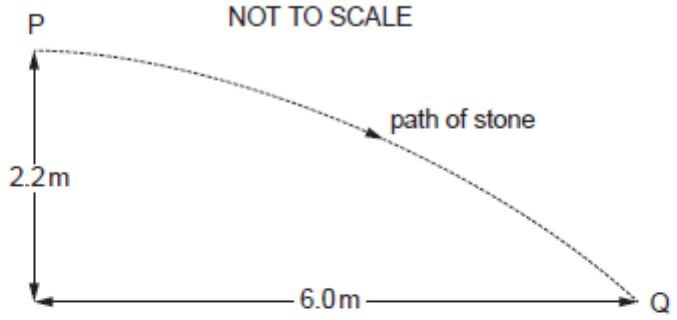
GCE PHYSICS

S21-A420QS

Assessment Resource number 4

Newtonian Physics Resource D

1. *(a)* In an investigation of projectile motion, a student throws a stone. It is moving horizontally when it leaves his hand (at point P). It reaches the ground at point Q.



(i) By analysing a video of the stone's flight, its horizontal velocity component, v_h, is found to be almost constant. Discuss whether or not this is to be expected. [2]

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(ii) The approximate value of v_h obtained from the video was $9.0\,m\,s^{-1}$. Determine whether this value is consistent with the measured distances recorded in the diagram. Show your reasoning clearly. [3]

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(b) Calculate the magnitude **and direction** of the stone's velocity just before it hits the ground. [4]

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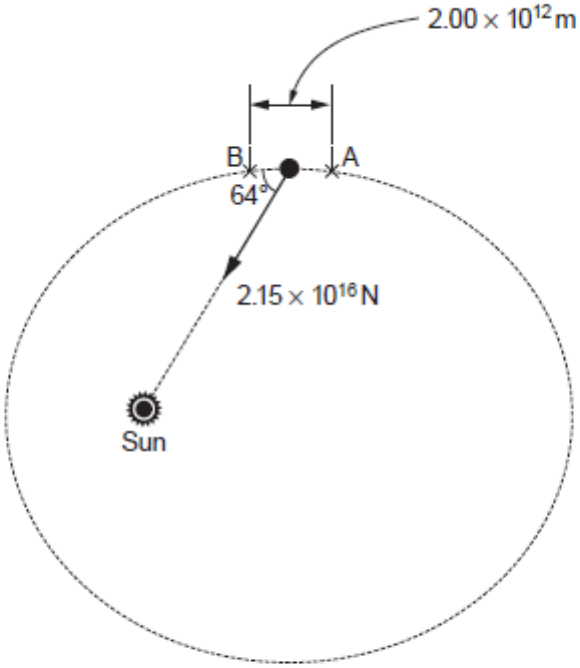
2. The diagram shows the dwarf planet, Eris, at one point in its orbit.



(a) Explain why the *moment* (about the centre of the Sun) of the Sun's force on Eris is zero. [1]

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(b) Calculate the *work* done by the Sun's gravitational force on Eris as Eris moves from A to B. The mean values of the force and the angle at which it acts are shown on the diagram. [2]

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(c) Showing your reasoning clearly, determine whether your answer to *(b)* is consistent with these data:

Mass of Eris = 1.66×10^{22} kg

Speed of Eris at A = $3460\,m\,s^{-1}$

Speed of Eris at B = $3770\,m\,s^{-1}$ [3]

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3. *(a)* State the principle of conservation of momentum. [2]

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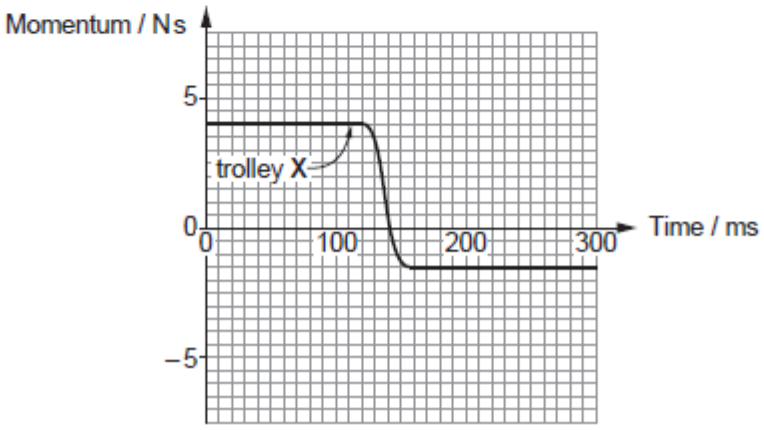
(b) A trolley, **X**, travels towards a stationary trolley, **Y**. See diagram.

The trolleys collide head-on. A momentum-time graph is given for trolley **X**.



(i) Trolley **Y** has a mass of 2.4 kg. Determine its velocity after the collision. [3]

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(ii) **Using the same graph grid (opposite)** carefully sketch a graph of **Y**'s momentum between 0 and 300 ms. [3]

(iii) Use the momentum-time graph for **X** to estimate the mean *force* on **X** during the collision. [2]

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(a) Vadim uses a ruler to measure the sides of a copper block. He records the measurements as:

length = 50 ± 1 mm, breadth = 42 ± 1 mm, height = 36 ± 1 mm.

Using an electronic balance he measures the mass of the block as 670.85 ± 0.01 g.

Use Vadim's data to answer the following.

(i) Determine a value for the density of copper in kg m^{-3} and the **absolute** uncertainty in this value. [4]

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(ii) Determine the number of atoms per m^3 of copper. The uncertainty is **not** required. The atomic mass of copper is 63.5 u. [2]

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(b) (i) I. Calculate the number of molecules per m^3 for a gas (assumed to be ideal) at a temperature of 15 °C and a pressure of 101 kPa. [3]

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II. When asked why there are far fewer gas molecules per m^3 than atoms per m^3 in the copper block, a student replies, "Each molecule of the gas takes up much more space." Discuss whether or not he is right. [2]

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(ii) I. Two gases have molecular masses $m_{(1)}$ and $m_{(2)}$. Show clearly that when the gases are at the same temperature, the ratio of the rms speeds of their molecules is: [2]

$$\frac{c_{\text{rms}(1)}}{c_{\text{rms}(2)}} = \sqrt{\frac{m_{(2)}}{m_{(1)}}}$$

II. Calculate the percentage difference in the rms speeds of nitrogen and oxygen molecules in the same sample of air. Take the percentage difference to be defined as:

$$\frac{\text{rms speed for nitrogen} - \text{rms speed for oxygen}}{\text{rms speed for oxygen}} \times 100\%$$

[Molecular mass for nitrogen = 28.0 u. Molecular mass for oxygen = 32.0 u.] [2]

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