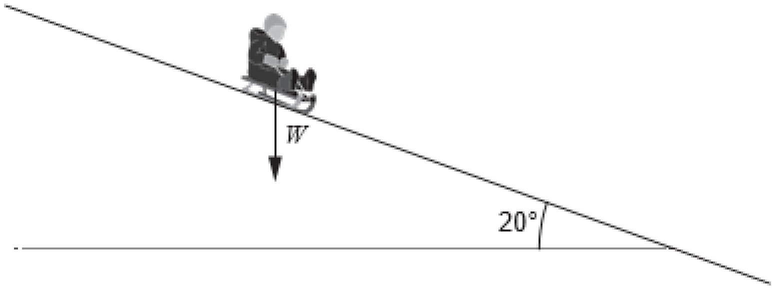
GCE PHYSICS

S21-A420QS

Assessment Resource number 2

Newtonian Physics Resource B

1. Matthew is sliding down a snow-covered slope on a sledge. The total mass of Matthew and the sledge is 62 kg.



(a) On the diagram the arrow represents the total weight, W, of Matthew and the sledge. **Add two more arrows** to show the normal contact force on the sledge and the frictional force on the sledge. [1]

(b) (i) Show that the component of W parallel to the slope is approximately 200 N. [2]

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(ii) Calculate the magnitude of the normal contact force. [2]

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(c) The sledge's acceleration just after it has started moving is measured to be 2.5 m s^{-2}. Matthew believes that, starting from rest, it will take him less than 9.0 s to slide 100 m down the slope. Evaluate whether or not he is correct, commenting on whether or not your calculation is conclusive. [3]

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2

(a) State Newton's second law of motion in terms of *momentum*. [2]

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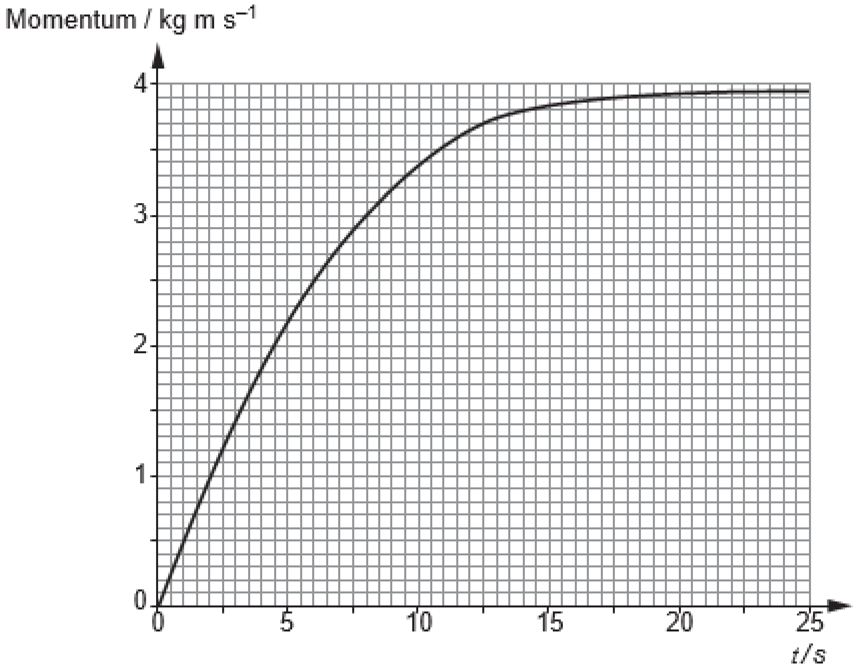
(b) A momentum-time graph is plotted below for an object of mass 0.050 kg dropped (at time $t = 0$) from the top of a high cliff.



(i) Show clearly that the resultant force on the object at $t = 10$ s is approximately 0.15 N. [3]

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(ii) Deduce the magnitude of the force of air resistance on the object at $t = 10$ s. [2]

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(iii) State the magnitude of the force of air resistance on the body when it has reached its terminal velocity. [1]

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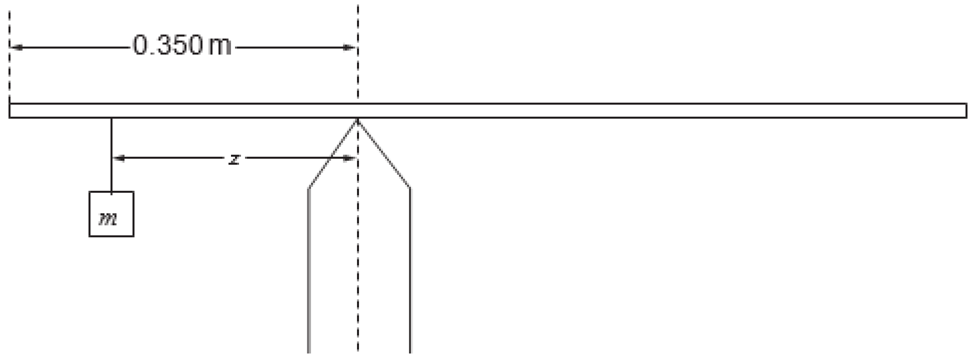
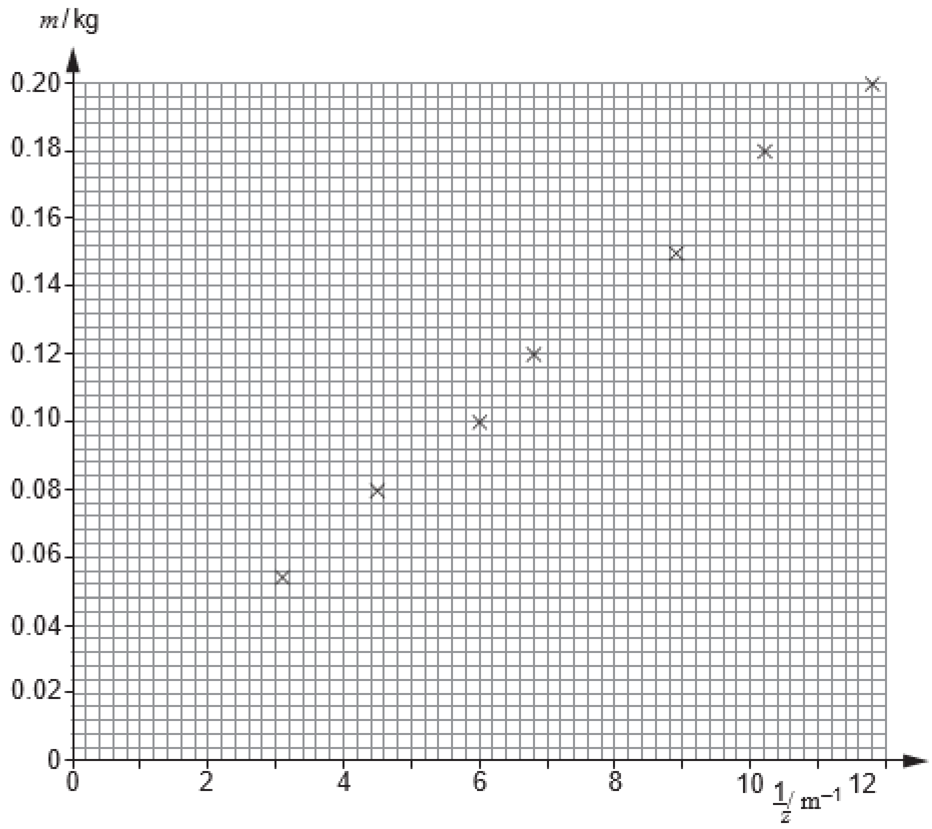
3

Nathan pivots a uniform metre ruler at 0.350 m from one end. He hangs a mass, m, from the ruler and moves the mass along until the ruler balances.



He records the distance, z (see diagram) and repeats the experiment with different masses, keeping the pivot in the same position on the ruler.

He plots m against $\frac{1}{z}$ on the grid below.



(a) Nathan correctly believes that m and z are related by the equation:

$$mz = M \times 0.150$$

in which M is the mass of the ruler and z is in metres.

Explain, in terms of moments, why this equation is correct. [3]

(b) Determine from the graph the best value for M, showing your working. The uncertainty is **not** required. [4]

(c) Discuss whether or not Nathan could have obtained readings for lower values of m than 0.050 kg, for the pivot in the same position on the ruler. [2]

4

(a) State two assumptions that must be made about the molecules of an ideal gas in order to derive the kinetic theory equation: [2]

$$p = \frac{1}{3}\rho\overline{c^2}$$

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(b) A cylinder of volume 5.0×10^{-2} m^3 contains 2.20 mol of argon gas (relative molecular mass, M_r = 39.9) at a pressure of 250 kPa.

(i) Calculate the rms speed of the argon molecules. [3]

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(ii) I. State what would happen to the rms speed if the kelvin temperature of the gas in the cylinder were doubled, justifying your answer. [2]

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II. Explain briefly whether or not your answer to *(b)* (ii) I. would still apply if some gas escaped from the cylinder while the temperature was being raised. [1]

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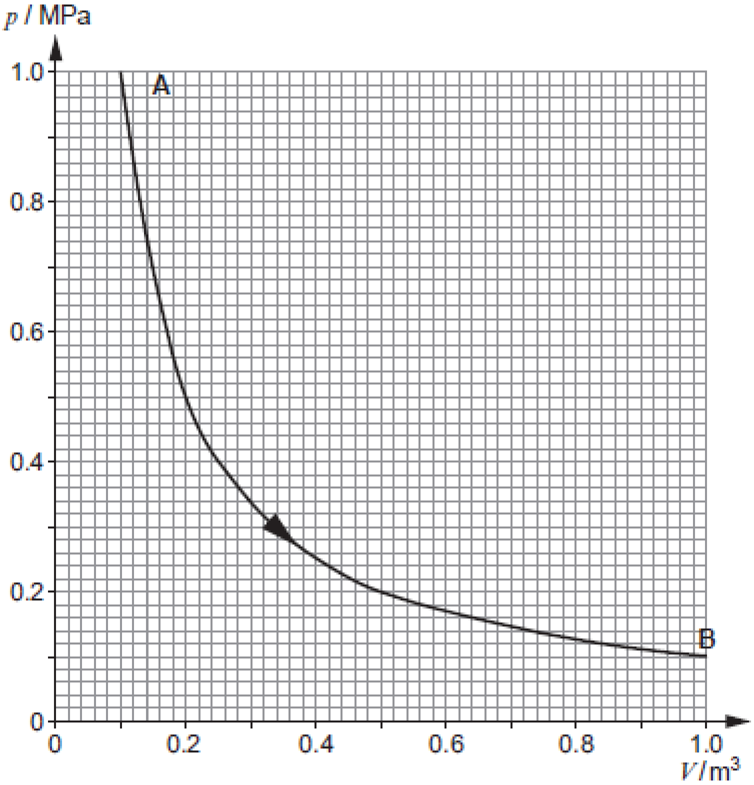
5

(a) 33.2 mol of nitrogen gas is contained in a cylinder fitted with a piston. The gas is allowed to expand from A to B, doing work against the piston. A p–V graph for the expansion is given below.



(i) Show that the expansion occurs at a constant temperature of approximately 360 K. [3]

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(ii) Determine the approximate amount of work done by the gas during the expansion. [2]

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(iii) Rini claims that the work done by the gas results in an equal amount of internal energy being lost by the gas. Give the *correct* application of the first law of thermodynamics to this isothermal expansion. [2]

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(b) An estimated 600 MJ of work can be produced by an ordinary car engine burning 0.10 m^3 (100 litre) of petrol. An estimated 15 MJ of work can be produced by the expansion of the same volume of air compressed to the highest safe (initial) pressure.

Discuss the advantages and disadvantages of powering cars by compressed air rather than petrol. Calculations are not required. [3]

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