2 The distance between an approaching aircraft and an airport can be determined using the pulse-echo technique with radio waves.

The time between the pulse of radio waves being emitted and the reflected pulse being received is t and the velocity of radio waves in air is c.

Which of the following expressions can be used to determine the distance of the aircraft from the airport?

☒ **A** $2 \times c \times t$

☒ **B** $\frac{c \times t}{2}$

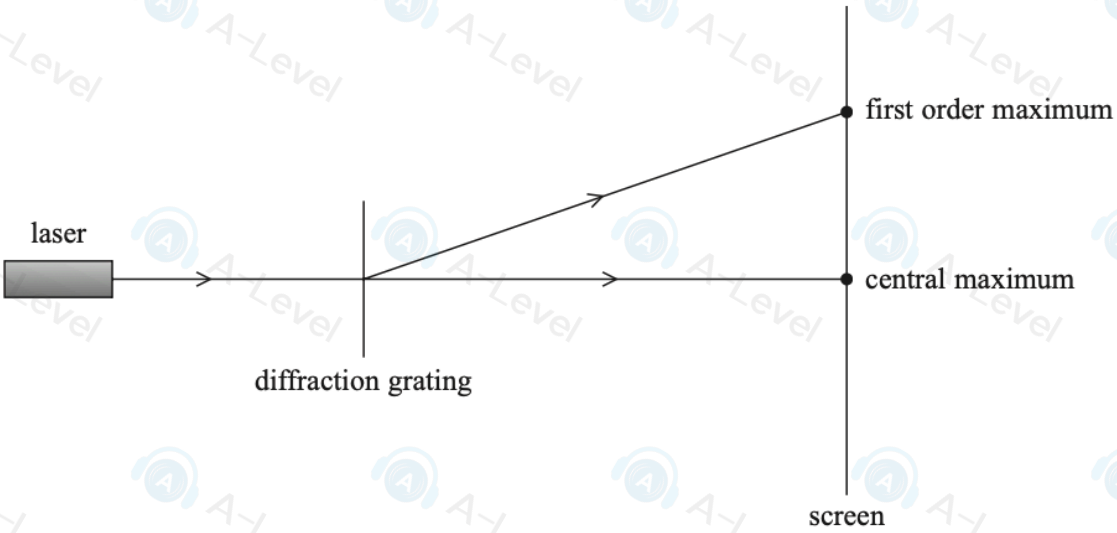
☒ **C** $\frac{c}{2 \times t}$

☒ **D** $c \times t$

(Total for Question 2 = 1 mark)

8 Light from a laser is incident on a diffraction grating, causing a series of maxima to be seen on a screen.

The positions of the central maximum and first order maximum are shown.



Which of the following changes would decrease the distance between the central maximum and the first order maximum?

☒ **A** Decreasing the distance from the laser to the diffraction grating

☒ **B** Increasing the distance from the diffraction grating to the screen

☒ **C** Using a diffraction grating with more lines per millimetre

☒ **D** Using light with a smaller wavelength

(Total for Question 8 = 1 mark)

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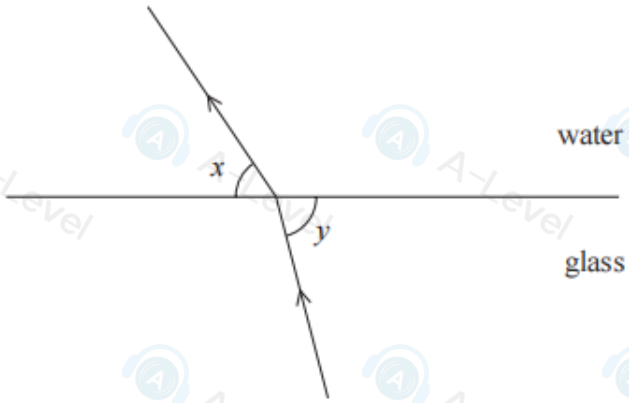
7 The diagram shows a ray of light passing from glass to water.



Which of the following is a correct expression for the refractive index for light passing from glass to water?

☒ **A** $\frac{\sin x}{\sin y}$

☒ **B** $\frac{\sin y}{\sin x}$

☒ **C** $\frac{\sin (90° - x)}{\sin (90° - y)}$

☒ **D** $\frac{\sin (90° - y)}{\sin (90° - x)}$

(Total for Question 7 = 1 mark)

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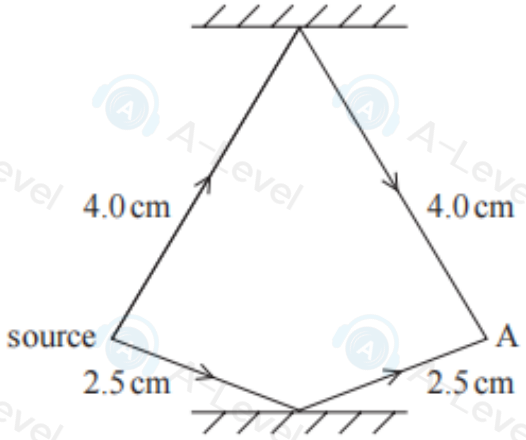
7 Two waves, each with a wavelength of 2 cm, leave a single source in phase and follow the paths shown.



Which of the following is the phase difference, in radians, between the two waves as they meet at point A?

☒ **A** $\frac{\pi}{4}$

☒ **B** $\frac{\pi}{2}$

☒ **C** π

☒ **D** $\frac{3\pi}{2}$

(Total for Question 7 = 1 mark)

2 A student determines the wavelength of the light emitted by a laser. She uses the laser, a diffraction grating and a screen.

Which of the following measurements is **not** required?

☒ **A** the distance from the diffraction grating to the screen

☒ **B** the distance from the central maximum to the first order maximum

☒ **C** the distance from the laser to the diffraction grating

☒ **D** the distance between the slits in the diffraction grating

(Total for Question 2 = 1 mark)

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9 Light travels through air and enters a glass block.

Which of the following quantities does **not** change as the light enters the glass block?

- ☒ **A** amplitude
- ☒ **B** frequency
- ☒ **C** velocity
- ☒ **D** wavelength

(Total for Question 9 = 1 mark)

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2 The time period of a wave decreases.

Which of the following properties of the wave increases?

- ☒ **A** amplitude
- ☒ **B** frequency
- ☒ **C** speed
- ☒ **D** wavelength

(Total for Question 2 = 1 mark)

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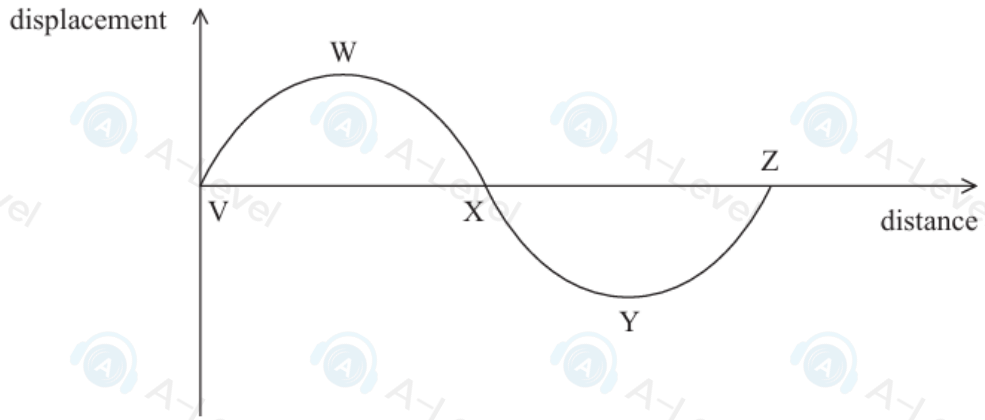
10 A sound wave travels through air. The diagram represents the displacement of air particles along the wave at an instant in time.



There is a compression at position V.

At which position is there also a compression?

- ☒ **A** W
- ☒ **B** X
- ☒ **C** Y
- ☒ **D** Z

(Total for Question 10 = 1 mark)

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3 A car has a distance sensor that uses a pulse-echo technique to determine the distance between the car and a nearby object.

The sensor emits a pulse of sound and then detects the echo after time t.
The speed of sound is v.

Which of the following gives the distance between the car and the object?

☒ **A** $2vt$

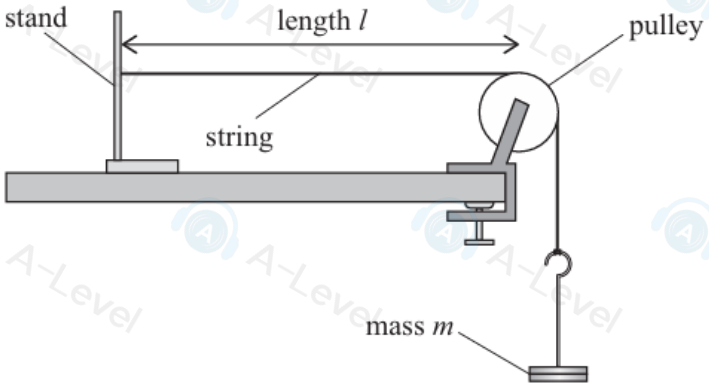
☒ **B** $2vt^{-1}$

☒ **C** $0.5vt$

☒ **D** $0.5vt^{-1}$

(Total for Question 3 = 1 mark)

4: A student sets up the apparatus shown.



When the string is plucked, it vibrates with a frequency f.

Which of the following single changes would increase f?

☒ **A** decreasing the length l

☒ **B** decreasing the mass m

☒ **C** increasing the cross-sectional area of the string

☒ **D** increasing the mass per unit length of the string

(Total for Question 4 = 1 mark)

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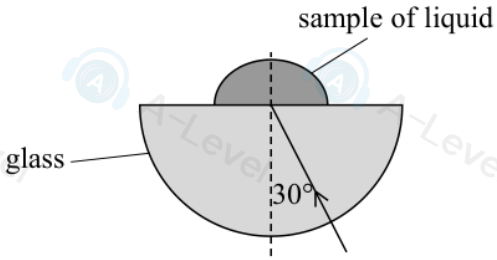
14 A refractometer can be used to measure refractive index. A refractometer makes use of the total internal reflection of light at a boundary between two materials.

(a) Describe the conditions required for total internal reflection to take place at a boundary.

(2)

(b) One type of refractometer is shown.

A sample of liquid is placed on one side of a semicircular glass prism. A ray of light is shown passing into the prism.



Determine whether this ray will be totally internally reflected from the boundary between the prism and the liquid.

$_{\text{liquid}}\mu_{\text{glass}} = 1.15$

(3)

(c) The graph shows how the refractive index $_{\text{sugar solution}}\mu_{\text{glass}}$ varies with the mass of sugar dissolved in a fixed volume of water.

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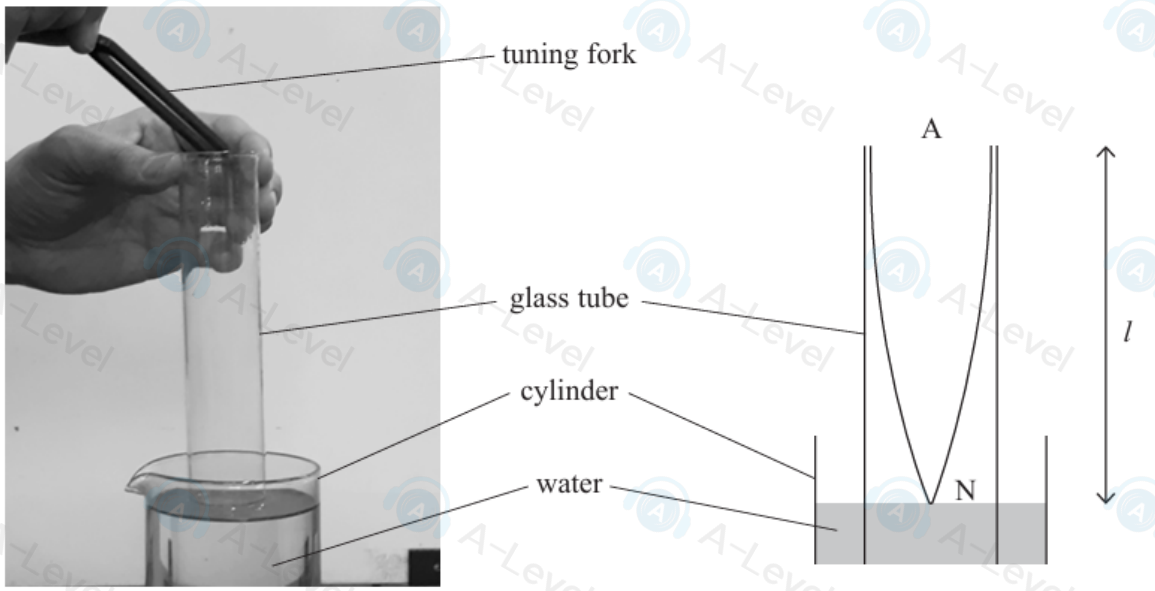
12 In an experiment to determine the speed of sound in air, a student held a vibrating tuning fork above a glass tube. The air column in the tube could be adjusted by raising or lowering the tube into a cylinder containing water. When the length of the air column was l, a stationary wave with one node and one antinode was produced as shown. This caused a sound to be heard.



(a) Explain how the stationary wave was formed in this experiment.

(2)

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(b) (i) A sound was heard when l was 19.3 cm.

18 The photograph shows a typical lightning strike which occurs as a result of an electrical discharge through the atmosphere in a narrow channel between a cloud and the ground.



(Source: © Joshua Lewis/EyeEm/Getty Images)

The high current in a lightning strike heats the air sufficiently to cause rapid expansion; the resulting shock wave is heard as thunder.

(a) A teacher says that a lightning strike taking place 1 km away from the observer will result in a time of 3 s between seeing the lightning and hearing the thunder.

Determine whether the teacher is correct.

speed of sound in air = 340 m s^{-1}

(3)

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(b) The following data was collected for one particular lightning strike:

distance between cloud and ground = 400 m
current = 25 000 A
duration of lightning strike = 30 μs
potential difference between cloud and ground = 1.2×10^9 V
diameter of lightning channel = 5.0 cm

(i) Calculate the total charge transferred during the lightning strike.

(2)

Total charge transferred = ...

(ii) Calculate the power dissipated by the lightning strike.

(2)

Power dissipated = ...

(iii) Show that the resistivity of the air in the lightning channel is about 0.2 Ω m.

(3)

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(iv) The accepted value for the resistivity of air is $10^{16}\,\Omega$m.

Suggest why the value calculated from the data is so much less than the accepted value.

(1)

(c) Air consists mainly of nitrogen and oxygen molecules. Analysis of the light produced during a lightning strike shows a weak line spectrum.

(i) Explain the process by which nitrogen atoms produce a line spectrum.

(4)

(ii) State why the line spectrum produced by oxygen atoms in the air would be different from the line spectrum produced by nitrogen atoms.

(1)

(Total for Question 18 = 16 marks)

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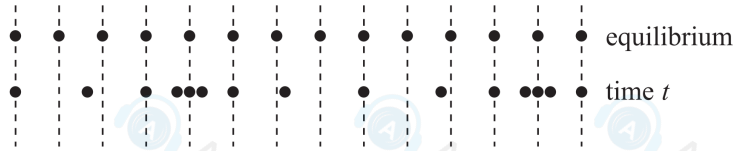
14 A longitudinal wave consists of a series of compressions and rarefactions.

The diagram represents the position of the particles at equilibrium and the position of the particles at a time *t*.



(a) (i) Label with a C on the diagram a position where a compression occurs at time *t*.

(1)

(ii) Take a measurement from the diagram to determine the wavelength of the wave.

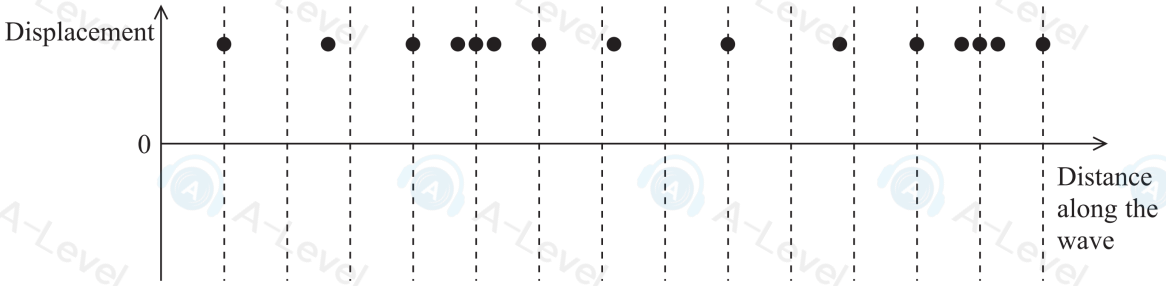
(1)

Wavelength = ...

(b) A longitudinal wave can also be represented as a sine graph of the displacement of the particles against distance along the wave.

On the axes below, draw a displacement-distance graph that corresponds to the longitudinal wave.

(2)



(Total for Question 14 = 4 marks)

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