Oxford Cambridge and RSA

Wednesday 22 May 2024 – Afternoon

AS Level Physics B (Advancing Physics)

H157/02 Physics in depth

Time allowed: 1 hour 30 minutes

You must have:
- the Data, Formulae and Relationships Booklet

You can use:
- a scientific or graphical calculator
- a ruler (cm/mm)

Please write clearly in black ink. **Do not write in the barcodes.**

Centre number | | | | | | Candidate number | | | | |

First name(s) ______________________

Last name ______________________

INSTRUCTIONS
- Use black ink. You can use an HB pencil, but only for graphs and diagrams.
- Write your answer to each question in the space provided. If you need extra space use the lined page at the end of this booklet. The question numbers must be clearly shown.
- Answer **all** the questions.
- Where appropriate, your answer should be supported with working. Marks might be given for using a correct method, even if your answer is wrong.

INFORMATION
- The total mark for this paper is **70**.
- The marks for each question are shown in brackets **[ ]**.
- Quality of extended response will be assessed in questions marked with an asterisk (*).
- This document has **24** pages.

ADVICE
- Read each question carefully before you start your answer.

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ERRATUM NOTICE

Wednesday 22 May 2024 – Afternoon

AS Level Physics B (Advancing Physics)

H157/02 Physics in depth

FOR THE ATTENTION OF THE EXAMS OFFICER

To be opened on the day of the exam

Instructions to invigilators:

Before the start of the exam, give one copy of this erratum to each candidate.

Ask all candidates to correct **pages 5** and **7** of the **Data, Formulae and Relationships Booklet** as per the instructions to candidates below before starting the exam.

Instructions to candidates:

Add these equations to the **Data, Formula and Relationships Booklet.**

On **page 5** in the section **Motion and Forces:**

power $P = Fv$, $\boxed{P = \frac{\Delta E}{t}}$

In the same section **Motion and Forces:**

for circular motion $a = \frac{v^2}{r}$, $F = \frac{mv^2}{r}$ $\boxed{= mr\omega^2}$

On **page 7** in the section **Field and Potential:**

gravitational fields $g = \frac{F}{m}$, $\boxed{E_{grav} = -\frac{GmM}{r}}$

$V_{grav} = -\frac{GM}{r}$, $F = -\frac{GmM}{r^2}$

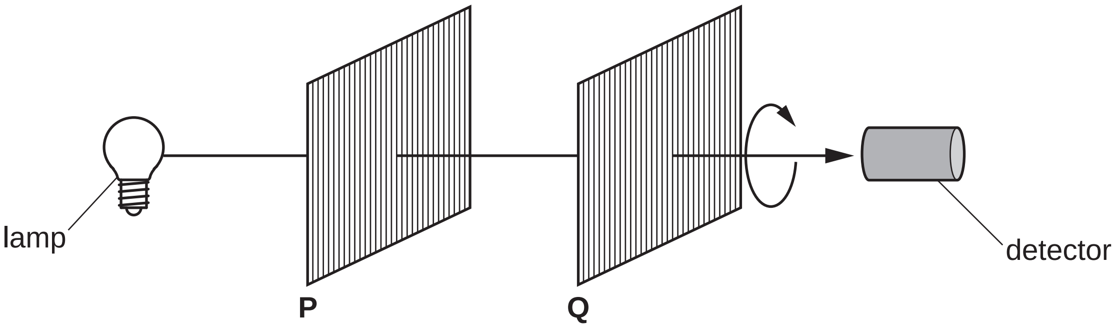
If you have any queries, please call our Customer Support Centre on 01223 553998 or email support@ocr.org.uk

Section A

1

(a) **Fig. 1.1** shows two polarising filters **P** and **Q**, placed between a lamp and a detector.

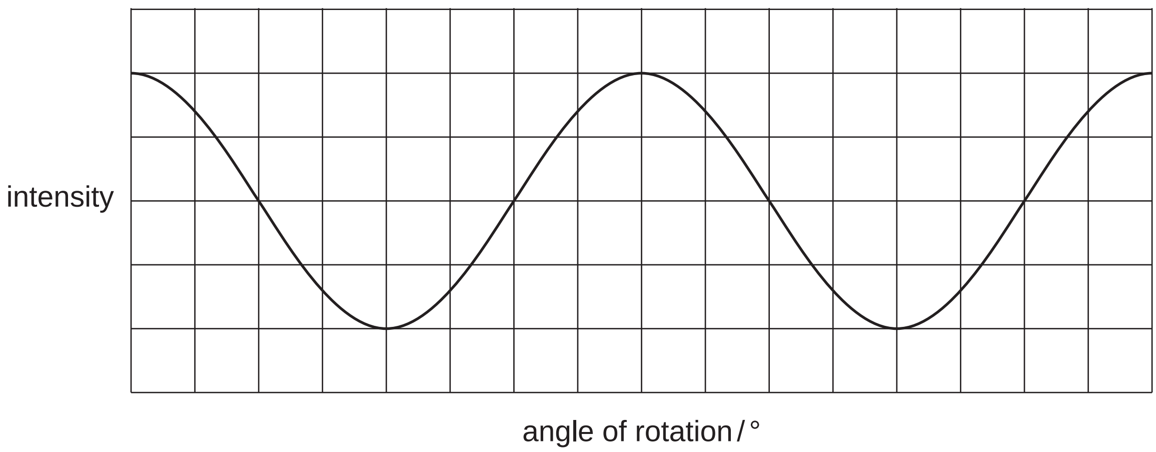
Fig. 1.1



Initially the polarising filters are orientated with their planes of polarisation parallel to each other. **Q** is then rotated, as shown, about the beam of light travelling from the lamp to the detector.

(i) **Fig. 1.2** is a graph of the light intensity registered by the detector against the angle of rotation of polaroid **Q** from its initial position.

Fig. 1.2



Label the horizontal scale, angle of rotation / ° of the graph with the appropriate scale.

[1]

(ii) What characteristic of a light wave allows it to be polarised?

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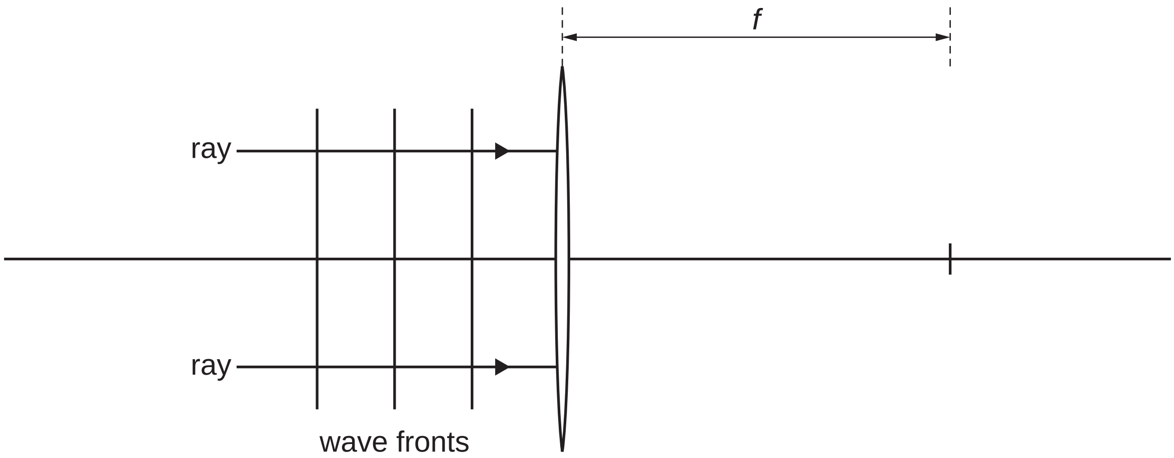
.... **[1]**

(b) **Fig. 1.3** shows two rays and three wave-fronts in a beam of light that is incident on a thin converging lens. The focal length of the lens is *f*.

Fig. 1.3

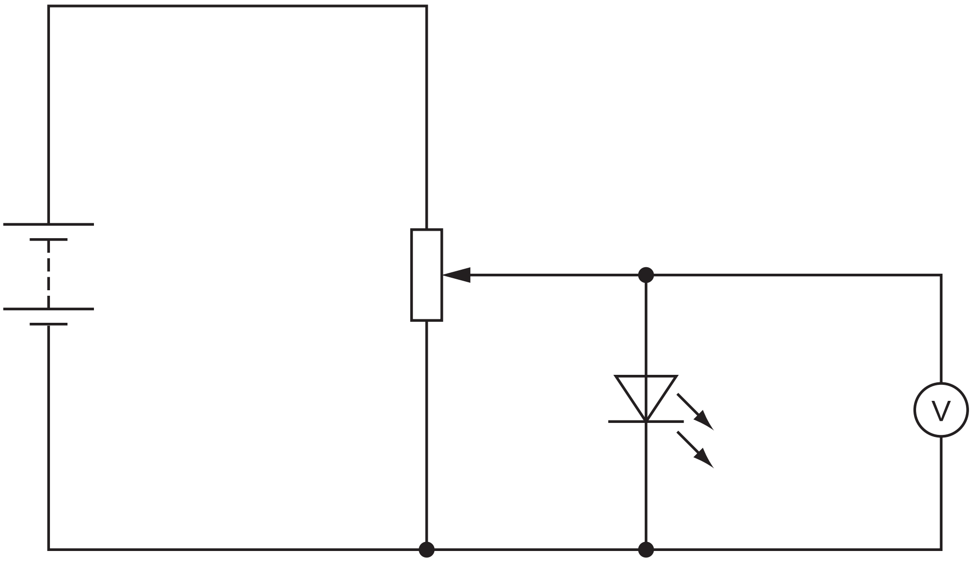


Complete **Fig. 1.3** by drawing the rays and at least **three** wave fronts after they have passed through the lens.

[2]

2 **Fig. 2.1** shows a circuit used by a student to determine the Planck constant.

Fig. 2.1



The potential difference at which the diode begins to emit photons is called its threshold voltage.

In the experiment the student increases the potential difference across the light emitting diode (LED) until it just starts emitting photons and notes the threshold voltage, *V*, shown on the voltmeter.

At the threshold voltage each electron passing through it loses an amount of energy equal to *eV* and emits a photon of light having the same energy.

The table shows the results for one LED.

Colour	Wavelength / nm	Threshold voltage / V
green	565	1.9

(a) Use information from the table to calculate the Planck constant.

Planck constant = ... J s **[2]**

(b) State and explain how the experiment and apparatus could be modified to give a more accurate value of the Planck constant.

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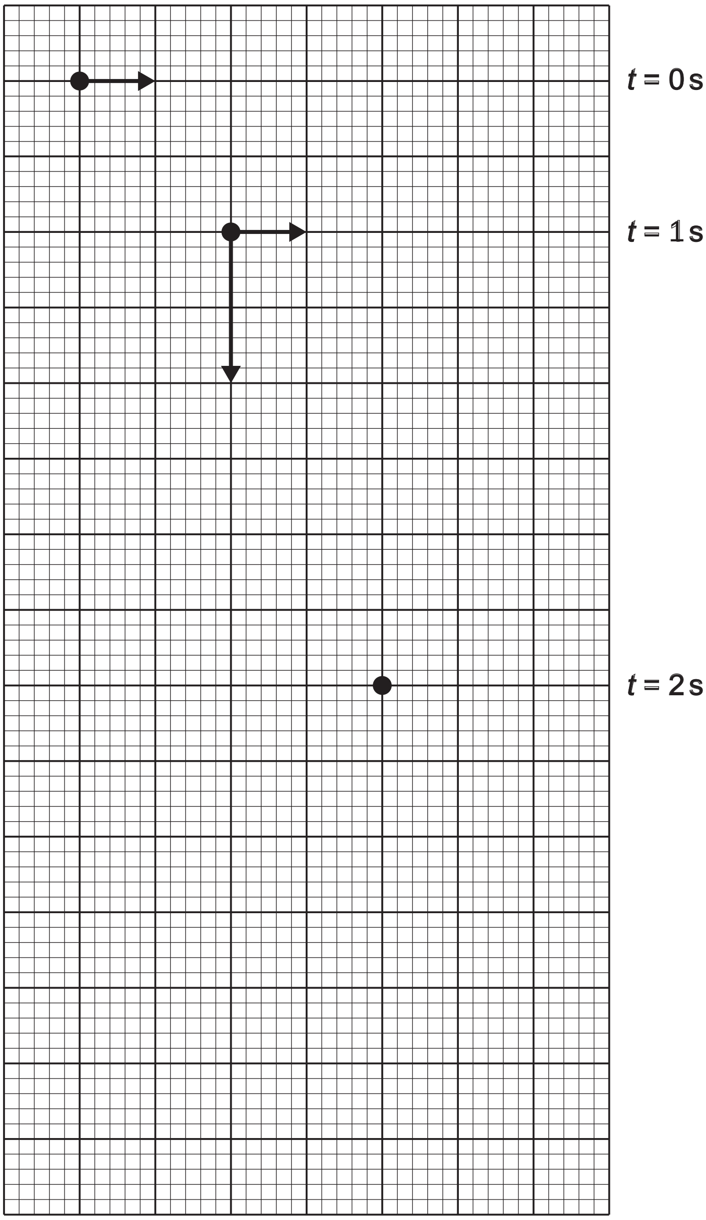
.... **[3]**

3 A ball is projected horizontally at a speed of $5\,m\,s^{-1}$ from the top of a cliff.

Fig. 3.1 shows the relative positions of the ball at 1 second intervals for 2 seconds after it is projected.
Fig. 3.1 has been drawn on graph paper that has large squares measuring 1 cm by 1 cm.

Fig. 3.1



The dots show the positions of the ball, and the arrows are vectors representing the horizontal and vertical components of the velocity of the ball at each position.

On **Fig. 3.1**, the arrows representing the velocity components have been drawn to a scale of 5 squares to $5\,ms^{-1}$.

(a) Explain how **Fig. 3.1** shows that air resistance acting on the ball is negligible.

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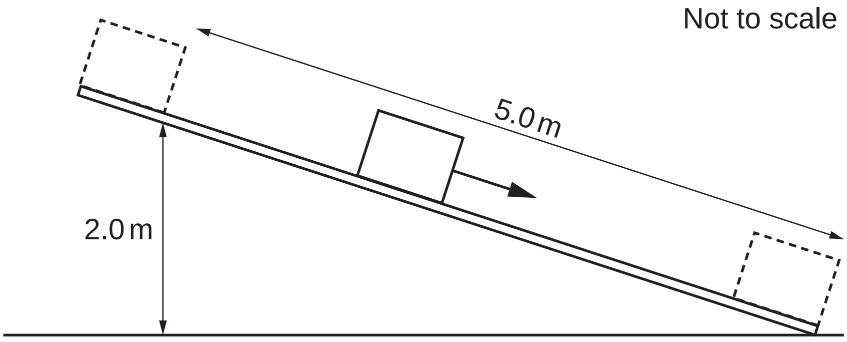
.... **[2]**

(b) On **Fig. 3.1** draw arrows to represent the horizontal and vertical components of the ball's velocity at time 2 s and use the diagram to calculate the magnitude of the resultant velocity at that time.

magnitude of velocity = ... $m\,s^{-1}$ **[3]**

4 **Fig. 4.1** shows a box sliding down a slope.

Fig. 4.1



The mass of the box is 50 kg.

The box starts from rest at the top of the slope and then accelerates uniformly and reaches a speed of 4.0 m s^{-1} at the bottom of the slope.

(a) Show that the frictional force acting on the box as it slides down the slope is about 120 N.

[4]

(b) Calculate the average rate at which energy is transferred to the surroundings.

average rate of transfer of energy = ... W **[3]**

5

(a) Newton's 2nd law can be expressed as $F = \frac{\Delta p}{\Delta t}$.

Explain the significance of the symbols Δp and Δt in this equation and show how this expression leads to the equation $F = ma$.

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.... **[2]**

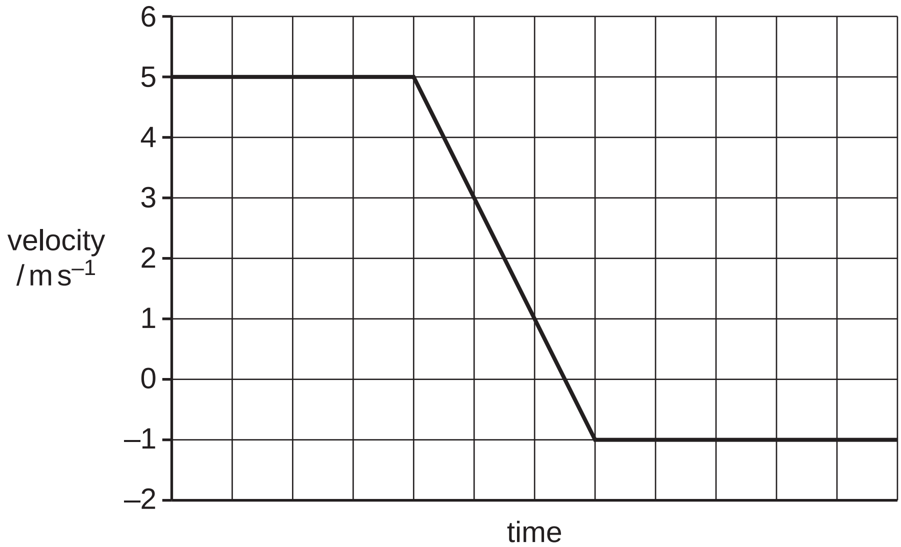
(b) **Fig. 5.1** shows sphere **P** moving towards sphere **Q**, which is initially at rest.

Fig. 5.1

Sphere **P** has a mass of 1 kg and sphere **Q** has a mass of 4 kg.

Fig. 5.2 shows how the velocity of sphere **P** changes before, during and after its collision with sphere **Q**.

Fig. 5.2



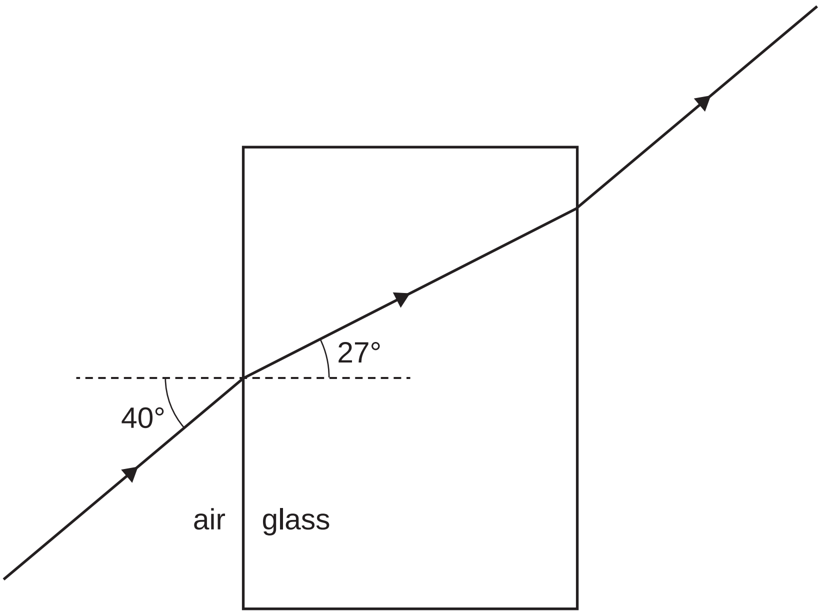
On **Fig. 5.2** draw a line to show the velocity of sphere **Q** before, during and after the collision.
[2]

Section B

6

(a) **Fig. 6.1** shows a ray of red light passing from air into and through a glass block.
The wavelength of the red light is 650 nm and the speed of light in air is $3.0 \times 10^8\,\mathrm{m\,s^{-1}}$.

Fig. 6.1



Calculate the speed of the red light and its wavelength in glass.

speed = ... $\mathrm{m\,s^{-1}}$

wavelength = ... nm

[2]

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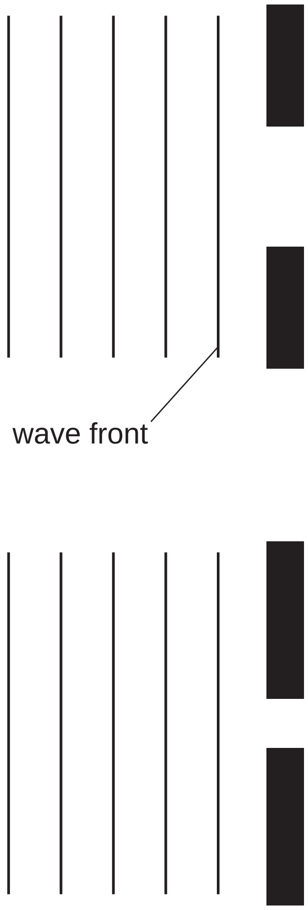
Question 6(b) starts on page 12

(b) The diagrams in **Fig. 6.2** show identical sets of water waves moving towards different sized gaps in a barrier.

Fig. 6.2

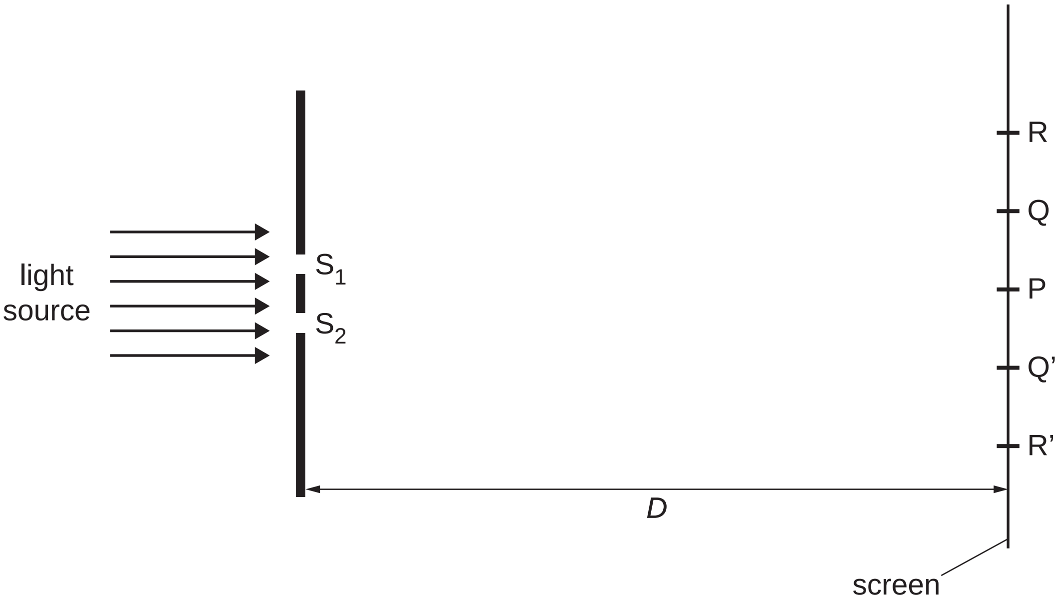


Complete the diagrams in **Fig. 6.2** by drawing on the wave-fronts for the water waves after they have passed through the gaps.

[2]

(c) **Fig. 6.3** shows Young's double slit experiment. A narrow beam of monochromatic light is incident normally on two narrow slits, S_1 and S_2, and the resulting interference pattern is viewed on a screen placed a distance *D* from the slits.

Fig. 6.3



Lines of maximum light intensity are seen at points P, R and R' on the screen, and lines of minimum light intensity are seen at points Q and Q' on the screen.

The following measurements are made:

S_1S_2 = 0.2 mm
D = 2.5 m
RR' = 1.25 cm

(i) Calculate the wavelength of the light used in the experiment.

wavelength = ... nm **[3]**

(ii) Describe how the pattern on the screen would change if a white light source was used instead of a monochromatic source.

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.... **[2]**

(iii)* The behaviour of light can be explained in terms of the wave model or the model of photons with a phasor amplitude.

Describe how both the wave model of light and the photon model of light can be applied to explain the formation of the interference pattern seen on the screen.

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.... **[6]**

7 This question is about the forces acting on a falling object and how they interact.

(a) A student holds a paper cone above the ground and then releases it so that it falls vertically. The student monitors the speed of the cone with a motion sensor, as shown in **Fig. 7.1**.

Fig. 7.1

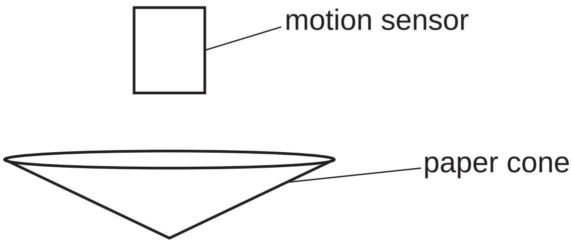
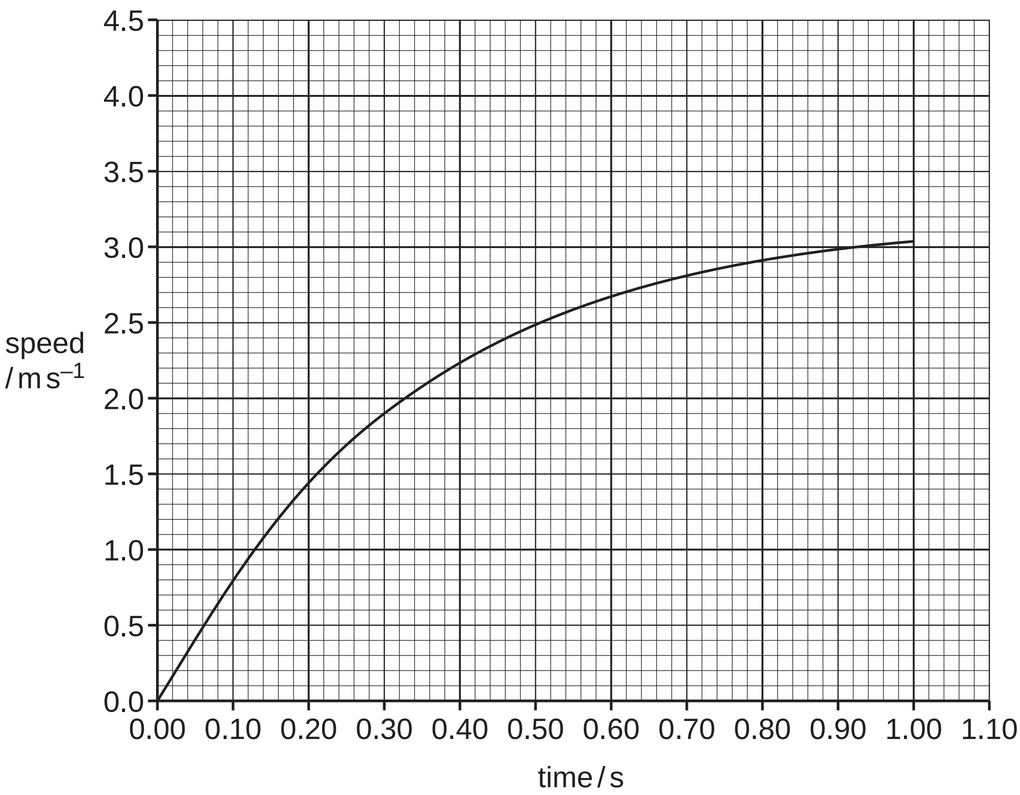


Fig. 7.2 shows the results obtained by the student.

Fig. 7.2



(i) Use the graph to calculate the acceleration of the cone at 0.40 s.

acceleration = ... m s^{-2} **[4]**

(ii) The student repeats the experiment with a 20 g mass placed in the cone.

On **Fig. 7.2** sketch a graph for the 2nd experiment and explain the shape of the graph you have drawn.

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.... **[3]**

(b) When a table tennis ball moves through air it experiences air resistance. It is found that the vertical acceleration of the falling ball satisfies the equation:

$a = 9.8 - kv^2$

where v is velocity of the ball and k is a constant.

(i) The terminal velocity of the ball is found to be 9.5 m s^{-1}.

Show that the value of k for the ball is about 0.1 m^{-1}.

[2]

The student uses an computational model with a computer spreadsheet to model the change in velocity of the ball as it falls. The table shows part of the spreadsheet used by the student.

The rows in the table are numbered 1 to 5 and the columns are labelled **A**, **B** and **C**.

	A	**B**	**C**
1	time / s	acceleration / $m\,s^{-2}$	velocity / $m\,s^{-1}$
2	0.00	9.800	0.000
3	0.10	9.800	0.980
4	0.20	9.704	1.960
5	0.30		

Row 2 in the spreadsheet gives the initial conditions for the ball at the moment it is released. The following rows show values of acceleration and velocity at 0.1 s intervals.

The student uses the following equation to calculate the acceleration of the table tennis ball at 0.1 s intervals.

$a_{new} = 9.8 - 0.1 \times (v_{previous})^2$.

To do this the student types the following formula into the cell B3.

'=9.8-0.1*C2^2'.

The student then drags the contents of cell B3 downwards to populate the cells below.

(ii) Calculate the acceleration of the ball at 0.30 s.

acceleration = ... $m\,s^{-2}$ **[1]**

(iii)
(1) Write down the equation in terms of $a_{previous}$, Δt, v_{new} and $v_{previous}$ to calculate the velocity of the ball at a given time.

[1]

(2) Write down the formula that the student should type into cell C3 to calculate the velocity of the ball at time 0.10 s.

[1]

(3) Calculate the velocity of the ball at time 0.30 s.

velocity = ... $m\,s^{-1}$ **[1]**

(iv) Describe an advantage of using this computational method to model the motion of a falling ball experiencing a changing resultant force. Suggest how the model can be made more accurate.

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.... **[2]**

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Section C

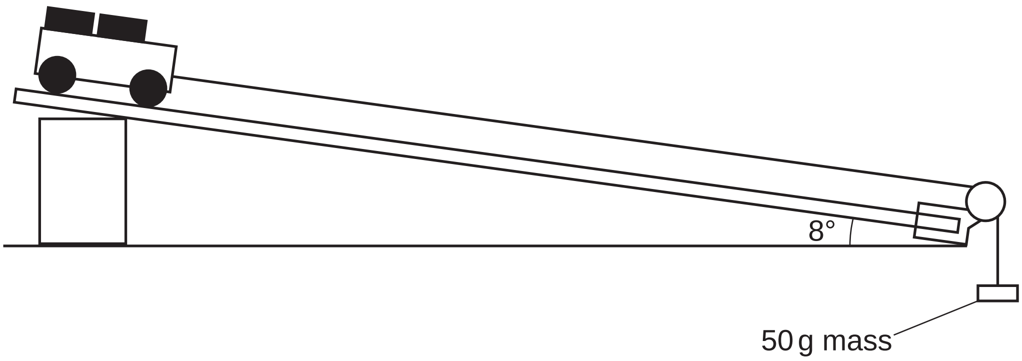
8 A student investigates the effect of changing the mass of a trolley on its acceleration when the resultant force acting on it is constant.

The trolley is placed on a runway inclined at 8° to the horizontal and it is accelerated by a falling 50 g mass, which is attached to it by a string that passes over a frictionless pulley. The mass of the trolley is 500 g and the student increases the mass by placing 100 g masses on top of the trolley.

The student releases the trolley from rest and uses a stopwatch to measure the time taken for the trolley to travel 1 metre along the runway and carries out this measurement three times for each trolley mass.

Fig. 8.1 shows the experimental set-up used by the student.

Fig. 8.1



(a) The 500 g trolley moves with constant velocity along the slope when the 50 g mass is removed.

Calculate the component of the weight of the 500 g trolley that acts down the slope and explain its significance.

weight component = ... N

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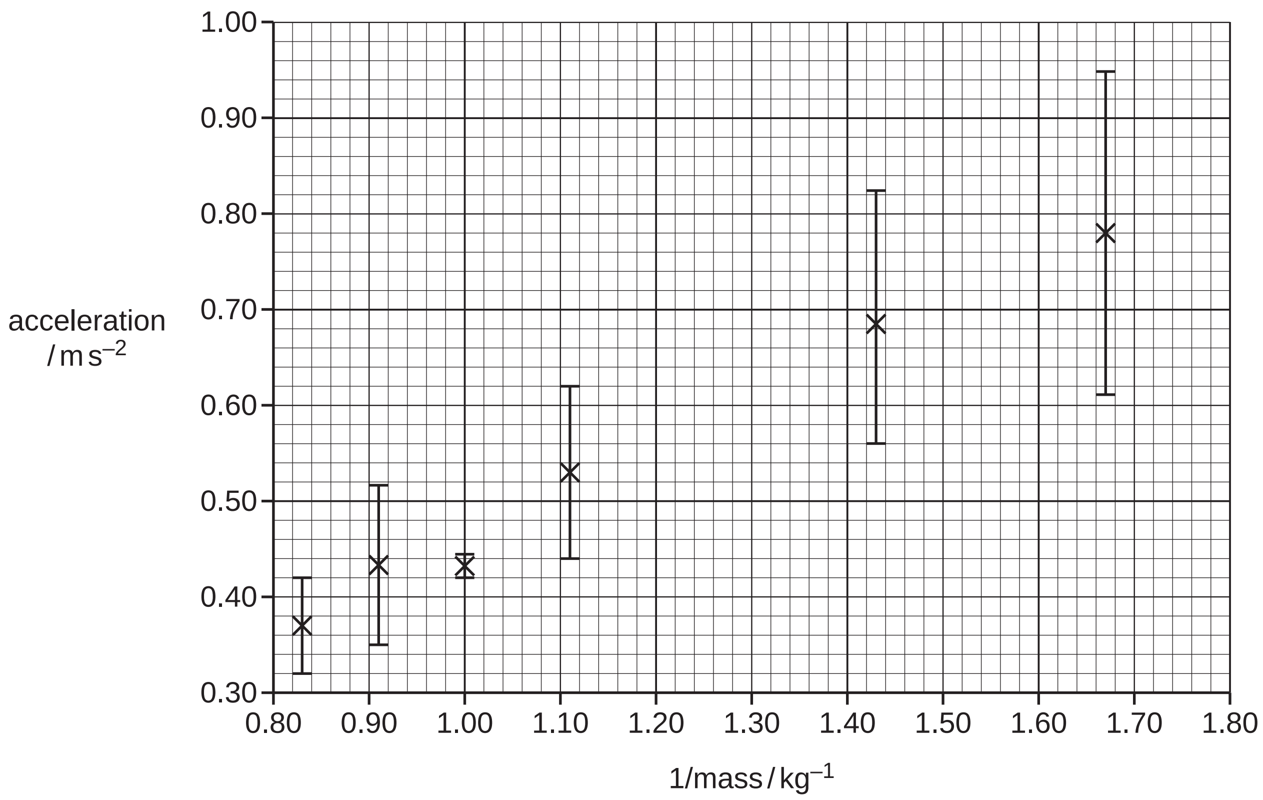
.... **[3]**

(b) **Table 8.1** and **Fig. 8.2** show the student's results.

Table 8.1

trolley mass / kg	1/mass / kg^{-1}	time to travel 1 m / s	average time / s	acceleration ± Δa / $m s^{-2}$
0.600	1.667	1.61, 1.43, 1.77	1.60	0.781 ± 0.165
0.700	1.429	1.93, 1.58, 1.63	1.71	0.684 ± 0.140
0.800	1.250	2.06, 1.74, 1.78		
0.900	1.111	2.05, 2.07, 1.74	1.95	0.526 ± 0.089
1.000	1.000	2.12, 2.20, 2.12	2.15	0.433 ± 0.016
1.100	0.909	1.93, 2.32, 2.21	2.15	0.433 ± 0.079
1.200	0.833	2.41, 2.45, 2.14	2.33	0.368 ± 0.049

Fig. 8.2



(i) Use data from **Table 8.1** to calculate the value of the acceleration when the trolley mass is 0.800 kg. Include the uncertainty in your answer.

acceleration = ± .... $m\,s^{-2}$

uncertainty = ± .... $m\,s^{-2}$
[5]

(ii) Complete the graph and plot the point when the trolley mass is 0.800 kg on **Fig. 8.2** and include the error bar for the acceleration calculated from **(b)(i)**. **[1]**

(iii)* Draw the line of best fit on the graph and determine its equation in the form $y = mx + c$.

Explain how the graph **Fig. 8.2** can be used to determine the relationship between the acceleration of the trolley and 1/mass. Comment on whether the results of the experiment support Newton's 2nd law of motion.

Use information from the graph in your answer.

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.... **[6]**

END OF QUESTION PAPER

EXTRA ANSWER SPACE

If you need extra space use this lined page. You must write the question numbers clearly in the margin.