Name	Date started	Target end date

GCE AS / A LEVEL — LINEAR KINEMATICS & GRAPHS QUESTION PACK

Legacy PH1 · New spec Unit 1 Topic 2a · AS unit, 20% of A-level

REVISE
.wales

PHYSICS — UNIT 1 · LINEAR KINEMATICS & GRAPHS

PH1.2 Kinematics — vectors, motion definitions, motion graphs & SUVAT

Vectors and scalars, defining displacement / speed / velocity / acceleration, reading and constructing motion graphs, and applying SUVAT under constant acceleration (incl. free fall).

NEW 2015 SPEC · UNIT 1 TOPIC 2A

Estimated time for entire question pack: ~3 h 36 min

Derived from the legacy PH1 paper's pace of 80 marks in 1¼ hours.

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

ABOUT THIS QUESTION PACK

This is a **comprehensive practice question pack**, not a single mock paper. It contains every question from the legacy WJEC PH1 papers (2008 modular spec) that maps onto new-spec Unit 1 Topic 2a (1.2).

Questions are ordered chronologically within each section.

INSTRUCTIONS

Use black ink or black ball-point pen. Answer all questions 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.

For Examiner's use only

Q	Source	Max	Mark
1	PH1 Jun 09 Q1	10	
2	PH1 Jan 10 Q4	6	
3	PH1 Jun 10 Q1	7	
4	PH1 Jan 11 Q6	6	
5	PH1 Jan 14 Q1	9	
6	PH1 Jun 13 Q1	10	
7	PH1 Jan 09 Q8	13	
8	PH1 Jun 11 Q4	15	

Q	Source	Max	Mark
9	PH1 Jan 12 Q7	13	
10	PH1 Jan 13 Q1	8	
11	PH1 Jan 14 Q3	13	
12	PH1 Jun 15 Q7	15	
13	PH1 Jan 12 Q3	7	
14	PH1 Jan 13 Q4	10	
15	PH1 Jun 14 Q6	12	
	Total	**154**	

Linear Kinematics & Graphs — what the new spec asks

WJEC GCE AS / A Level Physics (from 2015) · Unit 1: Motion, Energy & Matter · Topic 1.2.

Scalars & vectors (A)

- Distinguish scalar and vector quantities; give examples of each.
- Add and subtract two perpendicular coplanar vectors.
- Resolve a vector into perpendicular components.

Motion definitions (A)

- Define displacement; mean and instantaneous speed, velocity & acceleration.
- Tangent-gradient method for instantaneous values on motion graphs.

Motion graphs (B)

- Represent displacement, speed, velocity and acceleration graphically.
- Gradients and areas under d-t, v-t, a-t graphs.
- Interpret graphs for non-uniform acceleration.

Equations of motion (C)

- Derive and apply $v = u + at$; $s = ut + \frac{1}{2}at^2$; $v^2 = u^2 + 2as$; $s = \frac{1}{2}(u+v)t$.
- Describe motion of bodies in free fall under gravity.

Linear Kinematics & Graphs in one page

Quick-reference notes — revisit before each section.

Motion definitions

Speed = scalar, |distance/time|.

Velocity = vector, displacement/time.

Acceleration = rate of change of velocity (vector).

Mean = total/total; instantaneous = tangent gradient.

Motion graphs

x-t: gradient = velocity.

v-t: gradient = a; area = displacement.

a-t: area = change in v.

Curved sections ⇒ non-uniform a — use a tangent.

SUVAT (constant a)

$v = u + at$

$s = ut + \frac{1}{2}at^2$

$v^2 = u^2 + 2as$

$s = \frac{1}{2}(u+v)t$

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

Resolving vectors

For vector V at angle θ to horizontal:

$V_x = V \cos \theta$, $V_y = V \sin \theta$.

Resultant of perpendiculars: $R = \sqrt{(R_x^2 + R_y^2)}$, $\tan \theta = R_y/R_x$.

Free fall

Near Earth's surface $g \approx 9.81 \text{ m s}^{-2}$ downward.

Air resistance ignored ⇒ motion is mass-independent.

Pick a sign convention (up = + or down = +) and stick with it.

Vertical throw

Throw up at speed u:

- Time to peak: $t = u/g$
- Max height: $h = u^2/(2g)$
- Time up = time down (same h)
- Speed back at launch = u

Section index

Use this index to jump straight to the section you need.

1. (a) Define acceleration.

[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.

[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]

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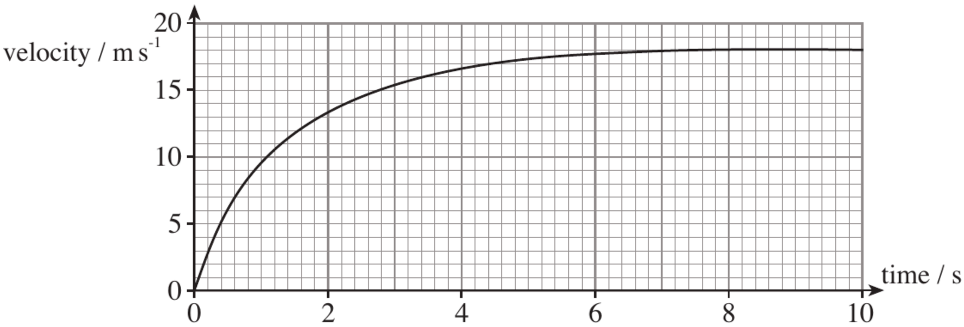
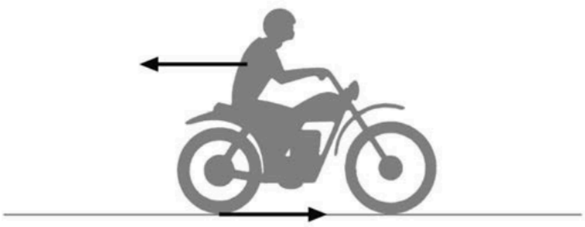
(b) The graph represents the motion of the motorcycle over a 10 s period.



(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 350 kg. [3]

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

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(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]

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(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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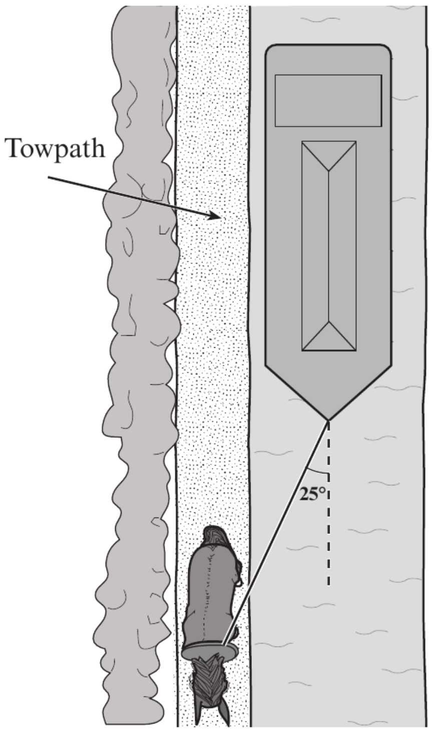
.... [1]

(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]

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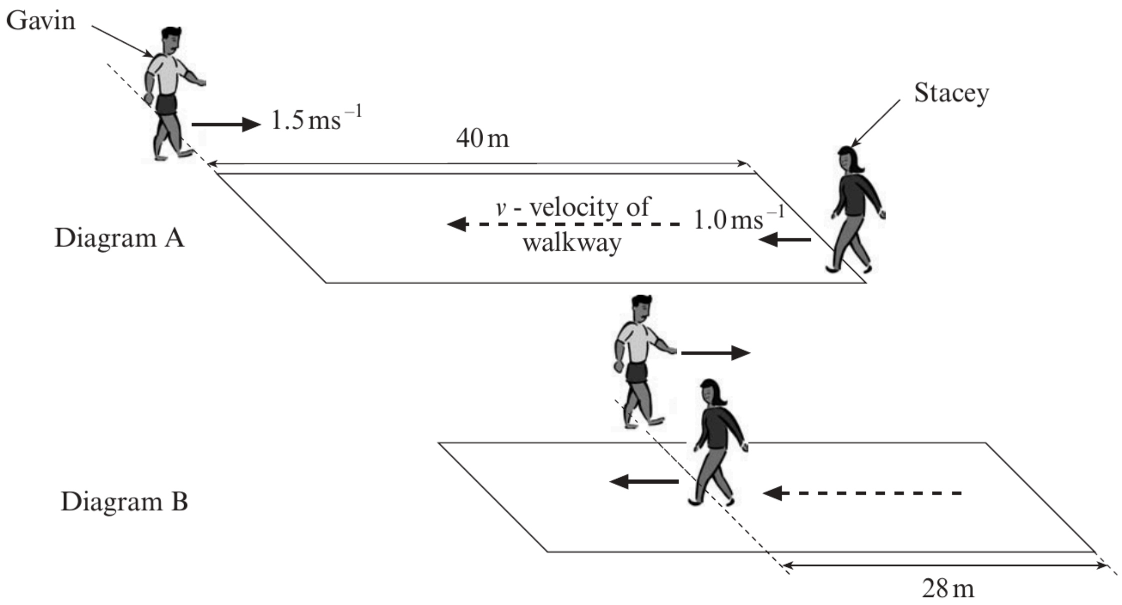
(ii) Gavin walks with a velocity of $1.5\,\text{ms}^{-1}$ in the opposite direction to Stacey. He **does not** get on the walkway but instead walks in a straight line beside the walkway as shown in diagram A. At the instant Stacey steps onto the walkway, Gavin is positioned at the far end, 40 m away.



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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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:

$$\Sigma F = ma$$

Name the vector quantities in this equation. [2]

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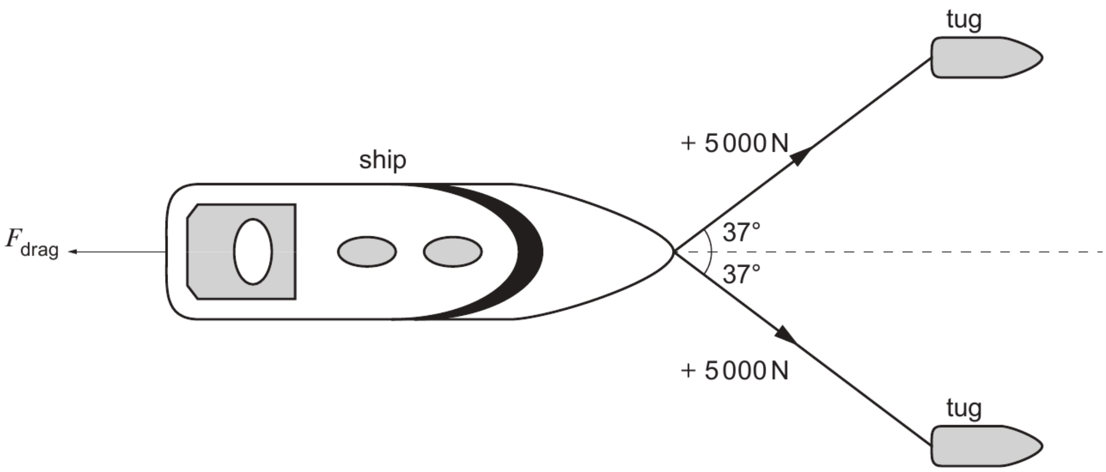
(c) A ship is being pulled along by cables attached to two tugs as shown. F_{drag} represents the total drag force that acts on the ship at the instant shown.



(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 $\Sigma F = + 2000$ 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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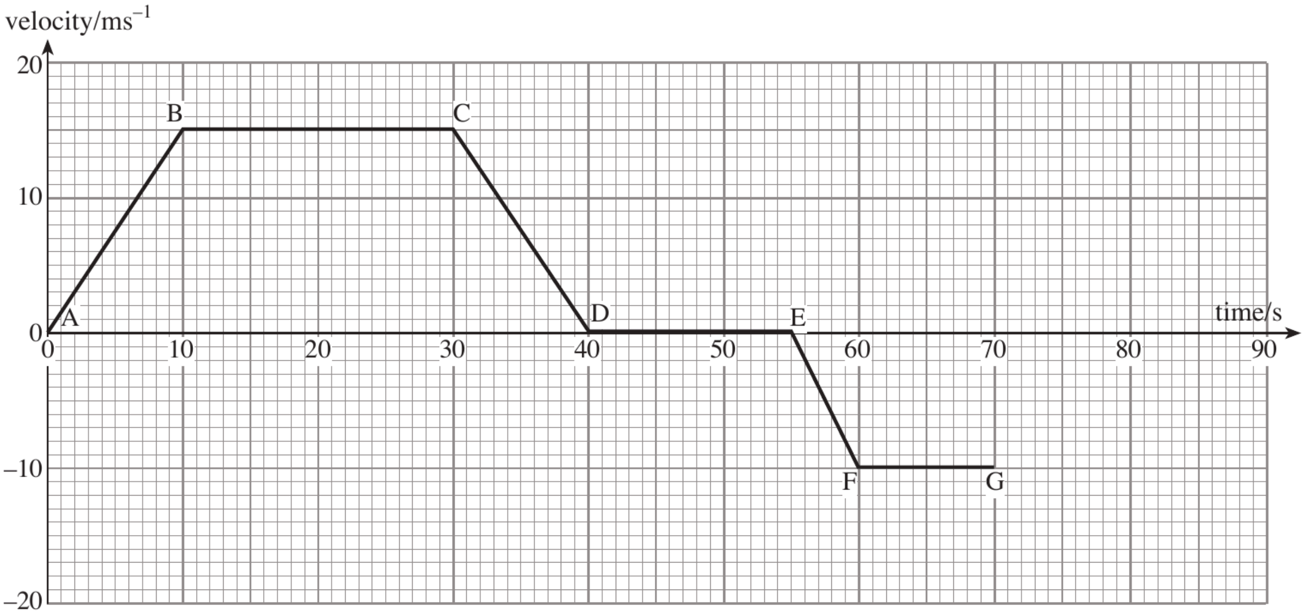
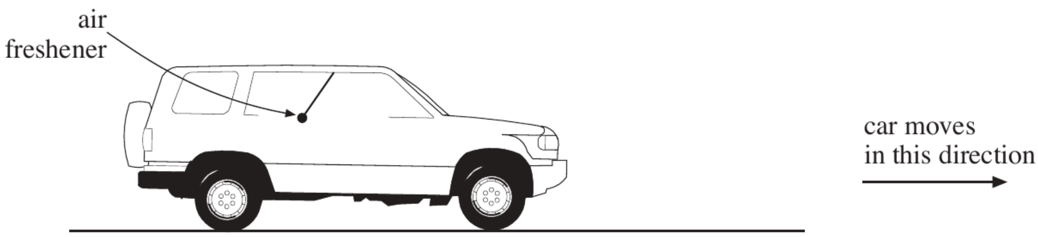
Examiner only

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

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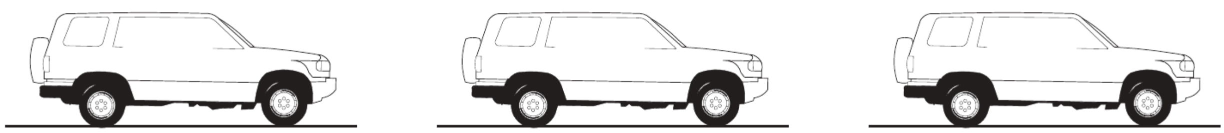
(ii) Sketch, on the diagrams below, how the thread is inclined (if at all), when the car is moving between the points indicated beneath each picture. [3]



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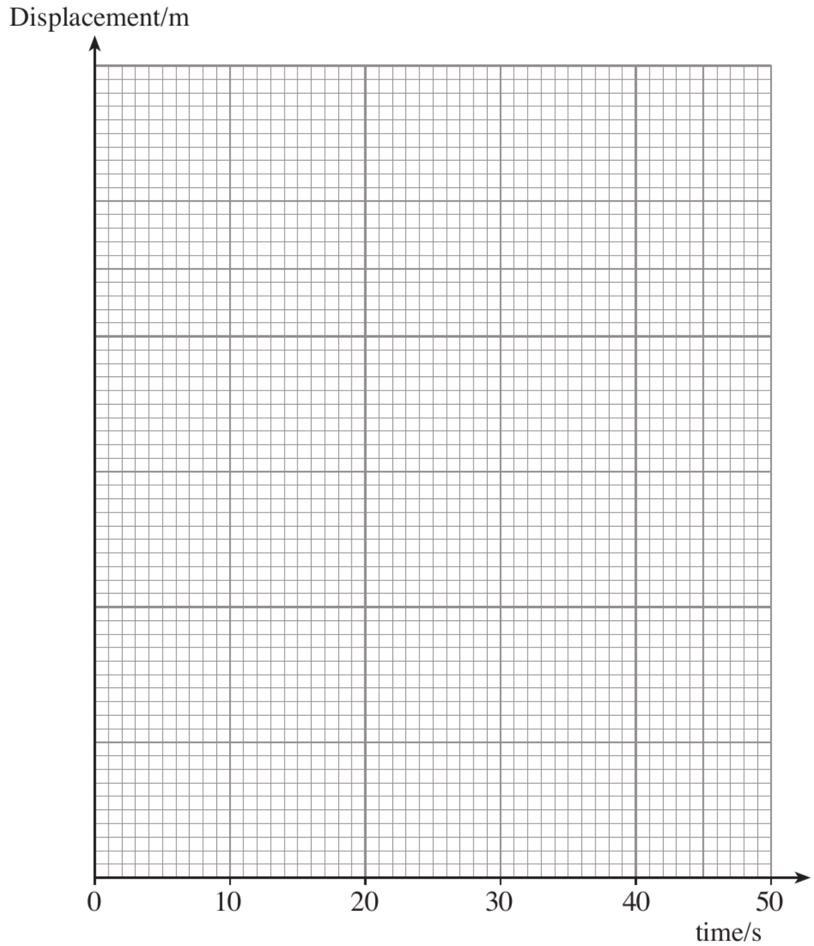
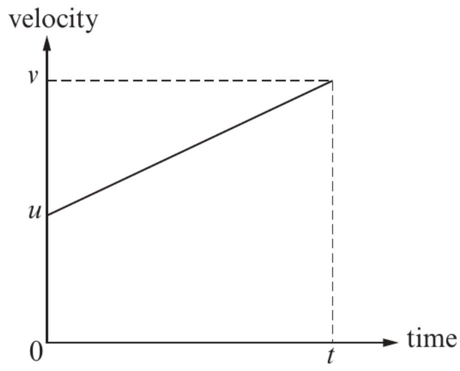
(ii) Hence, sketch a displacement-time graph for the first 50 seconds of the motion on the grid on page 14. Start by providing a scale on the vertical axis and plotting the points obtained from (c)(i).

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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(b) A cyclist accelerates **from rest** with a constant acceleration of $0.50\,m\,s^{-2}$ 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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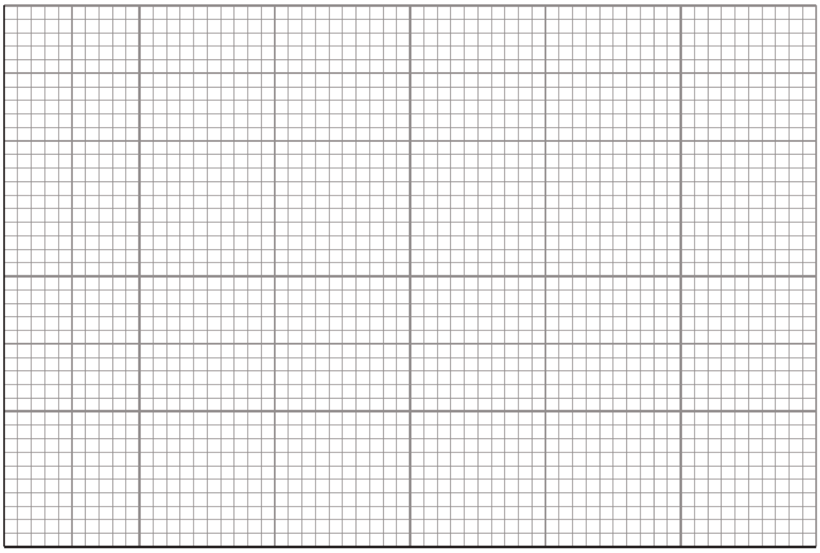
Examiner only

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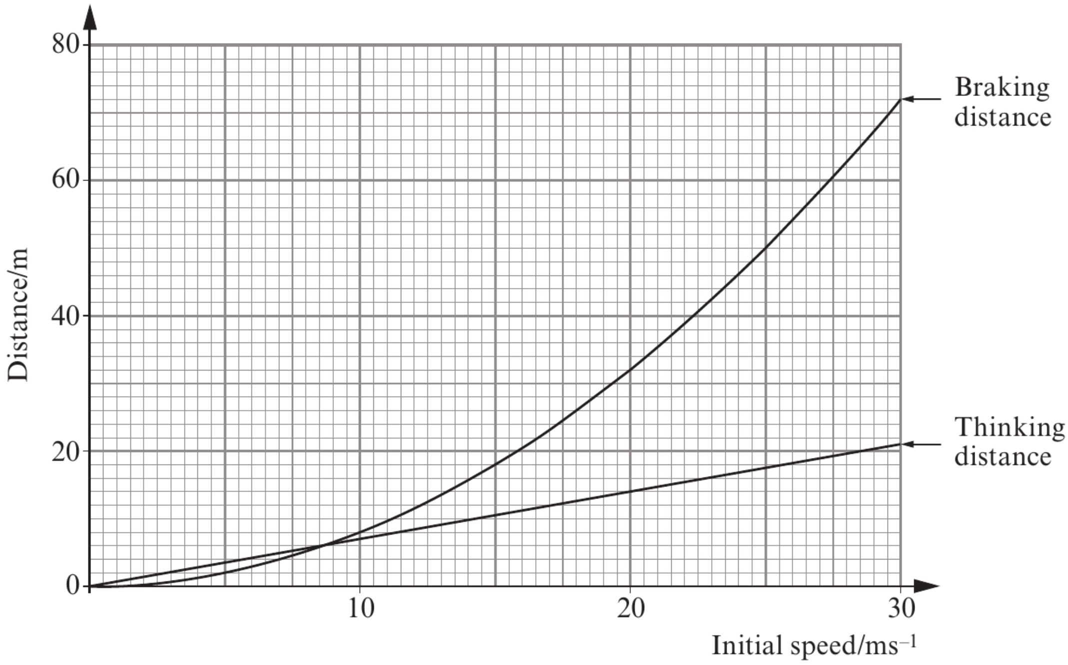
7. The following graph gives data taken from the 'Highway Code' for 'Thinking' and 'Braking' distances for a car when stopping. Thinking distance is the distance a car travels between the driver seeing an incident and beginning to apply the brakes. Braking distance is the distance a car travels while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

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

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

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(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]

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(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]

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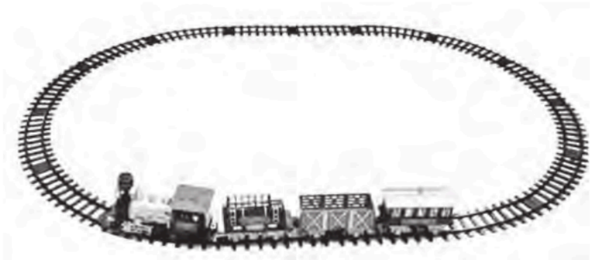
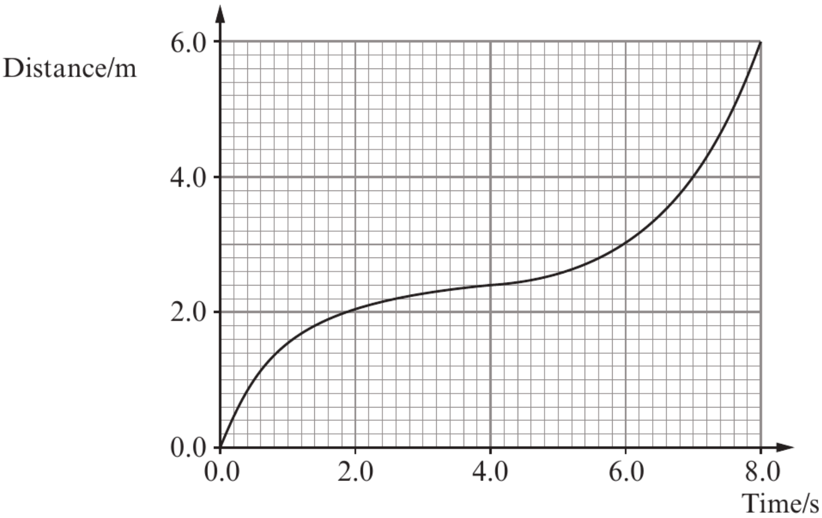
1. The diagram shows a toy train track. One complete lap is 6.0 m.



(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]

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....

(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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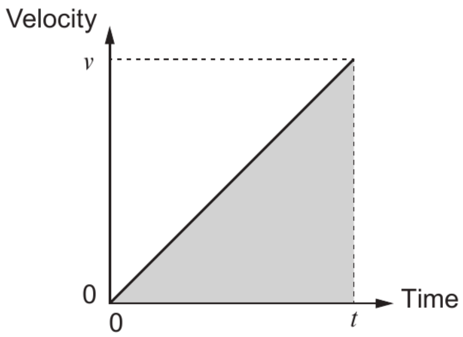
Examiner only

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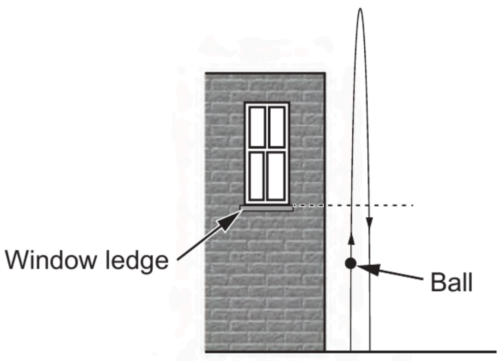
(b) A ball is thrown vertically upwards and passes a window ledge 0.3 s after being released. It passes the window ledge on its way back down, 1.6 s **later**. Ignore air resistance.



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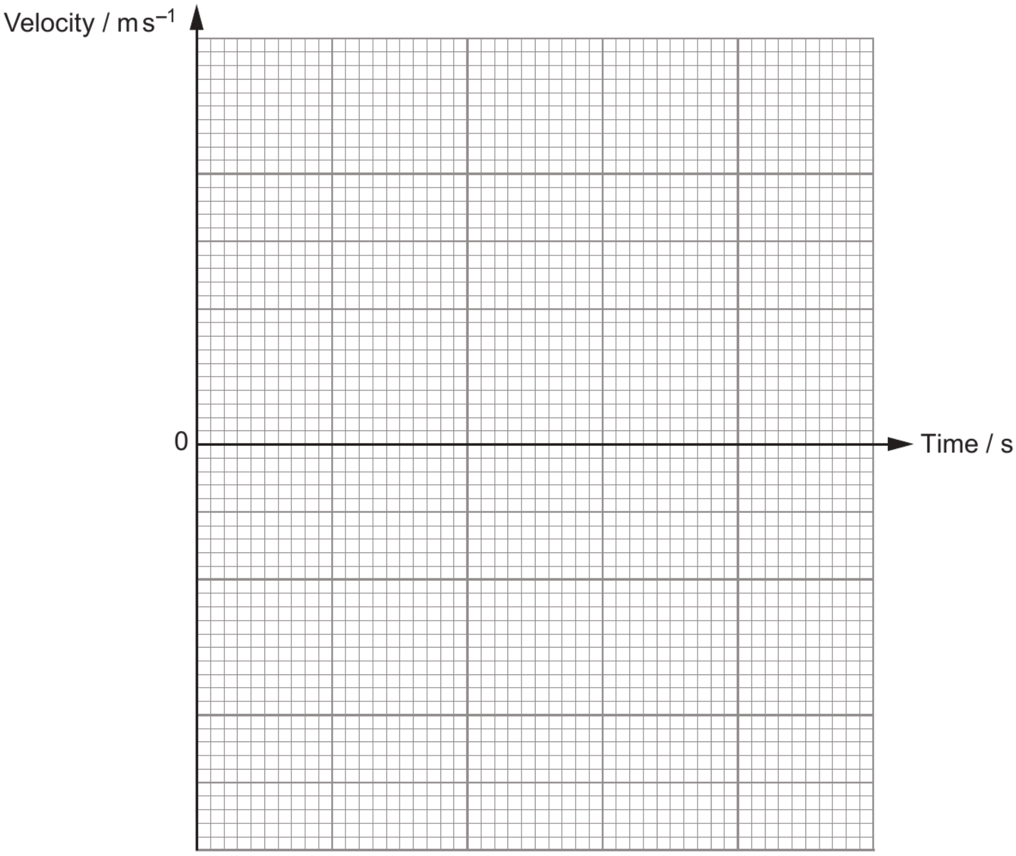
(c) Draw, on the grid below, a velocity-time graph for the whole of the ball's flight. Include suitable scales on both axes. [3]



(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**

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

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(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]

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

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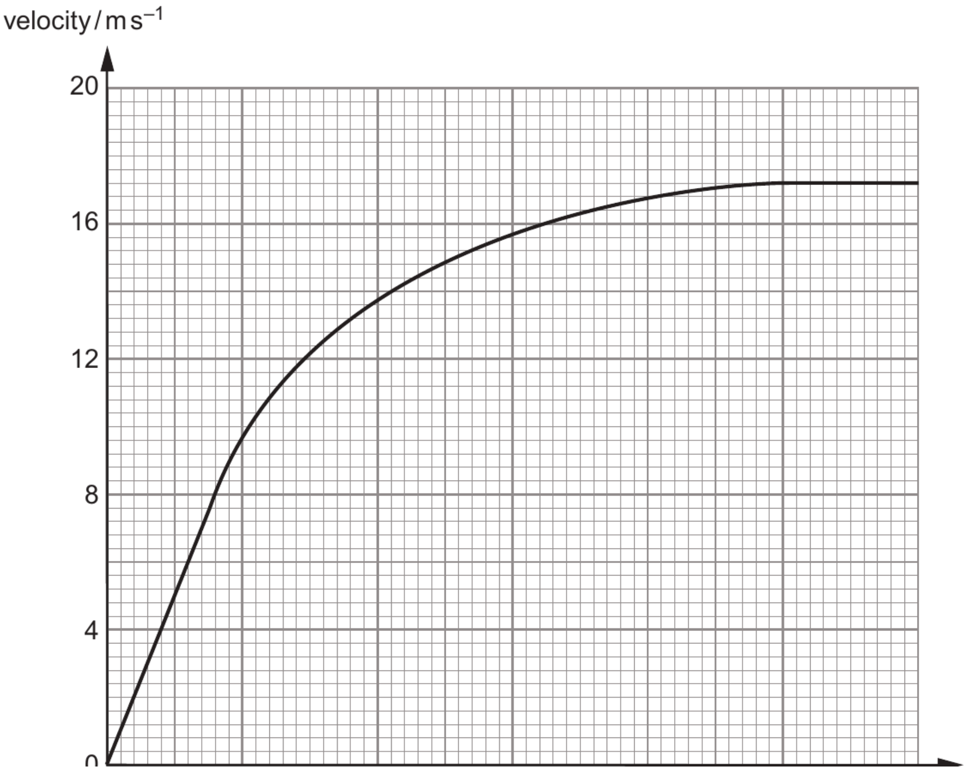
(b) The graph represents the motion of the train over a 120 second period as it departs from a station.



Examiner only

(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]

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(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]

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(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]

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

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(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]

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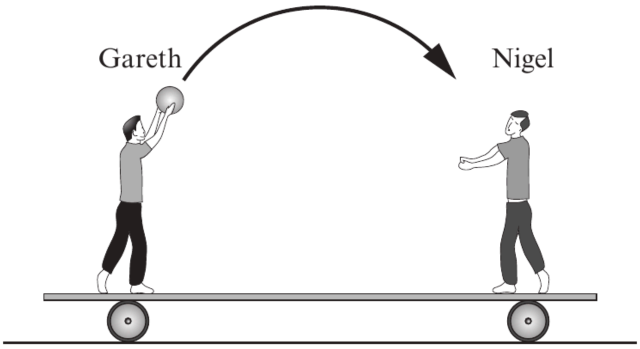
END OF PAPER

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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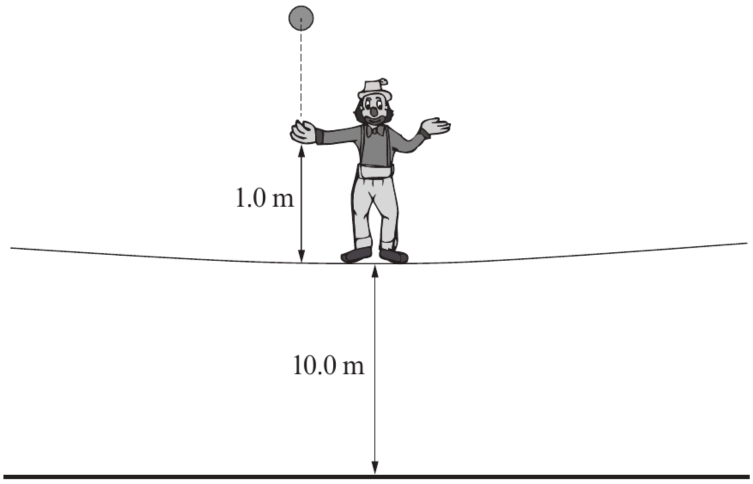
Examiner only

4. *(a)* A circus performer standing on a tightrope 10.0 m above the ground throws a ball vertically upwards at a speed of $6.0\,\text{m}\,\text{s}^{-1}$. 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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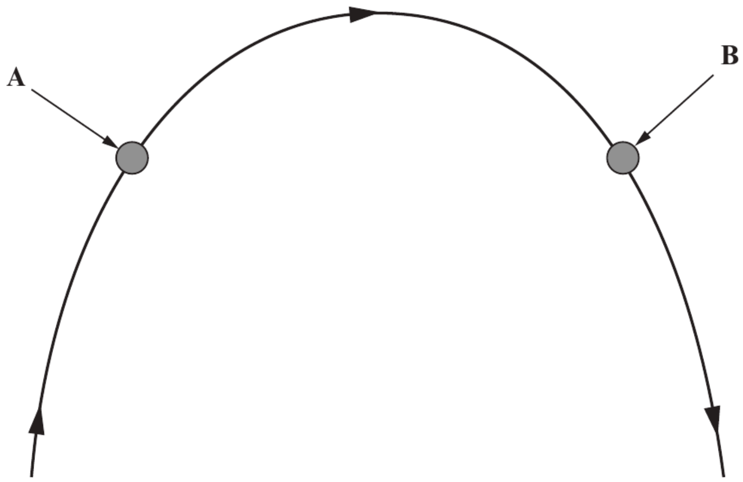
(b) Another ball is thrown into the air and follows the path shown. The ball is shown in two places, **A** and **B**.



(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]

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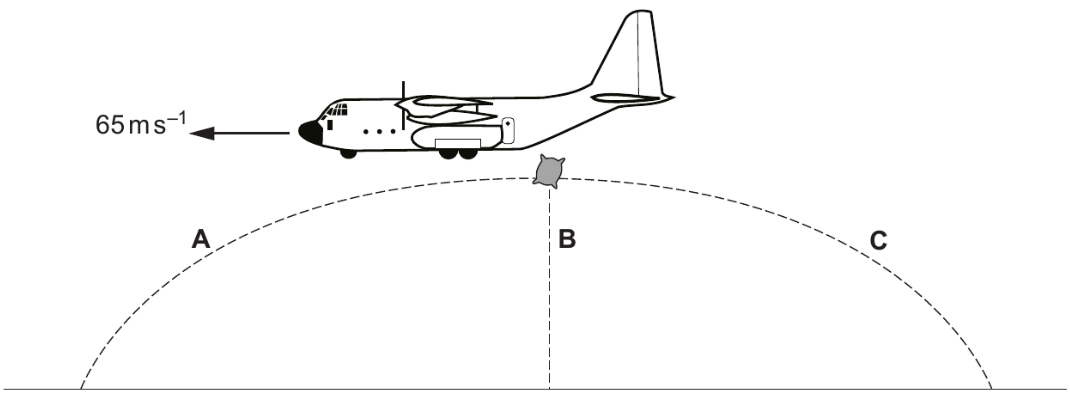
(b) The aeroplane shown below is travelling **horizontally** at 65 m s⁻¹. It is used to drop sacks of flour as emergency supplies. A sack is shown at the instant it is released from the low flying aeroplane. Ignore air resistance for this question. The diagram is not to scale.



(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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END OF QUESTION PACK

15 questions · 154 marks · ~3 h 36 min

Source: WJEC PH1 (2008 modular spec)

Curated for WJEC Physics 2015 spec AS Unit 1 — Topic 2a (1.2)