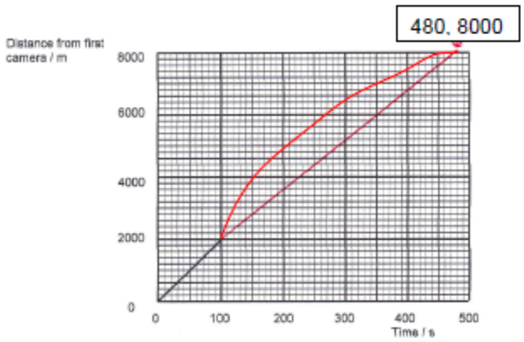
Marking Scheme

1.

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
1	*(a)*	(i)	Constant horizontal velocity if/because no horizontal <u>force</u> [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, $y = \frac{1}{2}9.81 \times \left(\frac{6.0}{9.0}\right)^2$ = 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 [m s^{-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 [m s^{-1}] or 6.6 [m s^{-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 [m s^{-1}] [1] ecf on v_v		4		4	3	
			Question 1 total	**2**	**4**	**3**	**9**	**5**	**0**

2.

<table>
<tr><th colspan="3" rowspan="2">Question</th><th rowspan="2">Marking details</th><th colspan="6">Marks available</th></tr>
<tr><th>AO1</th><th>AO2</th><th>AO3</th><th>Total</th><th>Maths</th><th>Prac</th></tr>
<tr><td>2</td><td>(a)</td><td></td><td>Vector: Magnitude (size) and direction
Scalar: Magnitude (size) only
Minimum acceptable response: a vector has direction [1]
Relevant example of each e.g. independent mark [1]
<table>
<tr><th>Vectors</th><th>Scalars</th></tr>
<tr><td>Displacement
Velocity
Acceleration
Force</td><td>Speed
Time
Distance
Pressure
Temperature</td></tr>
</table></td><td>2</td><td></td><td></td><td>2</td><td></td><td></td></tr>
<tr><td></td><td>(b)</td><td>(i)</td><td>From graph speed = $\frac{2\,000}{100}$ or equiv [e.g. $\frac{1000}{50}$] (or 20 m s^{-1}) seen [1]
Convincing conversion to km h^{-1} (i.e. $\times\frac{3\,600}{1000}$) or 72 [km h^{-1}] seen or convert 70 km h^{-1} into 19.4 m s^{-1} [1]</td><td>1</td><td>1</td><td></td><td>2</td><td>2</td><td></td></tr>
<tr><td></td><td></td><td>(ii)</td><td>Time to complete distance at mean speed of 60 km h^{-1} = $\frac{8}{60}$ [1] (= 0.1333)
Conversion t = 480 s [1] Accept rounded values e.g. 17 m s^{-1} gives t = 471 s
Alternative for first 2 marks:
60 km h^{-1} = $\frac{1000}{60}$ m s^{-1} (1)
$t = \frac{8000}{\left(\frac{1000}{60}\right)}$ = 480 s (1)
Alternative for first 2 marks:
1 km per minute (1)
t = 8 minutes or 480 s (1)
3rd mark - Continuous (though not necessarily straight) line drawn on graph from (100, 2 000) to (480ecf, 8 000) tolerance ± small square - two possible examples shown: [1]

</td><td></td><td>3</td><td></td><td>3</td><td>3</td><td></td></tr>
<tr><td></td><td>(c)</td><td></td><td>Correct substitution into $v^2 = u^2 + 2ax$ (i.e. 0 = u^2 – (2 × 8 × 85) [1] don't award mark if incorrect signs
u = 36.9 [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 × 8 × x) [1] don't award mark if incorrect signs
x = 56.3 [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 s (1)
Using $x = \frac{1}{2}(u+v)t$ i.e. 3.75 × mean velocity (15) = 56.3 [m] (1)
No, greater than speed limit [1] must correlate with working</td><td></td><td></td><td>3</td><td>3</td><td>2</td><td></td></tr>
<tr><td></td><td></td><td></td><td>Question 2 total</td><td>3</td><td>4</td><td>3</td><td>10</td><td>7</td><td>0</td></tr>
</table>

3.

(a) (i) **Correct use** 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) [3]

(ii)
(I) $v^2 = 2 \times 9.81 \times 12.8$ (ecf) (1) or suitable alternative
$v = 15.9$ [m s^{-1}] (1) [2]

(II) $t_{up} = \left(\dfrac{0-6}{-9.81}\right) = 0.6$ [s] (1)

$t_{down} = \left(\dfrac{15.9(ecf) - 0}{9.81}\right) = 1.6$ [s] (1)

Total time = 2.2 [s] (1) (other solutions possible) [3]

(b) (i)

(1) Ball only acted upon by **force due to gravity / weight** is the only force acting (1)
Only award 2nd mark if 1st mark correct. [2]

(ii)

(1) Marks are independent.
If additional arrows present deduct 1 mark for each extra arrow. [2]
(1)

4. (a)		Relevant pairs of values chosen (1) [e.g. 10 m $s^{-1} \rightarrow$ 8 m and 20 m $s^{-1} \rightarrow$ 32 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 m (1) deceleration = 6.3 [m s^{-2}] or a = -6.3 [m s^{-2}] (1)	3
	(ii)	$F = 800 \times 6.3 = 5000$ [N] allow e.c.f. from (b)(i)	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 [m]	1
	(ii)	No change to thinking distance (1) [Reduced acc/deceleration would] increase braking distance (1)	2
(e)		Time required = $\frac{\text{total distance}}{\text{speed}} = \frac{10}{50}$ [= 0.2 hour] (1) Time for first 6.0 km = $\frac{6.0}{80}$ [= 0.075 hour] (1) remaining time = 0.2 – 0.075 = 0.125 hour (1) Speed for remaining 4 km = $\frac{4}{0.125}$ = 32 [km / h] or 8.9 [m s^{-1}] (1)	4

5.

4	*(a)*	(i)	[gradient =] $\dfrac{v-u}{t}$ (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) $x = ut + ½t(ut)$ shown (1) [or other convincing working] Or: $v = u + at$ (1) $x = ½(u + u + at)t$(1) [or other convincing working]	2
	(b)	(i)	$x = ut + ½at^2$ used with $u = 0$ (1) $x = 36$ m (1)	2
		(ii)	$v = u + at$ used with $u = 0$ (1) [or $v^2 = u^2 + 2ax$ used with $u = 0$] $v = 6$ m s^{-1} (1)	2
	(c)	(i)	$x = \frac{1}{2}(u+v)t$ used (1) $t = 40$ s (1) [Use of $u = 0$ seen $\rightarrow$ 1 mark penalty]	2
		(ii)	Use of $a = \dfrac{v-u}{t}$ (1) [Use of $u = 0$ seen $\rightarrow$ 1 mark penalty] $a =$ [–] 0.15 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)	$\left(\dfrac{157(\text{ecf})}{4(1)}+8\right)$ [= 47 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 = ½ 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 [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 10.8 ms^{-1}) (1) x = 2.8 [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					
				AO1	AO2	AO3	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 × (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					
				AO1	AO2	AO3	Total	Maths	Prac
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) $v = 25.3$ [m s^{-1}] (1)		4		4	4	
		(ii)	Use of $v^2 = u^2 + 2ax$ (1) Use $v^2 = 0$ and manipulation (1) $x = 3.82$ [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)	$v_H = 16 \cos 40°$ (1) $= 12.3$ [m s^{-1}]	
		$v_V = 16 \sin 40°$ (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)	
		$t_{flight} = 12.8$ [s] (1) ecf between 2nd and 3rd 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)	$v_H = 16 \cos 40°$ (1) $= 12.3$ [m s^{-1}]	
		$v_V = 16 \sin 40°$ (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)	
		$t_{flight} = 12.8$ [s] (1) ecf between 2nd and 3rd 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 velocity [or equivalent] or $a = \frac{(v-u)}{t}$ (1) Clear manipulation to show that $v=u+at$ (1)	[2]
	(ii)		$v=u+at$ substituted into $x = (u+v)t/2$ (1) Clear manipulation shown (1)	[2]
(b)	(i)		A (1) Horizontal velocity (= 65 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)	[3]
	(ii)	(I)	Substitution into $v^2=u^2+2ax$ **and** $u = 0$ shown (1) x calculated= 45.9 [m] (1)	[2]
		(II)	Correct substitution into $v = at$ **or** $x=1/2at^2$ *or* $x=\frac{(u+v)t}{2}$ (1) t=3.1 [s] (1)	[2]
	(iii)		$v_R^2= (65^2 + 30^2)$ (correct substitution into Pythagoras) (1) v_R= 71.6 [m s^{-1}] (1) Valid angle calculated and shown or described e.g. $\theta = 24.8°$ below horizontal (1)	[3]
			Question 6 Total	**[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 + ½at2 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 α speed2. 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 3.0 ms-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 ½ vt, far fewer were able to proceed with a convincing explanation of how this led to x = ½ at2. 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 acing 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 ½ 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 m s-2.

(ii) The majority of candidates attempted to use dH = vH x 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)***