Name: _____

Motion and SUVAT

Mark Scheme

Date:

Time:

Total marks available:

Total marks achieved: _____

Mark Scheme

Q1.

Question Number	Answer	Mark
	C	1

Q2.

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	

Q3.

Question Number	Acceptable Answer	Additional Guidance	Mark
	B Average speed		1

Q4.

Question Number	Answer	Mark
	D	1

Q5.

Question Number	Acceptable Answers	Reject	Mark
	C		1

Q6.

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

Q7.

Question Number	Answer	Mark
	C	**1**

Q8.

Question Number	Answer	Mark
	B	**1**

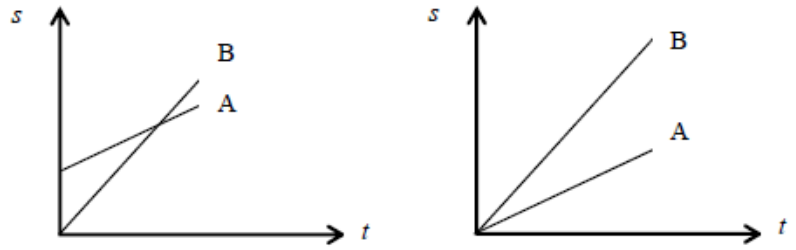
Q9.

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})) <u>Example of calculation</u> $\text{Velocity} = \frac{0.022\,\text{m}}{0.02\,\text{s}}$ or $\text{Velocity} = \frac{0.146\,\text{m} \times 2}{0.02\,\text{s} \times 13}$ Velocity = 1.1 m s^{-1}	**2**

Question Number	Acceptable Answers	Mark
(a)(ii)	Use of $a = \frac{v-u}{t}$ 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) <u>Example of calculation</u> Using $a = \frac{v-u}{t}$ $a = \frac{1.1\,\text{m s}^{-1} - 0}{13 \times 0.02\,\text{s}}$ 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**

Q10.

Question Number	Answer		Mark
(i)	Both graphs straight from $t = 0$ (labels not required)	(1)	
	Initial gradient of A less than gradient of B (minimum of 1 label required)	(1)	2
	(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)		
			
(ii)	Measurement from photographs 0.5 - 0.7 (cm)	(1)	
	Use of distance = measurement × 12	(1)	
	Use of speed = distance/time	(1)	
	speed = 0.18 – 0.25 m s^{-1}	(1)	4
	<u>Example of calculation</u> Measurement = 0.55 cm Distance = 0.55 × 10^{-2} m× 12 = 6.6 × 10^{-2} m speed = $\frac{6.6 \times 10^{-2}\ \text{m}}{0.33\ s}$ speed = 0.20 m s^{-1}		

Q11.

<table>
<tr><th>Question Number</th><th></th><th>Mark</th></tr>
<tr><td>(a)</td><td>Calculation leading to $v = 18.1$ (m s^{-1}) (1)

(A reverse argument gives 64.8 (km h^{-1}) and scores the mark)

<u>Example of calculation</u>
$v = 65\ 000$ m / 60×60 s
$= 18.06$ m s^{-1}</td><td>1</td></tr>
<tr><td>(b)(i)</td><td>Use of distance = speed × time (see the calculation or use of 3 km) (1)

Use of emission = distance × reading from graph (1)

Use of difference between emissions at different speeds for 1 or 3 cars (1)

(This mark may still be awarded if the difference is between a 5 m s^{-1} for 10 minutes journey and an 18 m s^{-1} for 10 minutes journey)

CO_2 emission = 0.72 kg (1)

(allow range 0.63 kg to 0.81 kg)

<table>
<tr><th>Journey</th><th>CO_2 emission</th><th>Range</th><th>Marks</th></tr>
<tr><td>1 car 1 km</td><td>0.08 kg</td><td>0.07 to 0.09</td><td>1 (MP3)</td></tr>
<tr><td>3 cars 1 km</td><td>0.24 kg</td><td>0.21 to 0.27</td><td>1 (MP3)</td></tr>
<tr><td>1 car 3 km</td><td>0.24 kg</td><td>0.21 to 0.27</td><td>3 (MP1,2,&3)</td></tr>
<tr><td>1 car travelling for 10 minutes at 5 m s^{-1} and 18 m s^{-1}</td><td>(-) 1.164 kg</td><td>1.02 to 1.31</td><td>3 (MP1,2,&3)</td></tr>
<tr><td>3 cars travelling for 10 minutes at 5 m s^{-1} and 18 m s^{-1}</td><td>(-) 3.49 kg</td><td>3.06 to 3.93</td><td>3 (MP1,2 &3)</td></tr>
</table>

<u>Example of calculation</u>
Distance = 5 m s^{-1} × 10 × 60 s = 3000 m = 3 km
3 × 3 km × (0.26 kg km^{-1} – 0.18 kg km^{-1}) = 0.72 kg</td><td>4</td></tr>
<tr><td>(b)(ii)</td><td>Quantitative comparison of values 0.72 kg and 0.54 kg to indicate that the cyclist causes more CO_2 emissions
Or qualitative statement e.g. more carbon dioxide emitted when he cycles (1)
candidates answer must be consistent with their value from part (i)</td><td>1</td></tr>
<tr><td></td><td>Total for question</td><td>6</td></tr>
</table>

Q12.

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

Q13.

Question Number	Acceptable Answer		Additional guidance	Mark
(a)	• Use of $v = u + at$ • Max acceleration from 0-60 time = 2.8 ($m\ s^{-2}$)	(1) (1)	Example of calculation $\frac{(60 \times 1600)\ m}{(60 \times 60)\ s} = 0 + a \times 9.5\ s$ Max acceleration = 2.8 $m\ s^{-2}$	2

Question Number	Acceptable Answer	Additional guidance	Mark
(b)	• Use of $v^2 = u^2 + 2as$ **(1)** • Max speed with manufacturer's acceleration = 18 m s^{-1} **Or** acceleration shown by police = 3.3 m s^{-2} **(1)** • Decision **and** evidence required consistent with calculated values **(1)**	Examples for MP3: e.g. 18.3 m s^{-1} is lower than 20 m s^{-1} so should be challenged e.g. 18.3 m s^{-1} is lower than the maximum speed so should be challenged e.g. The police are suggesting a greater acceleration than the manufacturers, so it should be challenged e.g. The maximum speed achievable is less than that suggested by the police, so it should be challenged MP2: maximum manufacturer's speed with show that value of acceleration = 19.0 m s^{-1} Example of calculation $v^2 = 0^2 + 2 \times 2.8$ m s^{-2} $\times$ 60 m $v = 18.3$ m s^{-1}	3

Question Number	Acceptable Answer	Additional guidance	Mark
(c)	• Air resistance increases with speed so acceleration decreases (at higher speeds) **(1)** • The car could brake with greater negative acceleration/force than the positive acceleration/force **(1)**	Ignore references to the mass of the car Accept friction for air resistance	2

Q14.

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')

(a) (ii)	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)	**(1)**	**1**
(b)	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)	**(1)** **(1)**	**2**
(c)	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).	**(1)** **(1)**	**2**

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

Q15.

Question Number	Answer		Mark
(a)	Same (downwards) acceleration **Or** acceleration = g (accept constant acceleration)	(1)	1
(b)(i)	The ball is in contact with the floor (accept the ball bounces)	(1)	1
(b) (ii)	Lower gradient **Or** the lines would be not be as steep	(1)	1
(c)	Use of equation(s) of motion to find s **Or** use of distance = area under the graph **Or** use of GPE = KE s = 1.1 m – 1.4 m Example of calculation $(4.7\ \text{m s}^{-1})^2 = (0\ \text{m s}^{-1})^2 + (2 \times 9.81\ \text{m s}^{-2} \times s)$ s = 1.13 m	(1) (1)	2
(d)(i)	Use of KE = ½ mv^2 KE = 1.1 – 1.3 (J) (no ue) Example of calculation KE = ½ × 0.40 kg × $(2.4\ \text{m s}^{-1})^2$ = 1.15 J	(1) (1)	2
(d)(ii)	Use of GPE = KE h = 0.27 m – 0.32 m (ecf from 16(d)(i)) (If area under graph or an equation of motion is used e.g. $h = \frac{(u+v)t}{2}$ or $v^2 = u^2 + 2as$ only MP2 can be scored) Example of calculation $h = \frac{1.2\ \text{J}}{0.4\ \text{kg} \times 9.81\ \text{Nkg}^{-1}}$ h= 0.31 m	(1) (1)	2
(e)	(Elastic potential) energy transferred to thermal energy **Or** energy dissipated as heat	(1)	1
	Total for question		10