Kinematics - Mark Scheme

Q1.

Question Number	Answer	Mark
	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)**

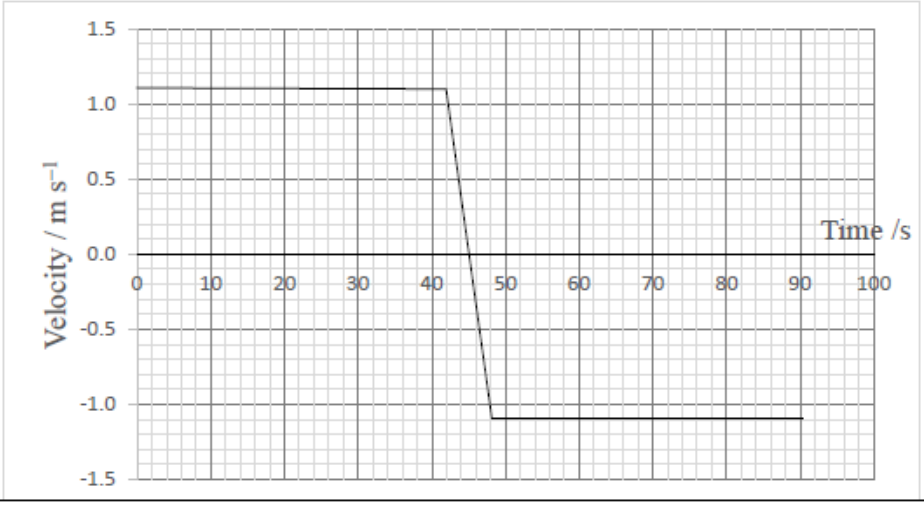
Q2.

Question Number	Answer	Mark
	The only correct answer is C as the acceleration is positive while the fuel is still burning. It then becomes negative, while still travelling upwards, as the only forces acting on it are downwards (weight and drag). **A** *is not the correct answer because the acceleration should be constant as there is a constant upwards thrust from the fuel.* **B** *is not the correct answer because the acceleration should be constant as there is a constant upwards thrust from the fuel. The acceleration should become negative before T.* **D** *is not the correct answer because the acceleration becomes negative as the fuel runs out and not at the maximum height.*	**(1)**

Q3.

Question Number	Answer		Mark
	• 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)	3
	Example of calculation $a = \frac{14\ \text{m s}^{-1} - 0}{9} = 1.56\ \text{m s}^{-2}$		
	Total for question		**3**

Q4.

Question Number	Answer		Mark
(a)	• Use of $v = s/t$ **Or** use of gradient	(1)	
	• $v = (\pm)$ 1.1 to 1.2 (m s^{-1})	(1)	
	• Scaling of the velocity axis so that the graph covers at least 50% of the paper above and below the axes. (A minimum of 1 number on each axis required e.g. 1 and −1)	(1)	
	• A positive constant velocity from 0 to 42 s and the same negative constant velocity from 48 s to 90 s with connecting line/curve (tolerance of ± 1 s)	(1)	4
	<u>Example of calculation</u> Initial velocity $= \frac{46\text{ m}}{40\text{ s}} = 1.15\text{ m s}^{-1}$		
			

(b)(i)	The graph should be a curve initially	(1)	
	with a decreasing gradient up to 15 m (by eye) (ignore any part of the graph above 15 m)	(1)	2

(b)(ii)	1 mark for a simplification (1) 1 mark for a corresponding explanation (1) Treat references to drag as neutral.	2
	Total for question	**8**

Simplification	Explanation
Velocity constant **Or** velocity doesn't change **Or** velocity is an average **Or** no regions of acceleration/deceleration	• Variation in velocity during each stroke • The force applied to the swimmer/water varies (within the stroke) • As the swimmer moves above/below water to breathe, the velocity changes • The speed would change as they went from gliding to swimming
The velocity of the swimmer has the same magnitude in both parts of the race	The swimmer may have tired and this could be less for the second half of the race
The initial velocity after the turn would be greater	The swimmer would probably glide (underwater) after the turn
Gradient should initially increase from zero	Swimmer initially pushes off from starting block/turn

Q5.

Question Number	Answer	Mark
	The only correct answer is B as $s = vt$ and $s = 1.2 \times 0.9$ **A** *is not the correct answer as* $s = vt$ *and* $s = 1.2 \times 0.9$ **C** *is not the correct answer as* $s = vt$ *and* $s = 1.2 \times 0.9$ **D** *is not the correct answer as* $s = vt$ *and* $s = 1.2 \times 0.9$	**(1)**

Q6.

Question Number	Answer	Mark
	C is the correct answer as there is always an acceleration of 9.81 m s^{-2} A is not the correct answer as there is always an acceleration of 9.81 m s^{-2} B is not the correct answer as there is always an acceleration of 9.81 m s^{-2} D is not the correct answer as there is always an acceleration of 9.81 m s^{-2}	**(1)**

Q7.

Question Number	Answer		Mark
(a)	**<u>Method 1</u> – Calculate the vertical displacement at 102 m.**		
	See (u_v =) 33sin28 **Or** 15 to 16 (m s^{-1}) **Or** (u_h =) 33cos28 **Or** 29 (m s^{-1})	(1)	
	Use of v = s/t with s = 102 m for the time of flight needed **Or** Use of v = s/t with s = 10 m for the extra time of flight needed	(1)	
	Use of equation(s) to determine the vertical displacement at the time calculated	(1)	
	Vertical displacement = (–) 5.8 to 6.0 m	(1)	
	Comparison with required height **AND** height is insufficient (Allow correct conclusion based on the calculated height)	(1)	
	<u>Method 2</u> – Calculate the horizontal displacement for a height of 4.5 m.		
	See (u_v =) 33sin28 **Or** 15 to 16 (m s^{-1}) **Or** (u_h =) 33cos28 **Or** 29 (m s^{-1})	(1)	
	Use of vertical equation(s) with s = (–)4.5 m to determine the actual time of flight **Or** to determine the time beyond 92 m	(1)	
	Use of v = s/t to determine the range **Or** Use of v = s/t for the extra displacement beyond 92 m	(1)	
	Horizontal displacement = 98 to 101 m **Or** extra displacement = 7.7 to 7.9 m	(1)	
	Comparison with required displacement **AND** height is insufficient **Or** Comparison of extra displacement **AND** height is insufficient (Allow correct conclusion based on the calculated distance)	(1)	
	<u>Method 3</u> – Calculate the actual time of flight and that needed for 102 m		
	See (u_v =) 33sin28 **Or** 15 to 16 (m s^{-1}) **Or** (u_h =) 33cos28 **Or** 29 (m s^{-1})	(1)	
	Use of v = s/t with s = 102 m for the time of flight needed	(1)	
	Use of vertical equation(s) to determine the actual time of flight	(1)	
	Time of flight needed = 3.5 s **AND** actual time of flight = 3.4 s	(1)	**(5)**
	Time needed > actual time **AND** height is insufficient (Allow correct conclusion based on the calculated times)	(1)	
	<u>Example of calculation</u> u_v = (33m s^{-1}) sin28 ° = 15.5 m s^{-1} u_h = (33 m s^{-1}) cos28 °= 29.1m s^{-1} $t = \frac{102\text{ m}}{29.1\text{ m s}^{-1}}$ t = 3.50 s s = (15.5 m s^{-1} × 3.50 s) + (½ × (–9.81 N kg^{-1}) ×(3.50 s)^2) s = – 5.87 m		

* **(b)**	This question assesses a student's ability to show a coherent and logically structured answer with linkages and fully-sustained reasoning. Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning. The following table shows how the marks should be awarded for indicative content and lines of reasoning. **IC points / IC mark / Max linkage mark available / Max final mark** **6** / 4 / 2 / **6** **5** / 3 / 2 / **5** **4** / 3 / 1 / **4** **3** / 2 / 1 / **3** **2** / 2 / 0 / **2** **1** / 1 / 0 / **1** **0** / 0 / 0 / **0** **Number of marks awarded for structure of answer and sustained line of reasoning** Answer shows a coherent and logical structure with linkages and fully sustained lines of reasoning demonstrated throughout — 2 Answer is partially structured with some linkages and lines of reasoning — 1 Answer has no linkages between points and is unstructured — 0 **Indicative content** With air resistance: Vertical motion • When moving up weight and (vertical component of) air resistance are acting. **Or** When moving up air resistance increases the resultant force. • (When moving up,) downwards/vertical acceleration/deceleration increases **Or** upward velocity decreases more quickly. • (So maximum) height is lower. Horizontal motion • There is a horizontal deceleration/force (due to air resistance). • (So the average) horizontal velocity is lower. • The (ball travels a) shorter (total) distance.	**(6)**
	Total for question	**11**