Name: ______________________________________

Forces and Motion

Mark Scheme

Date:

Time:

Total marks available:

Total marks achieved: ______

Mark Scheme

Q1.

Question Number	Answer	Mark
	A	**1**

Q2.

Question Number	Answer	Mark
	C	**1**

Q3.

Question Number	Acceptable answers		Additional guidance	Mark
	• Initial acceleration due to a resultant force	**(1)**		
	• Decreasing acceleration as resistive forces increase **Or** Decreasing acceleration as resultant force decreases	**(1)**	Accept reference to gradient of graph for acceleration for MP2 & MP3.	**3**
	• No acceleration as resultant force is zero **Or** constant velocity as resultant force is zero	**(1)**	Accept terminal velocity for constant velocity	

Q4.

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

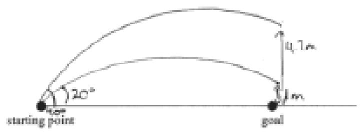
Q5.

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 <u>Example of calculation</u> $(4.7 \text{ m s}^{-1})^2 = (0 \text{ m s}^{-1})^2 + (2 \times 9.81 \text{ m s}^{-2} \times s)$ $s = 1.13$ m	(1) (1)	2
(d)(i)	Use of KE = ½ mv^2 KE = 1.1 – 1.3 (J) (no ue) <u>Example of calculation</u> 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) <u>Example of calculation</u> $h = \frac{1.2 \text{ J}}{0.4 \text{ kg} \times 9.81 \text{ N kg}^{-1}}$ 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

Q6.

<table>
<tr><th>Question Number</th><th>Answer</th><th></th><th>Mark</th></tr>
<tr><td>(a)(i)</td><td>The ball has bounced Or the ball would be below initial height Or the ball has landed before reaching the goal Or the ball has hit the ground</td><td>(1)</td><td>1</td></tr>
<tr><td>(a)(ii)</td><td>Correct shape of at least one trajectory, starting at the kick and ending at/beyond the goal

Range/position of the higher angle > range/position of lower angle ball seen with paths labelled

Example of response scoring 2 marks

</td><td>(1)

(1)</td><td>2</td></tr>
<tr><td>(b) (i)</td><td>Use of (u_H) = u cos15 Or u sin75 Or see 25(.1) m s^{-1}
Use of $u = s/t$ to calculate the time to the goal Or see 0.44 s
Use of (u_V) = u sin15 Or u cos75 Or see 6.7 m s^{-1}
Use of $s = ut + ½ at^2$ (a must be negative)
s = 2.0 m

Use of (value obtained + the 0.22 m (or 0.11 m)) to make a sensible statement as to whether or not the goal will be scored
e.g. the top of the ball on reaching the goal 2.23 m. (This is less than 2.4 m and) the goal will be scored

(Answer must be consistent with calculated distance. For calculated heights greater than 2.4 m, candidates do not need to refer to radius /diameter but a comparison of heights is needed.)

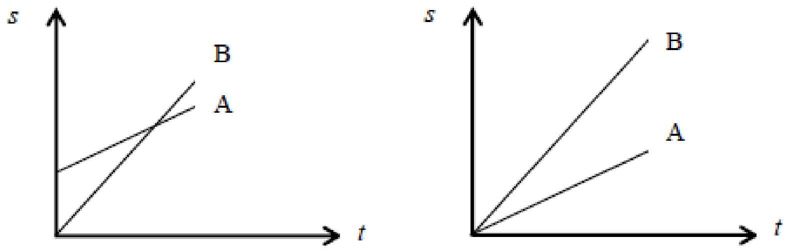
<u>Example of calculation</u>
$t = \frac{11\text{ m}}{26\text{ ms}^{-1} \times \cos 15°} = 0.44\text{ s}$
$s = (26\text{ m s}^{-1} \times \sin 15°)(0.44\text{ s}) + (½)(-9.81\text{ N kg}^{-1})(0.44\text{ s})^2$
s = 2.01 m
Height of the top of the ball on reaching the goal = 2.01 m + 0.22 m = 2.23 m</td><td>(1)
(1)
(1)
(1)
(1)

(1)</td><td>6</td></tr>
<tr><td>(b) (ii)</td><td>Air resistance is in the opposite direction to the ball's motion Or air resistance adds a backwards force Or work is done against air resistance

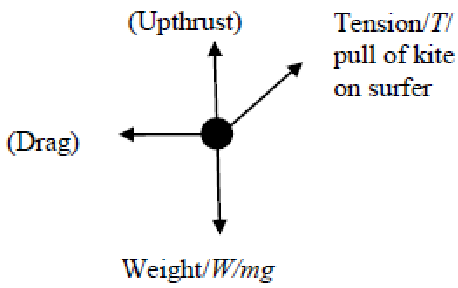
The ball will decelerate (horizontally) Or the ball will have a decreasing velocity/speed Or the ball will not travel as far Or this reduces the maximum height the ball reaches Or the ball is in the air for less time Or the ball will take longer to reach the goal</td><td>(1)

(1)</td><td>2</td></tr>
<tr><td></td><td>Total for question</td><td></td><td>11</td></tr>
</table>

Q7.

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
	Example of calculation 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}		

Q8.

Question Number	Answer		Mark
(a)(i)	Tension line and arrow correctly drawn and labelled Weight line and arrow correctly drawn and labelled  (Tension can be on either side. If 2 marks have been awarded subtract 1 mark if the drag has been included and is not a horizontal force opposing the tension)	(1) (1)	2
(a)(ii)	Use of correct trig function to find horizontal component of the tension $T_{horizontal}$ = 840 (N) <u>Example of calculation</u> Horizontal component of tension = $T\cos\theta$ $T_{horizontal}$ = 1100 N × cos 40° $T_{horizontal}$ = 843 N	(1) (1)	2

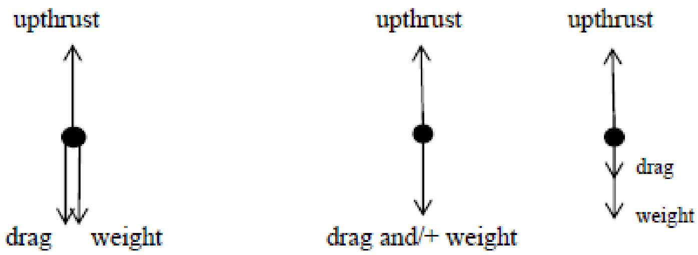
(a)(iii)	$T_{vertical}$ = 1100 sin 40° **Or** $T_{vertical}$= 707 (N) seen Use of $W = mg$ Use of $mg = U + T_{vertical}$ with a sensible statement discussing what would happen if $T_{vertical}$ = W **Or** $T_{vertical}$ > weight **Or** $T_{vertical}$ < weight e.g. $T_{vertical}$ = W **Or** mass = 72 kg: Upthrust is zero $T_{vertical}$ > weight **Or** mass < 72 kg: Can't have a negative upthrust $T_{vertical}$ < weight **Or** mass > 72 kg : To provide some upthrust <u>Example of calculation</u> $T_{vertical}$ = T sin 40° (= 707 N) **OR** $mg = U + T_{vertical}$ $mg = U$ + 707 N mass = $\frac{707\text{ N}}{9.81\text{ N kg}^{-1}}$ = 72.1 kg	(1) (1) (1)	3

*(b)	**(QWC – work must be clear and organised in a logical manner using technical terminology where appropriate)** C **(1)** **Max 3** The horizontal component of the tension in the line produces the forward force acting on the surfer **Or** horizontal component of tension = $T\cos\theta$ (accept $T_{horizontal} = 1100\cos\theta$) **(1)** As the angle to the horizontal (θ) decreases **Or** As the angle to the vertical (θ) decreases ➔ $T\cos\theta$ increases **Or** the forwards force on the surfer increases **Or** the smallest θ gives the maximum/greatest force **(1)** Work done increases **(1)** Power transferred to surfer= $\frac{\text{work done}}{\text{time}}$ has increased hence the power increases **Or** more work done per second on the surfer so the power increases **(1)**	**4**
	Total for question	**11**

Q9.

<table>
<tr><th>Question Number</th><th>Answer</th><th>Mark</th></tr>
<tr><td>(i)</td><td>Weight/W/mg (1)
Upthrust/U (1)
Drag/Friction/Fluid resistance/F/D/V (1)

(all lines must touch the black dot and should be approximately vertical by eye)
(−1 for each additional force)


</td><td>3</td></tr>
<tr><td>(ii)</td><td>(QWC – work must be clear and organised in a logical manner using technical terminology where appropriate)

<u>Upthrust</u> is greater for the larger bubble (1)

Drag/friction increases (1)

Upthrust increases more than drag
Or greater (initial) resultant force on bubble
Or higher terminal velocity
Or upthrust is related to volume/radius^3 and drag related to area/radius$^{(2)}$ (1)</td><td>3</td></tr>
</table>