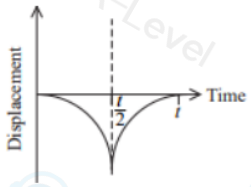
7	**B**  Incorrect Answers: A – Correct shape graph but, relative to the given *v-t* graph the direction is incorrect C – Initial direction incorrect but final direction correct D – Initial direction correct but final direction incorrect	**1**

5	**C 0.850 m** Incorrect Answers: a metre rule measures to 3 sf so the final answer must be to 3 sf regardless of the units used A – answer to 2 sf in cm B – answer to 2 sf in m D – answer to 2 sf in m (using standard form)	**1**

7	**The only correct answer is C (Quantity plotted on x-axis is (time)^2, and gradient of graph is $\frac{g}{2}$)** A is not correct because time on the x-axis will not give a straight line B is not correct because time on the x-axis will not give a straight line D is not correct because the gradient of this graph is $g / 2$	**1**

6	**A is the correct answer** B is not the correct answer as the change in velocity is not 2 m s^{-1}. C is not the correct answer as it gives a negative time, and the collision takes a positive amount of time. D is not the correct answer for the same reason that B is not.	**(1)**

1	**C is the correct answer** A is incorrect because the velocity should be squared B is incorrect because the displacement should be doubled and the velocity squared D is incorrect because the displacement should be doubled	**(1)**

3	**The only correct answer is B (*t*)** A is not correct because the vertical acceleration is the same for both balls and vertical motion is independent of horizontal motion C is not correct because the vertical acceleration is the same for both balls and vertical motion is independent of horizontal motion D is not correct because the vertical acceleration is the same for both balls and vertical motion is independent of horizontal motion	**1**

3	**The only correct answer is D (The displacement at 4 hours divided by a time of 4 hours)** A is not correct because the area under a displacement-time graph has no significance B is not correct because this would give the instantaneous speed at the end of the marathon C is not correct because this would give the instantaneous speed at 2 hours	**1**

4	**4. The only correct answer is C** *A is not correct as ucosθ, the horizontal and not the vertical component of the initial velocity was used in the equation* $a = \frac{v-u}{t}$ ***B** is not correct as ucosθ, the horizontal and not the vertical component of the initial velocity was used in the equation* $a = \frac{v-u}{t}$ *and the negative sign implies that u and a are in the same, and not opposite directions.* ***D** is not correct as the negative sign implies that u and a are in the same, and not opposite directions.*	**(1)**

9	**C is the correct answer** This is because $s=\frac{1}{2}gt^2$. So if in one unit of time the sphere has fallen one unit of distance, i.e. from image 1 to image 2, then in 2 units of time it will have fallen 4 units of distance, i.e. from image 1 to R.	**(1)**

1	**B is the correct answer** A is incorrect because gradient is velocity, not acceleration C is incorrect because gradient is rate of change of acceleration,not velocity D is incorrect because gradient is rate of change of acceleration, not displacement	**1**

2	**The only correct answer is C (initial acceleration is same for coin and feather, and time taken to reach the ground is less for coin)** A is not correct because both objects have the same initial acceleration B is not correct because both objects have the same initial acceleration and object A has a greater terminal velocity D is not correct because object A has a greater terminal velocity	**1**

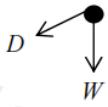
9	**B is the correct answer** A is not the correct answer as areas above and below time axis not equal C is not the correct answer as graph starts from zero D is not the correct answer as graph starts from zero	**(1)**

10	**The only correct answer is A** $(\frac{v}{4})$ B is not correct because conserving momentum does not lead to this answer C is not correct because the new speed is not just the difference between the initial speeds D is not correct because the initial velocities are in opposite directions	**1**

5	**D is the correct answer** A is not the correct answer as the areas under the two graphs are not both zero. B is not the correct answer as the areas under the two graphs are not equal. C is not the correct answer as P is at the initial position.	**(1)**

4	**The only correct answer is B** (y-axis $2s$; x-axis t^2) A is not correct because this would give a gradient of $g/2$ C is not correct because this would give a gradient of $2/g$ D is not correct because this would give a gradient of $1/g$	**1**

Question Number	Answer	Mark
13(a)	There is a deceleration then an acceleration. (1) The initial deceleration/change is due to friction/drag. (1) The final acceleration/change is due to magnetic force/field/attraction. (1)	**3**
13(b)	Use of gradient of the graph **Or** Uses $\Delta v/\Delta t$ (1) (must be taken at or beyond 0.5 s) Attempt to draw tangent at 0.64 s (1) $a = 2.8$ to 3.6 m s^{-2} (1) Example of calculation $\text{Acceleration} = \frac{(0.50-0)\text{ m s}^{-1}}{(0.65-0.49)\text{ s}} = 3.1\text{ m s}^{-2}$	**3**
	Total for question 13	**6**

<table>
<tr><th>Question Number</th><th>Answer</th><th>Mark</th></tr>
<tr><td>15(a)(i)</td><td>Weight /W/ mg (1)
Air resistance/drag /AR/D /F_D (1)
(angle to the horizontal for the air resistance must not be 0 or 90° by eye)
 

(Ignore upthrust if correctly drawn vertically upwards.
Otherwise max 1 if more than two forces are drawn)</td><td>2</td></tr>
<tr><td>*15(a)(ii)</td><td>(QWC – work must be clear and organised in a logical manner using technical terminology where appropriate)

One mark from each cell of the table for any one of the statements

<table>
<tr><th>Difference between paths</th><th>Explanation (mark dependent upon the difference)</th></tr>
<tr><td><u>For path P:</u>

Less distance is travelled

Range is less</td><td>

<u>Horizontal</u> velocity is decreasing/less

Ball is slowing down <u>horizontally</u>

Ball has a <u>horizontal</u> deceleration

There is a backward <u>horizontal</u> force on the ball (1)

Ball is in the air for a shorter time (1)</td></tr>
<tr><td><u>For path P:</u>

Maximum height reached is lower

The path is lower</td><td>

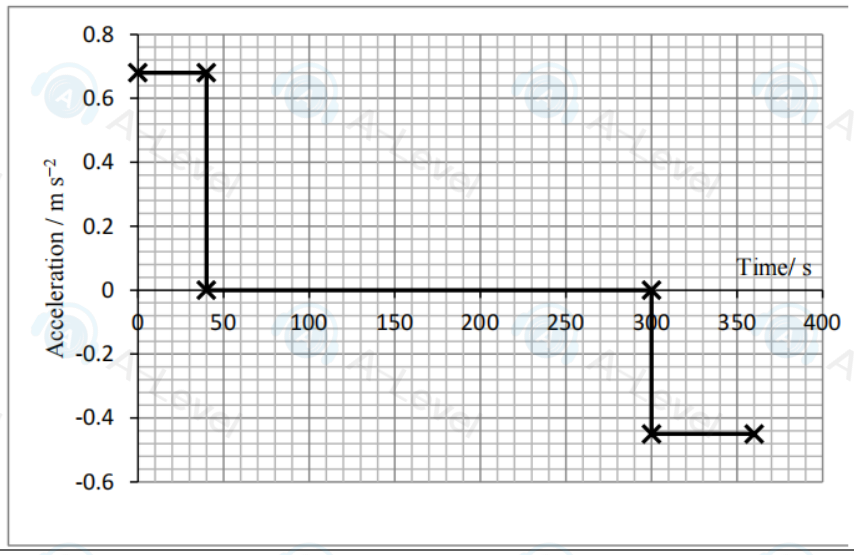
The <u>vertical</u> deceleration is greater

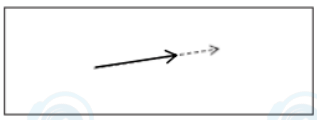
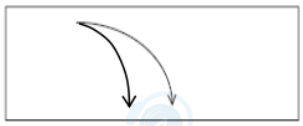
The (average) <u>vertical</u> velocity is lower (1)

As the ball rises, there is a greater downward force (1)</td></tr>
</table>

(For horizontal/vertical allow x-direction, y-direction)
(Allow the opposite comparisons in terms of path Q)</td><td>4</td></tr>
</table>

15(b)	See (u_H =) 35cos25° or 32 (m s^{-1}) or (u_V =) 35sin25° or 15 (m s^{-1}) (1) Correct use of vertical equations to find the full time of flight (1) Use of $s = u_H t$ to find the range (1) Horizontal distance travelled = 96 (m) (>85 m) so six 'runs' are scored. (1) **Or** See (u_H =) 35cos25° or 32 (m s^{-1}) or (u_V =) 35sin25° or 15 (m s^{-1}) (1) Correct use of vertical equations to find the full time of flight (1) Use of $u_H = s/t$ with s = 85 m to find the time to the boundary (1) Time of flight = 3.0 (s) **and** time to boundary = 2.7 (s) so six 'runs' are scored (1) **Or** See (u_H =) 35cos25° or 32 (m s^{-1}) or (u_V =) 35sin25° or 15 (m s^{-1}) (1) Use of $v = s/t$ with s = 85 m to find the time to the boundary (1) Correct use of vertical equations to find the height at the boundary (1) Height = 4.4 (m) so six 'runs' are scored. (1) <u>Example of calculation</u> $t = \frac{0 - (35\ \text{m s}^{-1} \times \sin 25°)}{-9.81\ \text{N kg}^{-1}} = 1.508\ \text{s}$ time to same height = 3.02 s horizontal distance at 3.02 s = (35 m s^{-1} × cos25°) × 3.02 s = 95.80 m	**4**
	Total for question 15	**10**

Question Number	Answer		Mark
14(a)	Acceleration axis scaled, using at least half of grid (Minimum of two values both above and below 0, scale must be linear, no false origin, negative on negative acceleration axis, no scales in 3,7 etc.)	(1)	
	Constant acceleration drawn onto graph between 0s and 40 s	(1)	
	0 acceleration between 40 s and 300 s and vertical solid/dashed lines at 40 s and 300 s	(1)	
	Final negative constant acceleration drawn onto graph between 300 s and 360 s	(1)	
	Use of $a = \frac{v-u}{t}$	(1)	
	Acceleration plotted at 40 s = 0.68 (m s^{-2}) **and** acceleration plotted at 360 s = −0.45 (m s^{-2})	(1)	**6**
	Example of calculation $a = \frac{27\ \text{m s}^{-1} - 0\ \text{m s}^{-1}}{40\ \text{s}} = 0.675\ \text{m s}^{-2}$ $a = \frac{0\ \text{m s}^{-1} - 27\ \text{m s}^{-1}}{60\ \text{s}} = -0.45\ \text{m s}^{-2}$		
			

14(b)(i)	**Either** It's a straight line (1) As no horizontal forces are acting (1) **Or** The path shown is caused by the resultant/sum/addition/combination of two velocities/displacements (1) The velocity/displacement in the direction of the train and the velocity/displacement in the direction of the throw (1)	**2**
14(b)(ii)	The vertical velocity is increasing **Or** there is a vertical acceleration/force (1) The horizontal velocity is constant **Or** there is no horizontal acceleration/force (1)	**2**
14(b)(iii)	Figure 2: straight line in the same direction but shorter than the original line (1) Figure 3: shallower curve under the drawn curve (1) [be generous as to the exact shape of the curve]  Figure 2  Figure 3	**2**
	Total for question 14	**12**

12(a)	the total momentum before (a collision) = the total momentum after (a collision) **Or** Sum of momentum values before (collision) = sum of momentum values after (collision) **Or** total momentum remains constant **Or** **(1)** the momentum of a system remains constant Provided no external/unbalanced/resultant force acts (on the system) **Or** **(1)** in a closed/isolated system	**2**
12(b)	Use of $p = m\,v$ **(1)** Uses conservation of momentum **(1)** Velocity = − 4.6 m s^{-1} **(1)** Example of calculation 2.7 kg × 10 m s^{-1} = 2.7 kg × v + 7.9 kg × 5.0 m s^{-1} v = (27.0 − 39.5) kg m s^{-1} ÷ 2.7 kg = −4.6(3) m s^{-1}	**3**
	Total for question 12	**5**

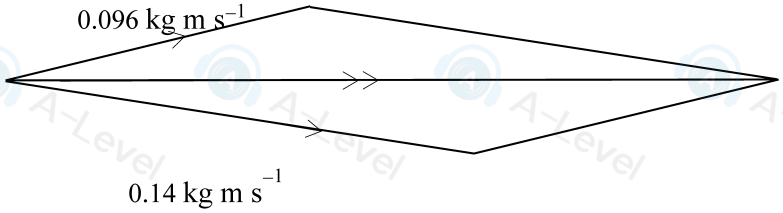
Question Number	Answer	Mark
15(a)	$20\ m\ s^{-1}$ is the average velocity **Or** the velocity is not constant **Or** the car is accelerating (1) Tangent drawn onto graph at $t = 15$ s **Or** use of correct equations of motion with $u = 0$ (1) Velocity = 40 ($m\ s^{-1}$) (1) (Do not award MP2 for approximation of the curve to a straight line at 15 s) Example of calculation Gradient of tangent $= \frac{520\ m - 100\ m}{20.0\ s - 10.5\ s} = 44.2\ m\ s^{-1}$	**3**
15(b)	The acceleration is decreasing **Or** the rate of change of velocity is decreasing (1) Drag forces are increasing (with increased velocity) **Or** the car is heading towards terminal velocity **Or** the resultant force is decreasing due (to the increasing drag force) **Or** air resistance is proportional to velocity (squared) (1)	**2**
	Total for question 15	**5**

Question Number	Answer	Mark
12(a)	• Length/height of wooden rod (1) • Distance from the rod to the light gate (1)	**2**
12(b)	• $v = \frac{\text{length of rod}}{\text{time (to pass through light gate)}}$ (1) • Repeat (at each height) and (calculate) an average (1)	**2**
12(c)	• Repeat at different (release) heights (above the light gate and calculate v for each height) (1) • States an appropriate graph to draw (1) • Corresponding description of how to obtain the acceleration from the gradient (1)	**3**
	Total for question 12	**7**

Graph	$s - v^2$	$v^2 - s$	$2s - v^2$	$v^2 - 2s$	$v^2/2 - s$	$s - v^2/2$
a	1/(2×gradient)	gradient/2	1/gradient	gradient	gradient	1/gradient
Gradient	$1/2a$	$2a$	$1/a$	a	a	$1/a$

14(a)	The ball fell a smaller distance (during each flash of the laboratory strobe) **Or** Each image of the ball would be smaller (using the laboratory strobe)	**(1)**	
	The uncertainty was less (with the laboratory strobe) MP2 dependent on MP1	**(1)**	**2**
14(b)(i)	(allow a for g throughout) $s = (ut+)\frac{1}{2}gt^2$ **and** g is constant	**(1)**	
	Comparison of $s = \frac{1}{2}gt^2$ $(+ut)$ with $y = mx$ $(+c)$ **Or** s is proportional to t^2 so the gradient of graph is constant	**(1)**	**2**
14(b)(ii)	Use of $s = \frac{1}{2}at^2$ and a pair of corresponding values from the graph **Or** Pair of corresponding values from the graph used to determine gradient	**(1)**	
	$g = 10.0$ m s^{-2} (allow answers in the range 9.8 m s^{-2} to 10.1 m s^{-2}) (dependent on MP1) (answer must be consistent with their calculation) Example of calculation $\frac{\Delta h}{\Delta t^2} = \frac{0.30}{0.060} = 5.00$ $g = 5.00 \text{ m s}^{-2} \times 2 = 10.00 \text{ m s}^{-2}$	**(1)**	**2**
	Total for question 14		**6**

14(a)	The ball fell a smaller distance (during each flash of the laboratory strobe) **Or** Each image of the ball would be smaller (using the laboratory strobe)	**(1)**	
	The uncertainty was less (with the laboratory strobe) MP2 dependent on MP1	**(1)**	**2**
14(b)(i)	(allow a for g throughout) $s = (ut+)\frac{1}{2}gt^2$ **and** g is constant	**(1)**	
	Comparison of $s = \frac{1}{2}gt^2$ $(+ut)$ with $y = mx$ $(+c)$ **Or** s is proportional to t^2 so the gradient of graph is constant	**(1)**	**2**
14(b)(ii)	Use of $s = \frac{1}{2}at^2$ and a pair of corresponding values from the graph **Or** Pair of corresponding values from the graph used to determine gradient	**(1)**	
	$g = 10.0$ m s^{-2} (allow answers in the range 9.8 m s^{-2} to 10.1 m s^{-2}) (dependent on MP1) (answer must be consistent with their calculation) Example of calculation $\frac{\Delta h}{\Delta t^2} = \frac{0.30}{0.060} = 5.00$ $g = 5.00 \text{ m s}^{-2} \times 2 = 10.00 \text{ m s}^{-2}$	**(1)**	**2**
	Total for question 14		**6**

Question Number	Answer		Mark
15(a)	• Construction of correct vector diagram (parallelogram or triangle) with all 3 directions and 0.096 (kg m s^{-1}) and 0.14(kg m s^{-1}) labelled	(1)	
	• Momenta correctly scaled (ratio of lengths 0.14 to 0.096 rounds to between 1.40 and 1.50)	(1)	
	• Horizontal resultant (to within a slope of 1 small square)	(1)	
	• Total momentum = 0.22 to 0.24 (kg m s^{-1})	(1)	**4**
	(Do not award MP4 if this value has been obtained by calculation or from an incorrect diagram)		
			
15(b)	• The sum/total momentum before a collision is equal to the sum/total momentum after a collision	(1)	
	• Provided no external forces act (on the system) **Or** in a closed system	(1)	**2**
15(c)	• Use of $p = mv$	(1)	
	• v = 1.9 m s^{-1}	(1)	**2**
	(v = 1.7 m s^{-1} using show that value and allow ecf from (a), v = 2.0 m s^{-1} if 0.236 kg m s^{-1} used)		
	Example of calculation 0.23 kg m s^{-1} = 0.12 kg × v v = 1.92 m s^{-1}		
	Total for question 15		**8**

Question Number	Answer	Mark
11	• Use of $a = \frac{v-u}{t}$ (1) • See 1.6 m s^{-2} **Or** see (−)4.9 to (−)5.2 m s^{-2} (1) **Max 1** • At 9 s the acceleration becomes negative (1) • From 9 s to 12 s the object is decelerating (1) • From 12 s to 17.5 seconds the object is accelerating while moving in the opposite direction (1) Example of calculation $a = \frac{14 \text{ m s}^{-1} - 0}{9} = 1.56 \text{ m s}^{-2}$	3
	Total for question 11	**3**

Question Number	Answer	Mark
11	• Reference to $s = ut + \frac{1}{2}at^2$ with $u = 0$ **(1)** • Correct variable labels on graph axes to give a straight line through origin. **(1)** • Reference to time in s and distance in m (this can be taken from the axes labels or a suitable unit conversion) **(1)** • Straight line through origin. **(1)** • Correct method to determine g using their graph. **(1)**	**(5)**
	Total for question 11	**5**