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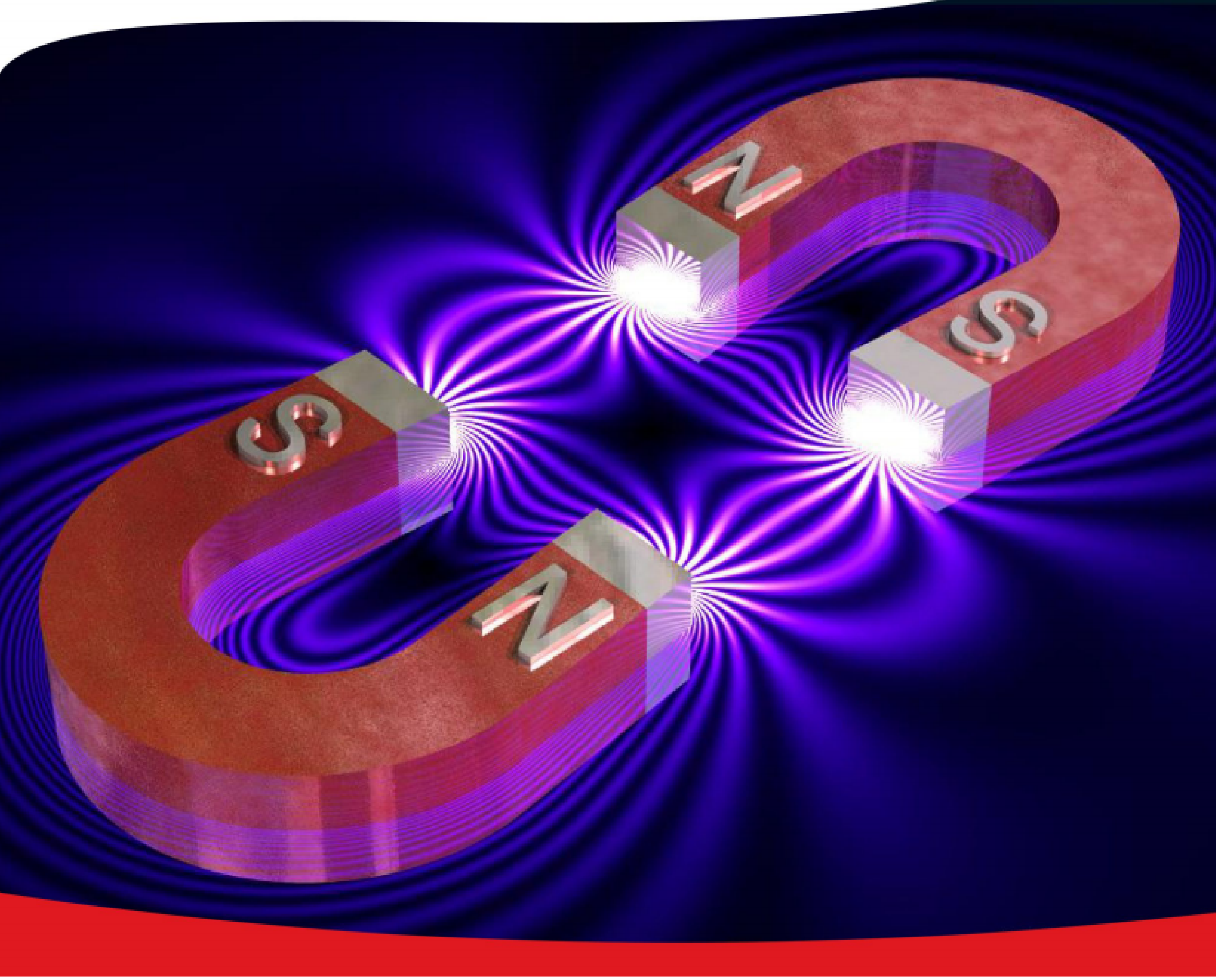
Cambridge International AS & A Level

PHYSICS (9702) P2

TOPIC WISE QUESTIONS + ANSWERS | COMPLETE SYLLABUS



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Chapter 8

Waves

8.1 Progressive waves

129. 9702_w20_qp_21 Q: 5

A progressive wave Y passes a point P. The variation with time t of the displacement x for the wave at P is shown in Fig. 5.1.

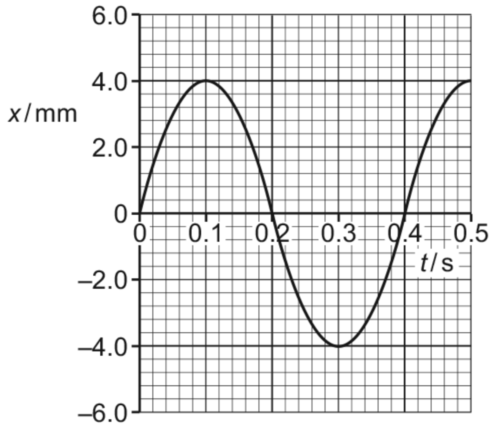

Fig. 5.1

The wave has a wavelength of 8.0 cm.

(a) Determine the speed of the wave.

speed = ... m s^{-1} [2]

(b) A second wave Z has wavelength 8.0 cm and amplitude 2.0 mm at point P. Waves Y and Z have the same speed.

For the waves at point P, calculate the ratio

$$\frac{\text{intensity of wave Z}}{\text{intensity of wave Y}}.$$

ratio = ... [3]

[Total: 5]

130. 9702_w15_qp_21 Q: 2

The signal from a microwave detector is recorded on a cathode-ray oscilloscope (c.r.o.), as shown in Fig. 2.1.

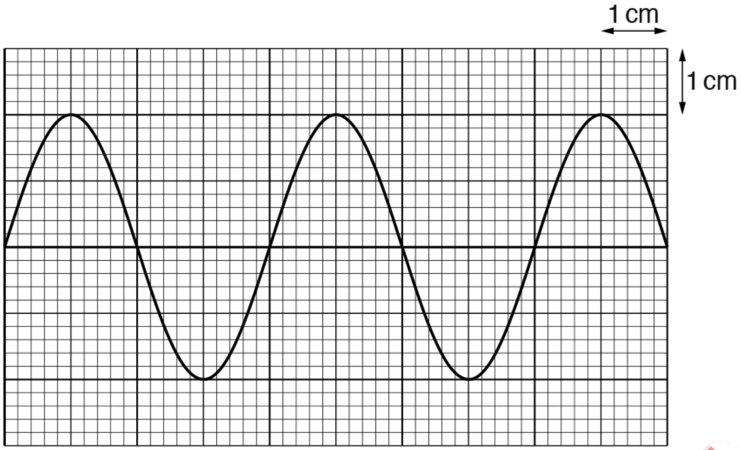

Fig. 2.1

The time-base setting on the c.r.o. is 50 ps cm^{-1}.

(a) Using Fig. 2.1, determine the wavelength of the microwaves.

wavelength = ... m [4]

(b) The signal from a radio wave detector is recorded on the same c.r.o.
The wavelength of the radio waves is 1.5×10^3 m.

Determine the time-base setting required to display the same number of oscillations on the c.r.o. as shown in Fig. 2.1.

time-base setting = ... unit........................ [2]

8.2 Transverse and longitudinal waves

131. 9702_w18_qp_22 Q: 4

(a) Sound waves are longitudinal waves. By reference to the direction of propagation of energy, state what is meant by a *longitudinal* wave.

....

....[1]

(b) A stationary sound wave in air has amplitude A. In an experiment, a detector is used to determine A^2. The variation of A^2 with distance x along the wave is shown in Fig. 4.1.

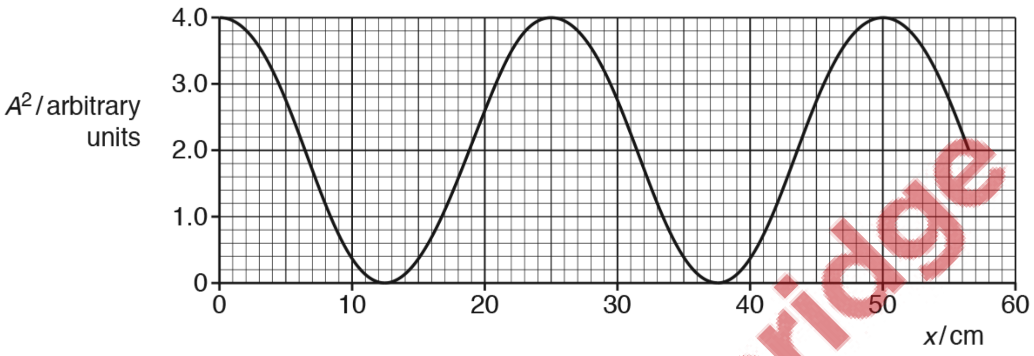

Fig. 4.1

(i) State the phase difference between the vibrations of an air particle at $x = 25$ cm and the vibrations of an air particle at $x = 50$ cm.

phase difference = ... ° [1]

(ii) The speed of the sound in the air is 330 m s^{-1}. Determine the frequency of the sound wave.

frequency = ... Hz [3]

(iii) Determine the ratio

$$\frac{\text{amplitude } A \text{ of wave at } x = 20\,\text{cm}}{\text{amplitude } A \text{ of wave at } x = 25\,\text{cm}}.$$

ratio = ...[2]

[Total: 7]

8.3 Determination of frequency and wavelength of sound waves

132. 9702_s19_qp_23 Q: 5

A vertical tube of length 0.60 m is open at both ends, as shown in Fig. 5.1.

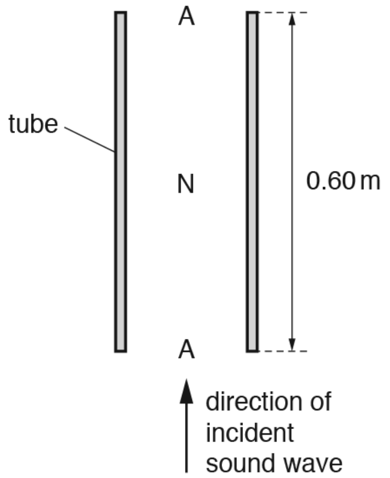

Fig. 5.1

An incident sinusoidal sound wave of a single frequency travels up the tube. A stationary wave is then formed in the air column in the tube with antinodes A at both ends and a node N at the midpoint.

(a) Explain how the stationary wave is formed from the incident sound wave.

....

....

....

....[2]

(b) On Fig. 5.2, sketch a graph to show the variation of the amplitude of the stationary wave with height *h* above the bottom of the tube.

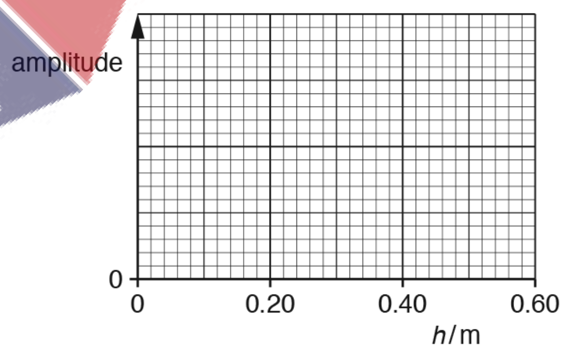

Fig. 5.2

[2]

(c) For the stationary wave, state:

(i) the direction of the oscillations of an air particle at a height of 0.15 m above the bottom of the tube

....[1]

(ii) the phase difference between the oscillations of a particle at a height of 0.10 m and a particle at a height of 0.20 m above the bottom of the tube.

phase difference = ... ° [1]

(d) The speed of the sound wave is 340 m s^{-1}.

Calculate the frequency of the sound wave.

frequency = ... Hz [2]

(e) The frequency of the sound wave is gradually increased.

Determine the frequency of the wave when a stationary wave is next formed.

frequency = ... Hz [1]

[Total: 9]

133. 9702_w19_qp_22 Q: 5

(a) State what is meant by the *wavelength* of a progressive wave.

....

.... [1]

(b) A cathode-ray oscilloscope (CRO) is used to analyse a sound wave. The screen of the CRO is shown in Fig. 5.1.

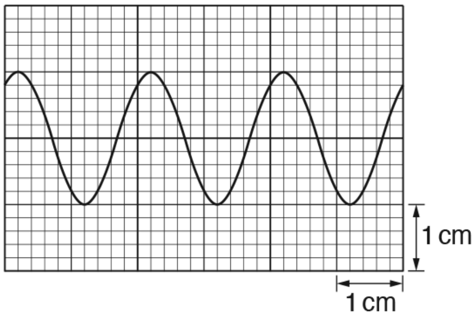

Fig. 5.1

The time-base setting of the CRO is 2.5 ms cm^{-1}.

Determine the frequency of the sound wave.

frequency = ... Hz [2]

(c) The source emitting the sound in **(b)** is at point A. Waves travel from the source to point C along two different paths, AC and ABC, as shown in Fig. 5.2.

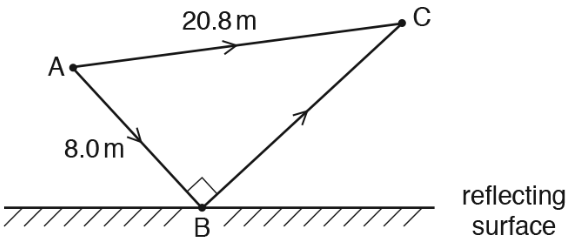

Fig. 5.2 (not to scale)

Distance AB is 8.0 m and distance AC is 20.8 m. Angle ABC is 90°. Assume that there is no phase change of the sound wave due to the reflection at point B. The wavelength of the waves is 1.6 m.

(i) Show that the waves meeting at C have a path difference of 6.4 m.

[1]

(ii) Explain why an intensity maximum is detected at point C.

....

....

.... [2]

(iii) Determine the difference between the times taken for the sound to travel from the source to point C along the two different paths.

time difference = ... s [2]

(iv) The wavelength of the sound is gradually increased. Calculate the wavelength of the sound when an intensity maximum is next detected at point C.

wavelength = ... m [1]

[Total: 9]

134. 9702_s17_qp_22 Q: 5

(a) Define the *frequency* of a sound wave.

....

....[1]

(b) A sound wave travels through air. Describe the motion of the air particles relative to the direction of travel of the sound wave.

....

....[1]

(c) The sound wave emitted from the horn of a stationary car is detected with a microphone and displayed on a cathode-ray oscilloscope (c.r.o.), as shown in Fig. 5.1.

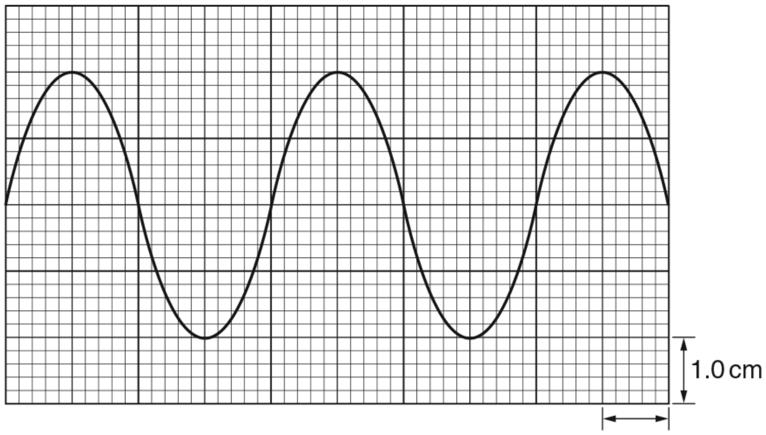

Fig. 5.1

The *y*-axis setting is 5.0 mV cm^{-1}.
The time-base setting is 0.50 ms cm^{-1}.

(i) Use Fig. 5.1 to determine the frequency of the sound wave.

frequency = ... Hz [2]

(ii) The horn of the car sounds continuously. Describe the changes to the trace seen on the c.r.o. as the car travels at constant speed

1. directly towards the stationary microphone,

....

....

2. directly away from the stationary microphone.

....

....

[3]

[Total: 7]

8.4 Doppler effect

135. 9702_m20_qp_22 Q: 2

A dolphin is swimming under water at a constant speed of $4.50\,\text{m}\,\text{s}^{-1}$.

(a) The dolphin emits a sound as it swims directly towards a stationary submerged diver. The frequency of the sound heard by the diver is 9560 Hz. The speed of sound in the water is $1510\,\text{m}\,\text{s}^{-1}$.

Determine the frequency, to three significant figures, of the sound emitted by the dolphin.

frequency = ... Hz [2]

(b) The dolphin strikes the bottom of a floating ball so that the ball rises vertically upwards from the surface of the water, as illustrated in Fig. 2.1.

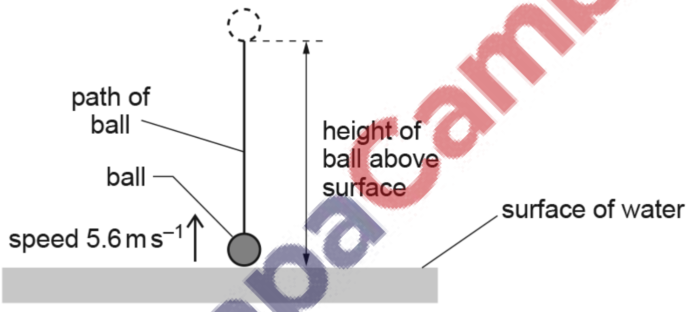

Fig. 2.1

The ball leaves the water surface with speed $5.6\,\text{m}\,\text{s}^{-1}$.

Assume that air resistance is negligible.

(i) Calculate the maximum height reached by the ball above the surface of the water.

height = ... m [2]

(ii) The ball leaves the water at time t = 0 and reaches its maximum height at time t = T.

On Fig. 2.2, sketch a graph to show the variation of the speed of the ball with time t from t = 0 to t = T. Numerical values are **not** required.

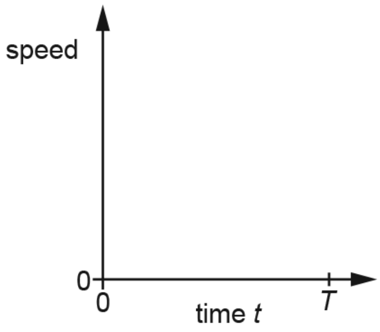

Fig. 2.2

[1]

(iii) The mass of the ball is 0.45 kg.

Use your answer in **(b)(i)** to calculate the change in gravitational potential energy of the ball as it rises from the surface of the water to its maximum height.

change in gravitational potential energy = ... J [2]

(iv) State and explain the variation in the magnitude of the acceleration of the ball as it falls back towards the surface of the water if air resistance is **not** negligible.

....

....

....

....

.... [2]

[Total: 9]

136. 9702_s19_qp_22 Q: 2

(a) State Newton's second law of motion.

....

....[1]

(b) A car of mass 850 kg tows a trailer in a straight line along a horizontal road, as shown in Fig. 2.1.

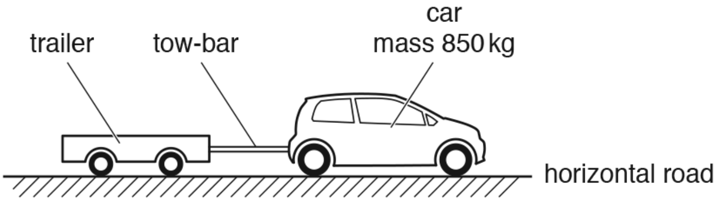

Fig. 2.1

The car and the trailer are connected by a horizontal tow-bar.

The variation with time t of the velocity v of the car for a part of its journey is shown in Fig. 2.2.

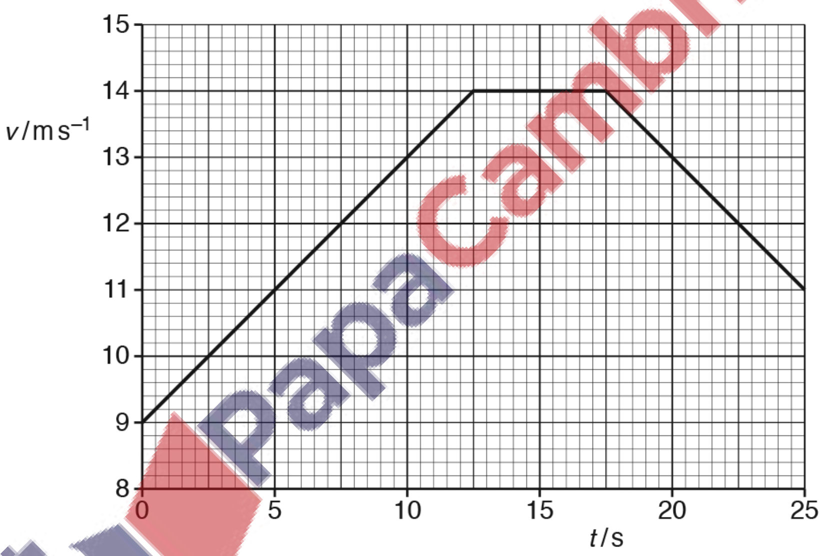

Fig. 2.2

(i) Calculate the distance travelled by the car from time $t = 0$ to $t = 10$ s.

distance = ... m [2]

(ii) At time $t = 10$ s, the resistive force acting on the car due to air resistance and friction is 510 N. The tension in the tow-bar is 440 N.

For the car at time $t = 10$ s:

1. use Fig. 2.2 to calculate the acceleration

acceleration = ... m s^{-2} [2]

2. use your answer to calculate the resultant force acting on the car

resultant force = ... N [1]

3. show that a horizontal force of 1300 N is exerted on the car by its engine

[1]

4. determine the useful output power of the engine.

output power = ... W [2]

(c) A short time later, the car in **(b)** is travelling at a constant speed and the tension in the tow-bar is 480 N.

The tow-bar is a solid metal rod that obeys Hooke's law. Some data for the tow-bar are listed below.

Young modulus of metal = 2.2×10^{11} Pa

original length of tow-bar = 0.48 m

cross-sectional area of tow-bar = 3.0×10^{-4} m^2

Determine the extension of the tow-bar.

extension = ... m [3]

(d) The driver of the car in **(b)** sees a pedestrian standing directly ahead in the distance. The driver operates the horn of the car from time t = 15 s to t = 17 s. The frequency of the sound heard by the pedestrian is 480 Hz. The speed of the sound in the air is 340 m s^{-1}.

Use Fig. 2.2 to calculate the frequency of the sound emitted by the horn.

frequency = ... Hz [2]

[Total: 14]

137. 9702_w19_qp_21 Q: 3

A small remote-controlled model aircraft has two propellers, each of diameter 16 cm. Fig. 3.1 is a side view of the aircraft when hovering.

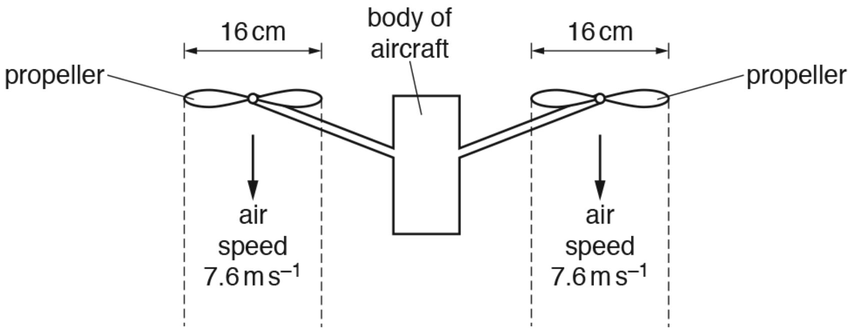

Fig. 3.1

Air is propelled vertically downwards by each propeller so that the aircraft hovers at a fixed position. The density of the air is $1.2\,kg\,m^{-3}$. Assume that the air from each propeller moves with a constant speed of $7.6\,m\,s^{-1}$ in a uniform cylinder of diameter 16 cm. Also assume that the air above each propeller is stationary.

(a) Show that, in a time interval of 3.0 s, the mass of air propelled downwards by **one** propeller is 0.55 kg.

[3]

(b) Calculate:

(i) the increase in momentum of the mass of air in **(a)**

increase in momentum = ... N s [1]

(ii) the downward force exerted on this mass of air by the propeller.

force = ... N [1]

(c) State:

(i) the upward force acting on **one** propeller

force = ... N [1]

(ii) the name of the law that explains the relationship between the force in **(b)(ii)** and the force in **(c)(i)**.

.... [1]

(d) Determine the mass of the aircraft.

mass = ... kg [1]

(e) In order for the aircraft to hover at a very high altitude (height), the propellers must propel the air downwards with a greater speed than when the aircraft hovers at a low altitude. Suggest the reason for this.

....

.... [1]

(f) When the aircraft is hovering at a high altitude, an electric fault causes the propellers to stop rotating. The aircraft falls vertically downwards. When the aircraft reaches a constant speed of 22 m s^{-1}, it emits sound of frequency 3.0 kHz from an alarm. The speed of the sound in the air is 340 m s^{-1}.

Determine the frequency of the sound heard by a person standing vertically below the falling aircraft.

frequency = ... Hz [2]

[Total: **11**]

138. 9702_s18_qp_22 Q: 3

A child on a sledge slides down a steep hill and then travels in a straight line up an ice-covered slope, as illustrated in Fig. 3.1.

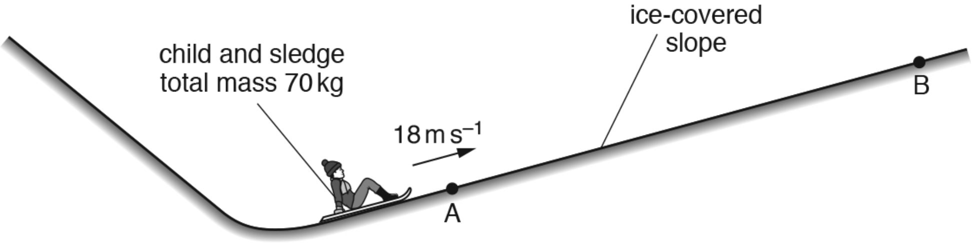

Fig. 3.1 (not to scale)

The sledge passes point A with speed $18\,\text{m s}^{-1}$ at time $t = 0$ and then comes to rest at point B. The child applies a brake to the sledge at point B. The brake does not keep the sledge stationary and it immediately slides back down the slope towards A.

The variation with time t of the velocity v of the sledge from $t = 0$ to $t = 24\,\text{s}$ is shown in Fig. 3.2.

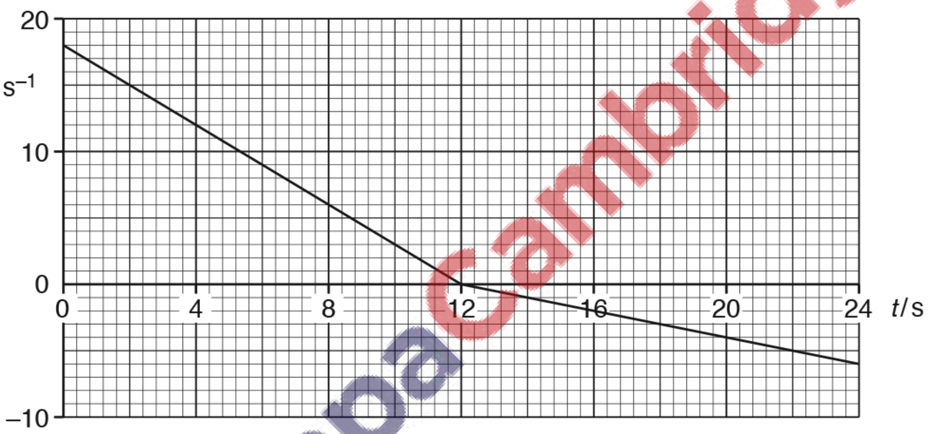

Fig. 3.2

(a) State the time taken for the sledge to travel from A to B.

time = ... s [1]

(b) Determine the displacement of the sledge up the slope from point A at time $t = 24$ s.

displacement = ...m [3]

(c) Show that the acceleration of the sledge as it moves from B back towards A is $0.50\,\text{m}\,\text{s}^{-2}$.

[2]

(d) The child and sledge have a total mass of 70 kg. The component of the total weight of the child and sledge that acts down the slope is 80 N.

Determine

(i) the frictional force on the sledge as it moves from B towards A,

frictional force = ... N [2]

(ii) the angle θ of the slope to the horizontal.

θ = ... ° [2]

(e) The child on the sledge blows a whistle between $t = 4.0\,s$ and $t = 8.0\,s$. The whistle emits sound of frequency 900 Hz. The speed of the sound in the air is $340\,m\,s^{-1}$. A man standing at point A hears the sound.

Use Fig. 3.2 to

(i) determine the initial frequency of the sound heard by the man,

initial frequency = ... Hz [2]

(ii) describe and explain qualitatively the variation, if any, in the frequency of the sound heard by the man.

....

....[1]

[Total: 13]

139. 9702_s18_qp_23 Q: 2

(a) State what is meant by *work done*.

....

....[1]

(b) A diver releases a solid sphere of radius 16 cm from the sea bed. The sphere moves vertically upwards towards the surface of the sea.

The weight of the sphere is 20 N. The upthrust acting on the sphere is 170 N. The upthrust remains constant as the sphere moves upwards.

(i) Calculate the density of the material of the sphere.

density = ... $kg\,m^{-3}$ [2]

(ii) Briefly explain the origin of the upthrust acting on the sphere.

....

....

....[1]

(iii) Calculate the acceleration of the sphere as it is released from rest.

acceleration = ... $m\,s^{-2}$ [2]

(iv) The viscous (drag) force D acting on the sphere is given by

$$D = kr^2v^2$$

where r is the radius of the sphere and v is its speed.
The constant k is equal to $810\,kg\,m^{-3}$.

Determine the constant (terminal) speed reached by the sphere.

speed = ... $m\,s^{-1}$ [3]

(v) The diver releases a different sphere that moves with a constant speed of $6.30\,m\,s^{-1}$ directly towards a stationary ship. The sphere emits sound of frequency 4850 Hz. The ship detects sound of frequency 4870 Hz as the sphere moves towards it.

Determine, to three significant figures, the speed of the sound in the water.

speed = ... $m\,s^{-1}$ [2]

[Total: 11]

140. 9702_m17_qp_22 Q: 4

(a) State what is meant by the *Doppler effect*.

....

....

....[2]

(b) A child sits on a rotating horizontal platform in a playground. The child moves with a constant speed along a circular path, as illustrated in Fig. 4.1.

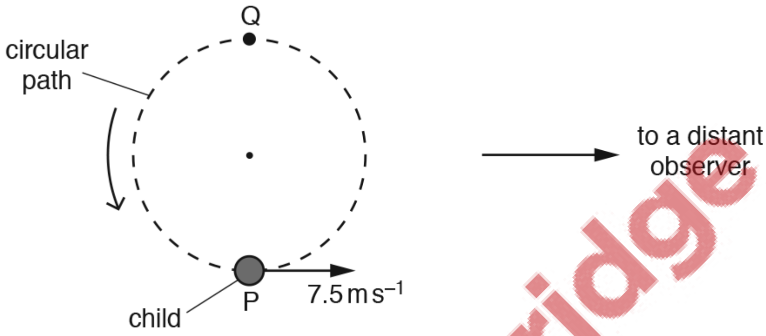

Fig. 4.1

An observer is standing a long distance away from the child. During one particular revolution, the child, moving at a speed of $7.5\,\mathrm{m\,s^{-1}}$, starts blowing a whistle at point P and stops blowing it at point Q on the circular path.

The whistle emits sound of frequency 950 Hz. The speed of sound in air is $330\,\mathrm{m\,s^{-1}}$.

(i) Determine the maximum frequency of the sound heard by the distant observer.

maximum frequency = ... Hz [2]

(ii) Describe the variation in the frequency of the sound heard by the distant observer.

....

....

....

....[2]

[Total: 6]

141. 9702_s17_qp_21 Q: 5

(a) Describe the Doppler effect.

....

....

....[1]

(b) A car travels with a constant velocity along a straight road. The car horn with a frequency of 400 Hz is sounded continuously. A stationary observer on the roadside hears the sound from the horn at a frequency of 360 Hz.
The speed of sound is 340 m s^{-1}.

Determine the magnitude v, and the direction, of the velocity of the car relative to the observer.

v = ... m s^{-1}

direction ....
[3]

[Total: 4]

142. 9702_w17_qp_23 Q: 4

(a) By reference to the direction of propagation of energy, explain what is meant by a *longitudinal* wave.

....

....[1]

(b) A car horn emits a sound wave of frequency 800 Hz. A microphone and a cathode-ray oscilloscope (c.r.o.) are used to analyse the sound wave. The waveform displayed on the c.r.o. screen is shown in Fig. 4.1.

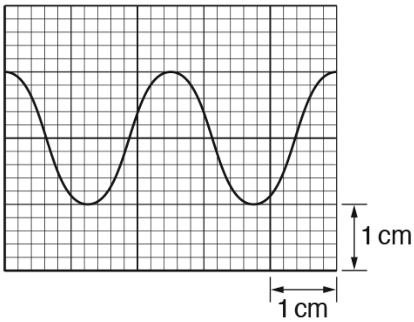

Fig. 4.1

Determine the time-base setting, in $s\,cm^{-1}$, of the c.r.o.

time-base setting = ... $s\,cm^{-1}$ [3]

(c) The intensity I of the sound at a distance r from the car horn in **(b)** is given by the expression

$$I = \frac{k}{r^2}$$

where k is a constant.

Fig. 4.2 shows the car in **(b)** on a road.

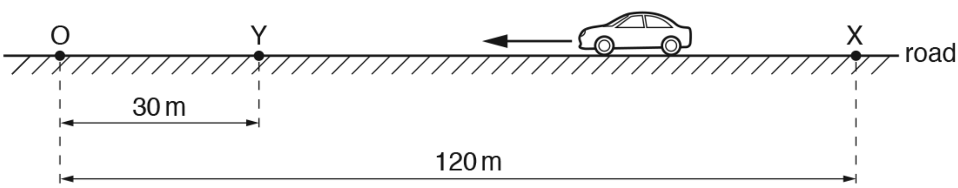

Fig. 4.2

An observer stands at point O. Initially the car is parked at point X which is 120 m away from point O. The car then moves directly towards the observer and stops at point Y, a distance of 30 m away from O.
The car horn continuously emits sound when the car is moving between points X and Y.

(i) The sound wave at point O has amplitude A_X when the car is at X and has amplitude A_Y when the car is at Y.

Calculate the ratio $\frac{A_Y}{A_X}$.

ratio = ... [3]

(ii) When the car is parked at X, the frequency of the sound from the horn that is detected by the observer is 800 Hz. As the car moves from X to Y, the maximum change in the detected frequency is 16 Hz. The speed of the sound in air is 330 m s^{-1}.

Determine, to two significant figures,

1. the minimum wavelength of the sound detected by the observer,

wavelength = ... m [2]

2. the maximum speed of the car.

speed = ... m s^{-1} [2]

[Total: 11]

143. 9702_s16_qp_22 Q: 4

(a) By reference to the direction of the propagation of energy, state what is meant by a *longitudinal* wave and by a *transverse* wave.

longitudinal: ....

....

....

transverse: ....

....

....
[2]

(b) The intensity of a sound wave passing through air is given by

$$I = Kv\rho f^2 A^2$$

where I is the intensity (power per unit area),
K is a constant without units,
v is the speed of sound,
ρ is the density of air,
f is the frequency of the wave
and A is the amplitude of the wave.

Show that both sides of the equation have the same SI base units.

(c) **(i)** Describe the *Doppler effect*.

....

....[1]

(ii) A distant star is moving away from a stationary observer.

State the effect of the motion on the light observed from the star.

....

....

....[1]

(d) A car travels at a constant speed towards a stationary observer. The horn of the car sounds at a frequency of 510 Hz and the observer hears a frequency of 550 Hz. The speed of sound in air is 340 m s^{-1}.

Calculate the speed of the car.

speed = ... m s^{-1} [3]

[Total: 10]

144. 9702_w16_qp_21 Q: 4

(a) State what is meant by the *frequency* of a progressive wave.

....

....

....[2]

(b) A cathode-ray oscilloscope (c.r.o.) is used to determine the frequency of the sound emitted by a loudspeaker. The trace produced on the screen of the c.r.o. is shown in Fig. 4.1.

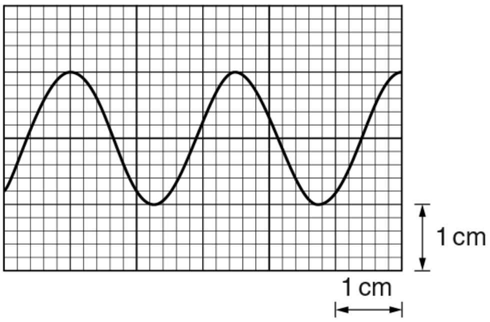

Fig. 4.1

The time-base setting of the c.r.o. is 250 $\mu s\,cm^{-1}$.

Show that the frequency of the sound wave is 1600 Hz.

[2]

(c) The loudspeaker in **(b)** emits the sound in all directions. A person attaches the loudspeaker to a string and then swings the loudspeaker at a constant speed in a horizontal circle above his head.

An observer, standing a large distance away from the loudspeaker, hears sound of maximum frequency 1640 Hz. The speed of sound in air is 330 $m\,s^{-1}$.

(i) Determine the speed of the loudspeaker.

speed = ... $m\,s^{-1}$ [2]

(ii) Describe and explain, qualitatively, the variation in the frequency of the sound heard by the observer.

....

....

....

....

....[2]

[Total: 8]

145. 9702_w16_qp_23 Q: 4

(a) State what is meant by the *frequency* of a progressive wave.

....

....

....[2]

(b) A cathode-ray oscilloscope (c.r.o.) is used to determine the frequency of the sound emitted by a loudspeaker. The trace produced on the screen of the c.r.o. is shown in Fig. 4.1.

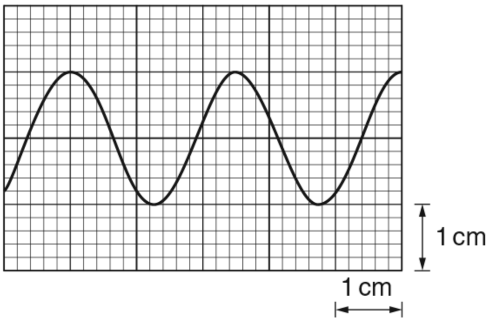

Fig. 4.1

The time-base setting of the c.r.o. is 250 μs cm^{-1}.

Show that the frequency of the sound wave is 1600 Hz.

[2]

(c) The loudspeaker in **(b)** emits the sound in all directions. A person attaches the loudspeaker to a string and then swings the loudspeaker at a constant speed in a horizontal circle above his head.

An observer, standing a large distance away from the loudspeaker, hears sound of maximum frequency 1640 Hz. The speed of sound in air is 330 m s^{-1}.

(i) Determine the speed of the loudspeaker.

speed = ... m s^{-1} [2]

(ii) Describe and explain, qualitatively, the variation in the frequency of the sound heard by the observer.

....

....

....

....

....[2]

[Total: 8]

8.5 Electromagnetic spectrum

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(a) An electromagnetic wave has a wavelength of 85 μm.

(i) State the wavelength, in m, of the wave.

wavelength = ... m [1]

(ii) Calculate the frequency, in THz, of the wave.

frequency = ... THz [2]

(iii) State the name of the region of the electromagnetic spectrum that contains this wave.

.... [1]

(b) The current I in a coil of wire produces a magnetic field. The energy E stored in the magnetic field is given by

$$E = \frac{I^2 L}{2}$$

where L is a constant.

The manufacturer of the coil states that the value of L, in SI base units, is $7.5 \times 10^{-6} \pm 5\%$. The current I in the coil is measured as (0.50 ± 0.02) A.

The values of L and I are used to calculate E.

Determine the percentage uncertainty in the value of E.

percentage uncertainty = ... % [2]

[Total: 6]