

WJEC A-LEVEL PHYSICS • UNIT 1

PHYSICS



EXAM QUESTION PACK

1.2 KINEMATICS

SCORE

/

PERCENTAGE

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STEMUP

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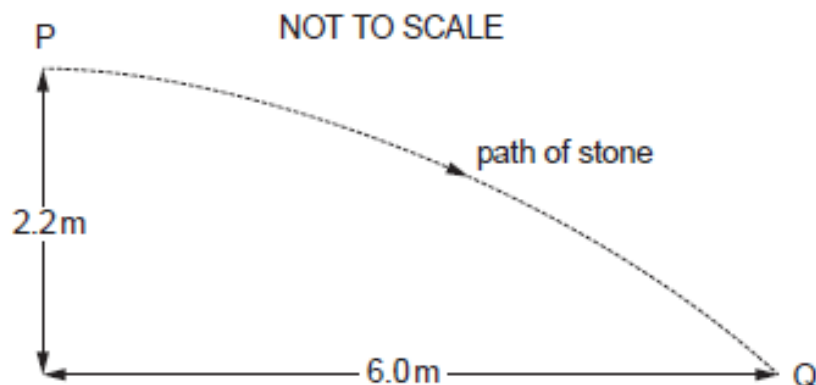
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1.

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 ms^{-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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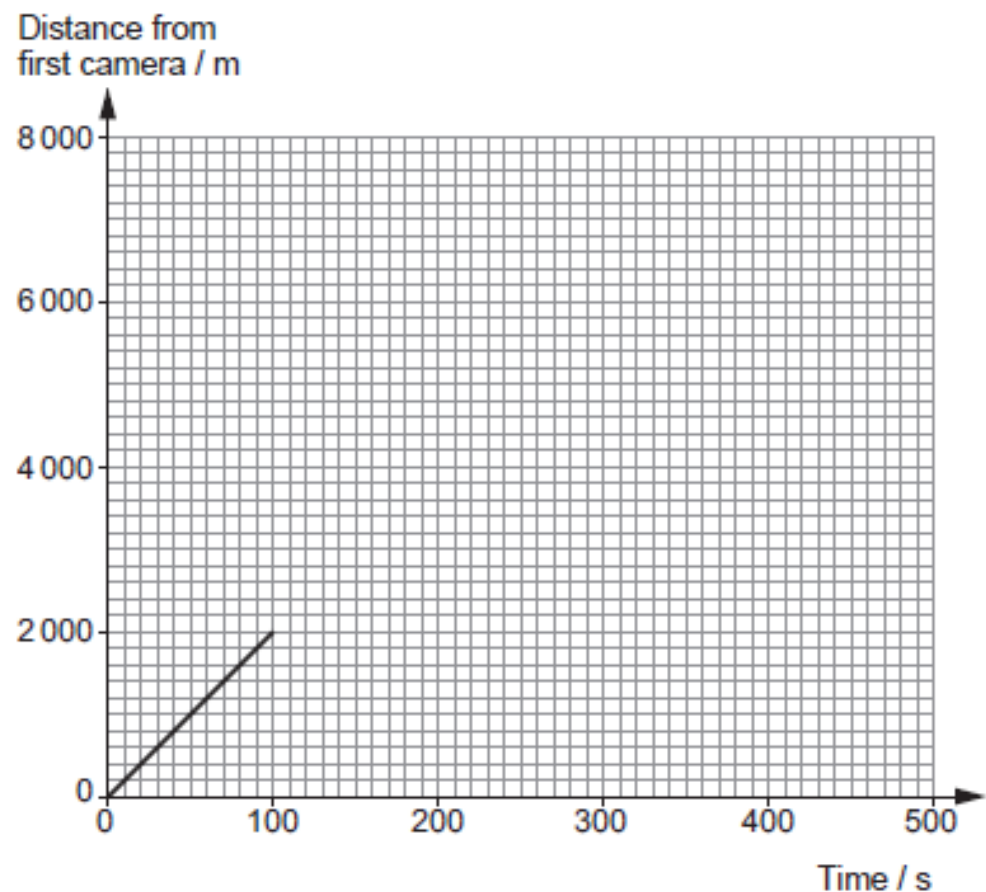
2. (a) State the difference between a vector and a scalar and give one example of each. [2]

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- (b) Average (or mean) speed areas are now found on many motorways. A section of motorway has a mean speed of 60 km h^{-1} . The mean speed is monitored between two cameras placed 8 km apart. The graph shows the first 100 seconds of the motion of a car as it travels between the two cameras.



- (i) Show that the instantaneous speed of the car at $t = 50$ s is approximately 70 km h^{-1} . [2]

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- (ii) The car covers the 8 km between the two cameras at a mean speed of exactly 60 km h^{-1} . Complete the graph to show this motion. [3]
Space is provided below for your calculations.

- (c) On another stretch of motorway, the speed limit is equivalent to 30 ms^{-1} . The maximum deceleration a normal car can achieve in dry conditions is assumed to be 8 ms^{-2} . Traffic police can estimate the speed of vehicles involved in accidents using the length of the marks made by skidding tyres on the road. In one accident, the skid marks were found to be 85 m long. Investigate whether or not the car that created the skid marks was travelling below the speed limit prior to the accident. [3]

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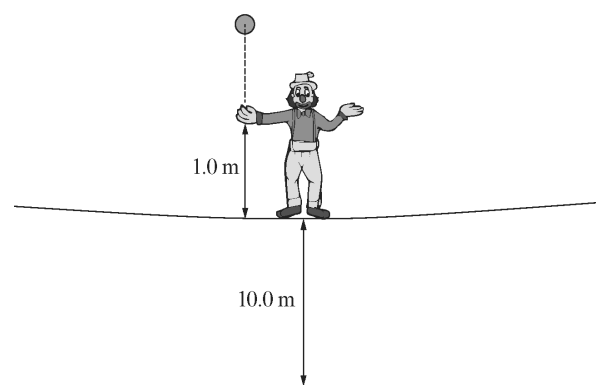
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3.

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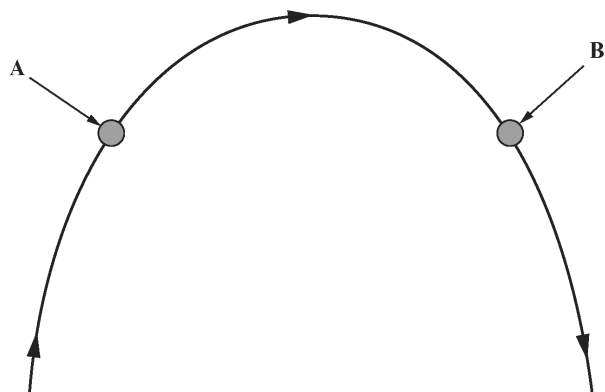
- (II) the **total** time the ball is in the air. [3]

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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]



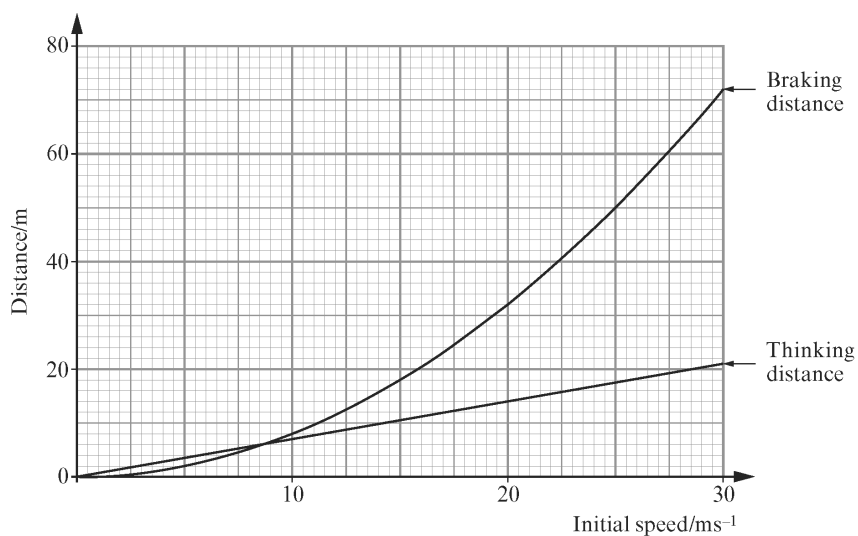
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- (ii) Assuming the force of air resistance **cannot** be neglected, sketch a diagram below to show the forces acting on the ball as it falls towards the ground in position **B** as shown in the above diagram. [2]

4.

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 ms⁻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 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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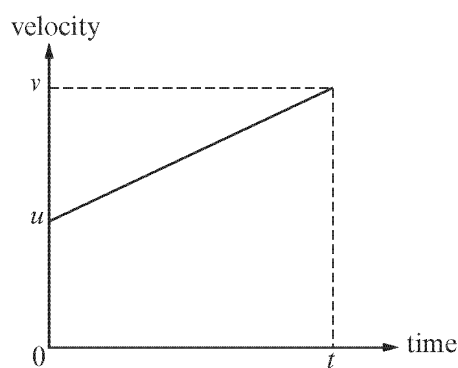
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5.

- (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,

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

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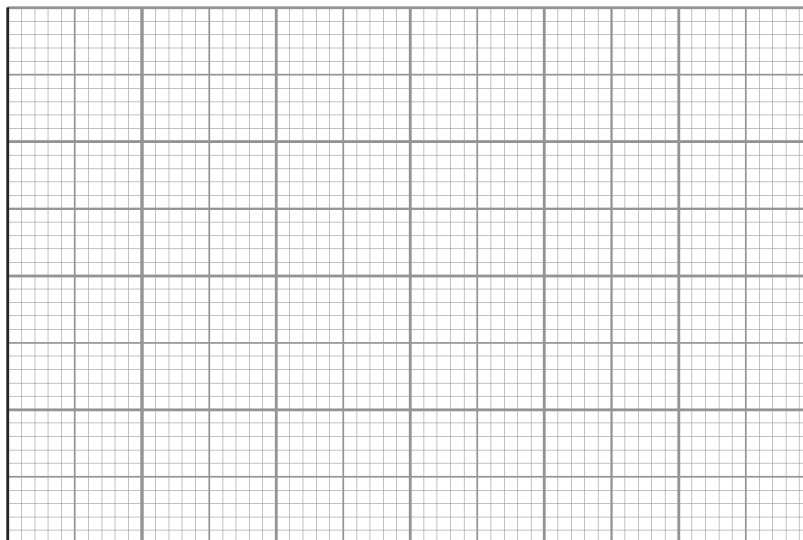
(ii) Calculate the magnitude of the cyclist’s deceleration. [2]

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- (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]

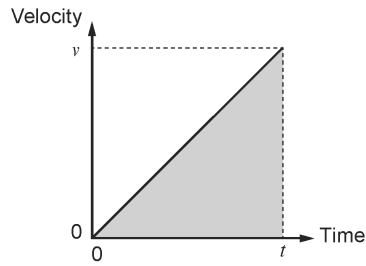
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6.

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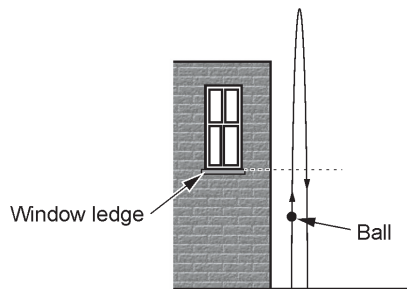
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- (b) A ball is thrown vertically upwards and passes a window ledge 0.3 s after being released. It passes the window ledge on its way back down, 1.6 s later. Ignore air resistance.



- (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]

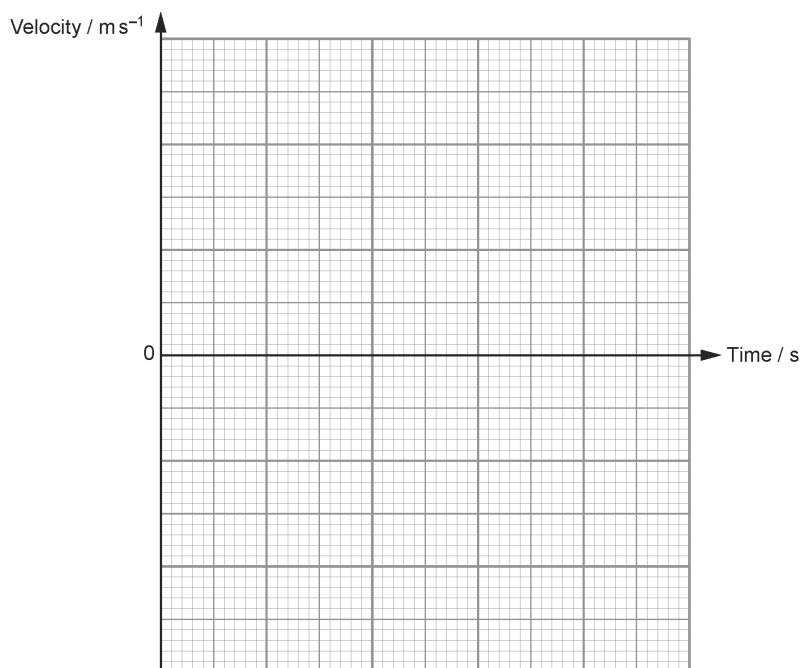
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- (c) Draw, on the grid below, a velocity-time graph for the whole of the ball's flight. Include suitable scales on both axes. [3]



- (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**

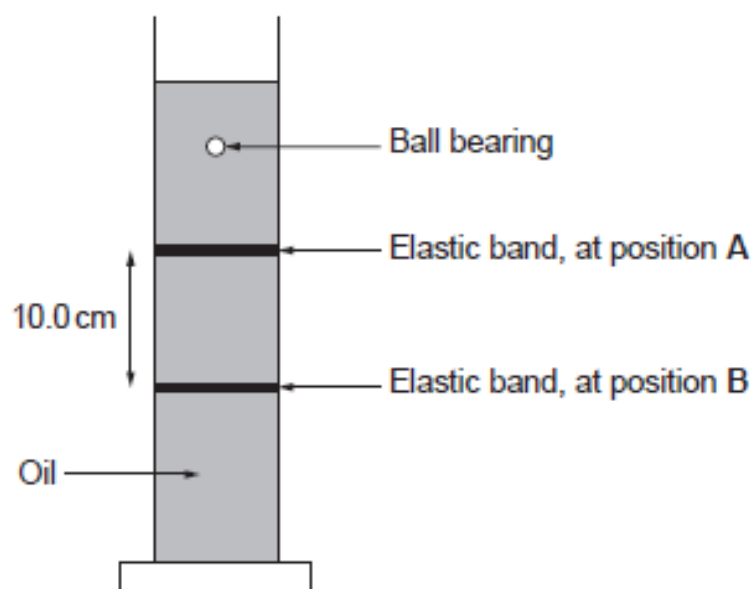


At maximum height above the ground



As the ball passes the window ledge **travelling downwards**

6. Emma investigates the viscosity of oil by measuring the terminal velocities of a number of different sized ball bearings as they move through it. She uses the following apparatus.



- (a) (i) Once released, a ball bearing attains terminal velocity before it reaches the elastic band at position A. Explain what is meant by terminal velocity. [1]

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- (ii) At terminal velocity the two main forces acting on the ball bearing are its weight and the drag of the oil. According to Newton's third law, for each of these forces there is a corresponding equal and opposite force. Identify each of these forces and the body upon which it acts. [2]

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- (b) Emma measures the time it takes the ball bearings to fall from the elastic band at position A to the elastic band at position B. She carries out each measurement twice, and obtains the following results. The distance between the two elastic bands is 10.0 cm. The uncertainty in this distance can be considered negligible when calculating the uncertainty in the terminal velocity.

Ball bearing		Time to fall			Terminal velocity	
Diameter, d/cm	(Diameter) ² , d^2/cm^2	Reading 1 /s	Reading 2 /s	Mean/s	Velocity, $v/\text{cm s}^{-1}$	Uncertainty, $\Delta v/\text{cm s}^{-1}$
0.24	0.058	14.0	14.6	14.3		± 0.01
0.32	0.10	8.0	8.6	8.3		± 0.05
0.40	0.16	5.3	5.9		1.8	$\pm$
0.48	0.23	3.6	4.1		2.6	$\pm$
0.64	0.41	2.2	1.9	2.1	4.8	± 0.3

Complete the table. *Space has been left for any calculations if needed.*

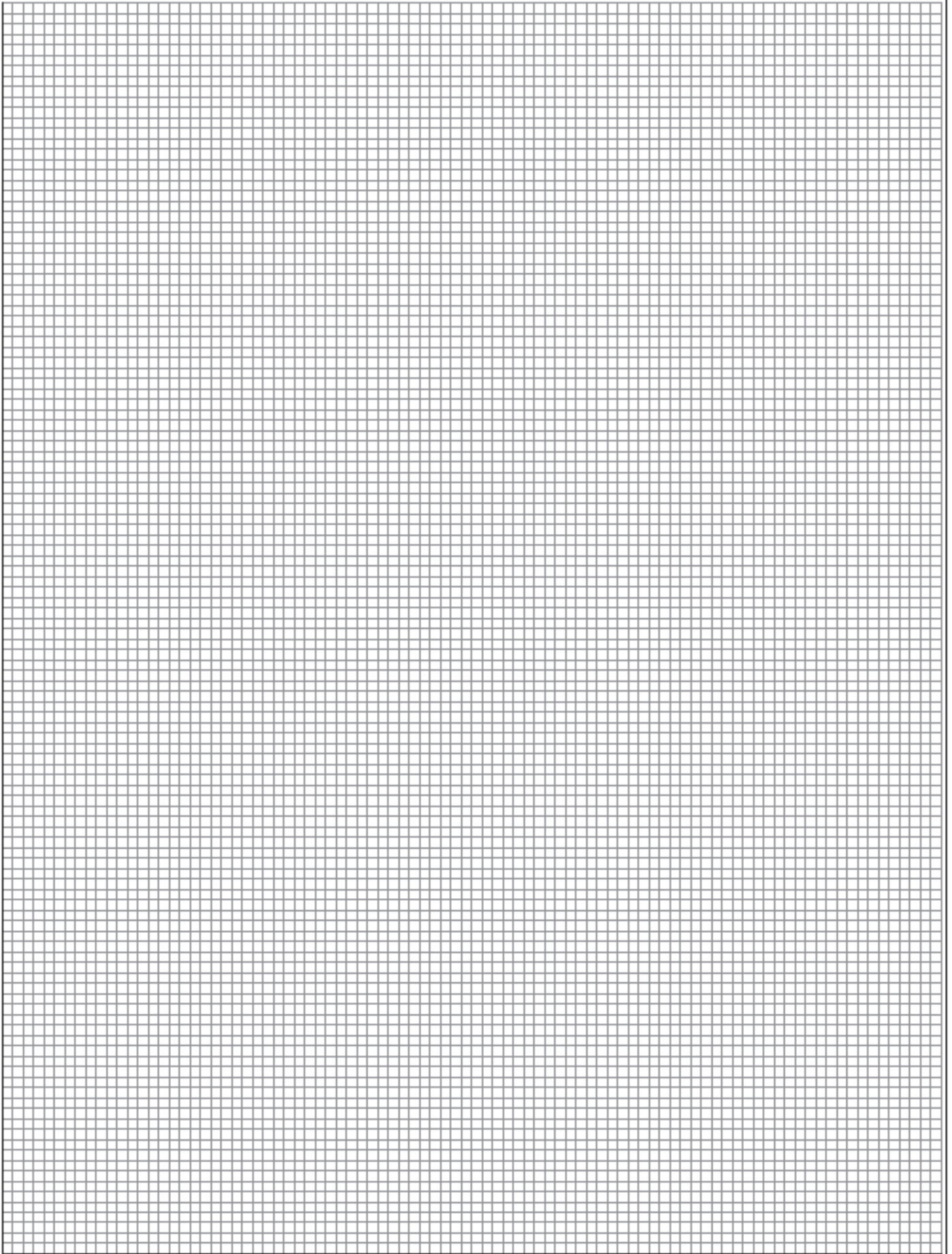
[4]

- (c) (i) Emma's friend, Fiona, thinks that the terminal velocity, v , is directly proportional to the square of the diameter, d , of the ball bearing,

$$v \propto d^2.$$

Plot a suitable graph to check whether Fiona is correct.

[4]



(ii) Evaluate whether or not Fiona is correct.

[2]

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8.

7. (a) Ignoring the effects of air resistance, describe how, if at all, the vertical and horizontal components of a projectile's velocity change during flight on Earth. [2]

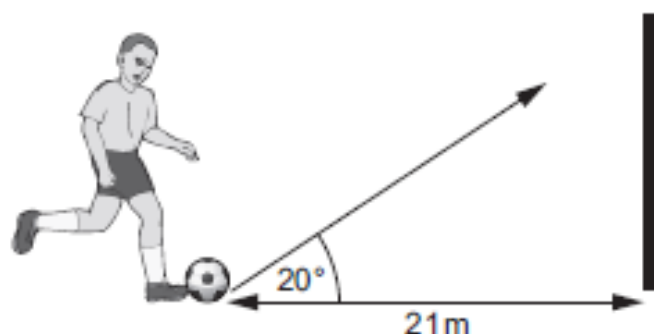
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- (b) (i) A football player takes a free kick 21 m away from the goal. The ball leaves the ground at an angle of 20° . Show that the velocity he must strike the ball at is approximately 25 m s^{-1} if it is to reach its maximum height at the moment it reaches the goal. *Ignore the effects of air resistance.* [4]



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- (ii) The height of the cross bar is 2.44 m above the ground. Justify numerically whether the ball crosses the goal line above or below the bar. [3]

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- (iii) Discuss how air resistance might affect the height at which the ball reaches the goal. [2]

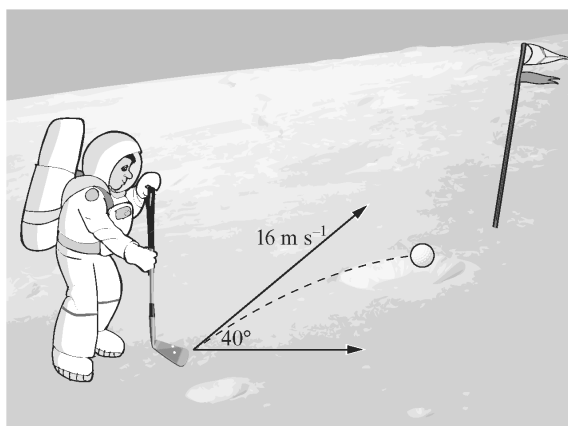
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9.

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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10. (a) (i) Show that $v = u + at$ is consistent with the definition of acceleration.

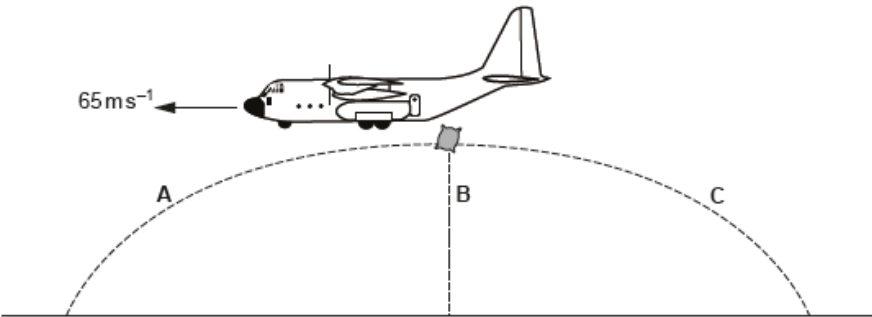
[2]

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

[2]

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

(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]

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]

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

[2]

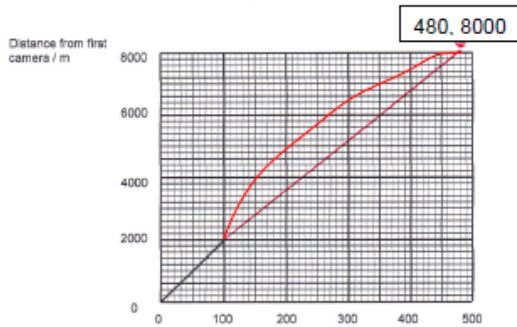
- (iii) Calculate the resultant velocity of the sack on impact with the ground when it is dropped from 46 m.

[3]

Marking Scheme

1.

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
1	(a)	(i)	Constant horizontal velocity if/because no horizontal force [1] That is if air resistance ignored or air resistance would/will make horizontal velocity decrease [1]	2			2		
		(ii)	From horiz motion, e.g. $t = \frac{6.0}{9.0} = 0.667$ [s] [1] So from vertical motion, $y = \frac{1}{2} \times 9.81 \times \left(\frac{6.0}{9.0}\right)^2 = 2.18$ [m] ecf on t [1] Conclusion consistent [1] Alternative: From vertical motion, e.g. $t = \sqrt{\frac{2 \times 2.2}{9.81}} = 0.67$ [0] [s] ecf on t [1] From horiz motion, $v_h = \frac{6.0}{0.67} = 8.96$ [ms ⁻¹] ecf on t or $x = 9.0 \times 0.67 = 6.03$ [m] [1] Conclusion consistent [1] Alternative: Time from horiz motion = 0.67 [s] [1] Time from vertical motion = 0.67 [s] [1] Conclusion consistent [1]			3	3	2	
	(b)		Vertical velocity component, $v_v = 6.5$ [ms ⁻¹] or 6.6 [ms ⁻¹] [1] Diagram showing v_v , v_h and v_{res} or by implication if correct answer [1] Angle to horiz = 36° or angle to vertical = 54° [1] ecf on v_v Magnitude of velocity = 11 [ms ⁻¹] [1] ecf on v_v		4		4	3	
Question 1 total				2	4	3	9	5	0

Question			Marking details	Marks available																	
				AO1	AO2	AO3	Total	Maths	Prac												
2	(a)		Vector: Magnitude (size) and direction Scalar: Magnitude (size) only Minimum acceptable response: <i>a vector has direction</i> [1] Relevant example of each e.g. independent mark [1] <table border="1"> <thead> <tr> <th>Vectors</th> <th>Scalars</th> </tr> </thead> <tbody> <tr> <td>Displacement</td> <td>Speed</td> </tr> <tr> <td>Velocity</td> <td>Time</td> </tr> <tr> <td>Acceleration</td> <td>Distance</td> </tr> <tr> <td>Force</td> <td>Pressure</td> </tr> <tr> <td></td> <td>Temperature</td> </tr> </tbody> </table>	Vectors	Scalars	Displacement	Speed	Velocity	Time	Acceleration	Distance	Force	Pressure		Temperature	2			2		
Vectors	Scalars																				
Displacement	Speed																				
Velocity	Time																				
Acceleration	Distance																				
Force	Pressure																				
	Temperature																				
	(b)	(i)	From graph speed = $\frac{2000}{100}$ or equiv [e.g. $\frac{1000}{50}$] (or 20 m s^{-1}) seen [1] Convincing conversion to km h^{-1} (i.e. $\times \frac{3600}{1000}$) or $72 [\text{km h}^{-1}]$ seen or convert 70 km h^{-1} into 19.4 m s^{-1} [1]	1			2	2													
		(ii)	Time to complete distance at mean speed of $60 \text{ km h}^{-1} = \frac{8}{60}$ [1] (= 0.1333) Conversion $t = 480 \text{ s}$ [1] Accept rounded values e.g. 17 m s^{-1} gives $t = 471 \text{ s}$ Alternative for first 2 marks: $60 \text{ km h}^{-1} = \frac{1000}{60} \text{ m s}^{-1}$ (1) $t = \frac{8000}{\left(\frac{1000}{60}\right)} = 480 \text{ s}$ (1) Alternative for first 2 marks: 1 km per minute (1) $t = 8 \text{ minutes}$ or 480 s (1) 3rd mark - Continuous (though not necessarily straight) line drawn on graph from (100, 2000) to (480ecf, 8000) tolerance $\pm$ small square - two possible examples shown: [1] 		3		3	3													
	(c)		Correct substitution into $v^2 = u^2 + 2ax$ (i.e. $0 = u^2 - (2 \times 8 \times 85)$) [1] don't award mark if incorrect signs $u = 36.9 [\text{m s}^{-1}]$ ecf on incorrect signs [1] No, greater than speed limit [1] must correlate with working Alternative: Correct substitution into $v^2 = u^2 + 2ax$ using 30 m s^{-1} to find x. (i.e. $0 = (30)^2 - (2 \times 8 \times x)$) [1] don't award mark if incorrect signs $x = 56.3 [\text{m}]$ ecf on incorrect signs [1] No, greater than speed limit [1] must correlate with working Alternative: Using $v = u + at$ to determine $t = 3.75 \text{ s}$ (1) Using $x = \frac{1}{2}(u + v)t$ i.e. $3.75 \times \text{mean velocity} (15) = 56.3 [\text{m}]$ (1) No, greater than speed limit [1] must correlate with working			3	3	2													
Question 2 total				3	4	3	10	7	0												

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|------|---|-----|
| (a) | <p>(i) <u>Correct use</u> of $v^2 = u^2 + 2ax$ (i.e. $0 = 6^2 - 2 \times 9.81 \times x$) (1)
 $x = 1.8$ [m] (1)
 Total height = 12.8 [m] (1) (ecf for x)</p> | [3] |
| (ii) | <p>(I) $v^2 = 2 \times 9.81 \times 12.8$ (ecf) (1) or suitable alternative
 $v = 15.9$ [m s^{-1}] (1)</p> | [2] |
| (II) | <p>$t_{\text{up}} = \left(\frac{0 - 6}{-9.81} \right) = 0.6$ [s] (1)</p> <p>$t_{\text{down}} = \left(\frac{15.9(\text{ecf}) - 0}{9.81} \right) = 1.6$ [s] (1)</p> <p>Total time = 2.2 [s] (1) (other solutions possible)</p> | [3] |
| (b) | <p>(i)  (1) Ball only acted upon by <u>force due to gravity / weight</u> is the only force acting (1)
 Only award 2nd mark if 1st mark correct.</p> <p>(ii)  (1) Marks are independent.
 If additional arrows present deduct 1 mark for each extra arrow.
 (1)</p> | [2] |

4.	(a)	Relevant pairs of values chosen (1) [e.g. $10 \text{ m s}^{-1} \rightarrow 8 \text{ m}$ and $20 \text{ m s}^{-1} \rightarrow 32 \text{ m}$] Method / strategy, e.g compare $\frac{\text{distance}}{\text{speed}^2}$ for the pairs of values. (1) Conclusion clearly linked to calculation (1) Allow e.c.f for values of pairs if marking points 2 and 3 completed correctly.	3
	(b)	(i) Identification of relevant equation: e.g. $v^2 = u^2 + 2ax$ (1) Identification of $x = 18 \text{ m}$ (1) deceleration = $6.3 \text{ [m s}^{-2}]$ or $a = -6.3 \text{ [m s}^{-2}]$ (1) (ii) $F = 800 \times 6.3 = 5000 \text{ [N]}$ allow e.c.f. from (b)(i)	3 1
	(c)	Reaction time is independent of speed / doesn't change (1) Then $v \propto d$ [from $d = vt$] (1)	2
	(d)	(i) $21 + 72 = 93 \text{ [m]}$ (ii) No change to thinking distance (1) [Reduced acc/deceleration would] increase braking distance (1)	1 2
	(e)	Time required = $\frac{\text{total distance}}{\text{speed}} = \frac{10}{50} [= 0.2 \text{ hour}]$ (1) Time for first $6.0 \text{ km} = \frac{6.0}{80} [= 0.075 \text{ hour}]$ (1) remaining time = $0.2 - 0.075 = 0.125 \text{ hour}$ (1) Speed for remaining $4 \text{ km} = \frac{4}{0.125} = 32 \text{ [km / h]} \text{ or } 8.9 \text{ [m s}^{-1}]$ (1)	4

4	(a)	(i)	[gradient =] $\frac{v-u}{t}$ (1); represents acceleration [accept: a] (1)	2
		(ii)	[Area =] $ut + \frac{1}{2}t(v-u)$ or $\frac{1}{2}(u+v)t$ (1) Represents displacement [accept: distance [travelled in a given direction]] (1)	2
		(iii)	Either: $v = u + at$ (1) $x = ut + \frac{1}{2}at^2$ shown (1) [or other convincing working] Or: $v = u + at$ (1) $x = \frac{1}{2}(u + u + at)t$ (1) [or other convincing working]	2
	(b)	(i)	$x = ut + \frac{1}{2}at^2$ used with $u = 0$ (1) $x = 36 \text{ m}$ (1)	2
		(ii)	$v = u + at$ used with $u = 0$ (1) [or $v^2 = u^2 + 2ax$ used with $u = 0$] $v = 6 \text{ m s}^{-1}$ (1)	2
	(c)	(i)	$x = \frac{1}{2}(u+v)t$ used (1) $t = 40 \text{ s}$ (1) [Use of $u = 0$ seen $\rightarrow$ 1 mark penalty]	2
		(ii)	Use of $a = \frac{v-u}{t}$ (1) [Use of $u = 0$ seen $\rightarrow$ 1 mark penalty] $a = [-] 0.15 \text{ m s}^{-2}$ (1)	2
	(d)		Axes [inc + and - acceleration; time; labelling] (1) Horizontal line from 0 s at 0.5 m s^{-2} (1) Horizontal line from at -0.15 m s^{-2} [ecf from (c)(ii)] (1) Change of a at 12 s and cease at 52 s (1)	4
	(e)	(i)	157 N	1
		(ii)	$\left(\frac{157(\text{ecf})}{4(1)} + 8 \right) [= 47 \text{ N}]$ (1) [or equivalent working.] NB Use of factor of 2 $\rightarrow$ 0 marks	2
				[21]

6.	(a)	(i)	Displacement (don't accept distance)	[1]
		(ii)	Shaded area = $\frac{1}{2}tv$ (1) $u = 0$ shown or implied (1) $v = at$ and clear substitution (1)	[3]
	(b)	(i)	2.2 [s]	[1]
		(ii)	Valid substitution into $v = u + at$ (e.g. $0 = u - g \times 1.1$ or $2u = 2.2g$ etc) Or any other valid kinematic equation (ecf on t from (i)) Correct algebra/manipulation (1) $u = 10.8[\text{ms}^{-1}]$ (1)	[3]
		(iii)	Correct substitution into $x = ut + \frac{1}{2}at^2$ (i.e. $x = 10.8 \times 0.3 - \frac{1}{2} \times 9.81 \times 0.3^2$) (ecf on 10.8ms^{-1}) (1) $x = 2.8[\text{m}]$ (1)	[2]
	(c)		Reasonable scales on both axes (1) Diagonal straight line from (0, ± 10.8 (ecf)) to (1.1 (ecf), 0) (1) Diagonal line continued to (2.2, ± 10.8) (1)	[3]
		(d)	Two vertical downwards arrows shown during upward motion (1) Single vertical downwards arrow shown at max height (1) Vertical upwards and vertical downwards arrows shown during downward motion (1) All labels correct (weight or force due to gravity, air resistance or force due to air) (1)	[4]

7.

Question			Marking details	Marks available					
				A01	A02	A03	Total	Maths	Prac
6	(a)	(i)	Constant / steady velocity no resultant / overall force acting	1			1		
		(ii)	Ball bearing attracted to (centre of) the earth and the earth attracted to the ball bearing/ w.t.t.e. (1) Ball bearing pushing down on the oil and the oil pushing up on the ball bearing / w.t.t.e. (1)			2	2		
	(b)		Mean time i.e. 5.6 and 3.9 (1) Velocity i.e. 0.699 or 0.70 and 1.2 or 1.20 (1) Uncertainty i.e. 0.1 and 0.2 (1) All s.f. consistent in all columns (accept first velocity value (i.e. 0.699 or 0.70) to 2/3 s.f.) (1)		4		4	4	4
	(c)	(i)	Scale suitable with at least half of the paper used (1) Axis labelled with units (1) All points plotted correctly with error bars for v except first value (1) Suitable line of best fit (1)		4		4	3	4
		(ii)	Any 2 $\times$ (1) from: - Straight line graph / constant positive gradient - Through the origin - Line of best fit through all the error bars / close to all points			2	2	2	2
			Question 6 total	1	8	4	13	9	10

8.

Question			Marking details	Marks available				Maths	Prac
				AO1	AO2	AO3	Total		
7	(a)		Horizontal remains constant (1) vertical decreases to zero then increases / downward component increases (1)	2			2		
	(b)	(i)	$u_y = u \sin 20$ and $u_x = u \cos 20$ (1) $t = 0.035u$ or $t = \frac{21}{u \cos 20}$ (1) Horizontally $x = u \cos 20 t$ (1) $v = 25.3 \text{ [m s}^{-1}\text{]}$ (1)		4		4	4	
		(ii)	Use of $v^2 = u^2 + 2ax$ (1) Use $v^2 = 0$ and manipulation (1) $x = 3.82 \text{ [m]}$ ball is above the bar (1)			3	3	3	
		(iii)	Ball wouldn't go as high / horizontal velocity decreases (1) [Vertical] velocity falls to $v = 0$ quicker / ball on the way down by the time it crosses the line (1)			2	2		
			Question 7 total	2	4	5	11	7	0

9.

(a)	(i)	$v_H = 16 \cos 40^\circ$ (1) = 12.3 [m s ⁻¹]	
		$v_V = 16 \sin 40^\circ$ (1) = 10.3 [m s ⁻¹]	2
	(ii)	Horizontal: constant velocity Vertical: acceleration / changing (both statements required)	1
(b)	(i)	$0 = 10.3 - 1.6 t$ (1) ecf from (a)(i) penalise only once for use of 9.8 m s ⁻² $t = 6.4$ [s] (1) $t_{\text{flight}} = 12.8$ [s] (1) ecf between 2 nd and 3 rd marks Or any other alternative method used to gain correct answer = 3 marks	3
	(ii)	$D_H = 12.3 \times 12.8 = 157$ [m] ecf from (b)(i)	1
	(iii)	$0 = (10.3)^2 - 2 \times 1.6 s$ (1) ecf from (a)(i) $S = 33.2$ [m] (1)	2
	(c)	Air resistance on Earth (1) g on Earth different (accept greater) than on the Moon (1)	2

(a)	(i)	$v_H = 16 \cos 40^\circ$ (1) = 12.3 [m s ⁻¹]	
		$v_V = 16 \sin 40^\circ$ (1) = 10.3 [m s ⁻¹]	2
	(ii)	Horizontal: constant velocity Vertical: acceleration / changing (both statements required)	1
(b)	(i)	$0 = 10.3 - 1.6 t$ (1) ecf from (a)(i) penalise only once for use of 9.8 m s ⁻² $t = 6.4$ [s] (1) $t_{\text{flight}} = 12.8$ [s] (1) ecf between 2 nd and 3 rd marks Or any other alternative method used to gain correct answer = 3 marks	3
	(ii)	$D_H = 12.3 \times 12.8 = 157$ [m] ecf from (b)(i)	1
	(iii)	$0 = (10.3)^2 - 2 \times 1.6 s$ (1) ecf from (a)(i) $S = 33.2$ [m] (1)	2
	(c)	Air resistance on Earth (1) g on Earth different (accept greater) than on the Moon (1)	2

10.	(a)	(i) Acceleration defined as rate of change of <u>velocity</u> [or equivalent] or $a = \frac{(v - u)}{t} \quad (1)$ <u>Clear manipulation</u> to show that $v = u + at$ (1) (ii) $v = u + at$ substituted into $x = (u + v)t/2$ (1) <u>Clear manipulation</u> shown (1)	[2]
	(b)	(i) A (1) Horizontal velocity ($= 65 \text{ m s}^{-1}$) constant or same speed as plane or sack lands directly underneath plane (1) Vertical velocity increases or there is a vertical acceleration (1) (ii) (I) Substitution into $v^2 = u^2 + 2ax$ and $u = 0$ shown (1) x calculated $= 45.9 \text{ [m]}$ (1) (II) Correct substitution into $v = at$ or $x = 1/2 at^2$ or $x = \frac{(u + v)t}{2}$ (1) $t = 3.1 \text{ [s]}$ (1) (iii) $v_R^2 = (65^2 + 30^2)$ (correct substitution into Pythagoras) (1) $v_R = 71.6 \text{ [m s}^{-1}\text{]}$ (1) Valid angle calculated <u>and shown</u> or described e.g. $\theta = 24.8^\circ$ below horizontal (1) Question 6 Total	[3] [2] [2] [3] [14]

Examiner's Comments

1. There are no examiner comments available for this question

2. There are no examiner comments available for this question

3. Mean Mark: 6.5/12 = 54%

- (a) (i) & (ii) Apart from the usual confusion over signs for the velocities and the acceleration due to gravity, most candidates were able to proceed and obtain a value for the maximum height reached by the ball above the ground. Candidates who obtain negative answers for obviously positive quantities should be encouraged to go back and check their working and not just cross out the negative sign or ignore it. Some candidates gave the height reached by the ball above the hand or the wire and not above the ground as required.

The majority of candidates were able to calculate the speed with which the ball hit the ground and a variety of different correct solution methods were seen.

Again the calculation of the total time that the ball was in the air was carried out well, with a variety of different methods used. However candidates who attempted to use $s = ut + \frac{1}{2}at^2$ often ran into difficulties because they were unable to solve the ensuing quadratic equation for t .

- (b) (i) & (ii) A very disappointing response. It was surprising to note the difficulty these parts caused for candidates of all abilities. In (i) only about 10% of candidates realised that, in the absence of air resistance, the direction of the resultant force on the ball would be vertically downwards. In (ii) only the more able candidates realised that the direction of the force of air resistance would be in the opposite direction to that in which the ball was moving at the instant it was at B. Most candidates assumed that it would be vertically upwards. Extra forces, such as the 'force of the throw' were often incorrectly included.

This comment originally referred to question 4 on paper 1321/01 (11/01/2013)

4. Mean Mark: 7.4/16 = 46%

- (a) The majority of candidates were able to use a successful strategy to correctly conclude that braking distance $\propto \text{speed}^2$. Unfortunately, a number of candidates rejected the relationship despite correct choice of data. Weaker candidates just said 'no' as the graph was not a straight line. Others, who applied correct strategies, rejected the relationship because of very small differences (rounding errors) in their calculated constant of proportionality.
- (b) (i) & (ii) The correct equation of motion was usually selected. Unfortunately many candidates were unable to find the correct displacement from the graph. The vast majority of candidates were able to calculate the mean braking force correctly in (ii), in many cases as ecf from (i).
- (c) For the second mark many candidates simply stated that distance increased with speed without direct reference to the equation and constant reaction time. Reaction speed rather than reaction time was ambiguously referred to on several scripts.
- (d) (i) & (ii) The majority of candidates calculated the stopping distance correctly although examiners reported many examples of poor graph reading and/or poor arithmetic. In (ii), 'no change in thinking distance' was often implied but omitted from answers. Many gave details of braking force and braking time but missed mentioning braking distance.
- (e) There was a pleasing response to this question. Examiners reported seeing many scripts with logical and correctly sequenced steps. Some got themselves in a knot however by trying to change units multiple times.

This comment originally referred to question 7 on paper 1321/01 (12/01/2012)

5. Mean Mark: 13.2/21 (62.9 %)

- (a) (i) & (ii) The majority of candidates were able to state what the gradient and the area under the graph represented. However a significant number of these were unable to use the symbols given to write expressions for acceleration and displacement.
- (iii) The better candidates were able to give correct responses here. Many of the less able struggled with the algebra, often scoring zero marks.
- (b) & (c) These questions asked for a straightforward application of the equations of accelerated motion and were well answered by nearly all candidates. A small number of candidates confused u and v in part (c) and were penalised one mark.
- (d) The majority of candidates were able to gain some of the marks available for drawing the graph- usually for labelling the axes correctly and/or for drawing the correct initial acceleration. Only the more able candidates achieved full marks here however. A minority drew velocity-time graphs.
- (e) (i) The majority of candidates correctly obtained the air resistance force at 6.0ms^{-1} .
- (ii) Only a minority of candidates were able to calculate the resistive force at 3.0ms^{-1} . Many candidates did not take into account the 'square' nature of the force due to air resistance, dividing their answer to (e)(i) by 2 instead of 4.

This comment originally referred to question 4 on paper 1321/01 (24/05/2011)

6. (a) (i) Around half of the candidates stated that the shaded area under the velocity-time graph represented displacement. A very common incorrect answer was 'distance', and less common, though still incorrect, was 'acceleration'.
- (ii) Although many candidates realised that the area under the graph, x , was equal to $\frac{1}{2}vt$, far fewer were able to proceed with a convincing explanation of how this led to $x = \frac{1}{2}at^2$. The body was often given an initial velocity u , when it is obvious from the graph, that $u = 0$. This having been said, many excellent and succinct solutions were seen.
- (b) (i) The determination of the time of flight caused more problems than anticipated. Many candidates ignored the symmetry of the flight path and arrived at the incorrect answer of 1.9 s for the time of flight.
- (ii) Candidates were generally successful in calculating the initial release velocity of the ball. The most common error was to forget to divide the total time of flight by 2 when considering the upward motion of the ball. Weaker candidates were often uncertain as to what sign to give to g , and ended up with negative answers.
- (iii) Those candidates who knew which equation of motion to use were able to calculate the height of the window ledge successfully. Those who were unsuccessful often used an incorrect value of time. Some candidates made the calculation unnecessarily long by first calculating the velocity of the ball when level with the window ledge and then going on to calculate its height.
- (c) The graph was usually drawn correctly. The choice of scale was sometimes inappropriate, resulting in too little of the grid being used. Weaker candidates confused velocity with speed and drew the final portion of the graph incorrectly.
- (d) Surprisingly, this was very poorly answered by the majority of candidates with very few achieving the full 4 marks on offer. Even the more able candidates were unable to correctly indicate the forces acting on the ball at the three stages of the motion given. Many candidates included an 'extra force' which they identified as 'the force of the throw' on the ball during its upward journey. Many candidates also assumed that air resistance continued to act on the ball when it was at maximum height (and at rest).

This comment originally referred to question 3 on paper 1321/01 (15/01/2014)

7. There are no examiner comments available for this question

8. There are no examiner comments available for this question

9. (a) (i) Most candidates were able to calculate the horizontal and vertical components of velocity correctly.

(ii) An unexpectedly poor response here. Few candidates stated that the horizontal component remained constant and that the vertical component changed. Many candidates simply said the components were independent of each other or gave other vague answers.

(b) (i) The majority of students chose to use $v = u + at$ to find the total time of flight. Less than $\frac{1}{2}$ managed to do so successfully however. Common errors included using 16 m s^{-1} (as opposed to 12.3 m s^{-1}) to represent the vertical velocity, forgetting to multiply their final answer (if required) by 2 and, in a small number of cases, using $g = 9.81 \text{ m s}^{-2}$.

(ii) The majority of candidates attempted to use $dH = vH \times t$ to calculate the horizontal distance travelled by the ball. Many candidates gained this mark as ecf from (b)(i).

(iii) The majority of candidates were able to use an appropriate equation correctly to find the maximum height reached by the ball.

(c) Most candidates gave two reasons why the maximum height reached on earth would be different.

This comment originally referred to question 5 on paper 1321/01 (17/05/2012)

10. a)(i) Most candidates gave a correct definition for acceleration but significantly fewer were able to manipulate their equation to show that $v = u + at$.

(ii) The majority of candidates understood that substituting for v was the most straightforward approach to answering this question. Some candidates lost marks by not including essential intermediate steps in their algebra.

(b) (i) Most candidates chose path A with the majority stating that the horizontal velocity of the sack was the same as the plane. However, a much smaller number considered the vertical motion of the sack.

(ii) (i) and (ii) Nearly all candidates were able to show that the maximum drop height was approximately 46 m and also that the time of flight was a little over 3.0 seconds. A few candidates lost marks for incorrect use of signs or for confusing 'u' and 'v'.

(iii) A majority of candidates lost 1 mark here for not including the direction of travel in their calculation of the resultant velocity of the sack on impact with the ground. Some candidates did calculate 'an angle of impact' but failed to identify or describe the significance of the angle which they had calculated.

This comment originally referred to question 6 on paper 1321/01 (05/08/2015)