Name	Date started	Target end date

GCE AS/A LEVEL – KINEMATICS QUESTION PACK

1321-01 (Legacy)

PHYSICS – PH1

PH1.2 Kinematics – Comprehensive question pack

Every kinematics question from the legacy WJEC PH1 papers (Jan 2009 – June 2016)

LEGACY 2008 SPECIFICATION

Estimated time for entire question pack: ~3 hours 45 minutes

Derived from the legacy PH1 paper's pace of ***~1 min/mark*** *(80 marks in 1¼ hours).*

You are advised to ***not*** *attempt to complete all of this in one sitting.*

For Examiner's use only

Q	Source	Max	Mark
1	Jun 09 Q1	10	
2	Jan 10 Q4	6	
3	Jun 10 Q1	7	
4	Jan 11 Q6	6	
5	Jan 14 Q1	9	
6	Jun 13 Q1	10	
7	Jan 09 Q8	13	
8	Jun 11 Q4	15	
9	Jan 12 Q7	13	
10	Jan 13 Q1	8	
11	Jan 14 Q3	13	

Q	Source	Max	Mark
12	Jun 15 Q7	15	
13	Jan 12 Q3	7	
14	Jan 13 Q4	10	
15	Jun 14 Q6	12	
16	Jun 09 Q7	13	
17	Jan 10 Q6	11	
18	Jun 10 Q6	12	
19	Jun 12 Q5	11	
20	Jun 12 Q7	17	
21	Jun 15 Q1	11	
22	Jun 16 Q2	11	
Total		240	

ABOUT THIS QUESTION PACK

This is a **comprehensive practice question pack**, not a single mock paper. It contains every kinematics question from the legacy WJEC PH1 papers between January 2009 and June 2016 (14 papers in total).

Questions are grouped by sub-topic within PH1.2 Kinematics, then ordered chronologically.

INSTRUCTIONS

Use black ink or black ball-point pen. Answer all questions. Write your answers in the spaces provided.

The number of marks is given in brackets at the end of each question or part-question.

A calculator is required. The Data Booklet is allowed.

PH1.2 Kinematics — what the legacy spec asks

WJEC GCE AS/A Level Physics (from 2008) · PH1 Assessment Unit *Motion, Energy & Charge* · PH1.2 *Kinematics* + vector content from PH1.1 Basic Physics.

PH1.1 Vectors & scalars (A)

- Contrast scalar and vector quantities and give examples of each — displacement, velocity, acceleration, force, speed, time, density, pressure, etc.
- Add and subtract coplanar vectors; calculations limited to two perpendicular vectors.
- Resolve a vector into two perpendicular components.

Definitions of motion (A)

- Define displacement, mean & instantaneous values of speed, velocity and acceleration.

Motion graphs (B)

- Use graphical methods to represent displacement, speed, velocity and acceleration.
- Understand and use the properties of displacement-time, velocity-time, acceleration-time graphs.
- Interpret speed-time and displacement-time graphs for non-uniform acceleration (tangent-gradient method).

Equations of motion (SUVAT) (C)

- Derive and use equations which represent uniformly accelerated motion in a straight line.

Free fall & terminal velocity (C · D)

- Describe the motion of bodies falling in a gravitational field with and without air resistance — terminal velocity.

Projectile motion (D)

- Recognise and understand the independence of vertical and horizontal motion of a body moving freely under gravity.
- Describe and explain motion due to a uniform velocity in one direction and uniform acceleration in a perpendicular direction; perform simple calculations.

Section index for this question pack

PH1.2 in one page

Quick-reference notes — revisit before each section. Identical physics to the 2015 spec; the differences are just the question style.

Scalars vs vectors

SCALAR magnitude only — distance, speed, mass, energy, time, temperature, density.

VECTOR magnitude *and* direction — displacement, velocity, acceleration, force, momentum.

Resolving vectors

A vector V at angle θ to the horizontal:

- Horizontal: $V\cos\theta$
- Vertical: $V\sin\theta$

Recombine perpendicular components: $R = \sqrt{R_x^2 + R_y^2}$; angle $\tan\theta = R_y/R_x$.

Mean & instantaneous

Mean speed = total distance / total time.

Mean velocity = total displacement / total time.

Instantaneous value — tangent gradient on the relevant graph.

Round trip ⇒ displacement = 0 ⇒ mean velocity = 0.

Motion graphs

x-t: gradient = velocity.

v-t: gradient = acceleration; *area* = displacement.

a-t: area = change in velocity.

Curved sections ⇒ non-uniform acceleration — draw a tangent.

SUVAT — constant a

- $v = u + at$
- $x = ut + \frac{1}{2}at^2$
- $x = \frac{1}{2}(u+v)\,t$
- $v^2 = u^2 + 2ax$

From rest? $u = 0 \;\Rightarrow\; x = \frac{1}{2}at^2$.

Free fall & g

Near Earth's surface $g \approx 9.81\ \mathrm{m\,s^{-2}}$ downward; on the Moon $g \approx 1.6\ \mathrm{m\,s^{-2}}$.

Ignore air resistance ⇒ mass-independent.

Sign-convention: choose up = + or down = +, then stick with it for the whole problem.

Vertical throw

Throw up at speed u:

- Time to peak: $t = u/g$.
- Max height: $h = u^2/(2g)$.
- By symmetry, time up = time down (same height).
- Speed back at launch point = u (in magnitude).

Projectile — horizontal launch

Speed u from height h:

- Fall time: $t = \sqrt{2h/g}$.
- Range: $R = ut$.
- Vertical impact speed: $v_y = gt$.
- Resultant: $v = \sqrt{u^2 + v_y^2}$.

Projectile — angled launch

Speed R at angle θ above horizontal:

- Horizontal: $u_x = R\cos\theta$.
- Vertical: $u_y = R\sin\theta$.
- Max height: $u_y^2/(2g)$.
- Time of flight (level ground): $T = 2u_y/g$.
- Range: $u_x T$.

Frame of reference

Velocity is relative. Ball dropped from a moving train, ignoring air resistance:

- **Passenger** sees the ball fall *straight down*.
- **Ground observer** sees a parabolic path (forward + falling).

With air resistance: ball decelerates horizontally, lands behind the window.

Terminal velocity

Falling body: weight pulls down, drag pulls up. Drag grows with speed until $F_{\mathrm{drag}} = W$.

Then resultant = 0 ⇒ acceleration = 0 ⇒ constant velocity = terminal velocity.

Common drag form: $F_{\mathrm{drag}} = \frac{1}{2}\rho D v^2$ (D = drag factor, units $\mathrm{m^2}$).

Reading graphs precisely

- Use a *large* tangent triangle on curves (two well-spaced points).
- Read off coordinates carefully — convert units before computing.
- For area under curve: count squares or use a trapezium rule estimate.
- Resultant force from v-t tangent: $a = \Delta v/\Delta t \Rightarrow F = ma$.

Questions begin overleaf.

SECTION A

Vectors, scalars & motion definitions

Questions 1 – 6 · 48 marks

1. (a) Define acceleration.

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[1]

(b) (i) Two horizontal forces of 12 N and 8 N are applied to a toy car of mass 2.0 kg which is on a level surface. Calculate the maximum and minimum acceleration that could be experienced by the car.

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[3]

(ii) Sketch a free-body diagram showing these forces when the car has minimum acceleration. [2]

(c) At a later time, the following condition applies to the toy car:

$$\Sigma F = 0$$

Complete the table below, indicating with a tick in one column, whether each of the statements given 'must be true', 'could be true' or 'cannot be true' when the above condition applies. [4]

Statement	Must be true	Could be true	Cannot be true
The car is accelerating.			
The car is stationary.			
The car is moving at constant speed.			
There are no forces acting on the car			

4. *(a)* (i) Define *mean speed*. [1]

....

(ii) The distance between two towns, A and B, is 240km. A motorcycle travels from A to B at a mean speed of 80km/h and then back from B to A at a mean speed of 60km/h. Calculate the mean speed for the whole journey. [3]

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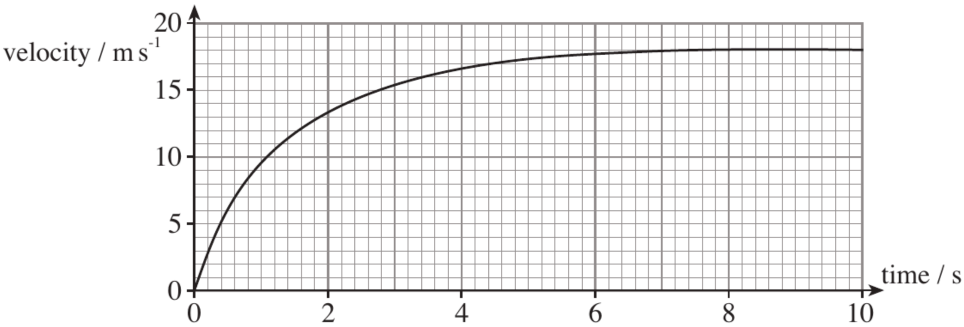
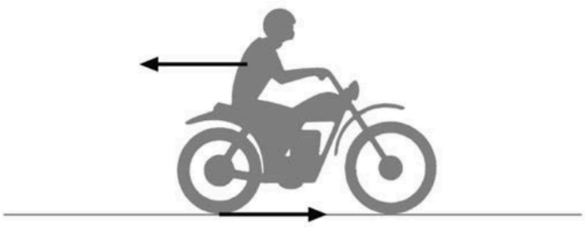
(b) The graph represents the motion of the motorcycle over a 10s period.



(i) Label the forces represented by arrows on the diagram below. [1]



(ii) Describe, without calculation, how the **resultant force** acting on the motorcycle varies over this 10 second interval. [3]

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(iii) By drawing a suitable tangent, determine the resultant force acting on the motorcycle at t = 2.0 s. The mass of the motorcycle and rider is 350kg. [3]

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....

(c) (i) Define *work done*. [2]

....

(ii) A force F acts on a body moving with a velocity v. F and v are in the same direction. Starting from the definition of power, show that [2]

$$\text{Power} = Fv$$

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....

(iii) When the motorcycle in part *(b)* is travelling at the steady velocity shown in the graph, the useful power output by the engine is 40 kW. Calculate the **driving force** required to maintain this velocity. [1]

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....

(iv) Assuming this driving force remains constant throughout the motion, calculate the resistive force acting on the motorcycle at $t = 2.0\,\text{s}$. [1]

....

(d) At a later time the motorcycle brakes until it stops. When this happens, brake pads are forced into contact with the wheel discs.

(i) State the Principle of Conservation of Energy. [1]

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(ii) Explain what happens to the motorcycle's kinetic energy. [2]

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1. *(a)* (i) State the difference between vector and scalar quantities.

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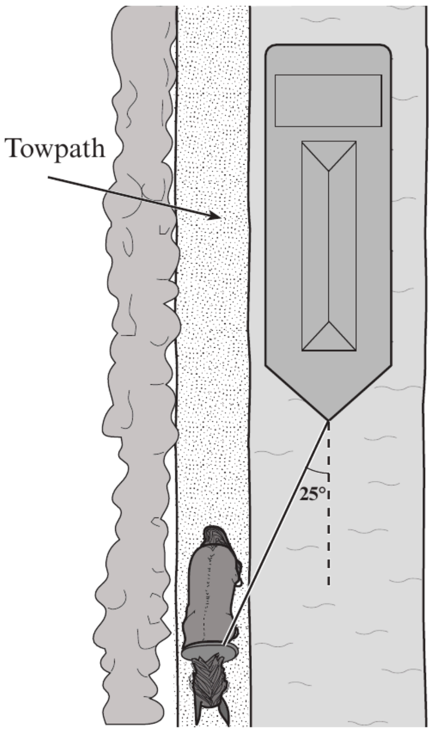
.... [1]

(ii) Place the following quantities in the correct column in the table below. [2]

distance *time* *velocity* *temperature* *force* *density*

Vector	Scalar

(b) A boat is pulled along a canal by a horse using a rope tied to the boat's bow. The rope makes an angle of 25° with the centre line of the canal as shown.



(i) Calculate the forward component of the force pulling the boat along the canal given that the tension in the rope is 1600 N. [2]

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(ii) Ignoring the effect of the mass of the rope, explain whether it is better to use a long rope or a short rope to pull the boat. [2]

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6. *(a)* Define *velocity.* [1]

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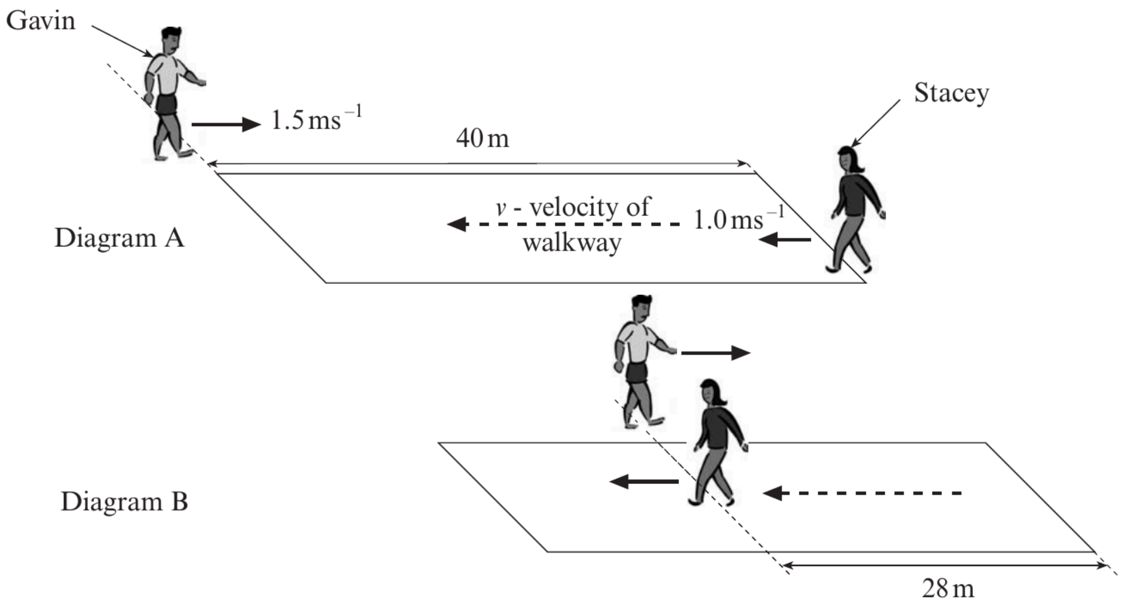
(b) (i) Stacey walks with a velocity of $1.0\,\text{ms}^{-1}$ onto a moving walkway at an airport and continues to walk at the same pace. The walkway is itself moving with a velocity v, and in the same direction as Stacey. Write down an expression for Stacey's resultant velocity. [1]

....

(ii) Gavin walks with a velocity of $1.5\,\text{ms}^{-1}$ in the opposite direction to Stacey. He **does not** get on the walkway but instead walks in a straight line beside the walkway as shown in diagram A. At the instant Stacey steps onto the walkway, Gavin is positioned at the far end, 40 m away.



At some time 't' later (diagram B), Stacey has travelled 28 m from her start point when she passes Gavin who continues to walk in the opposite direction. Show that 't' is 8.0 seconds. [2]

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....

(iii) Hence or otherwise calculate the velocity, v, of the walkway. [3]

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(iv) Calculate the velocity with which Gavin and Stacey approach each other. [1]

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....

Examiner only

Answer all questions.

1. *(a)* State what is meant by a vector quantity. [1]

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(b) Newton's second law of motion can be expressed by the equation:

$$\sum F = ma$$

Name the vector quantities in this equation. [2]

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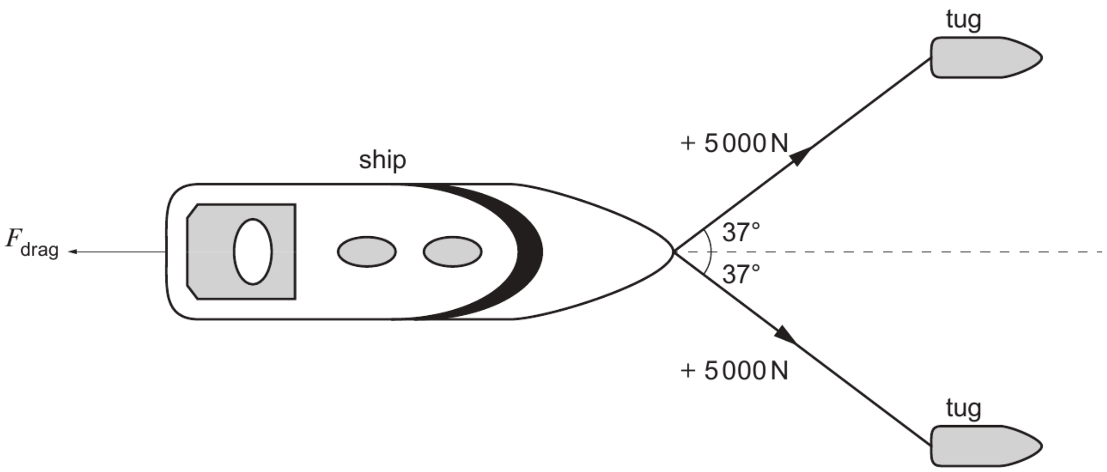
(c) A ship is being pulled along by cables attached to two tugs as shown. F_{drag} represents the total drag force that acts on the ship at the instant shown.



(i) Show clearly that the magnitude of the resultant of the forces applied **by the tugs** is approximately 8000 N. [2]

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(ii) Given that $\sum F = +\,2000\,\text{N}$ for the situation shown above, determine the value of F_{drag}. [1]

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Examiner only

(d) At a later stage the tension in the cables is changed so that the ship moves forward with a **constant speed** of 2.5 m s^{-1}. Calculate the work done on the ship by the tugs in one minute. [Assume F_{drag} is the same as that calculated in *(c)*(ii).] [3]

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1. *(a)* Velocity and acceleration are both vector quantities.

(i) State what is meant by a vector quantity. [1]

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(ii) Name **one** other vector quantity. [1]

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(b) One of the equations of motion for constant acceleration is $x = ut + \frac{1}{2}at^2$.

(i) Show that this equation is correct in terms of units. [3]

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(ii) The displacement x, in metres, of a car travelling in a straight line with uniform acceleration at a time t, in seconds, from the start of the motion is given by

$$x = 8t + 3t^2$$

(I) State the initial velocity, u, of the car (at $t = 0$). .... [1]

(II) Determine the car's acceleration. [1]

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(III) Calculate the displacement when $t = 5.0$ s. [1]

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(IV) Calculate the velocity when $t = 5.0\,\text{s}$. [3]

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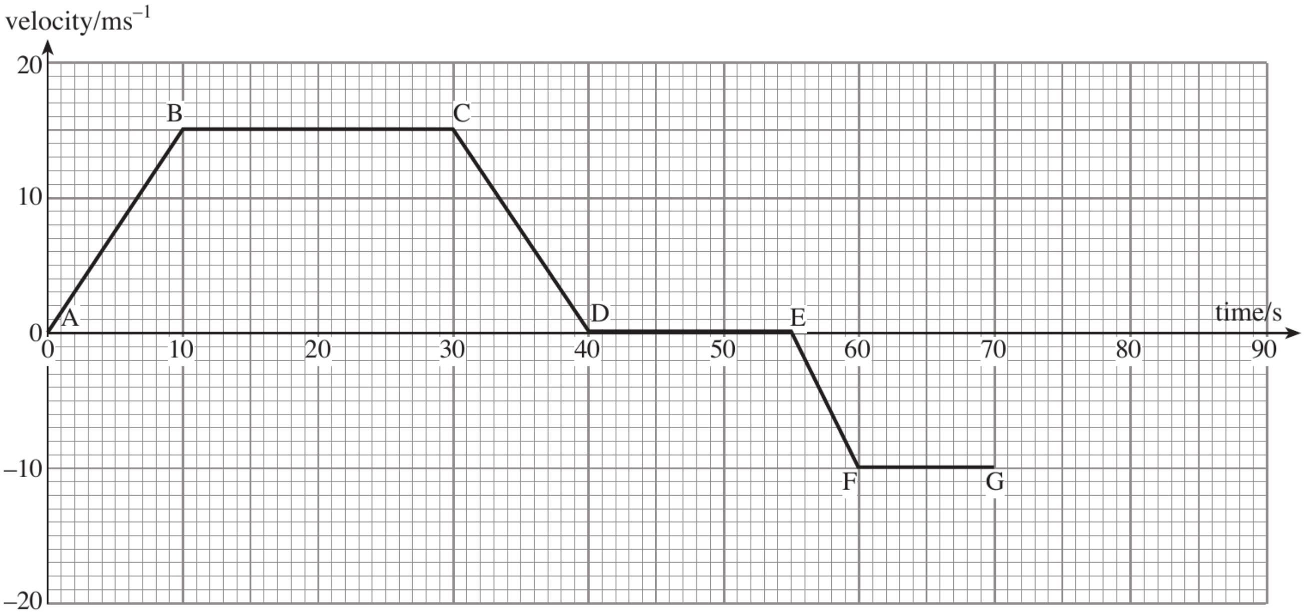
SECTION B

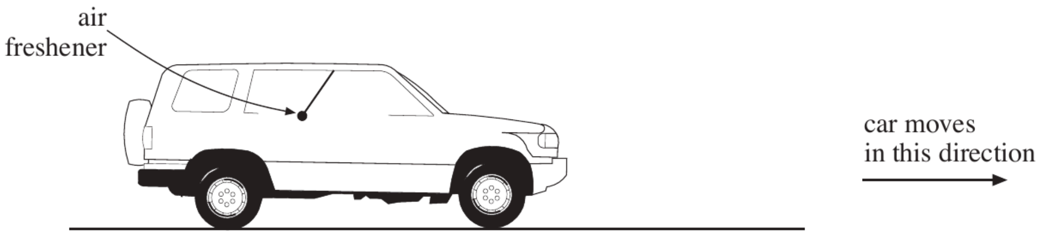
Motion graphs (d-t, v-t, a-t)

Questions 7 – 12 · 77 marks

8. The velocity-time graph shown represents the first 70 seconds of the motion of a car moving along a straight level road.



An air freshener hangs freely from a thread inside the car. During the first 10 seconds of the car's motion (A to B on the graph) the thread is inclined to the vertical as shown below.



(a) (i) Describe the motion of the car from A to B. [1]

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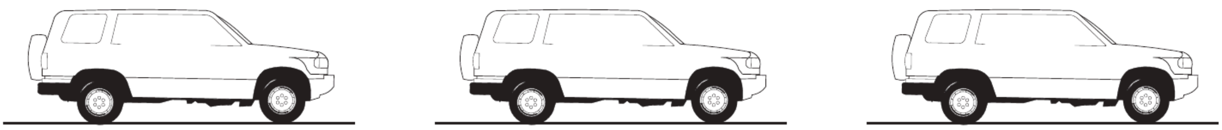
(ii) Sketch, on the diagrams below, how the thread is inclined (if at all), when the car is moving between the points indicated beneath each picture. [3]



(iii) Write down another period during the car's motion where the inclination of the thread would be the same as it was between B and C. [1]

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(iv) Explain your answer to (iii) in terms of the forces acting on the air freshener. [1]

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(b) At 70 seconds from the start the car starts to slow down at a uniform rate. During the deceleration the car travels a further 75 m before coming to rest. Calculate the time taken for the car to come to rest and complete the velocity-time graph to show this final stage. [3]

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(c) (i) Calculate the car's displacement between

(I) 0 and 10 seconds; [2]

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(II) 0 and 30 seconds; [1]

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(III) 0 and 40 seconds. [1]

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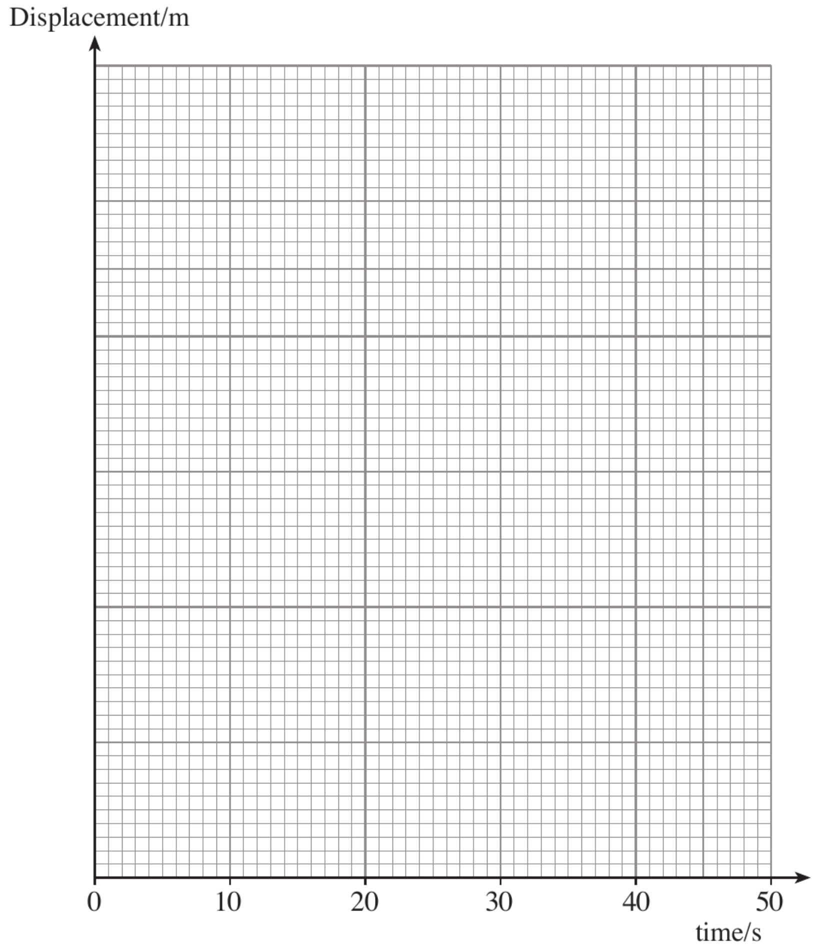
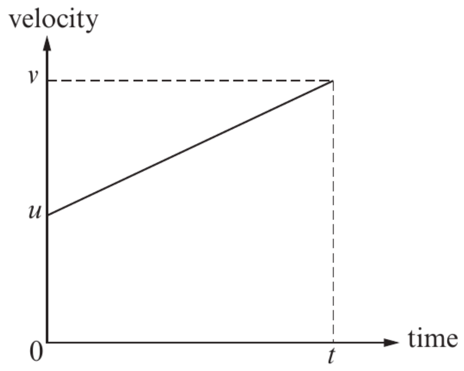
(ii) Hence, sketch a displacement-time graph for the first 50 seconds of the motion on the grid on page 14. Start by providing a scale on the vertical axis and plotting the points obtained from (c)(i).

THE GRAPH GRID IS ON PAGE 14



[5]

4. *(a)* A velocity-time graph is given for a body which is accelerating in a straight line.



(i) Using the symbols given on the graph, write down an expression for the gradient and state what it represents. [2]

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(ii) Using the symbols given on the graph, write down an expression for the area under the graph and state what it represents. [2]

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(iii) Hence or otherwise show clearly that, using the usual symbols,

$$x = ut + \tfrac{1}{2}at^2$$ [2]

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Examiner only

(b) A cyclist accelerates **from rest** with a constant acceleration of $0.50\,\text{m}\,\text{s}^{-2}$ for 12.0 s. Calculate

(i) the distance travelled in this time; [2]

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(ii) the maximum velocity attained. [2]

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(c) After 12.0 s, the cyclist stops pedalling and 'freewheels' to a standstill with constant deceleration over a distance of 120 m.

(i) Calculate the time taken for the cyclist to decelerate to a stand-still. [2]

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(ii) Calculate the magnitude of the cyclist's deceleration. [2]

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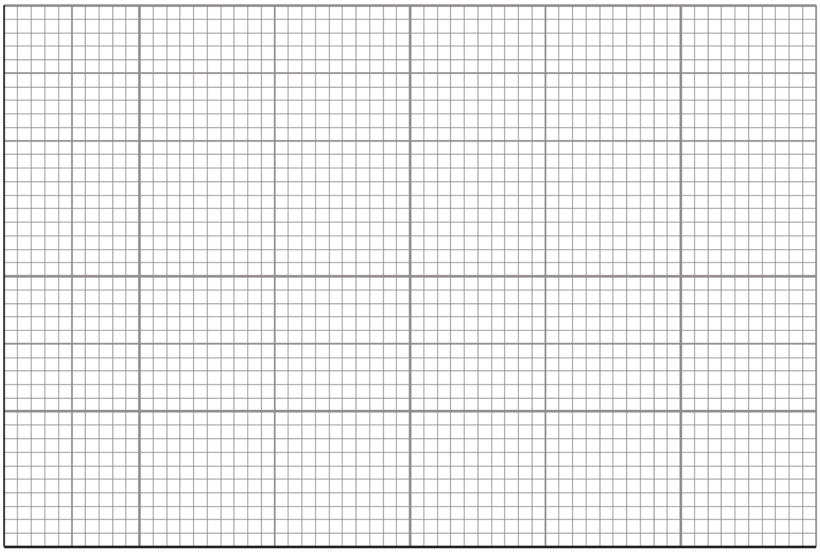
(d) Draw an acceleration-time graph on the grid below for the **whole of the cyclist's journey**. [4]



(e) In reality the cyclist would not slow down with constant deceleration. This is because the total resistive force acting on the cyclist consists of a constant frictional force of 8.0 N **and** an air resistance force which is proportional to the square of the cyclist's velocity.

(i) When the cyclist was travelling with maximum velocity, the total resistive force acting was 165 N. Calculate the force of air resistance at this velocity. [1]

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(ii) Hence calculate the total resistive force acting when the cyclist is moving at half the maximum velocity. [2]

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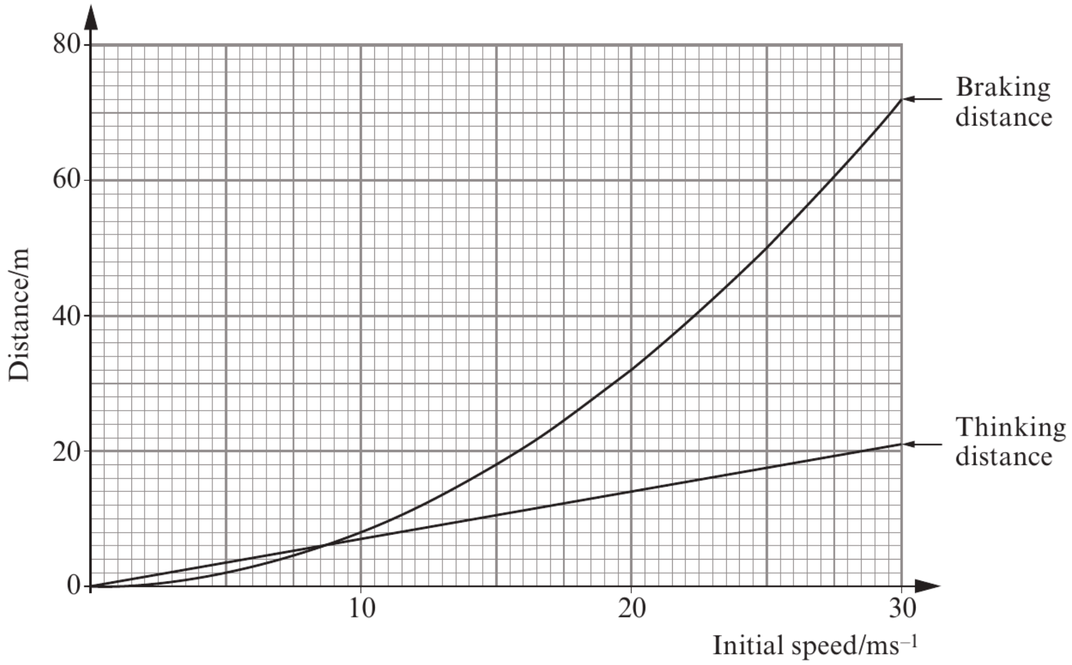
7. The following graph gives data taken from the 'Highway Code' for 'Thinking' and 'Braking' distances for a car when stopping. Thinking distance is the distance a car travels between the driver seeing an incident and beginning to apply the brakes. Braking distance is the distance a car travels while it is decelerating.



(a) The graph of braking distance against speed is curved. Use information from the graph to test whether braking distance is proportional to (initial speed)^2. [3]

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(b) (i) Calculate the mean deceleration of a car as it slows down from 15 m s^{-1} to rest. [3]

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(ii) Hence calculate the mean braking force acting on the car given that it has a mass of 800 kg. [1]

(c) Suggest why the graph of thinking distance against speed is a straight line. [2]

(d) (i) What is the **total** stopping distance for a car initially travelling at $30\,m\,s^{-1}$? [1]

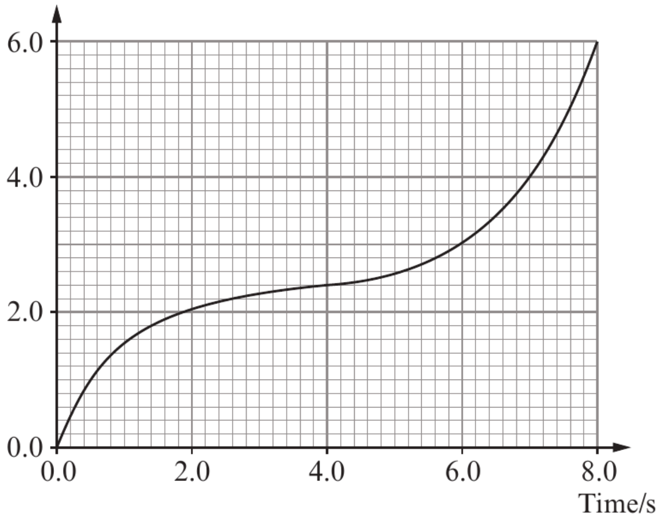
(ii) Ineffective brakes would increase the total stopping distance. Explain, in terms of thinking distance and braking distance why this would be the case. [2]

(e) 'Average speed areas' are now found on many motorways. One such stretch of motorway has a speed limit of 50 km/hour. The average speed is monitored between two cameras placed 10 km apart. The driver of a car notes that he has travelled 6.0 km from the first camera at a speed of 80 km/hour. Determine the speed with which he has to travel the remaining 4.0 km in order that his average speed for the whole 10 km is 50 km/hour. [4]

Examiner only

1. The diagram shows a toy train track. One complete lap is 6.0 m.

(a) A toy train takes 8.0 s to complete one lap. Its motion is described by the following distance-time graph.



(i) Describe the motion of the train in the region 1.0 s to 3.0 s. Explain your answer. [2]

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....

(ii) Determine the mean speed of the train over the lap. [1]

....

....

(iii) Determine the speed of the train at $t = 6.0$ s. [2]

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Examiner only

(iv) The gradient of the graph is very large between 7.0 s and 8.0 s. Explain, making reference to the motion of the train, whether or not it would be possible for the graph to be

(I) vertical; [1]

....

(II) horizontal. [1]

....

(b) Whilst playing with the train track a Physics student states:

"No matter how fast I make the train go, the mean velocity over one complete lap is always going to be zero."

Explain whether the above statement is correct. [2]

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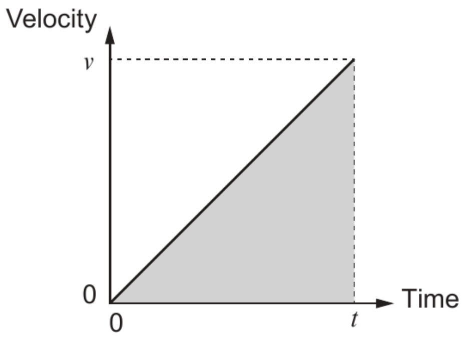
Examiner only

3. *(a)* A velocity-time graph is given for a body which is accelerating from rest in a straight line.



(i) What does the shaded area under the graph represent? [1]

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(ii) Use the graph to show that, using the usual symbols:

$$x = \frac{1}{2}at^2$$

[3]

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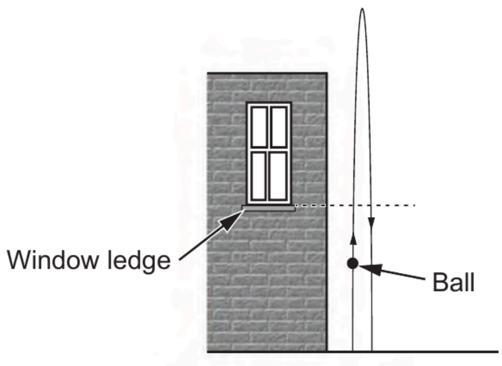
(b) A ball is thrown vertically upwards and passes a window ledge 0.3 s after being released. It passes the window ledge on its way back down, 1.6 s **later**. Ignore air resistance.



(i) Determine the time of flight of the ball. [1]

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(ii) Calculate the initial velocity of the ball when it is released. [3]

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(iii) Calculate the height of the window ledge above the ground. [2]

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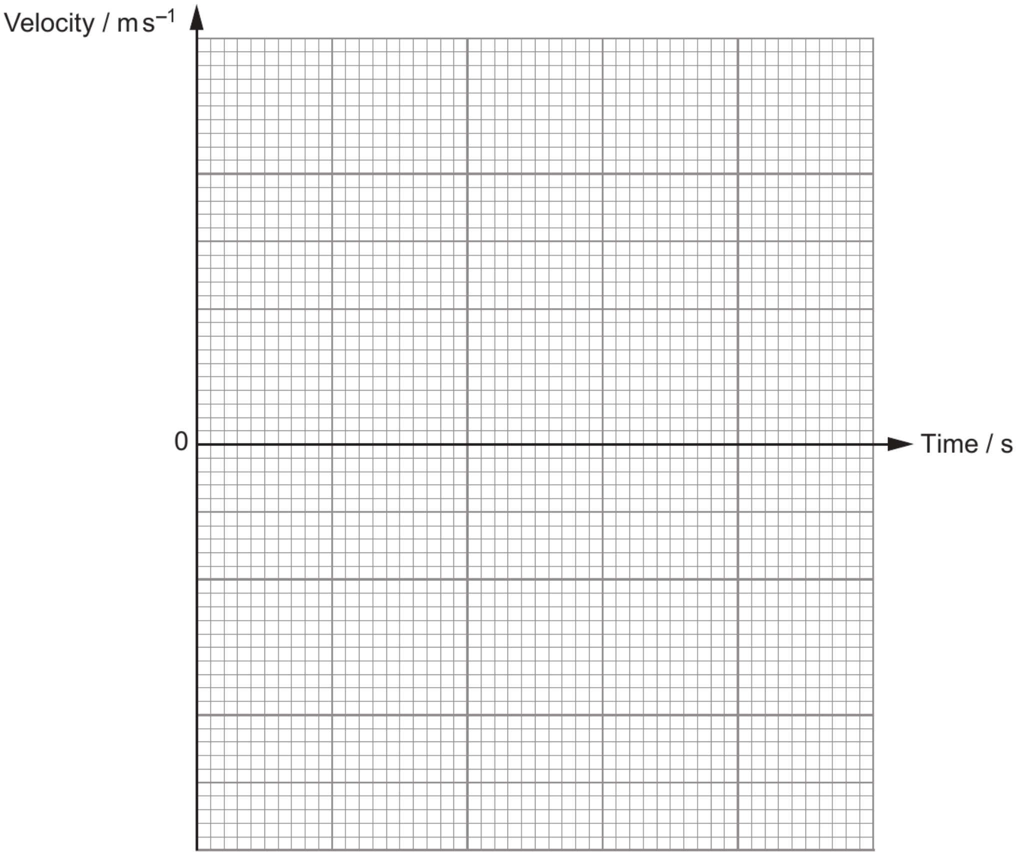
Examiner only

(c) Draw, on the grid below, a velocity-time graph for the whole of the ball's flight. Include suitable scales on both axes. [3]



(d) In reality, air resistance also acts on the ball. In the spaces provided draw **three** free body diagrams showing the forces acting on the ball at the positions indicated. **Label** these forces. [4]

As the ball passes the window ledge **travelling upwards**	At maximum height above the ground	As the ball passes the window ledge **travelling downwards**

1321 010007

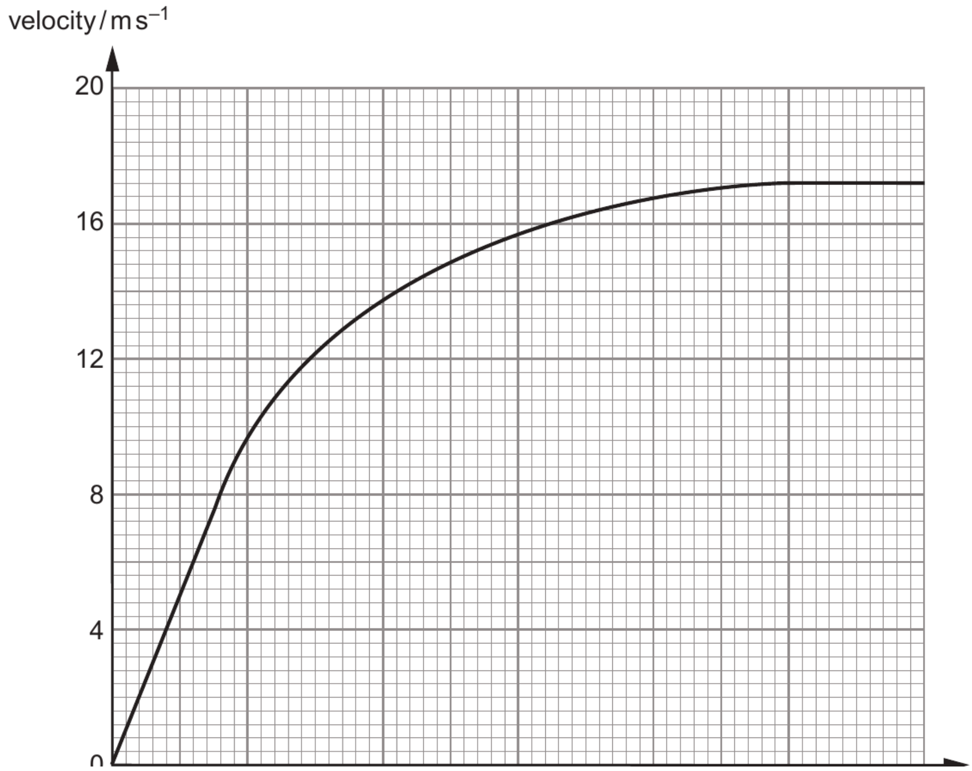
7. *(a)* (i) Define *displacement.* [1]

(ii) The distance between two towns A and B is 300 km. A train travels from A to B at a mean speed of 40 km/h and then back from B to A at a mean speed of 60 km/h.

(I) Calculate the mean speed for the **whole** journey. [3]

(II) What is the mean velocity for the whole journey? Explain your answer. [2]

(b) The graph represents the motion of the train over a 120 second period as it departs from a station.



(i) By drawing a suitable tangent, determine the resultant force ($\sum F$) acting on the train at t = 40 s. [Mass of train = 1.2×10^6 kg.] [3]

(ii) Label clearly on the graph a time when $\sum F = 0$. [1]

(iii) Describe and explain the motion of the train when $\sum F = 0$. [2]

(c) (i) The useful power output, P, of the engine is 4.5 MW. Show that:

$$P = Fv$$

where F is the driving force and v is the instantaneous velocity. [1]

(ii) Calculate the driving force when $\sum F = 0$. [2]

(d) Using your answers to *(b)*(i) and *(c)*(ii) and the assumption that the driving force remains constant throughout the motion, calculate the resistive force acting on the train at t = 40 s. [2]

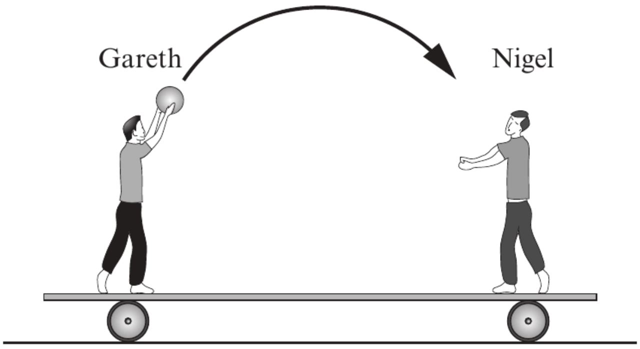
END OF PAPER

SECTION C

SUVAT & free fall

Questions 13 – 15 · 29 marks

3. Two boys stand each end of a trolley as shown. The trolley is initially at rest and can move without resistance on a horizontal surface.



(a) (i) Define acceleration. [1]

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(ii) Gareth takes 0.80 s to throw a ball from rest to a speed of 6.0 m s^{-1}. Calculate the acceleration of the ball. [2]

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(b) Describe and explain in terms of forces, the motion of **the trolley** from the instant the ball is released by Gareth until after it is caught by Nigel. [4]

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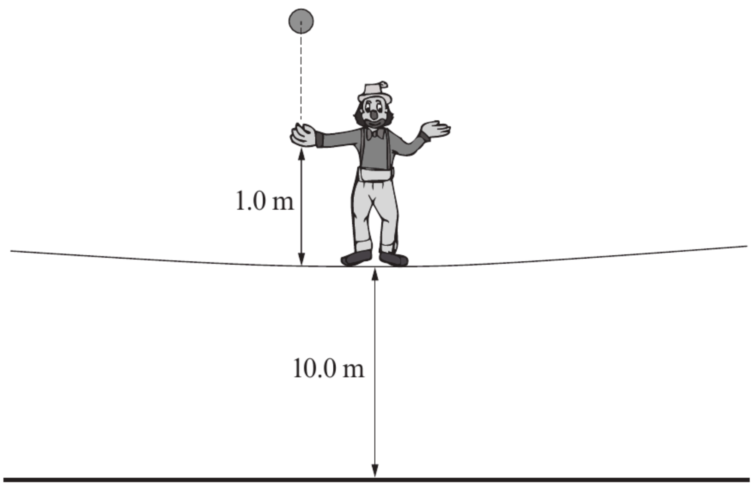
4. *(a)* A circus performer standing on a tightrope 10.0 m above the ground throws a ball vertically upwards at a speed of $6.0\,m\,s^{-1}$. The ball leaves his hand 1.0 m above the tightrope as shown. *The diagram is not to scale.*



(i) Calculate the maximum height **above the ground** that the ball reaches. [3]

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(ii) The performer fails to catch the ball as it drops. Calculate:

(I) the speed with which the ball hits the ground; [2]

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(II) the **total** time the ball is in the air. [3]

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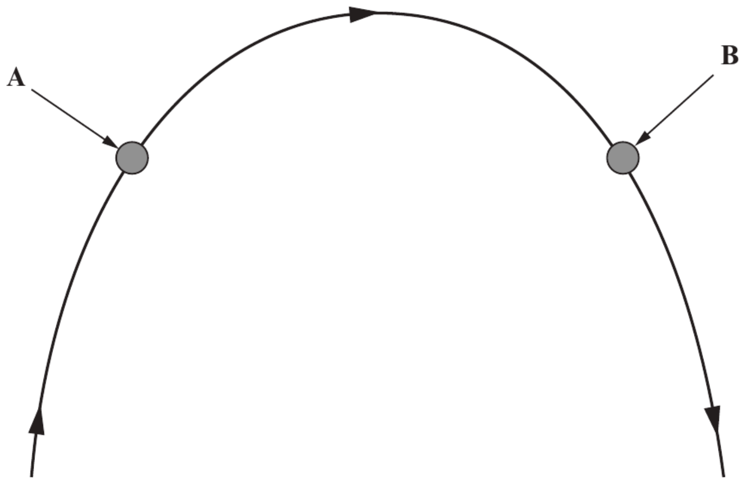
(b) Another ball is thrown into the air and follows the path shown. The ball is shown in two places, **A** and **B**.



(i) Assuming the force of air resistance is negligible, circle **one** of the following drawings that shows the direction of the resultant force on the ball when it is at **A**. Explain your answer. [2]

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(ii) Assuming the force of air resistance **cannot** be neglected, sketch a diagram below to show the forces acting on the ball as it falls towards the ground in position **B** as shown in the above diagram. [2]

Examiner only

6. *(a)* (i) Show that $v = u + at$ is consistent with the definition of acceleration. [2]

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(ii) $x = \frac{1}{2}(u + v)t$ is another equation of uniformly accelerated motion. Use this equation and $v = u + at$ to show clearly that:

$$x = ut + \frac{1}{2}at^2$$ [2]

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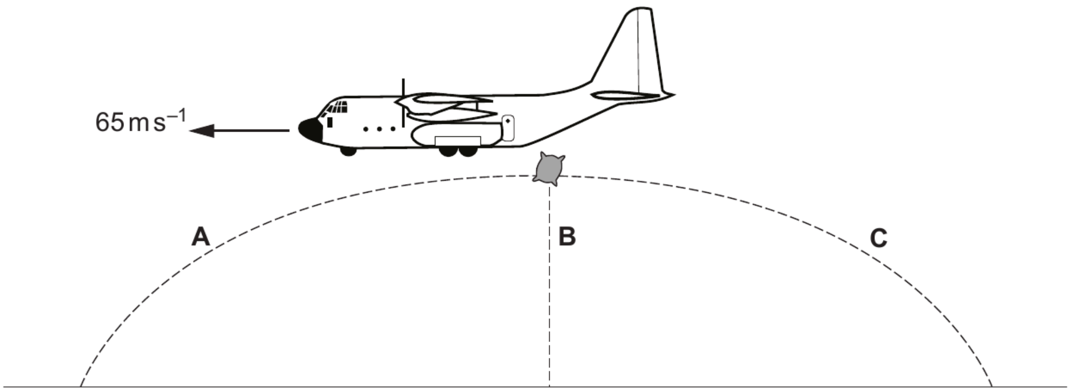
(b) The aeroplane shown below is travelling **horizontally** at $65\,m\,s^{-1}$. It is used to drop sacks of flour as emergency supplies. A sack is shown at the instant it is released from the low flying aeroplane. Ignore air resistance for this question. The diagram is not to scale.



(i) A villager standing to the side observes the flight path of the sack. Which path, **A**, **B** or **C** shows the path of the sack? Explain your answer. [3]

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(ii) (I) To avoid damaging the sack, the maximum **vertical** component of the sack's velocity must not exceed 30 m s^{-1}. Show that the maximum height from which the sack can be dropped is about 46 m. [2]

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(II) Calculate the time taken for the sack to reach the ground if it is dropped from a height of 46 m. [2]

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(iii) Calculate the resultant velocity of the sack on impact with the ground when it is dropped from 46 m. [3]

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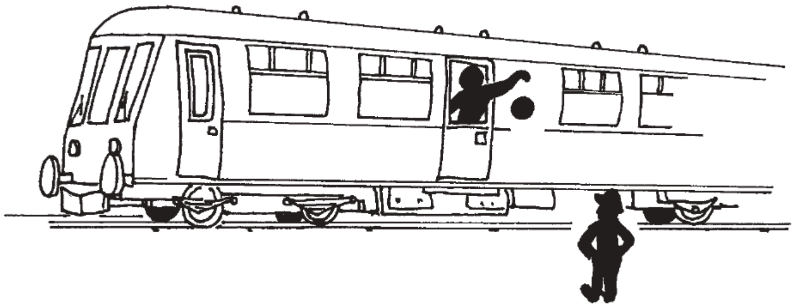
SECTION D

Projectiles & terminal velocity

Questions 16 – 22 · 86 marks

7. A passenger on a train, moving at constant speed, drops a ball out of a window as shown. A stationary observer is standing near the track and directly in front of the window when the ball is dropped.



(a) (i) If air resistance is neglected, describe and explain the horizontal motion of the ball as seen by the passenger.

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[2]

(ii) Describe the horizontal motion of the ball as seen by the observer.

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[1]

(b) If air resistance is now taken into account, how will your answers to (a) (i) and (ii) have to be modified?

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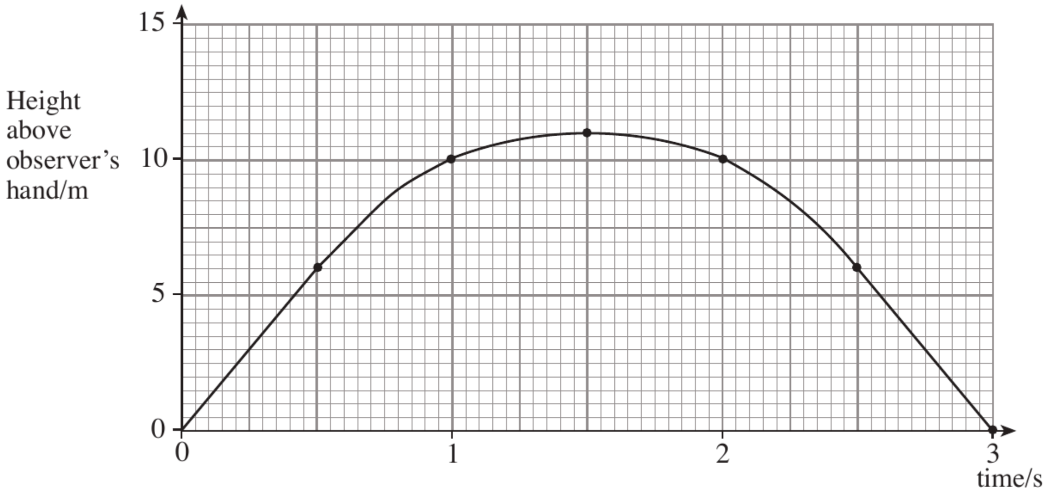
[3]

(c) The observer retrieves the ball and throws it vertically upwards, catching it on its return. A graph of height (from the observer's hand) against time is shown.



(i) How can you tell from the graph that the air resistance now acting on the ball is negligible?

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[1]

(ii) By considering the maximum height reached, determine the initial upward velocity of the ball.

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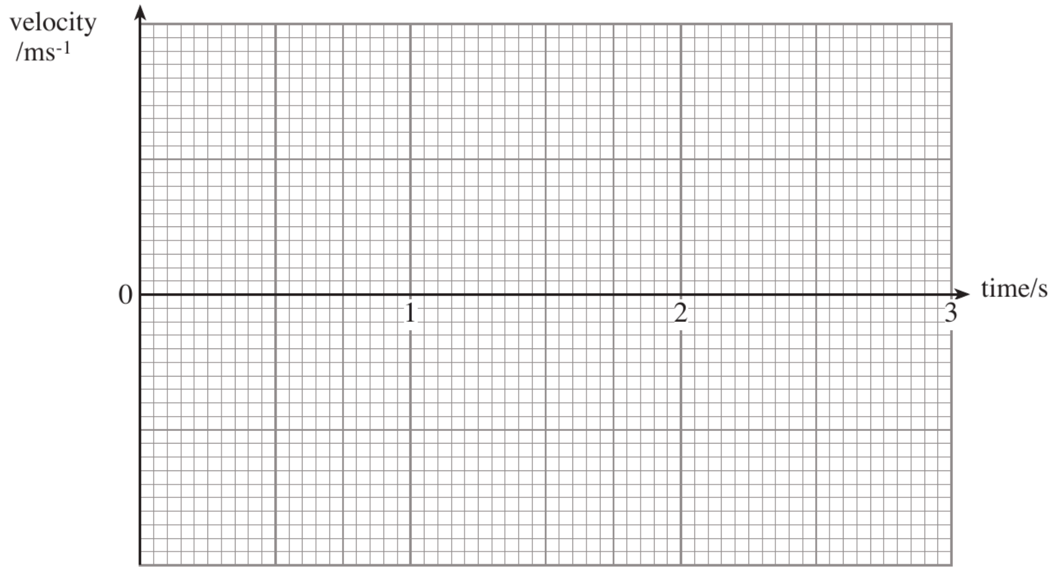
[3]

(iii) Use your answer to (c) (ii) and other data from the graph on the previous page to draw a velocity-time graph for the whole of the ball's flight. The time axis has been completed for you. [5]



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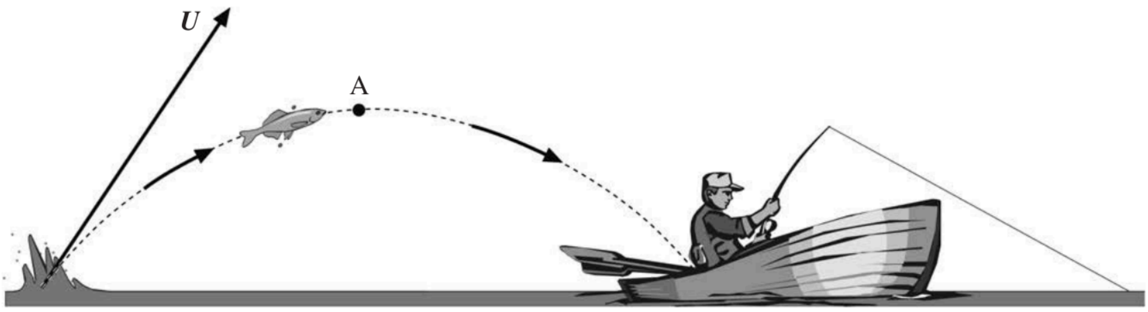
QUESTION 8 is on page 14

6. The Silver Carp is a fish which was accidentally introduced to the Mississippi river in the 1990s. It has since bred to such an extent that the river has become overpopulated with them. Many are seen to jump out of the water and they sometimes land in the boats of fishermen.
[Ignore air resistance throughout this question].



(a) The trajectory (flight path) of a Silver Carp is shown. Point **A** represents the highest point on the trajectory. Draw arrows at **A** to show

(i) the direction of motion of the Carp at this instant. (Label this arrow **D**);

(ii) the force (or forces) acting on the Carp at this instant. (Label this/these arrow(s) **F**). [2]

(b) A fisherman wishes to determine the velocity with which a Carp left the water (shown by the vector labelled ***U***). The fisherman makes the following estimations:

Horizontal distance travelled by the Carp = 4.50 m
Time of flight = 1.50 s
Maximum height = 2.75 m

Use this information to calculate:

(i) the horizontal component of the velocity of the Carp; [1]

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(ii) the initial vertical velocity of the Carp; [3]

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(iii) the magnitude of the velocity (***U***) with which the Carp left the water. [2]

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(c) Your answer to *(b)* (iii) can be checked by considering the energy changes that take place during the Carp's flight.

(i) Calculate the **total** energy possessed by the Carp at point **A**. [Assume the Carp has mass 6.0 kg] [3]

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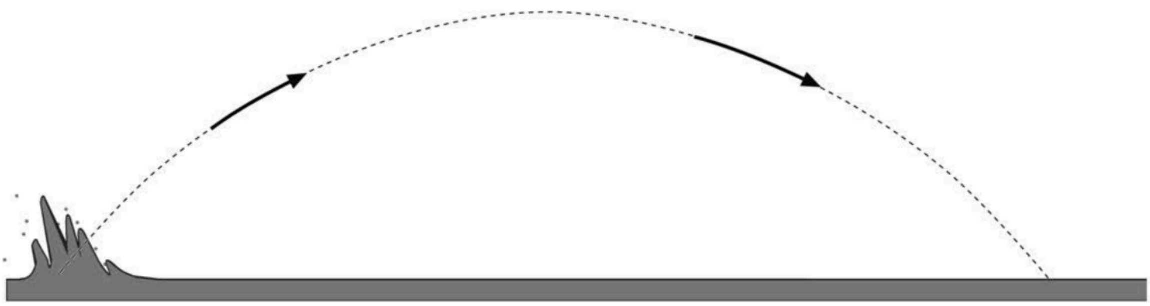
(ii) Below is a sketch of the Carp's trajectory but this time without the boat included. Mark on the diagram **two** points where the Carp will have its greatest kinetic energy. [Label both points with a letter **K**]. [1]



(iii) Use your answer to *(c)* (i) to show that the Carp's initial velocity (***U***) is the same as that calculated in *(b)* (iii). [2]

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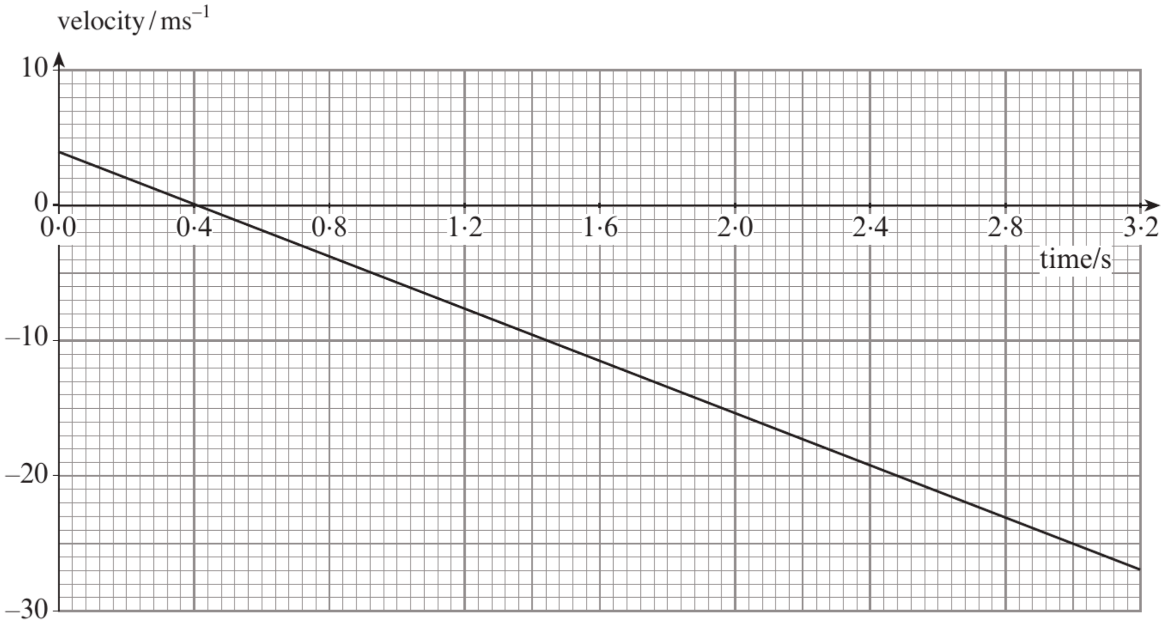
Examiner only

6. A stone is released from the basket of a hot-air balloon that is moving upwards.
The velocity-time graph describes the vertical motion of the stone from the moment it is released to the time it lands on the ground at 3.2 s. Ignore air resistance throughout this question.



(a) Calculate the gradient of the graph and explain its significance. [2]

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(b) State the velocity at which the balloon was ascending at the moment the stone was released. [1]

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(c) Describe the motion of the stone between 0.0 s and 0.8 s. [3]

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(d) (i) Shade the part of the graph which represents the height of the stone above the ground at the moment of release. [1]

(ii) Hence, or otherwise, calculate the height of the stone above the ground at the moment of release. [2]

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(e) The balloon is also moving **horizontally** at a steady velocity when the stone is released. State whether the stone will land on the ground behind, directly beneath or in front of the moving basket. Explain your answer. [3]

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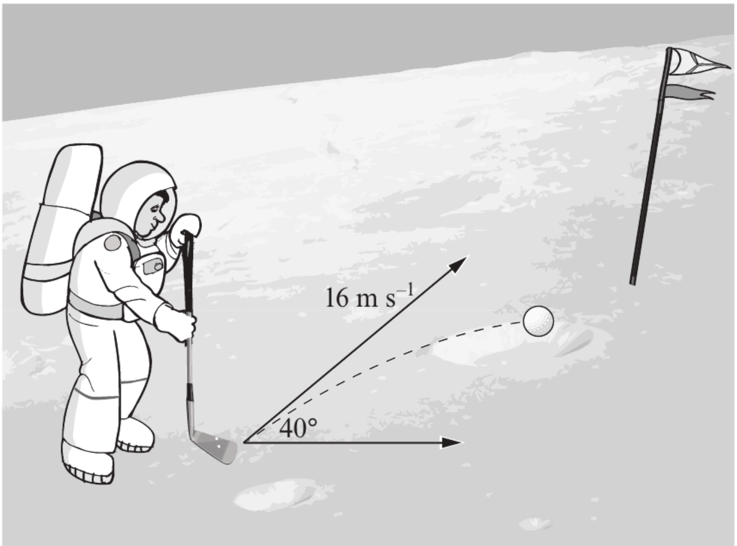
5. The astronauts of Apollo 14 played golf on the Moon. They struck a number of shots such as the one shown below.



(a) (i) Calculate the horizontal and vertical components of velocity of the golf ball at the instant it was struck. [2]

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(ii) Describe the essential difference between the horizontal and vertical components of velocity during the flight of the ball. [1]

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(b) The acceleration due to gravity on the Moon is 1.6 m s^{-2}. Assuming the shot is played on horizontal ground, calculate

(i) the total time of flight, [3]

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(ii) the horizontal distance the ball travels, [1]

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(iii) the maximum height reached. [2]

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(c) A similar golf shot is played on Earth. Give two reasons why your answer to *(b)*(iii) would be different. [2]

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2. ....

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7. The force due to air resistance F_{air} exerted on a skydiver due to her motion through the air is given by

$$F_{air} = \frac{\rho D v^2}{2}$$

where ρ is the density of air, v is the speed of the skydiver and D is a constant called the drag factor.

(a) Show that the SI unit of D is **metre^2**. [4]

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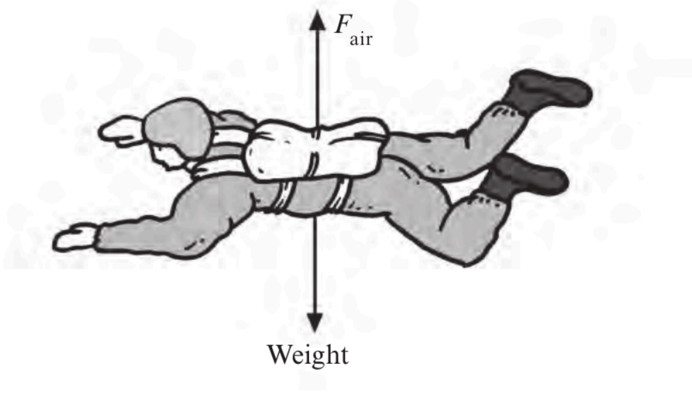
(b) The diagram shows two of the main forces acting on the skydiver during her descent.



(i) Newton's third law concerns pairs of forces. State the law. [1]

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(ii) Give **one** reason why the forces in the diagram are **not** a pair of Newton 3rd law forces. [1]

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(c) The table gives data for the first 16.0 seconds of the jump.

Time / s	0.0	2.0	4.0	6.0	8.0	10.0	12.0	14.0	16.0
Acceleration / $m\,s^{-2}$	9.8	8.8	6.6	4.3	2.5	1.4	0.8	0.4	0.2

(i) The mass of the skydiver is 60 kg. Calculate her weight. [1]

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(ii) Using your answer to *(c)*(i) and the information in the table, calculate the force due to air resistance acting on the skydiver at $t = 10.0$ s. [3]

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(d) (i) Draw a graph of acceleration (y-axis) against time (x-axis) for the skydiver. [3]

(ii) Use your graph to estimate the velocity of the skydiver at $t = 10.0\,\text{s}$. [2]

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(iii) Using your answers to *(c)*(ii), *(d)*(ii) and the equation given at the start of the question, calculate a value for the drag factor, D. Assume $\rho = 1.2\,\text{kg m}^{-3}$ [2]

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THERE ARE NO MORE QUESTIONS IN THE EXAMINATION.

GCE PHYSICS
TAG FFISEG
Advanced Level / Safon Uwch

Data Booklet

A clean copy of this booklet should be issued to candidates for their use during each GCE Physics examination.

Centres are asked to issue this booklet to candidates at the start of the GCE Physics course to enable them to become familiar with its contents and layout.

Values and Conversions

Avogadro constant	N_A	=	$6{\cdot}02 \times 10^{23}$ mol^{-1}
Fundamental electronic charge	e	=	$1{\cdot}60 \times 10^{-19}$ C
Mass of an electron	m_e	=	$9{\cdot}11 \times 10^{-31}$ kg
Molar gas constant	R	=	$8{\cdot}31$ J mol^{-1} K^{-1}
Acceleration due to gravity at sea level	g	=	$9{\cdot}81$ m s^{-2}
Gravitational field strength at sea level	g	=	$9{\cdot}81$ N kg^{-1}
Universal constant of gravitation	G	=	$6{\cdot}67 \times 10^{-11}$ N m^{2} kg^{-2}
Planck constant	h	=	$6{\cdot}63 \times 10^{-34}$ J s
Boltzmann constant	k	=	$1{\cdot}38 \times 10^{-23}$ J K^{-1}
Speed of light *in vacuo*	c	=	$3{\cdot}00 \times 10^{8}$ m s^{-1}
Permittivity of free space	ε_0	=	$8{\cdot}85 \times 10^{-12}$ F m^{-1}
Permeability of free space	μ_0	=	$4\pi \times 10^{-7}$ H m^{-1}
Stefan constant	σ	=	$5{\cdot}67 \times 10^{-8}$ W m^{-2} K^{-4}
Wien constant	W	=	$2{\cdot}90 \times 10^{-3}$ m K

T/K = θ/°C + 273·15

1 u = $1{\cdot}66 \times 10^{-27}$ kg

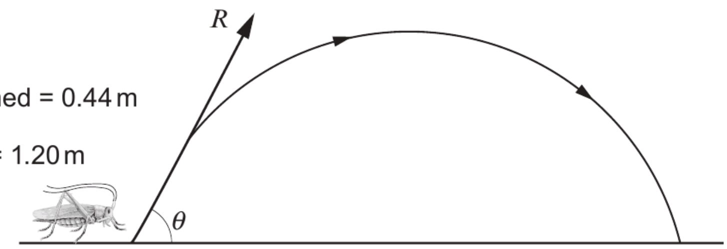
Answer **all** *questions.*

1. A science student is investigating the jump characteristics of a grasshopper. She makes the following observations when analysing one particular jump.

Maximum vertical height obtained = 0.44 m

Maximum horizontal distance = 1.20 m

Time of flight = 0.60 s



Air resistance can be ignored for parts *(a)* to *(c)*.

(a) Use the information to calculate:

(i) the horizontal component of the velocity of the grasshopper; [1]

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(ii) the initial vertical component of the velocity of the grasshopper. [2]

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(b) Hence calculate:

(i) the magnitude of the velocity at take-off, marked R in the diagram; [2]

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(ii) the angle of take-off, marked θ in the diagram. [1]

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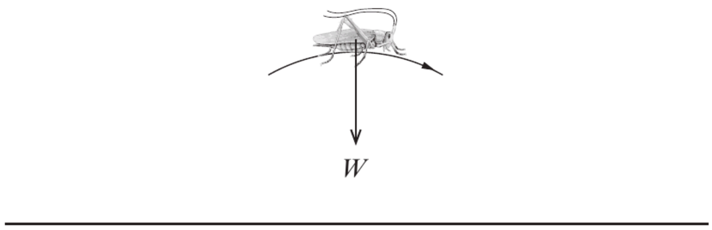
(c) The diagram below shows the grasshopper of mass 3.0×10^{-5} kg at the instant when it is at its maximum height above the ground.



(i) The arrow labelled W represents the force of gravity on the grasshopper due to the Earth. Identify the Newton third law 'equal and opposite' force to W. [1]

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(ii) Calculate the magnitude of the force you identified in *(c)*(i). [1]

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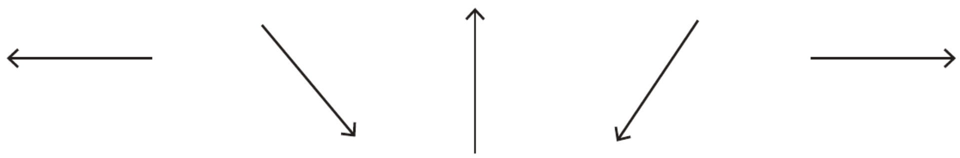
(d) Assume air resistance does act. **Circle the arrow** which correctly shows the direction of the force due to air resistance on the grasshopper at the instant it is at its maximum height. [1]



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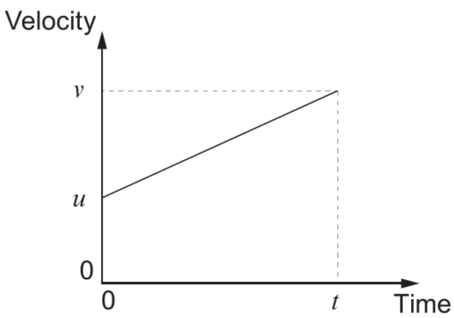
2. *(a)* A velocity-time graph is given for a body which is accelerating.



Using the symbols given on the graph, show that:

$$v = u + at$$ [2]

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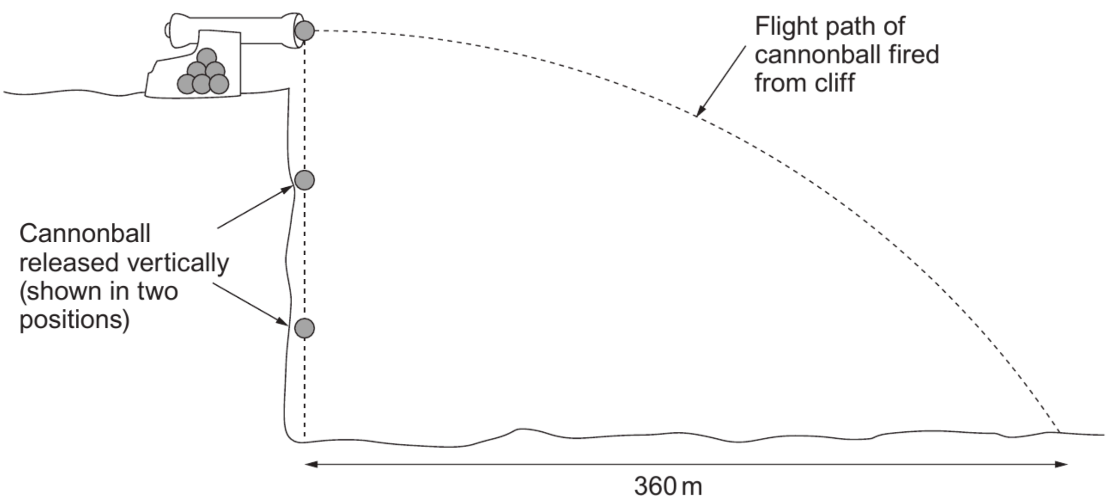
(b) The flight path for a cannonball fired horizontally from the top of a cliff is shown. **At the same instant**, a second cannonball is released and falls vertically from the same initial height. The second cannonball is shown at two positions during its descent.



Examiner only

(i) Draw on the diagram the expected positions of the fired cannonball at the same instants as **each** of the positions indicated by the dropped cannonball. Explain your reasoning. Ignore air resistance. [3]

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(ii) The cannonball fired from the cannon impacts with the ground 3.20 s after being fired.

I. Calculate the height from which the cannonball was fired. [2]

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II. Calculate the velocity with which the **fired** cannonball impacts with the ground. [4]

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END OF QUESTION PACK