Checkpoints Chapter 15 Wave basics.

Multiple choice questions

Question 1

In a transverse wave the vibrations are perpendicular to the movement of the wave, and in a longitudinal wave the vibrations are parallel to the movement of the wave.

∴ **B, C** **(ANS)**

Question 2

Wave motion is typically identified as the movement of energy from one place to another without the movement of matter. Wave motion is also typically classified as vibrations.

∴ **C** **(ANS)**

Question 3

The amplitude of the wave is the maximum variation from the rest position.

∴ **D** **(ANS)**

Question 4

The wavelength is defined as the distance between adjacent identical points on the disturbance.

∴ **C, E** **(ANS)**

Question 5

The frequency of the wave is the number of cycles per second. Mathematically it is given by

$f = \frac{1}{T}$ where T is the period.

∴ **C** **(ANS)**

Question 6

A compression is represented by the wave fronts being closest together.

∴ **C** **(ANS)**

Question 7

A rarefaction is represented by the wave fronts being apart as far as possible.

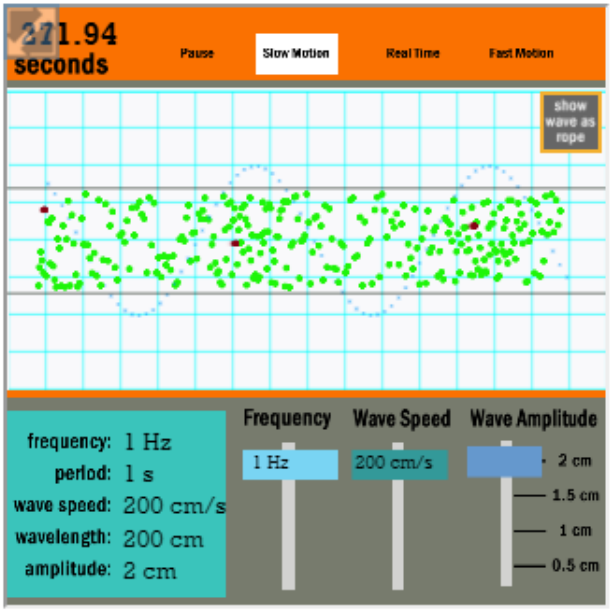
∴ **A** **(ANS)**

Question 8

The particles in the middle of the compression are travelling at the maximum speed. Have a look at the animation below. Look at the motion of an individual particle.
http://www.physicsclassroom.com/Physics-Interactives/Waves-and-Sound/Simple-Wave-Simulator/Simple-Wave-Simulator-Interactive

Look at the motion of a red dot to confirm this answer.

∴ **C** **(ANS)**



Question 9

The particles in the centre of the rarefaction are travelling to the left at their maximum speed. (See answer for Question 8)

∴ **A** **(ANS)**

Question 10

We should remember from Year 11 heat that the air particles are vibrating. The loudspeaker adds a longitudinal wave to this motion. To do this the loudspeaker cone needs to move backwards and forwards at the frequency of the sound it is transmitting.

∴ **D** **(ANS)**

Question 11

Loudness is a measure of the amplitude of the pressure variations in the air, and pitch is a measure of the frequency of the sound.

∴ **D** **(ANS)**

Question 12

A transverse wave is where the motion of the particles is perpendicular to the direction the wave travels in.

∴ **D** **(ANS)**

Question 13

If the wave is in exactly the same position, then 24 seconds is a multiple of the period T.

∴ **A** **(ANS)**

As the wave has completed two cycles in the 24 seconds.

Question 14

The relationship between v, f and λ, is given by $v = f \times \lambda$.

If 'f' doubles then λ must halve, as the speed remains constant.

∴ **C** **(ANS)**

Question 15

The Doppler effect is caused by the movement of the source. This movement means that the wavelengths in front of the source decrease and those behind the source increase. The speed of the waves remains the same in all directions.

∴ **D** **(ANS)**

Question 16

The Doppler effect caused by a moving detector (as distinct to a moving source) is due to the shortening of the apparent wavelength as the detector moves towards the source. As the speed of the waves remain constant the wavelengths detected by the detector are smaller as the detector moves towards the source. This in an increase in the frequency of the wave.

∴ **A** **(ANS)**

Question 17

The Doppler effect can be detected in all mechanical waves.

∴ **A** **(ANS)**

Question 18

How the moving surface of the baby's heart receives and reflects the signal depends on the movement of the heart.

∴ **D** **(ANS)**

Question 19

If the distance between the source and the receiver is decreasing then the received frequency will less than the emitted frequency. It doesn't make any difference if the source is moving towards the receiver or the receiver is moving towards the source.

∴ **D** **(ANS)**

Question 20

Sound waves are longitudinal waves.

∴ **B** **(ANS)**

Question 21

Sound waves need a medium to travel through.

∴ **D** **(ANS)**

Question 22

Electromagnetic radiation carries energy at the speed of light. EM radiation does not have any mass and it does not need a medium for transmission.

∴ **C** **(ANS)**

Question 23

The sound source is stationary with respect to Benita, so she will always hear 400 Hz.
The sound source is moving towards Jemima, so she will hear an increased frequency as Benita's car approaches her. Ted will also hear and increased frequency as Benita approaches him. Ted will hear a greater frequency than Jemima, because not only is Benita moving towards him, he is moving towards her, therefore the effective wavelength will be shorter than what Jemima is hearing.

∴ **A** **(ANS)**

Question 24

In light, the electric field and the magnetic field are always perpendicular to each other. The polariser only allows the electric field to be in one direction, therefore the associated magnetic field is also only in one direction.

∴ **C, D** **(ANS)**

Question 25

Plane polarisation is when the electric field is only allowed to continue in one plane. This only applies to light because it is a transverse wave.

∴ **A** **(ANS)**

Question 26

Sound is a longitudinal wave, the air particles vibrate about their mean position as the energy is transferred.

∴ **C** **(ANS)**

Question 27

As the car comes towards her the distance between successive compressions decreases, so Lee hears this as a higher frequency. As the car moves away from her the distance between successive compressions increases, so Lee hears this as a lower frequency.

∴ **A** **(ANS)**

Extended questions

Question 28a

The particles are the parts that move, typically they could be either the arms or the bodies of the people as they join in.

Question 28b

The people will move up and down, and the wave travels sideways, therefore transverse.

Question 28c

This could only be done if there happened to be more than one crest occurring at the same time, then measure the distance between adjacent crests. Typically, this doesn't happen.

Question 28d

I think that this is pushing the analogy much too far. The period is the time until a crest becomes a crest again.

Question 28e

Somehow, you would either use $v = f \times \lambda$ or use $v = \frac{x}{T}$, both of these are quite impractical.

Question 29a

The horizontal distance between A & B is $\frac{1}{2}\lambda$. Since λ = 6.0 mm, the distance between

A and B = 3 mm **(ANS)**

Question 29b

The amplitude is 46 mm, the vertical distance between A and B is twice this.

∴ **92 mm** **(ANS)**

Question 29c

You need information from 28d to answer this question.
Assume that it takes 2.0 s for the first time that B gets to the position of A. This means that the period of the wave will be twice this time, so that returns to its original position.

∴ **T = 4.0 s.**

Use $f = \frac{1}{T}$ to get **f = 0.25 Hz. (ANS)**

Question 29d

Use $v = f \times \lambda$ to get

$v = 0.25 \times 6.0$

∴ **v = 1.5 mm/s** **(ANS)**

Question 30a

Use $v = f \times \lambda$ to get

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

$\therefore f = \frac{340}{7.5 \times 10^{-3}}$

$\therefore f = 45{,}333$

∴ **f = 4.5 × 10^4 Hz** **(ANS)**

Question 30b

Use $v = f \times \lambda$ to get

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

$$\therefore f = \frac{4}{20 \times 10^{-2}}$$

$\therefore$ f = 20 Hz (ANS)

The answer in the back of the book has incorrect units.

Question 30c

Use $v = f \times \lambda$ to get

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

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

$\therefore$ f = 5.5 × 10^{14} Hz (ANS)

Question 31

A common transverse wave that moves energy around is radiation from the Sun. The energy is carried on the EM radiation from the Sun and when it is (partially) absorbed by objects on the Earth, the objects warm up through increased kinetic motion of the atoms in the object.

Question 32

Sound is the most common occurrence of longitudinal waves. The dulcet tones from the speaker in your classroom cause pressure variations which travel through the air at 340 m s^{-1}. These pressure variations cause the eardrum to move which transmits this to the brain, where it is interpreted as sound.

Question 33a

The amplitude is one half of the peak to peak value.

$\therefore$ 1.5 m (ANS)

Question 33b

The wavelength is the length from any spot on the waveform to the next identical spot. Therefore 14 m represents two wavelengths.

$\therefore$ 12 m (ANS)

Question 33c

There are two crests every 15 seconds.

$\therefore$ T = 7.5

Use $f = \frac{1}{T}$

$$\therefore f = \frac{1}{7.5}$$

$\therefore$ f = 0.13 Hz (ANS)

Question 33d

$\therefore$ T = 7.5 s (ANS)

Question 33e

Use $v = f \times \lambda$,

$\therefore$ $v = 0.13 \times 12$

$\therefore$ v = 1.6 m s^{-1} (ANS)

Alternatively

Use $v = \frac{d}{t}$, $\therefore v = \frac{24}{15}$

$\therefore$ v = 1.6 m s^{-1} (ANS)

Question 34

Use $v = f \times \lambda$, where λ = 5 m.

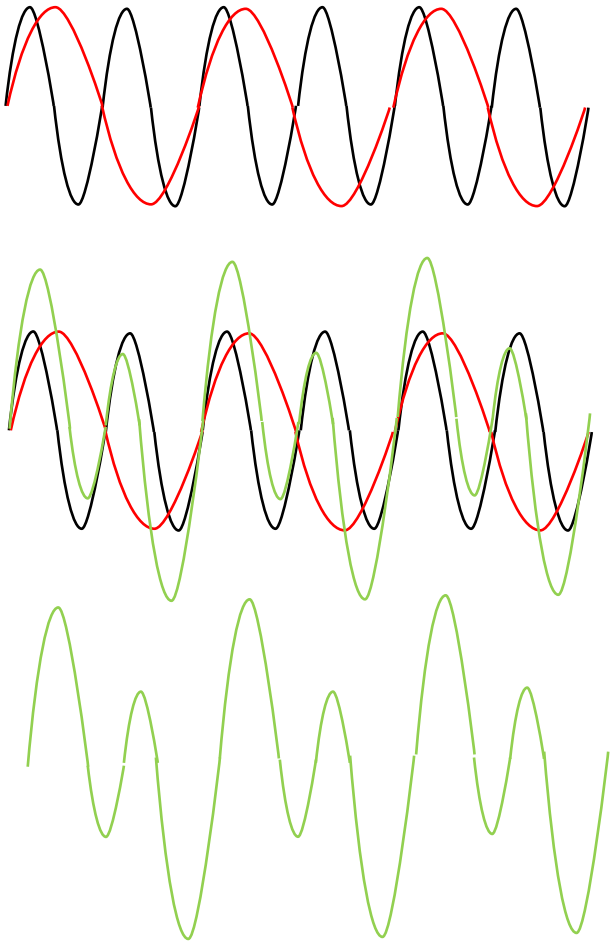
$\therefore$ $343 = f \times 5$

$\therefore$ f = 68.6

$\therefore$ f = 69 Hz (ANS)

Question 35

The addition of these two waves is given by the vector addition of the points on the two curves.



Question 36a

A rarefaction is when the air pressure is below atmospheric pressure. It is the troughs on this graph.

∴ **3 rarefactions (ANS)**

Question 36b

The period is the time is takes for the wave to repeat itself. The waveform is 3 wavelengths over 12 ms.

∴ **4 ms (ANS)**

Question 36c

Use $f = \frac{1}{T}$

$\therefore f = \frac{1}{4.0 \times 10^{-3}}$

∴ **f = 250 Hz (ANS)**

Question 36d

Use v = f × λ,

∴ 335 = 250 × λ

∴ **λ = 1.34 m (ANS)**

Question 37

If the echo reaches her 2.9 seconds, then the sound of the cracker has travelled to the cliff face and back (a total distance of 1000 m) in 2.9 sec.

Use $v = \frac{d}{t}$,

$\therefore v = \frac{1000}{2.9}$

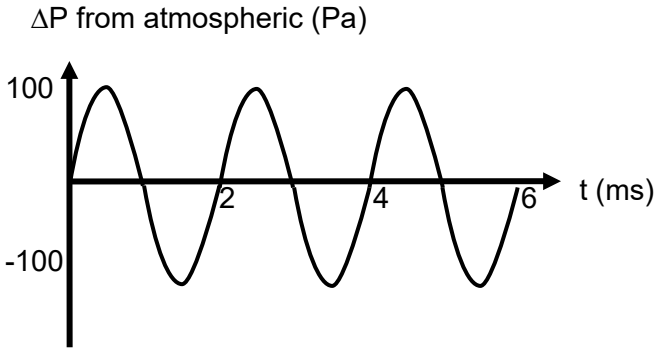
∴ **v = 345 m s^{-1} (ANS)**

(Check that your answer is physically possible).

Question 38

The sound of the clap will reflect from the vertical faces of the steps back to the tourist. As they are not the same distance the reflections will be heard as a series of echoes, pretty closely spaced.

Question 39



Question 40

Polarisation is the process where direction of oscillation of the electric fields are restricted to one plane. This is only possible with a transverse wave.

Question 41

Use $v = \frac{d}{t}$, to get $t = \frac{d}{v}$

$\therefore t = \frac{2.5 \times 10^{25}}{3 \times 10^{8}}$

$\therefore t = 8.3 \times 10^{16}$ s

Then use 86400 s in a day, and on average 365.25 days in a year.

$\therefore t = \frac{8.3 \times 10^{16}}{365.25 \times 86400}$

$\therefore$ t = 2.6 × 10^9 years (ANS)

Question 42

The two pulses are travelling towards each other. When they meet the disturbance is the result of the vector addition of the two individual pulse displacements. This is called superposition. The two pulses continue after this interaction as if nothing had happened.

Question 43

If you consider the vertical displacement as a vector, it shows that A is the sum of B and C.

$\therefore$ A (ANS)

Question 44a

The speed of the waves is the same in all directions, because it is determined by the medium the sound is travelling through.
If the source was stationary the wave fronts would be symmetrical about the origin of the sound. As the source is moving to the right, the wavefronts approaching the stationary observer have a reduced wavelength, therefore an increased frequency.

Question 44b

If the observer was to stand to the left of the moving source, the distance between adjacent crests would have increased. This mean that the observer would hear a lower frequency.

Question 44c

The speed of the waves is the same in all directions, because it is determined by the medium the sound is travelling through.
If observer A is moving towards the stationary source of the sound, they will encounter "crests" (that are moving towards them) closer together than if they were stationary. This means that they would hear this as an increase in the frequency of the sound.

For observer B, the crests and the observer are travelling in the same direction, therefore the observer will encounter the crests further apart than if they were stationary. This means that they would hear this as decrease in the frequency of the sound.

Question 44d

Observer A hears the sound at a higher frequency that what the source is emitting. Observer B hear the sound at a lower frequency than what the source is emitting. The change is the same size for both observers, except it goes up for observer A and down (by the same amount) for observer B.

Question 45

The amplitude of the wave is the distance from undisturbed position to the maximum. If the ground is measured travelling up 20 cm, that is from the bottom of the trough to the top of the crest, which is twice the amplitude of the wave.

$\therefore$ 10 cm (ANS)

The frequency is $f = \frac{1}{T}$,

$\therefore f = \frac{1}{4.0}$

$\therefore$ f = 0.25 Hz (ANS)

Use v = f × λ,

$\therefore$ 3.0 × 10^3 = 0.25 × λ

$\therefore$ λ = 1.2 × 10^4

$\therefore$ λ = 12 km (ANS)

Question 46

Sound waves can travel in 3 dimensions.
Waves in a guitar string travel only in 1 dimension
Microwaves can travel in 3 dimensions.
Both ripples in a pond, and waves on the surface of a drum will travel in 2 dimensions.

Question 47

Use $v = f \times \lambda$,

$\therefore\ 350 = 500 \times \lambda$

$\therefore \lambda = 70$ cm (ANS)

Question 48a

Use $v = f \times \lambda$,

$\therefore\ 340 = 440 \times \lambda$

$\therefore \lambda = 0.77$ m (ANS)

Question 48b

Use $v = f \times \lambda$,

$\therefore\ 3 \times 10^8 = 3 \times 10^9 \times \lambda$

$\therefore \lambda = 0.1$ m (ANS)

Question 48c

Use $v = f \times \lambda$,

$\therefore\ 1.5 = 2 \times \lambda$

$\therefore \lambda = 0.75$ m (ANS)

Question 49

Use $v = f \times \lambda$,

$\therefore\ 340 = 680 \times \lambda$

$\therefore \lambda = 50$ cm (ANS)
