

1 In this experiment, you will investigate the phase difference between the oscillations of two mass-spring systems.

- (a) • Assemble the apparatus as shown in Fig. 1.1.

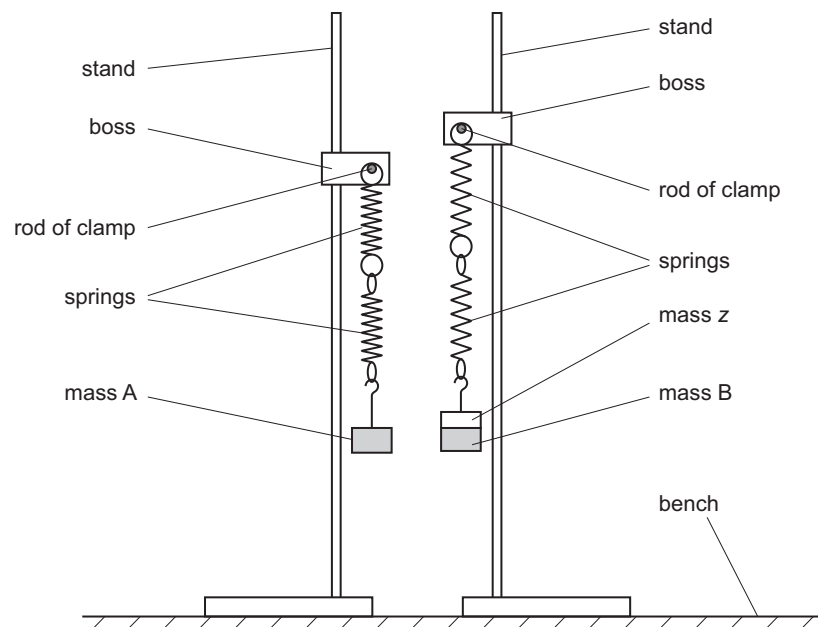


Fig. 1.1

- Mass A and mass B are each 200 g.
- Add a mass z of 40 g to mass B.

Record the value of z.

$z = \dots\dots\dots$ g

- M is given by $M = 200\text{ g} + z$.

Calculate M .

$M = \dots\dots\dots$ g

- Pull both A and B down a short distance and release them together. Observe the oscillations. A and B initially oscillate in phase (both moving up and down together), then their oscillations go out of phase and then become in phase again.
- The time from A and B oscillating in phase to the next time they oscillate in phase is P .

Measure and record P .

$P = \dots\dots\dots$ [2]

(b) Change z and determine P . Repeat until you have six sets of values of z and P .

Record your results in a table. Include values of M , $\frac{1}{\sqrt{M}}$ and $\frac{1}{P}$ in your table.

- (c) (i)** Plot a graph of $\frac{1}{P}$ on the y -axis against $\frac{1}{\sqrt{M}}$ on the x -axis.

(ii) Draw the straight line of best fit.

(iii) Determine the gradient and y -intercept of this line.

[10]

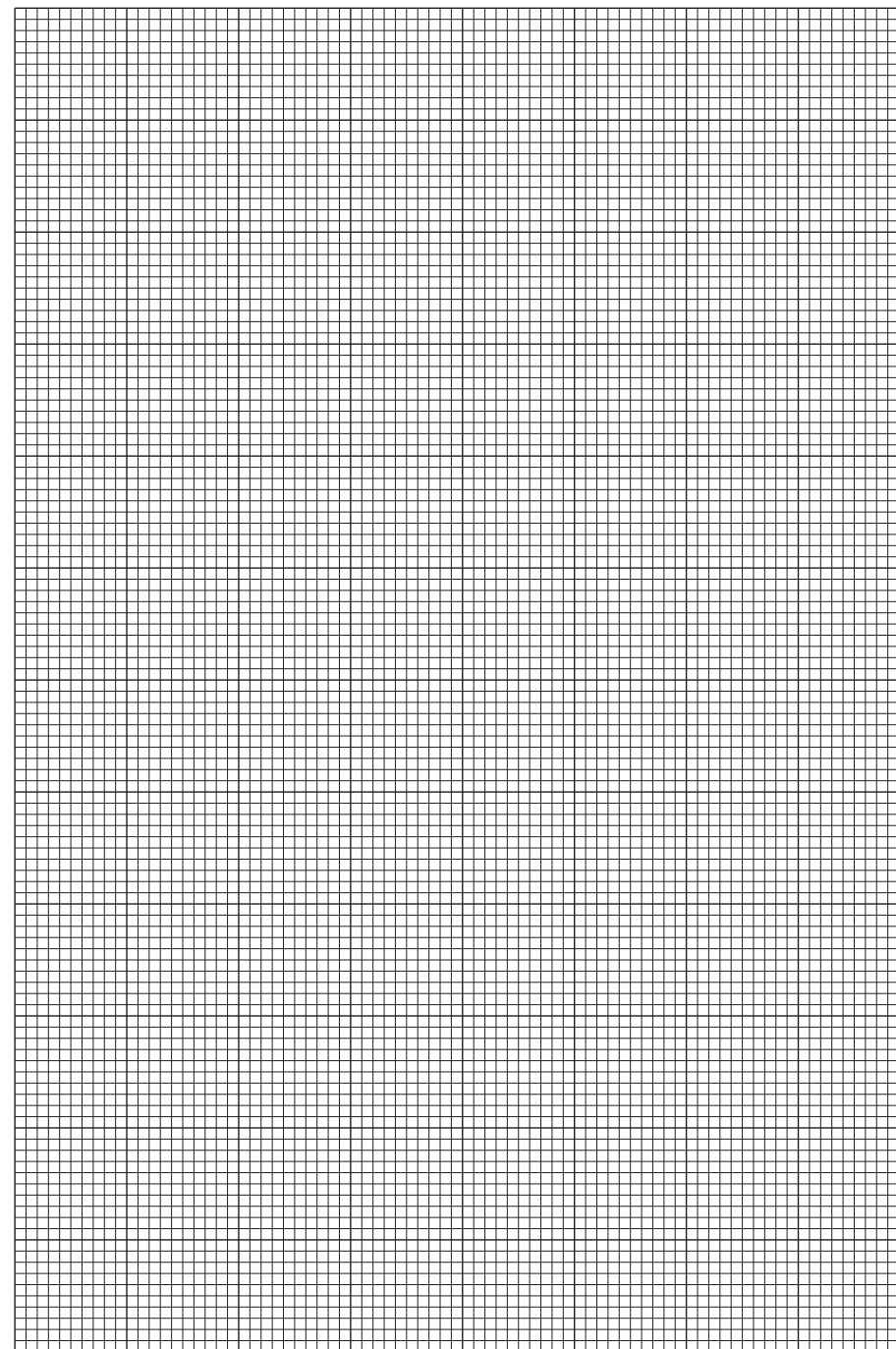
[3]

[1]

gradient =

y -intercept =

[2]



- (d) It is suggested that the quantities P and M are related by the equation

$$\frac{1}{P} = \frac{a}{\sqrt{M}} + b$$

where a and b are constants.

Use your answers in (c)(iii) to determine the values of a and b .
Give appropriate units.

$a =$

$b =$

[2]

[Total: 20]

You may not need to use all of the materials provided.

- 4 (a) State the value of absolute zero on:

- (i) the Celsius temperature scale

temperature = °C [1]

- (ii) the thermodynamic temperature scale. Give a unit with your answer.

temperature = unit [1]

- (b) A sample contains a fixed amount of gas. The gas has pressure p , volume V and thermodynamic temperature T .

Fig. 4.1 shows the variation of pV with kT for the sample, where k is the Boltzmann constant.

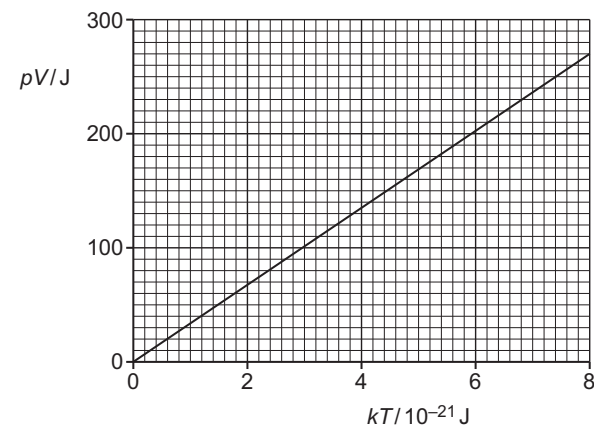


Fig. 4.1

- (i) State what is indicated about the nature of the gas from the variation shown in Fig. 4.1.

..... [1]

- (ii) Determine the number N of molecules of the gas in the sample.

$N =$ [2]

(iii) Use your answer in (b)(ii) to determine the amount n of gas in the sample.

$$n = \dots\dots\dots \text{mol} \quad [1]$$

(c) The root-mean-square (r.m.s.) speed of the molecules of the gas is 1900 ms^{-1} when pV is equal to 270 J .

Determine the mass, in u , of one molecule of the gas, where u is the unified atomic mass unit.

$$\text{mass} = \dots\dots\dots u \quad [4]$$

[Total: 10]

5 (a) Define electric potential at a point.

.....

 [2]

(b) A hydrogen atom may be considered to consist of a proton and an electron separated by a distance of 120 pm , as shown in Fig. 5.1.

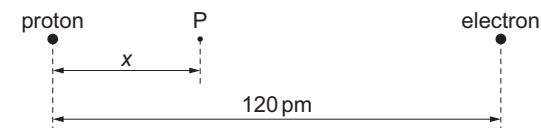


Fig. 5.1

The two particles may be considered as point charges.

Point P lies on the line joining the electron and the proton and is at a variable distance x from the proton.

(i) Show that the electric potential V at point P when $x = 10 \text{ pm}$ is equal to 130 V .

[2]

(ii) Calculate, to two significant figures, V when $x = 30 \text{ pm}$.

$$V = \dots\dots\dots \text{V} \quad [2]$$

(iii) On Fig. 5.1, draw a cross ($\times$) at one position, other than infinity, where the electric potential is zero. [1]

(iv) On Fig. 5.2, sketch the variation of V with x between $x = 10\text{ pm}$ and $x = 110\text{ pm}$.

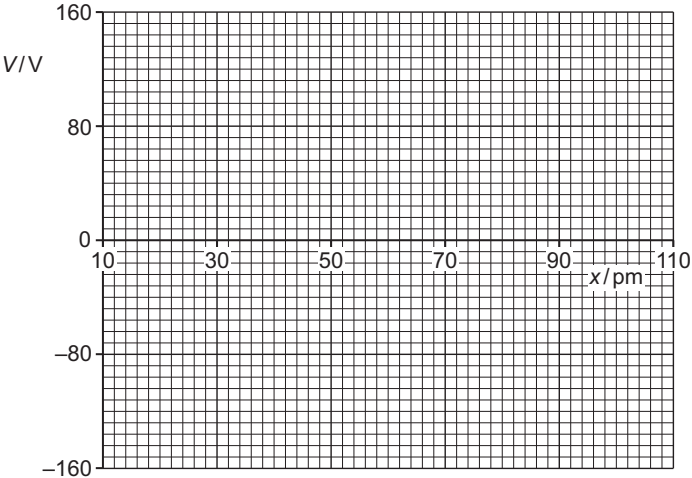


Fig. 5.2

[3]

[Total: 10]

- 6 (a) Two parallel plate capacitors C_1 and C_2 are connected to a supply that has a potential difference (p.d.) V_S . The capacitors may be connected in series or in parallel.

The supply provides charge Q_S and the plates of the two capacitors acquire charges Q_1 and Q_2 respectively. The p.d.s across the plates of the capacitors are V_1 and V_2 respectively.

Complete Table 6.1 to indicate how Q_S , Q_1 and Q_2 relate to each other, and how V_S , V_1 and V_2 relate to each other, for series and parallel connections of the capacitors to the supply.

Table 6.1

	relationship between charges	relationship between p.d.s
series		
parallel		

[4]

- (b) An isolated capacitor of capacitance $470\text{ }\mu\text{F}$ stores 19 mJ of energy.

(i) Calculate the p.d. across the capacitor.

p.d. =V [2]

(ii) Calculate the charge on the capacitor.

charge = C [2]

- (iii) The capacitor is now connected in parallel with a capacitor of capacitance $180\mu\text{F}$ that is initially uncharged.

Determine the total energy, in mJ, now stored in the two capacitors.

energy = mJ [3]
[Total: 11]

- 7 (a) State Faraday's law of electromagnetic induction.

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..... [2]

- (b) An aircraft is flying horizontally at constant speed v through the Earth's magnetic field, as shown in Fig. 7.1.

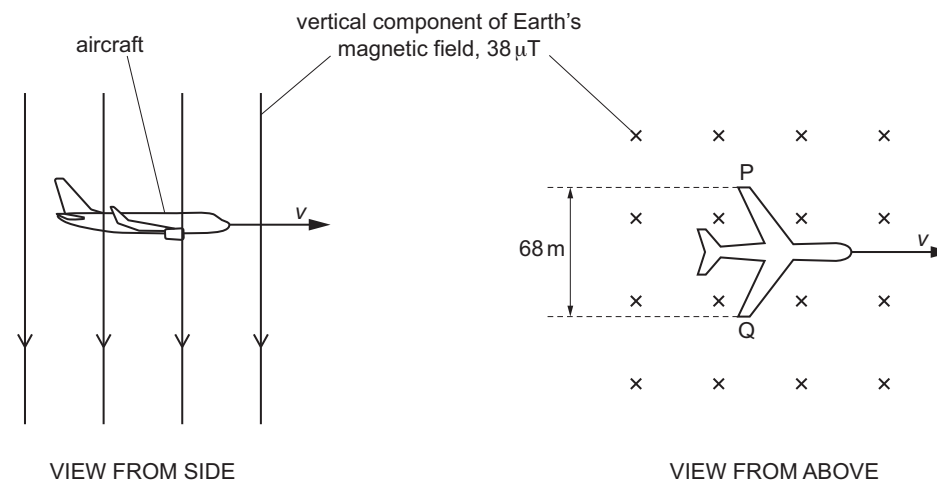


Fig. 7.1

At the location of the aircraft, the vertical component of the Earth's magnetic field is $38\mu\text{T}$ towards the ground.

The distance between the wingtips P and Q of the aircraft is 68 m.

As the aircraft moves through the magnetic field, an electromotive force (e.m.f.) of 0.54 V is induced between the wingtips P and Q.

- (i) Calculate the magnetic flux cut by the wings of the aircraft in a time of 15 s. Give a unit with your answer.

magnetic flux = unit [2]

(ii) Determine the area of flux cut by the wings in a time of 15 s.

area =m² [2]

(iii) Use your answer in (b)(ii) to determine the speed *v* of the aircraft.

v =ms⁻¹ [2]

(iv) Use Lenz’s law of electromagnetic induction to explain which of the wingtips P and Q is at the higher induced potential.

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..... [3]

[Total: 11]

2 (a) State **two** ways in which the first law of thermodynamics describes that the internal energy of a system may be changed.

1

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2

..... [2]

(b) (i) Use the first law of thermodynamics to explain why a bicycle pump gets hot when it is used to pump up a tyre quickly.

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..... [3]

(ii) With reference to molecular energies, explain why the temperature of water remains at 100 °C when it vaporises in a kettle, even though it is being heated.

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..... [3]

[Total: 8]