Question Number	Acceptable Answers	Mark
1(a)(i)	Measures the final interval = 2.2 cm **O**r 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
1(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
1(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**

Question Number	Answer	Mark
2(a)	Show that the acceleration is about 2 m s^{-2}. Use of equation of motion suitable to find acceleration Correct answer (1.5 (m s^{-2})) <u>Example of calculation</u> $s = ut + 1/2\ at^2$ a = 2 x 2 500 000 m / ((30 x 60)s)^2 = 1.54 m s^{-2}	 **(1)** **(1)**
2 (b)	Calculate the maximum speed. Use of equation of motion suitable to find maximum speed Correct answer (2700 m s^{-1}) <u>Example of calculation</u> $v = u + at$ = 0 + 1.5 m s^{-2} x (30 x 60)s = 1.5 m s^{-2} x (30 x 60)s = 2700 m s^{-1} (Use of 2 m s^{-2} → 3600 m s^{-1}, 1.54 m s^{-2} → 2772 m s^{-1}),	 **(1)** **(1)**
2 (c)	Calculate the force which must be applied to decelerate the train. Use of $F = ma$ Correct answer (680 000 N) <u>Example of calculation</u> $F = ma$ = 4.5 x 10^5 kg x 1.5 m s^{-2} = 675 000 N (Use of 2 m s^{-2} → 900 000 N, 1.54 m s^{-2} → 693 000 N)	 **(1)** **(1)**
	Total for question	**6**

Question Number	Answer		Mark
3(a)(i)	Use of $v^2 = u^2 + 2as$ $a = 2.9$ (m s^{-2}) <u>Example of calculation</u> $a = \frac{(15\text{ m s}^{-1})^2 - (0\text{ m s}^{-1})^2}{2 \times 39\text{ m}}$ $a = 2.88$ m s^{-2}	(1) (1)	**2**
3(a)(ii)	Use of $F = ma$ to find a or F Maximum $a = 3.2$ m s^{-2} **Or** Force in (a)(i) $F = 580$ N(or 600 N) (3.2 m s^{-2} is the maximum acceleration because) the box must have the same acceleration as the lorry <u>Example of calculation</u> $a = 630\text{N}/200\text{ kg}$ $a = 3.15$ m s^{-2}	(1) (1) (1)	**3**
3(b)(i)	$W_{parallel} = W\sin\theta$ $W_{perpendicular} = W\cos\theta$ (Accept mg, $200g$ or 1962 for W)	(1) (1)	**2**
3(b)(ii)	$F = W\sin\theta$ **Or** $F = W_{parallel}$ **Or** $R = W\cos\theta$ **Or** $R = W_{perpendicular}$ Substitute $F = 0.32R$ into candidate's equation for F or R Use of $\sin\theta/\cos\theta = \tan\theta$ $\theta = 18°$	(1) (1) (1) (1)	**4**
	Total for question		**11**

Question Number	Answer	Mark
4(a)	Correct trajectory (1) e.g. 	**1**
4(b)(i)	Use of trig function appropriate to calculate the horizontal component of velocity **Or** 2.25 (m s^{-1}) seen (1) Use of $v = s/t$ (1) time = 0.67 (s) (1) <u>Example of calculation</u> $u_h = 4.5\ \mathrm{m\ s^{-1}} \times \cos 60° = 2.25\ \mathrm{m\ s^{-1}}$ $t =$ [illegible] $t = 0.67$ s	**3**
4(b)(ii)	Use of trig function appropriate to calculate the vertical component of velocity **Or** 3.9 (m s^{-1}) seen (1) Use of suitable equation(s) of motion to find the vertical displacement from the release point after 0.67 s (1) Displacement from release point = 0.41 **-** 0.42 m (ecf for t from (b)(i)) (1) (show that value of 0.7 s gives displacement = 0.32 m – 0.33 m) Statement to explain why the ball will miss/overshoot the ring e.g. the ball passes below the net **Or** the ball will not have reached the height of the ring yet **Or** 0.41 < 0.7 **Or** ball undershoots ring (Explanation must be consistent with the calculated value of displacement) (1) <u>Example of calculation</u> $u_v = 4.5\ \mathrm{m\ s^{-1}} \times \sin 60° = 3.9\ \mathrm{m\ s^{-1}}$ $s = (3.9\ \mathrm{m\ s^{-1}} \times 0.67\ \mathrm{s}) + (-\frac{1}{2} \times 9.81\ \mathrm{m\ s^{-2}} \times (0.67\ \mathrm{s})^2)$ $s = 0.41$ m	**4**
4(b)(iii)	The ball would be travelling with a decreas<u>**ing**</u> (horizontal) speed **Or** there would be a (horizontal) deceleration (1) The (calculated) time would increase (1)	**2**
	Total for question	**10**

Question Number	Answer		Mark
5(a)	(Use of) acceleration = gradient **Or** $a = \dfrac{\Delta v}{(\Delta)t}$ stated **Or** use of $a = \frac{v-u}{t}$ with $u > 1$ Answers in range 2.0 to 2.8 (m s^{-2}) Answers in range 2.1 to 2.5 m s^{-2}	(1) (1) (1)	3
5(b)	**Max 4** changing gradient **Or** graph curves The idea of a changing acceleration Decreasing acceleration Resultant force decreasing Drag increases (with speed) [Ignore references to initial constant acceleration/straight line initially/(0-3) s]	 (1) (1) (1) (1) (1)	4
5(c)	Zero (no u.e.) **Or** there is no resultant force	(1)	1
5(d)	Attempt to find total distance travelled Distance in range 900 (m) to 1100 (m) Use of speed = distance / time Speed = 20.0 to 21.0 (m s^{-1}) **Or** comparison of their distance with 1100m [A number of incorrect methods give the value of 20 – 21 m s^{-1}. Only give final mark if correct method used using total distance and time of 50 s.] **OR** Use of line at 22 m s^{-1} Use of area under graph Simple comparison of area between graph and line above and below the line (e.g. more below than above) Quantitative comparison (e.g. 60 (m) above and 140 (m) below)	(1) (1) (1) (1) (1) (1) (1) (1)	4
	Total for question		**12**

Question Number	Answer	Mark
6(a)(i)	State or show $E_p \rightarrow E_k$ (1) $mgh = ½ mv^2$ Or $gh = ½ v^2$ (1) Use of $mgh = ½ mv^2$ Or $gh = ½ v^2$ (1) $v = 3.4$ (m s^{-1}) [no ue] (1) Calculation using $v^2 = u^2 + 2as$ scores 0 marks Use of $g = 10$ N kg^{-1} gives 3.46 m s^{-1}, 3.5 m s^{-1}, max 3 marks Do not credit bald answer (Candidates may calculate in steps using m = 40 kg, mark 2 becomes use of $E_p = mgh$ and mark 3 becomes use of $E_k = ½ mv^2$) <u>Example of calculation</u> $E_p = E_k$ $mgh = 1/2\ mv^2$ $gh = 1/2\ v^2$ $9.81 \text{ N kg}^{-1} \times 0.6 \text{ m} = 1/2\ v^2$ $v = 3.4 \text{ m s}^{-1}$	**4**
6(a)(ii)	All $E_p \rightarrow E_k$ / no friction/air resistance **/** no stretch of cable / u = 0 / no push at start / no energy transferred to other forms (1) (No energy lost is not sufficient.)	**1**
6(b)(i)	Label 2 x tension (T) parallel to cable and **away** from P only (1) Label weight / pull of child / W / mg vertically downward (1) One correct and one incorrect scores 1 mark. Two correct and one incorrect scores 1 mark. Two incorrect scores 0. Ignore unlabelled arrows.	**2**
6(b)(ii)	Use of $W = mg$ (1) Use of correct trigonometrical function ($T \sin 2 = W/2$)(accept with missing factor 2, i.e. $T \sin 2^\circ = W$)(do not accept tan) (accept cos 88)(1) Force = 5600 (N) [no ue] (1) Accept calculation of 11 200 N divided by 2 at the end for full marks only if accompanied by an explanation, such as 'there are two cables' <u>Example of calculation</u> $W = mg$ $W = 40 \text{ kg} \times 9.81 \text{ N kg}^{-1} = 392 \text{ N}$ $T \sin 2^\circ = W/2$ $T = 392 \text{ N} / 2 \times \sin 2^\circ$ $T = 5621 \text{ N}$	**3**
	Total for question	**10**

Question Number	Answer	Mark
7 (a)	Explain why the coin on the ruler has no horizontal motion Max 2 points – (Max 1 if no reference to force / friction) Initially at rest **(1)** (Smooth surface so) no friction **(1)** No horizontal force / only vertical forces **(1)** So (from Newton's first law) no horizontal acceleration / no change in horizontal velocity **(1)**	**(Max 2)**
7(b)	Explain how this demonstrates the independence of horizontal and vertical motion They have **the same** vertical acceleration / force / motion / (instantaneous) velocity **(1)** Although only one has horizontal motion/velocity **(1)**	**(2)**
7(c)	Show that the coin on the ruler strikes the ground with a speed of about 4 ms^{-1} Use of $v^2 = u^2 + 2as$ OR Use of $mgh = ½ mv^2$ Or other correct combinations of equations of motion **(1)** Correct answer (4.1 m s^{-1}) **(1)** *Example of calculation* $v^2 = u^2 + 2as$ v^2 = 2 x 9.81 m s^{-2} x 0.85 m = 4.1 m s^{-1}	**(2)**
7(d)	Calculate the velocity at which it strikes the ground. Use of distance/time for horizontal speed **(1)** Use of Pythagoras with velocity components **(1)** Correct answer for resultant velocity magnitude [4.9 m s^{-1}] **(1)** Use of trigonometrical function with velocities for the angle **(1)** Correct answer for angle [58°] **(1)** OR Use of distance/time for horizontal speed **(1)** Use of trigonometrical function with velocity components for the angle **(1)** Correct answer for angle [58°] **(1)** Use of trigonometrical function for the resultant velocity magnitude **(1)** Correct answer for resultant velocity magnitude [4.9 m s^{-1}] **(1)** [Allow ecf from mark 3 of the calculation in this question] *Example of calculation* $v = s/t$ = 1.1 m / 0.42 s = 2.6 m s^{-1} $v^2 = v_h^2 + v_v^2$	**(5)**

	$= (2.6\ \mathrm{m\ s^{-1}})^2 + (4.1\ \mathrm{m\ s^{-1}})^2$ $v = 4.9\ \mathrm{m\ s^{-1}}$ from horizontal, tan (angle) = $4.1\ \mathrm{m\ s^{-1}} / 2.6\ \mathrm{m\ s^{-1}}$ angle = 58° (N.B. Use of $4\ \mathrm{m\ s^{-1}}$ gives and answer of $4.8\ \mathrm{m\ s^{-1}}$ and 57°)	
	Total for question	**11**