Waves – 2021/20 GCE Physics A Component 02

1. Nov/2021/Paper_H556_02/No.2

Monochromatic light from a laser is incident normally on a diffraction grating.
A series of bright dots are formed on a distant screen.

Which **two** terms can be used to explain these bright dots?

A diffraction, interference

B reflection, interference

C refraction, diffraction

D refraction, reflection

Your answer ☐ **[1]**

2. Nov/2021/Paper_H556_02/No.8

A double-slit is used in an interference experiment to independently investigate the light from two sources **K** and **L**. The light from the sources have different wavelengths.
The table below shows some data.

Light source	Wavelength of light	Separation between adjacent bright fringes	Distance between screen and double-slit
K	λ	1.2 mm	D
L	0.80λ		$0.50D$

What is the separation between adjacent bright fringes for source **L**?

A 0.48 mm

B 1.2 mm

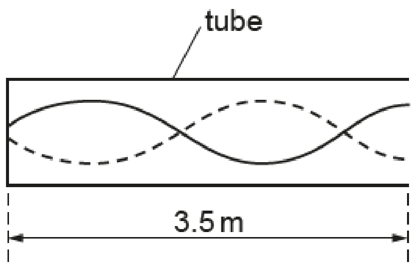
C 1.9 mm

D 3.0 mm

Your answer ☐ **[1]**

3. Nov/2021/Paper_H556_02/No.9

A stationary sound wave formed in a tube is shown below.



The tube is closed at one end. The length of the tube is 3.5 m.
The speed of sound is 340 m s^{-1}.

What is the frequency of the sound wave?

A 97 Hz

B 120 Hz

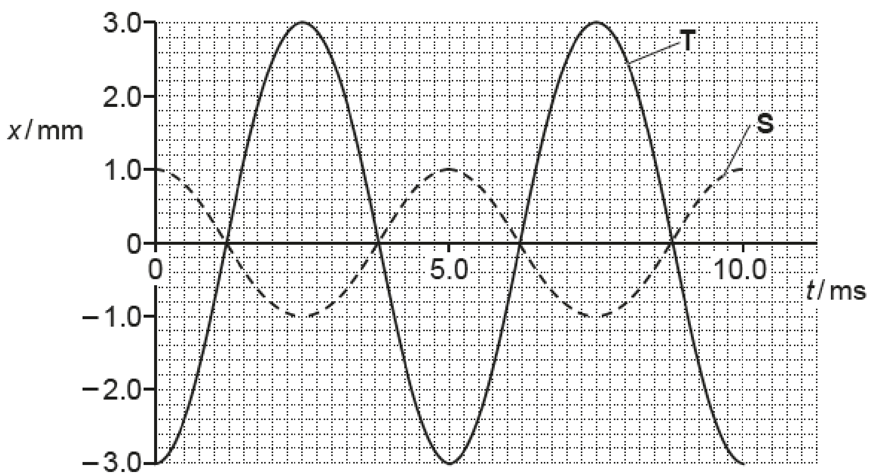
C 240 Hz

D 486 Hz

Your answer ☐ **[1]**

4. Nov/2021/Paper_H556_02/No.11

The diagram below shows the graphs of displacement x against time t for two waves **S** and **T**.



The waves meet at a point in space.
The superposition of these two waves produces a resultant wave.

What is the frequency f and the amplitude A of the resultant wave?

A $f = 100\,\text{Hz}$, $A = 2.0\,\text{mm}$

B $f = 100\,\text{Hz}$, $A = 4.0\,\text{mm}$

C $f = 200\,\text{Hz}$, $A = 2.0\,\text{mm}$

D $f = 200\,\text{Hz}$, $A = 4.0\,\text{mm}$

Your answer ☐ **[1]**

5. Nov/2021/Paper_H556_02/No.16

(a) The normal frequency range of hearing for young people is from 20 Hz to 20 kHz.

(i) The speed of sound in air is 340 m s^{-1}.

Calculate the **shortest** wavelength a young person can hear.

wavelength = ... m **[2]**

(ii) Describe how you can use an oscilloscope, and other additional laboratory equipment, to determine the actual upper limit of the frequency range for a young person.

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.... **[3]**

(b) State **one** difference and **one** similarity between the **oscillations** of a stationary sound wave and a progressive sound wave.

Difference: ....

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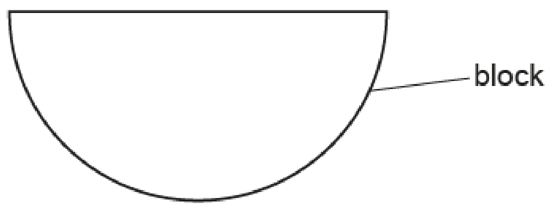
Similarity: ....

.... **[2]**

(c) You are provided with a ray-box, a semi-circular block of plastic and other normal laboratory equipment.
The outline of the block is shown below.



Describe how you could measure the refractive index n of the block using the critical angle method. Draw on the diagram and label it to make your answer clear.

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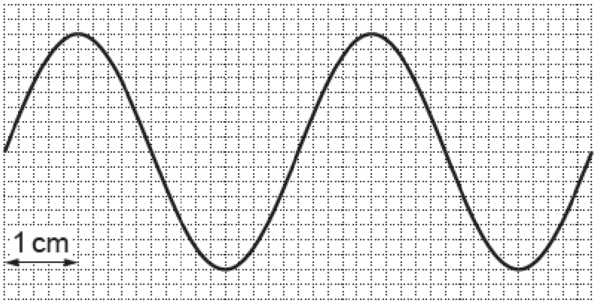
.... **[3]**

6. Nov/2020/Paper_H556_02/No.5

The diagram below shows the oscilloscope trace for an electrical signal.



The time-base setting of the oscilloscope is $2\,\mu s\,cm^{-1}$.

What is the frequency of the signal?

A 125 Hz

B 250 Hz

C 125 kHz

D 250 kHz

Your answer ☐ **[1]**

7. Nov/2020/Paper_H556_02/No.6

This question is about a progressive wave and a stationary wave.

Which statement is correct?

A A progressive wave has at least one node.

B All progressive waves are longitudinal.

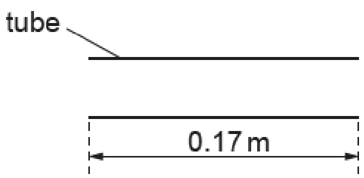
C All particles oscillating between two adjacent nodes in a stationary wave are in phase.

D The superposition of two waves travelling in the same direction produces a stationary wave.

Your answer ☐ **[1]**

8. Nov/2020/Paper_H556_02/No.11

A stationary sound wave, in its fundamental mode of vibration, is formed in a tube open at both ends.



The length of the tube is 0.17 m. The speed of sound in air is 340 m s^{-1}.

Which row for this stationary wave is correct?

	Number of nodes	Frequency of stationary wave / Hz
A	1	500
B	1	1000
C	2	1000
D	2	2000

Your answer ☐ **[1]**

9. Nov/2020/Paper_H556_02/No.20

(a) A sound wave is incident at the ear.

The amplitude of the sound wave is 7.8 nm. The intensity of the sound at the earhole is $4.8 \times 10^{-7}\,\text{W m}^{-2}$.

(i) Determine the power of the sound incident at the earhole by estimating the diameter of the earhole in mm.

diameter of earhole ≈ .... mm

power = ... W **[2]**

(ii) A different sound wave is now incident at the ear.
The intensity of this wave is $9.6 \times 10^{-7}\,\text{W m}^{-2}$.

Calculate the amplitude *A* in nm of this sound wave.

A = ... nm **[2]**

(b) State the **principle of superposition**.

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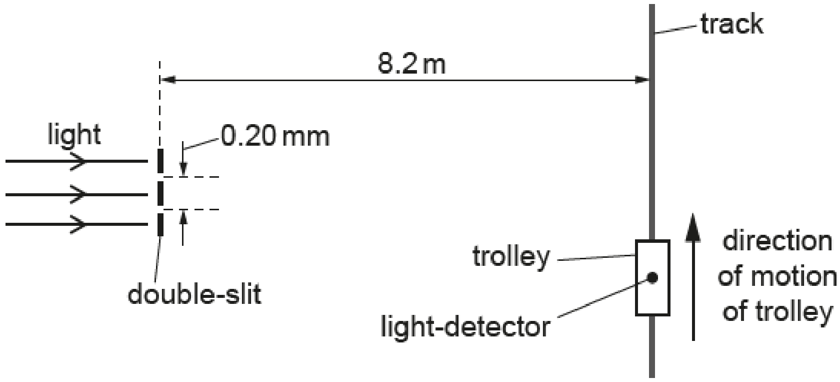
.... **[1]**

(c) The diagram below shows monochromatic light from a laser incident normally at a double-slit.



The diagram is **not** drawn to scale.

A small light-detector is mounted onto a trolley on a frictionless track. The trolley travels along the track at a constant speed.

The separation between the slits is 0.20 mm. The perpendicular distance between the slits and the track is 8.2 m.

A series of bright and dark fringes are detected at the moving light-detector.

(i) Explain, in terms of phase difference, the origin of the fringes.

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.... **[2]**

(ii) The speed of the trolley is 0.18 m s^{-1} and the frequency of the light is 4.75×10^{14} Hz.

Calculate the time interval *t* between successive bright fringes.
Write your answer to 2 significant figures.

t = ... s **[3]**

10. Nov/2021/Paper_H556_03/No.5

A student is investigating stationary waves in the air column inside a tube, using the apparatus shown in **Fig. 5.1**.

The loudspeaker emits sound of frequency *f* and wavelength λ. The tube is initially fully immersed in the water. The student then slowly raises the tube until the oscilloscope trace shows its first maximum. A stationary wave of fundamental frequency *f* is produced in the air column. When this occurs, the student measures the length *l* of the tube above the water level.

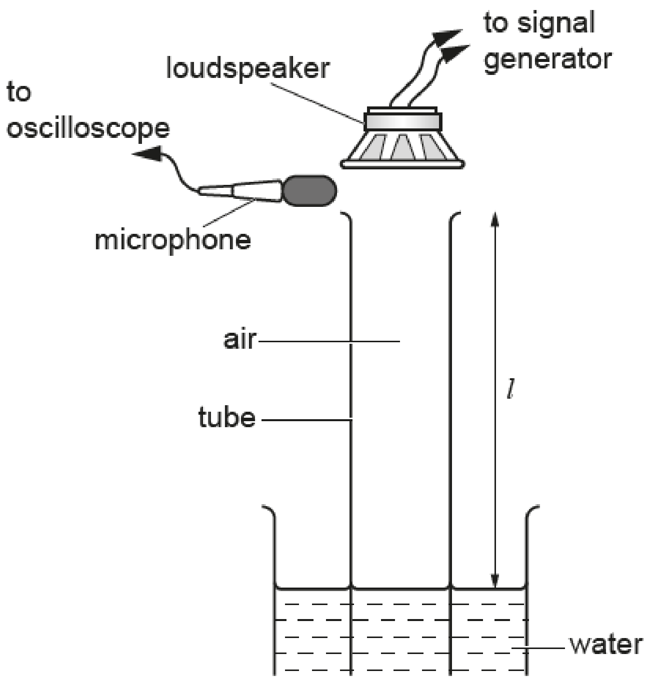

Fig. 5.1

(a) Explain how a stationary wave of fundamental frequency is produced and state the relationship between *l* and λ.

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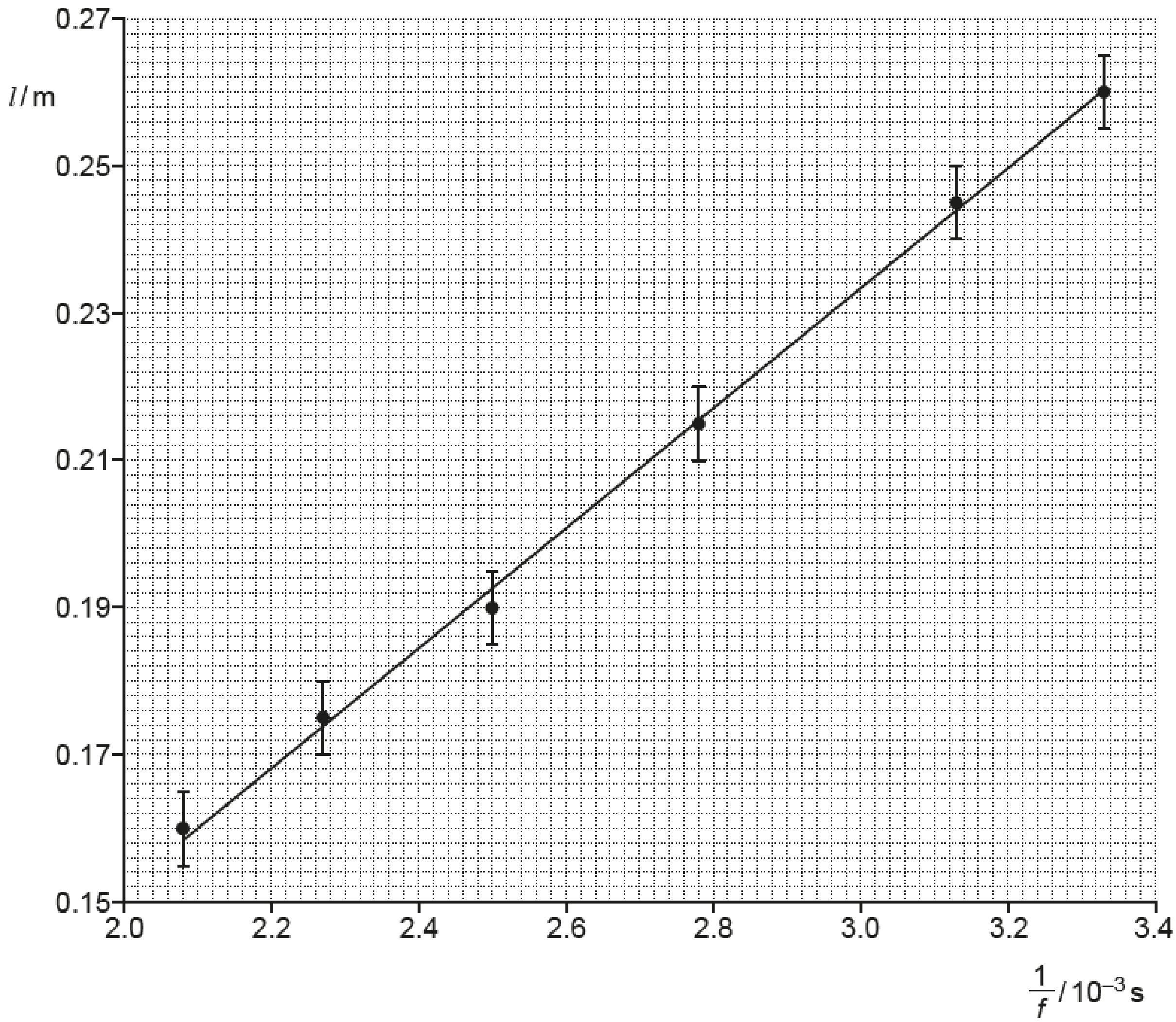
.... **[4]**

(b) Theory suggests that f and l are related by the equation $4(l + k) = \frac{v}{f}$, where v is the speed of sound in air and k is a constant.

The student measures corresponding values of l and f and plots a graph of l against $\frac{1}{f}$.

The data points, error bars and the line of best fit drawn by the student are shown in the graph below.



(i) Show that the line of best fit has gradient = $\frac{v}{4}$ and y-intercept = – k.

[2]

(ii) Calculate v from the gradient of the line of best fit.

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

(c) The experiment is repeated using the same tube and an unlabelled tuning fork, as shown in **Fig. 5.2**. The distance l is measured as 22 cm.

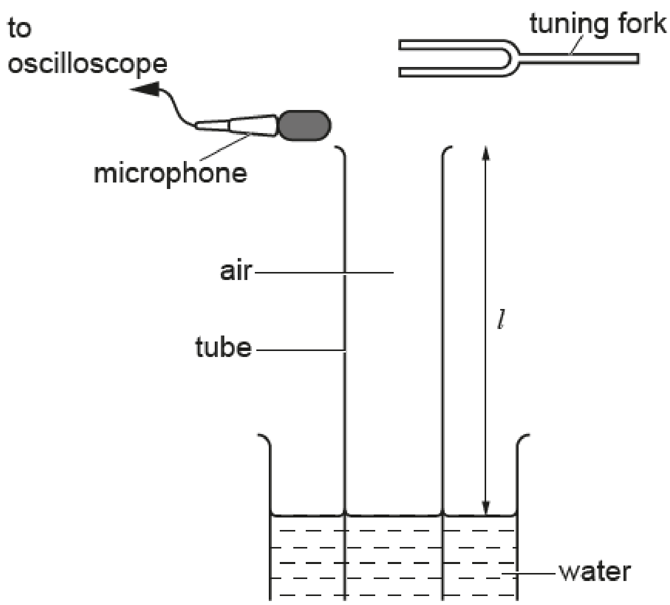


Fig. 5.2

The frequency of the vibrating tuning fork is F.

(i) Use the line of best fit on the graph to estimate F.

F = ... Hz **[2]**

(ii) The percentage uncertainty in the value of F can be written as $100\,\frac{\Delta F}{F}$ where ΔF is the absolute uncertainty in F.

Use the rules for combining uncertainties to write an expression for the percentage uncertainty in the value of F in terms of v and its absolute uncertainty Δv, l and its absolute uncertainty Δl, and k and its absolute uncertainty Δk.

[2]

11. Nov/2020/Paper_H556_03/No.5(a, c, d)

This question is about investigations involving an electromagnetic wave.

A vertical transmitter aerial emits a **vertically polarised** electromagnetic wave which travels towards a vertical receiver aerial. The wavelength of the wave is 0.60 m.

Fig. 5.1 shows a short section of the oscillating electric field of the electromagnetic wave.

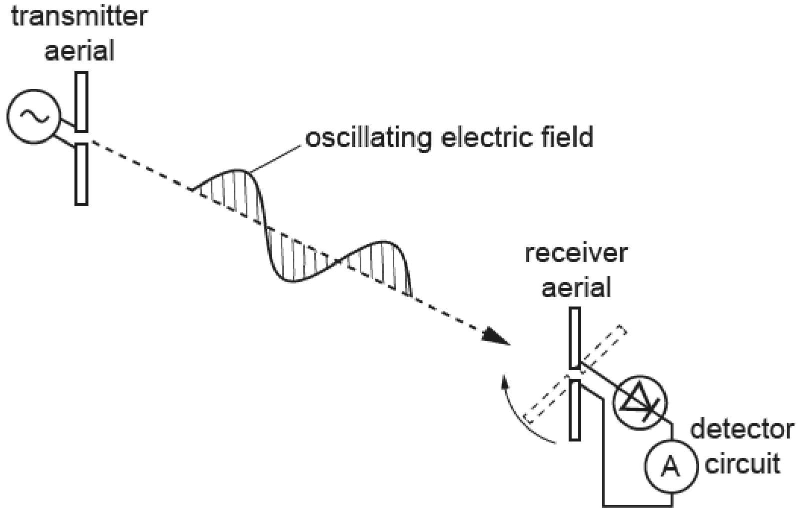


Fig. 5.1

(a) Calculate the frequency *f* of the transmitted wave.

f = ... Hz **[2]**

(c) Suggest why the diode in **Fig. 5.1** is necessary for an ammeter to detect a signal at the receiver aerial.

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.... **[1]**

***(d)** A student carries out two investigations with these electromagnetic waves.

In **investigation 1**, the student rotates the receiver aerial about the horizontal axis joining the two aerials, as shown in **Fig. 5.1**.

In **investigation 2**, the student places a metal sheet behind the receiver aerial. The student moves the sheet backwards and forwards along the horizontal axis joining the two aerials, as shown in **Fig. 5.2**.

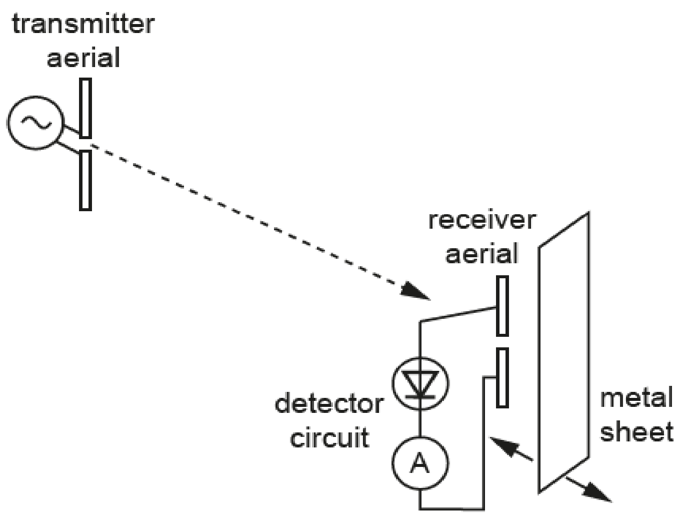

Fig. 5.2

For each of these two investigations:

- Explain why the ammeter sometimes gives a maximum reading and sometimes a zero (or near zero) reading.
- State the orientations of the receiver aerial in **investigation 1**, and the positions of the metal sheet in **investigation 2**, where these maximum and zero readings would occur.

[6]

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