one window has a fine steel mesh covering it and the other window is open, as shown in Figure 18. Assume that the sodium lamp is a point source at a distance.

A Physics student is surprised to see a pattern formed by the light passing through the steel mesh but no pattern for the light passing through the open window. She takes a photograph of the observed pattern to show her teacher, who assures her that it is a diffraction pattern.

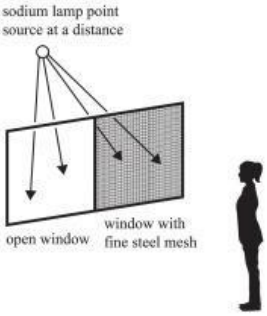


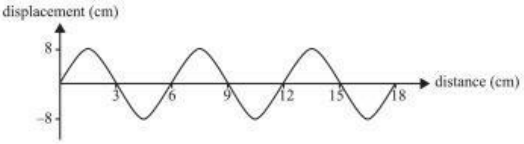
Figure 18

a. State the condition that the fine steel mesh must satisfy for a diffraction pattern to form. ***(1 mark)***

b. Explain why the condition stated in part a. does not apply to the open window. ***(2 marks)***

8. PHYSICS, M3 2021 VCE 13

The diagram below shows part of a travelling wave.



The wave propagates with a speed of 18 ms^{-1}.

What is the amplitude and frequency of the wave? ***(2 marks)***

9. PHYSICS, M3 2022 VCE 13*

A travelling wave produced at point **A** is reflected at point **B** to produce a standing wave on a rope, as represented in the diagram below.

The distance between points **A** and **B** is 2.4 m. The period of vibration of the standing wave is 1.6 s.

Find the speed of the travelling wave along the rope in metres per second. ***(2 marks)***

10. PHYSICS, M3 2017 VCE 16

Standing waves are formed on a string of length 4.0 m that is fixed at both ends. The speed of the waves is 240 m s^{-1}.

a. Calculate the wavelength of the lowest frequency resonance. ***(2 marks)***

b. Calculate the frequency of the second-lowest frequency resonance. ***(2 marks)***

c. Explain the physics of how standing waves are formed on the string. Include a diagram in your response. ***(3 marks)***

11. PHYSICS, M3 2023 VCE 11

A guitar string of length 0.75 m and fixed at both ends is plucked and a standing wave is produced. The envelope of the standing wave is shown in Figure 13.

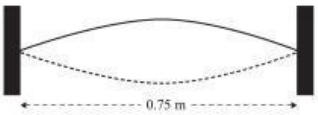


Figure 13

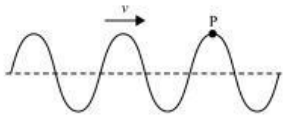
The speed of the wave along the string is 393 m s^{-1}.

a. What is the frequency of the wave? ***(1 mark)***

b. Describe how the standing wave is produced on the string fixed at both ends. ***(2 marks)***

12. PHYSICS, M3 2019 VCE 12

A sinusoidal wave of wavelength 1.40 m is travelling along a stretched string with constant speed v, as shown in the figure below. The time taken for point **P** on the string to move from maximum displacement to zero is 0.120 s.



Calculate the speed of the wave, v. Give your answer correct to three significant figures. Show your working. ***(3 marks)***

13. PHYSICS, M3 2018 VCE 11

Figure 13 shows two speakers, **A** and **B**, facing each other. The speakers are connected to the same signal generator/amplifier and the speakers are simultaneously producing the same 340 Hz sound.

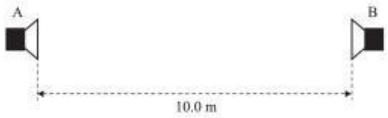


Figure 13

Take the speed of sound to be 340 ms^{-1}.

a. Calculate the wavelength of the sound. ***(1 mark)***

b. A student stands in the centre, equidistant from speakers **A** and **B**. He then moves towards speaker **B** and experiences a sequence of loud and quiet regions. He stops at the second region of quietness.

How far has the student moved from the centre? Explain your reasoning. ***(3 marks)***

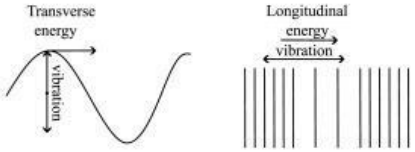
Worked Solutions

Worked Solutions

1. PHYSICS, M3 2022 VCE 11 MC

→ The energy transfer through transverse waves is perpendicular to the direction of vibrations.

→ The energy transfer through longitudinal waves is parallel to the direction of vibrations.



$\Rightarrow C$

2. PHYSICS, M3 2023 VCE 13 MC

→ Sound is a longitudinal wave where the particles travel parallel to the direction of motion and require a medium.

→ Light is a transverse wave of alternating electric and magnetic fields and therefore doesn't require a medium.

$\Rightarrow D$

3. PHYSICS, M3 2023 VCE 16 MC

→ Diffraction is the phenomena that can describe when waves bend around a corner after they pass a barrier, as can be observed in the diagram.

$\Rightarrow A$

4. PHYSICS, M3 2017 VCE 14 MC

→ Sound waves can range anywhere from 20mm to 17m and thus the some sounds made by the students would have a wavelength of 1 metre.

→ Therefore, sound will diffract through the doorway as it is the same order of magnitude of the size of the door whereas light will not as its wavelengths are much smaller in size.

$\Rightarrow D$

5. PHYSICS, M3 2020 VCE 14 MC

→ The greatest diffraction patterns are observed when the wavelength is the same size as the slit through which the wave passes.

$\Rightarrow B$

6. PHYSICS, M3 2017 HSC 21a

$$v = f\lambda$$

$$f = \frac{v}{\lambda}$$

$$f = \frac{3 \times 10^{8}}{550 \times 10^{-9}}$$

$$f = 5.45 \times 10^{14} \text{ Hz}$$

7. PHYSICS, M3 2022 VCE 16

a. Condition to satisfy:

→ The size of the gaps from the fine steel mesh must be of the same order of magnitude of the wavelengths of the light from the sodium lamp.

♦ Mean mark (b) 40%.

b. Open window differences:

→ The width of the window is significantly greater than wavelength of the light from the sodium lamp and the width of the glass molecules that make up the glass window is significantly smaller than the light from the sodium lamp.

→ These widths contrast greatly to the size of the steel mesh and are not of the same order of magnitude of the light from the sodium lamp, hence no diffraction will occur.

8. PHYSICS, M3 2021 VCE 13

→ Amplitude: the distance from the centre line to maximum displacement.

→ Amplitude = 8 cm.

→ Frequency: can be determined using $f = \frac{v}{\lambda}$, (wavelength must be in metres)

$$f = \frac{v}{\lambda} = \frac{18}{0.06} = 300 \text{ Hz}$$

9. PHYSICS, M3 2022 VCE 13*

$\rightarrow \lambda = 1.2 \text{ m}$

$\rightarrow f = \frac{1}{T} = \frac{1}{1.6} = 0.625$

$v = f\lambda$

$= 0.625 \times 1.2$

$= 0.75 \text{ ms}^{-1}$

10. PHYSICS, M3 2017 VCE 16

a. Lowest frequency resonance:

→ Occurs at the maximum wavelength. The maximum wavelength is 8 metres since the half wavelength is the length of the string (4m).

$$f = \frac{v}{\lambda} = \frac{240}{8} = 30 \text{ Hz}$$

b. When $\lambda = 4$:

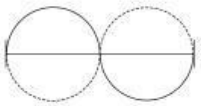
$$f = \frac{v}{\lambda} = \frac{240}{4} = 60 \text{ Hz}$$

c. Standing waves:

♦ Mean mark (c) 43%.

→ Produced when a wave travels down a string and is reflected back on itself such that the superposition of the two waves produce an interference pattern to form a standing wave.

→ The two waves must be travelling in opposite directions with the same frequency, wavelength and amplitude.



11. PHYSICS, M3 2023 VCE 11

a. $f = \frac{v}{\lambda} = \frac{393}{1.5} = 262 \text{ Hz}$

b. Standing wave:

♦ Mean mark (b) 47%.

→ When waves encounter fixed ends, they reflect.

→ If the string's length is a multiple of half the wavelength, the reflected wave combines with the original wave, resulting in interference that forms a standing wave pattern

12. PHYSICS, M3 2019 VCE 12

♦ Mean mark 50%.

→ Using $v = f\lambda$ and $f = \frac{1}{T}$:

$$\begin{aligned} v &= \frac{\lambda}{T} \\ &= \frac{1.4}{4 \times 0.120} \\ &= 2.92 \text{ ms}^{-1} \end{aligned}$$

13. PHYSICS, M3 2018 VCE 11

a. $\lambda = \frac{v}{f} = \frac{340}{340} = 1 \text{ m}$

♦♦♦ Mean mark (b) 20%.

b. → At the centre of the speakers, there is an area of relative loudness

→ This is due to a path difference of 0 metres between the wavelengths of sounds coming from both speaker **A** and speaker **B**.

→ As the student moves towards speaker **B**, the two sound waves will experience constructive and destructive interference.

→ The peak of speaker **A** will move into the trough of speaker **B** where he experiences the first region of quietness (node) which is 1 quarter wavelength (0.25m) from the centre.

→ The second region of quietness (node) will be half of a wavelength (0.5m) from the first region of quietness. Thus, the total distance from the centre to the second region of quietness is 0.75m.