Mark Scheme

Q1.

Question Number	Acceptable Answer	Additional Guidance	Mark
	B Average speed		**1**

Q2.

Question Number	Answer	Mark
	C	**1**

Q3.

Question Number	Answer	Mark
	C	**1**

Q4.

Question Number	Answer	Mark
	A area under an acceleration-time graph	**1**
	Incorrect Answers: B – this is equivalent to the displacement C – this is equivalent to the rate of change of acceleration D – this is equivalent to the acceleration	

Q5.

Question Number	Answer	Mark
	D	1

Q6.

Question Number	Acceptable Answers	Reject	Mark
	C		**1**

Q7.

Question Number	Acceptable Answers	Reject	Mark
	D		**1**

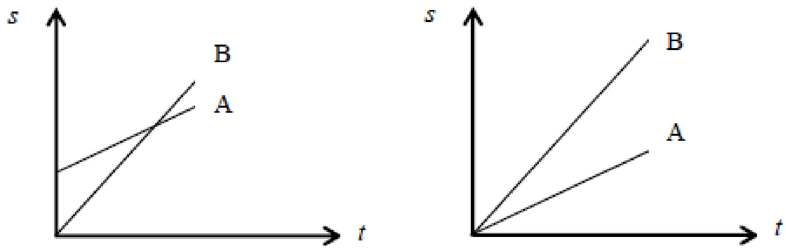
Q8.

Question Number	Acceptable Answers	Mark
(a)(i)	Measures the final interval = 2.2 cm **Or** measures the total distance = 14.6cm **(1)** Velocity = 1.1 (ms^{-1}) **(1)** (independent marks, even if MP1 not awarded, 2nd mark can be awarded if value rounds to 1.1(ms^{-1})) Example of calculation $\text{Velocity} = \dfrac{0.022\ \text{m}}{0.02\ \text{s}}$ or $\text{Velocity} = \dfrac{0.146\ \text{m} \times 2}{0.02\ \text{s} \times 13}$ Velocity = 1.1 m s^{-1}	2

Question Number	Acceptable Answers	Mark
(a)(ii)	Use of $a = \dfrac{v-u}{t}$ or suitable equation of motion to calculate a **(1)** a = 4.2 or 4.3 m s^{-2} (allow full ecf for values substituted from (i)) **(1)** (in (i) and (ii) only penalise once for use of 14 gaps) Example of calculation Using $a = \dfrac{v-u}{t}$ $a = \dfrac{1.1\ \text{m s}^{-1} - 0}{13 \times 0.02\ \text{s}}$ a = 4.2 m s^{-2}	2

Question Number	Acceptable Answers	Mark
(b)	No friction/drag between tape/trolley and timer. **Or** The computer does the calculation **Or** Student doesn't calculate velocity **(1)** (NOT precision, accuracy, plots graph automatically, reaction time, parallax, human error)	1
	Total for question	**5**

Q9.

Question Number	Answer		Mark
(i)	Both graphs straight from $t = 0$ (labels not required) Initial gradient of A less than gradient of B (minimum of 1 label required) (The lines do not have to meet i.e. the lines could stop before the meeting point The lines can start anywhere on the displacement axes) 	(1) (1)	2
(ii)	Measurement from photographs 0.5 - 0.7 (cm) Use of distance = measurement × 12 Use of speed = distance/time speed = 0.18 – 0.25 m s $^{-1}$ <u>Example of calculation</u> Measurement = 0.55 cm Distance = 0.55×10^{-2} m× 12 = 6.6×10^{-2} m speed = $\frac{6.6 \times 10^{-2}\ \text{m}}{0.33\ \text{s}}$ speed = 0.20 m s^{-1}	(1) (1) (1) (1)	4

Q10.

Question Number	Answer		Mark
(a)(i)	1 velocity correct 2 or 3 velocities correct 4 velocities correct (no unit error) 0.66	0.42 0.91	0.58	(1) (1) (1)	3
(a)(ii)	A (Can be implied within the answer) The idea that the time increments are smaller **Or** the idea that the velocity is (constantly) changing **Or** Not B(Can be implied within the answer) As B gives the value over the whole journey **Or** B does not take into account that the velocity of the battery is (constantly) changing	(1) (1)	1
(b)	Source of error: (Human) reaction time **Or** recording the exact position of the battery at the correct time **Or** parallax when marking the position of the battery Changes to the method: Film/video camera with a measuring tape/scale along the ramp (and watch frame by frame) **Or** Motion sensor Connected to a computer/data logger (to directly plot/record distance against time) **Or** Strobe (as a timer) Set with a frequency of 1 Hz (or any sensible frequency suggested with a reason)	(1) (1) (1) (1) (1) (1) (1)	3
	Total for question		**7**

Q11.

Question Number	Answer		Mark
(a) (i)	Each row of the table contains a suitable method. One mark for each column, do not allow a mix and match of methods (rows)	(1) (1) (1) (1)	

Distance measured with the metre rule	**<u>Corresponding</u> time**	**<u>Correct</u> use of measurements referred to in columns 1 and 2**	**To calculate g use:** (formula/expression seen)
Record the position on the **rule** for each frame	Time between frames	Plot distance against t^2	g = 2 x gradient
Measure distance between (successive) frames against a metre **rule**	Time between frames	Calculate the speed each frame using distance /time and plot against time	g = gradient
Use metre **rule** to measure: (total) distance ball falls through **Or** height from which the ball was dropped (e.g. 1 m)	Number of frames × time between frame **Or** total time of journey recorded/found	Use of: $s = ut + ½ at^2$ **Or** $s = ½ at^2$ **Or** $s = ½ gt^2$	$g = 2s/t^2$ **Or** Re-arrange $s = ½ gt^2$ substituting in s and t to find g.
Measure distance between frames (at beginning and) end of drop using the **rule**	Time between frames known and count frames **Or** if stated $u = 0$ then time for ball to fall and the time between frames.	Use speed = $\Delta s/\Delta t$ to find their final velocity using correct time interval [may take u as 0]	$g = (v-u)/t$ **Or** $a = (v-u)/t$
Record the position on the **rule** each frame	Time between frames	Calculate the speed each frame using d/t and plot a graph of v^2 against s.	Gradient/2 = acceleration

Accept metre stick or ruler in place of metre rule
(The candidate may refer to the acceleration of free fall as '*a*' or 'g')

<table>
<tr><td>(a) (ii)</td><td>Ball may be released between 1st and 2nd images (so times used all too long because they include a short time before it is dropped)
Or ball released before the 1st image so u is not 0
Or the ruler is not vertical/straight
Or the idea that the camera has not been calibrated correctly i.e. runs too fast/slow
Or the idea that there is a parallax error from camera to object

(Parallax alone is insufficient)
(Do not award a mark for air resistance)</td><td>(1)</td><td>1</td></tr>
<tr><td>(b)</td><td>Small / dense / streamlined shape / smooth surface / shiny

Correct explanation, e.g.:
Small surface area– minimise drag
Dense – weight > upthrust Or weight > drag
Streamlined /aerodynamic– minimise drag Or ensure laminar flow
Smooth surface – minimise drag Or ensure laminar flow
Shiny – easy to see on the recording
Small – easier to read scale (precisely)

(Sphere is not acceptable for a property but statement such as ‘sphere to minimise drag’ can score 2nd mark)</td><td>(1)

(1)</td><td>2</td></tr>
<tr><td>(c)</td><td>Advantage
Explanation
(to score both marks the explanation must be linked to the advantage. Accept reverse arguments. Human error is not sufficient for reaction time).

<table>
<tr><th>Advantage</th><th>Explanation</th></tr>
<tr><td>No reaction time</td><td>Reduces uncertainties Or (time recorded) more precise/accurate</td></tr>
<tr><td>Can be paused /stopped to take readings.</td><td>Measurements taken at exact times
Or positions against rule recorded more accurately.
Or velocities can be calculated frame by frame (more readings</td></tr>
<tr><td>Allows repeated playback Or rewinding</td><td>Allows values to be checked/confirmed
Or values obtained are more reliable</td></tr>
</table>
</td><td>(1)
(1)</td><td>2</td></tr>
</table>

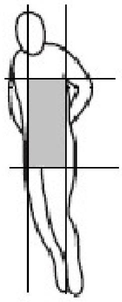
Q12.

Question Number	Acceptable Answers	Mark
(a)	Use of an equation of motion involving $a = g$ *or* $-g$ **(1)** $v = u + at$ with v or $u = 0$ and double t **Or** Use of $s = ut + ½ at^2$ with $s = 0$ **Or** Use of $a = \frac{v-u}{t}$ with $v = -u$ **Or** Find max $s = 0.40$ m then use $s = ½(v + u)t$ and double t **(1)** (do not award MP2 if 8 m s^{-1} used) Time = 0.57 or 0.58(s) **(1)** (Do not award 3rd mark if negatives have been ignored.) <u>Example of calculation:</u> using $a = \frac{v-u}{t}$ $t = \frac{0 - 2.8\,\text{ms}^{-1}}{-9.81\,\text{ms}^{-2}} = 0.285\,\text{s}$ to reach top of jump $t = 0.57$ (s)	**3**

Question Number	Acceptable Answers	Mark
(b)	Use of distance = 8 m s^{-1} × time (either their time or 0.6 s) **(1)** Distance = 4.6 m (ecf (a)) **(1)** (If show that value of 0.6 s used then $d = 4.8$ m) <u>Example of calculation</u> Distance = 8.0 m s^{-1} × 0.57 s Distance = 4.6 m	**2**

Question Number	Acceptable Answers	Mark
(c)	Attempt to calculate total / extra time using correct equations with correct vertical values **(1)** t = 0.14 s or 1/7 s extra time for additional drop assuming u = 2.8 m s^{-1} t =0.43 s or 3/7 s time from calculation of maximum height using u = 0 t = 0.71 s or 5/7s time for whole trajectory using s = − 0.5 m **(1)** Distance = 8.0 m s^{-1} × time **(1)** Extra horizontal distance travelled = 1.1m to 1.2m **(1)** Example of calculation $v^2 = (2.8\ \text{m s}^{-1})^2 + (2 \times 9.81\ \text{m s}^{-2} \times 0.50\ \text{m})$ $v = 4.2\ \text{m s}^{-1}$ $t = \dfrac{4.2\ \text{m s}^{-1} - 2.8\ \text{m s}^{-1}}{9.81\ \text{m s}^{-2}}$ $t = 0.14$ s Distance = 8.0 m s^{-1} × 0.14 s Distance = 1.1 m	**4**
	Total for question	**9**

Q13.

Question Number	Answer		Mark
(a)	Correctly marks position of centre of gravity within grey box below  Point where all of the weight (can be assumed to) act **Or** the point at which all the weight is centred upon **Or** the point that can be used to represent the whole weight	**(1)** **(1)**	**2**
(b)	Vertically: the jumper is accelerating **Or** the velocity is increasing **Or** Gravity/weight acts vertically (downwards) Horizontally: the velocity remains constant **Or** there is no horizontal acceleration **Or** no (resultant) force acts on the man horizontally (ignore all references to air resistance)	**(1)** **(1)**	**2**
(c)	Use of equations of motion suitable to find time Time = 2.5 (s) Picture rate = 3.2 (s^{-1}) Candidates may adopt a circuitous route with multiple equations, so check back over apparently incorrect answers, but only credit if they lead to time <u>Example of calculation</u> $s = ½ gt^2$ $t^2 = 2 \times 30 \text{ m} / 9.81 \text{ ms}^{-2}$ $t = 2.47$ s Picture rate = 8 pictures / 2.47 s = 3.2 (s^{-1})	**(1)** **(1)** **(1)**	**3**

(d)	Vertical distance range 10.0 cm to 10.4cm. Horizontal distance range 4.3 cm to 4.7 cm Scale calculation Horizontal distance 12.4 (m) to 14.1 (m) (Note: numerical values in the mark scheme are based on a full sized examination paper. Enlarged papers or papers printed from pdf etc will give different scale values but the same final answer.) <u>Example of calculation</u> Vertical distance 10.2 cm to horizontal distance 4.5 cm Scale calculation: 4.5 cm x 30 m / 10.2 cm Horizontal distance = 13.2 (m)	**(1)** **(1)** **(1)**	**3**
(e)	Use of (horizontal) velocity = horizontal distance / time (Horizontal) velocity = 5.3 m s^{-1} (ecf of time from part (c)) (Candidates may use their own value for horizontal distance or any value in the range 12 m to 15 m.) Use suitable equation of motion for vertical velocity Vertical velocity = 24.5 m s^{-1} (ecf of time from part (c)) <u>Example of calculation</u> Horizontal v = 13.2 m / 2.5 s = 5.28 m s^{-1} Vertical v = 0 m s^{-1} +(9.81 m s^{-2} x 2.5 s) = 24.5 m s^{-1}	**(1)** **(1)** **(1)** **(1)**	**4**