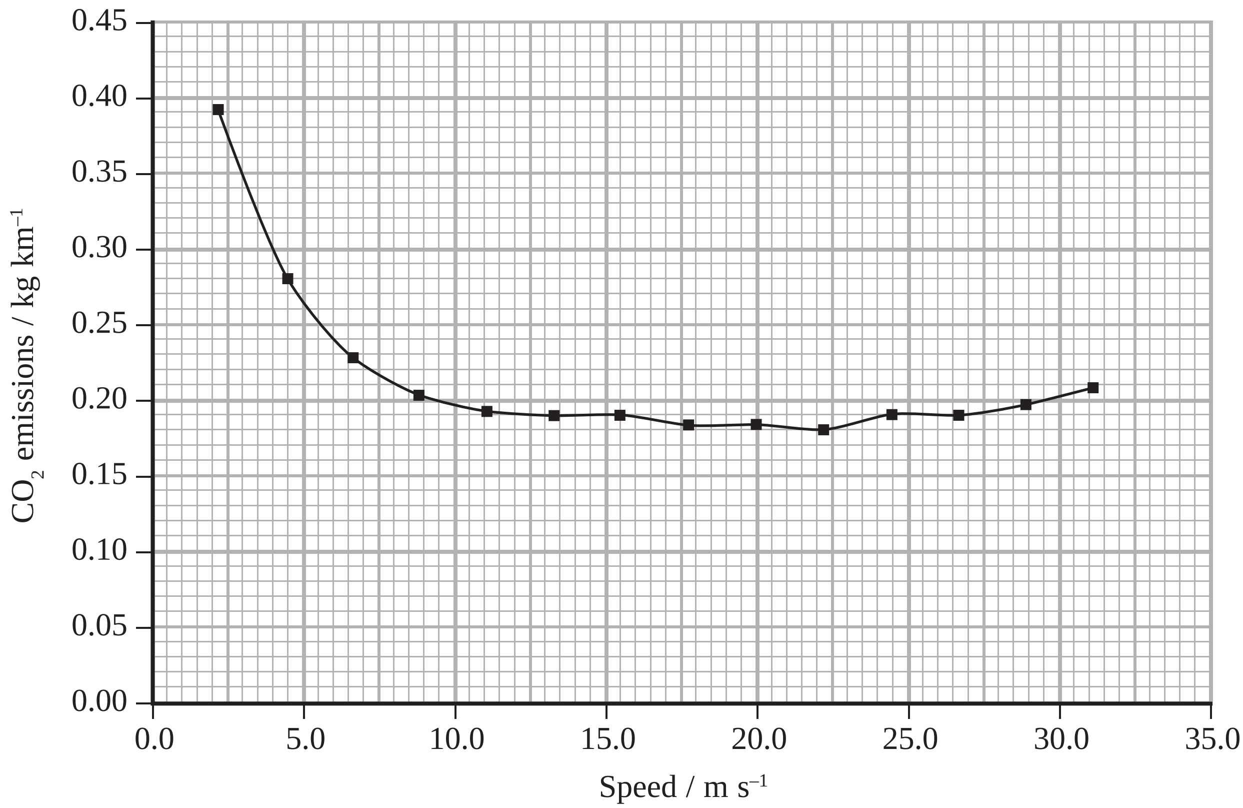
1 Queues of cars often form behind cyclists on narrow, rural roads.

Sometimes cars that would normally travel at 65 km hour^{-1} may be limited to about 20 km hour^{-1} by a cyclist.

(a) Show that 65 km hour^{-1} is about 18 m s^{-1}.

(1)

(b) The graph shows the amount of carbon dioxide emitted per kilometre by a typical car at different speeds.



During a 10 minute journey a cyclist, travelling at 5 m s^{-1}, has an average of three cars queuing behind him. The cars would otherwise be travelling at 18 m s^{-1}. The cars emit more carbon dioxide because they are travelling slowly.

(i) Calculate the extra carbon dioxide emitted by the 3 cars due to travelling at this reduced speed for 10 minutes.

(4)

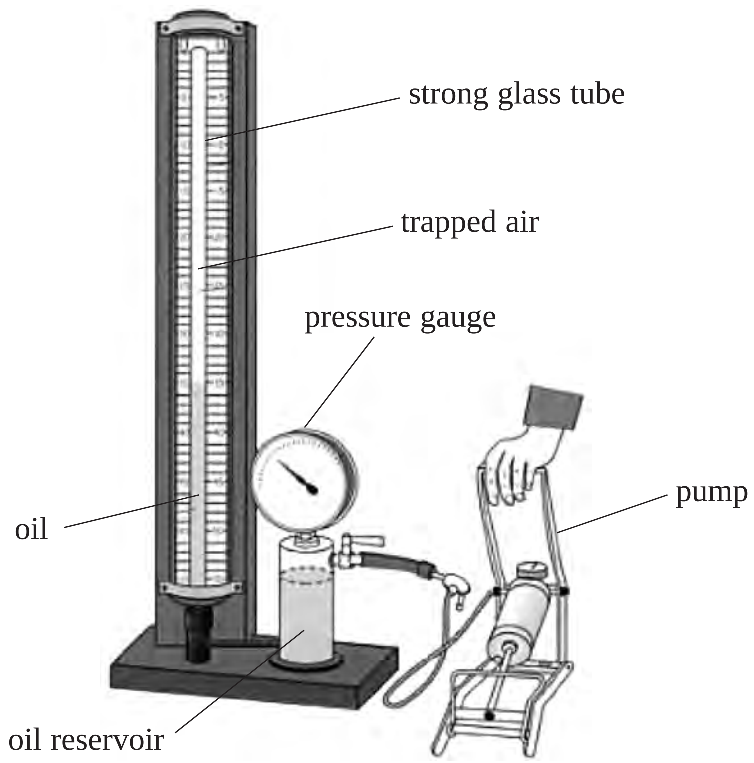
Extra carbon dioxide emitted =

(ii) If the cyclist had made the same journey in his car at 18 m s^{-1}, his car would have emitted 0.54 kg of carbon dioxide. Comment on the significance of this.

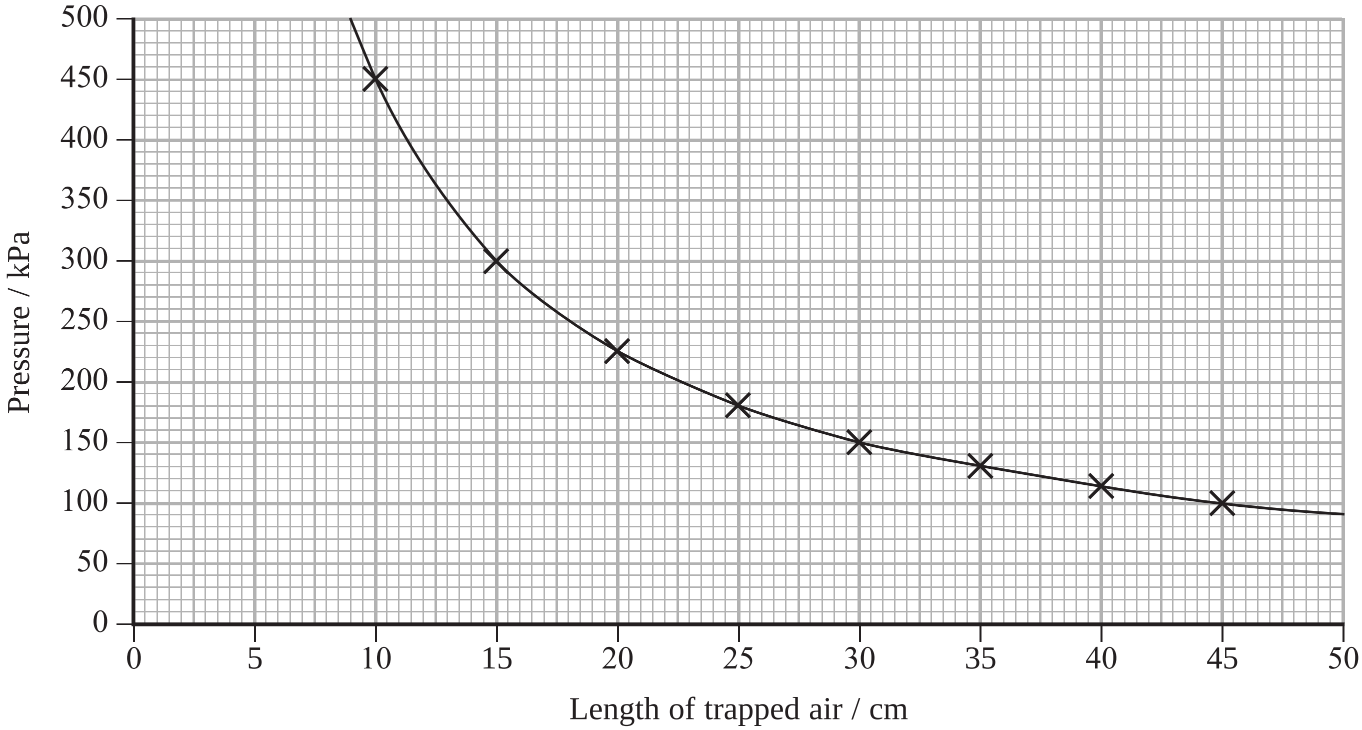
(1)

(Total for Question = 6 marks)

2 A student uses the apparatus shown to investigate the relationship between pressure and volume of a gas.



Air is trapped in a glass tube of uniform cross-sectional area. As the pressure of the trapped air is increased, the length of trapped air decreases. The student collects data and plots the following graph.



(a) State the variables that should be controlled in this investigation.

(2)

(b) Theory suggests that, for the air trapped in the tube, the pressure p is inversely proportional to the volume V.

Use the graph to show that this relationship is correct. State an assumption that you are making.

(4)

(c) On the day that the investigation was carried out, the temperature in the laboratory was 20 °C.

Calculate the number of air molecules trapped in the tube.

cross-sectional area of tube = 7.5×10^{-5} m^2

(3)

Number of air molecules =

(d) State how the graph would change if

(i) the air molecules in the tube were replaced by the same number of molecules of hydrogen gas.

(1)

(ii) the temperature of the laboratory was substantially higher.

(2)

(Total for Question = 12 marks)

3 A student has the equipment shown in Figure 1:

- protractor
- 15 cm ruler
- laser light source
- pencil
- sheet of paper
- rectangular block of plastic.

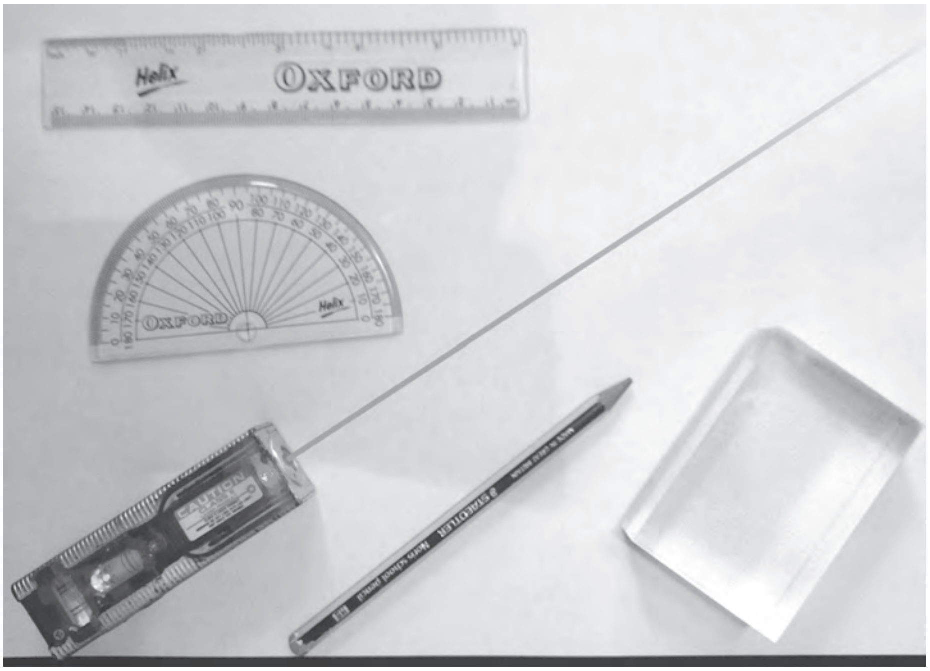


Figure 1

(a) The student uses the equipment shown in Figure 1 to take the measurements needed to determine the refractive index for light travelling from air into the plastic.

Explain **one** limitation of this equipment when used to obtain the measurements.

(2)

(b) The value of refractive index obtained by the student was 1.52.

(i) Calculate the speed of light in the plastic.

(2)

Speed of light in the plastic =

(ii) Calculate the critical angle for the plastic.

(2)

Critical angle =

*(c) The student was given the shape shown in Figure 2 made from the same plastic.

Figure 3 shows what happens when light from a laser was directed at one end of the shape.

Figure 2

Figure 3

Explain the path of the laser light through the plastic as shown in Figure 3.

(4)

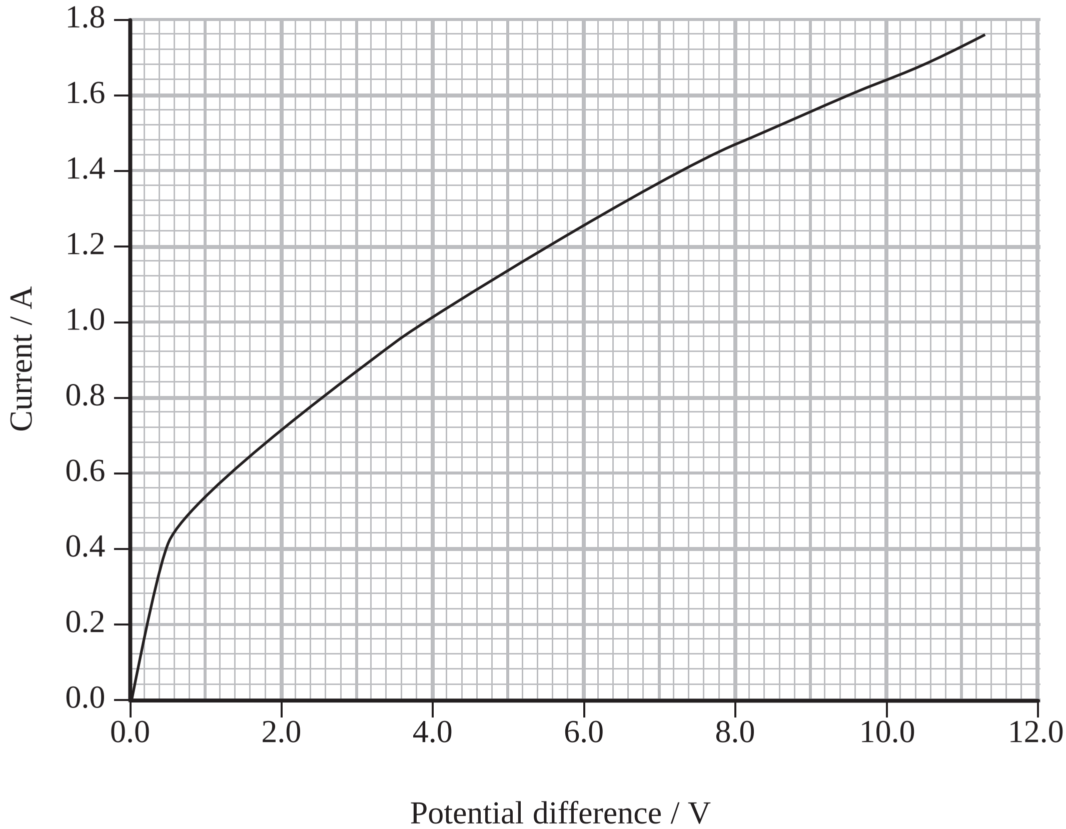
(Total for Question = 10 marks)

4 A student investigates how the current through a filament light bulb varies with the potential difference across it.

(a) Draw a diagram of a circuit the student could use to obtain suitable measurements for a range of potential difference from 0 V to 12 V.

(3)

(b) The student's results are shown on the graph.



The student decides to draw a tangent to the curve at a potential difference of 6 V and use the gradient of the tangent to determine the resistance of the bulb.

(i) Explain why this is **not** a correct method to determine the resistance.

(2)

(ii) Calculate the resistance of the bulb when the potential difference across it is 6 V.

(2)

Resistance =

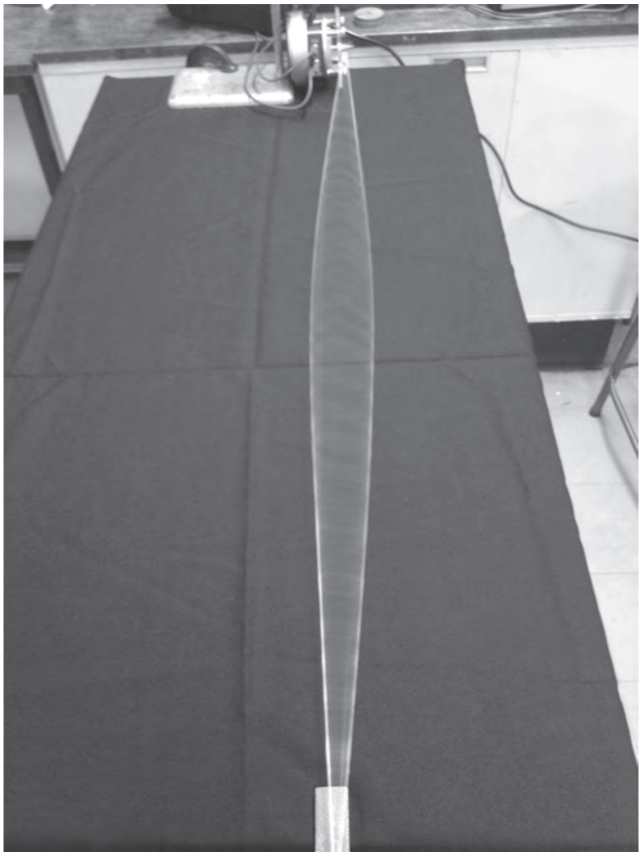
*(c) Describe and explain the change in the resistance of the bulb as the potential difference across it is increased.

(4)

(Total for Question = 11 marks)

5 A student investigates the effect of changing the frequency of waves on a string held in tension.

The string is fixed at one end and has a vibration generator attached to the other end. When the vibration generator is switched on a wave is produced on the string as shown in the photograph.



(a) Name the type of wave produced on the string and explain how it has been formed.

(4)

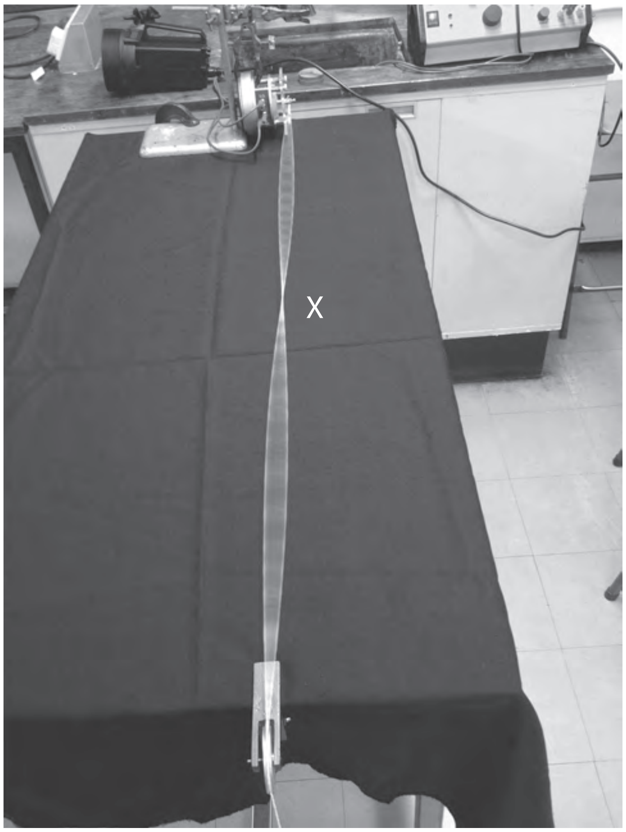
(b) The length of string between the vibration generator and the fixed end is 1.8 m. The string is vibrating with a frequency of 330 Hz.

Calculate the speed of the waves on the string.

(3)

Speed of the waves =

(c) The frequency of the vibration generator is changed from 330 Hz. The new wave produced on the string is shown in the photograph below.



(i) The student is able to touch the string at point X without disturbing the pattern.

Explain why.

(2)

(ii) Calculate the new frequency of the vibration generator.

(1)

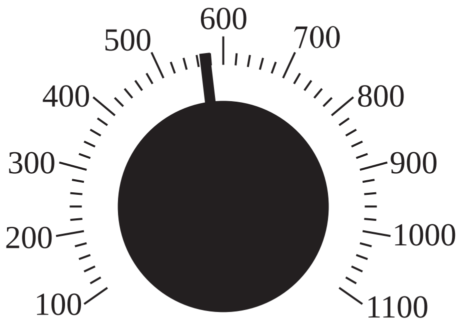
Frequency =

(iii) The vibrating string is now illuminated using a strobe lamp without adjusting the frequency of the vibration generator. The lamp flashes on and off many times a second at a frequency which may be varied by the student. The picture below shows a section of the string that now appears to be two separate strands.

Calculate the maximum possible frequency of the strobe lamp which will cause the appearance of two separate strands and explain why this is a maximum frequency.

(2)

(d) The frequency of the vibration generator is adjusted by turning the dial shown below. The student measures the frequency of vibration by reading from the scale shown on the dial.



Explain a disadvantage of this method of measuring the frequency.

(2)

(Total for Question = 14 marks)