1)

(a)		A quantity that has (both) magnitude / size and direction	**B1**	**Not** 'A quantity that has direction'
(b)		Circled /underlined quantities are: acceleration, displacement and weight	**B1**	**Note**: All three need to be identified for a mark
(c)	**(i)**	Constant / steady / uniform acceleration (up to 4 s) Or Velocity increases at a steady / constant / uniform rate Or Has acceleration of 3.5 (m s^{-2}) Constant / steady / uniform velocity (after 4 s) Or Zero acceleration Or Travels at a velocity of 24 (m s^{-1})	**B1** **B1**	**Not** Accelerates up to 4 s / 'uniform motion' for the first B1 mark **Not** 'Accelerates at a constant rate'. **Allow**: 'speed' instead of velocity **Allow**: 2 mark for 'Constant acceleration and then constant speed / velocity'
	(ii)	distance = area (under graph) distance = 68 (m)	**C1** **A1**	**Allow**: The C1 mark is for … distance = $\frac{1}{2}(10+24)\times 4.0$ **Allow**: Bald 68 (m) scores 2 marks Bald $\frac{1}{2}(4\times 14)$ or 28 (m) scores 1 mark for 'area of triangle'
	(iii) 1	Answer in the range: 1.1 to 1.2 (s)	**B1**	
	(iii) 2	Same areas under graphs $14t = 10t + (0.5\times 3.5\times t^2)$ t = 2.28 (s) ≈ 2.3 (s)	 **C1** **A1**	 **Note**: The C1 mark is for substitution **Allow**: Bald 2.3 (s) scores 2 marks **Allow:** Bald 't = 2 × **(iii)1**.' Scores 2 marks

2)

(a)		acceleration = rate of change of velocity	B1	**Allow**: $a = \frac{v-u}{t}$ where v = final velocity, u = initial velocity and t = time **Allow**: 'acceleration = change in velocity over time' **Not**: 'acceleration = rate of change of speed' **Not**: mixture of quantity and unit, e.g. 'change of velocity per second'
(b)	(i)	$a = \frac{v-u}{t}$ (Any subject) $a = \frac{0-6.0}{2400}$ a = (-) 2.5 × 10^{-3} (m s^{-2})	C1 C1 A1	 **Allow**: $a = 6.0/2400$ Ignore sign
	(ii)	distance = av speed × time or $v^2 = u^2 + 2as$ distance = 3.0 × 2400 or $0 = 6.0^2 - (2\times 2.5\times 10^{-3}\times s)$ distance = 7200 (m)	C1 A1	Possible ecf. from **(b)(i)** **Allow**: $v^2 = u^2 + 2as$ with v = 6.0, u = 0 and a = 0.0025 **Allow**: Full credit for correct use of $s = ut + ½\,at^2$ **Note**: Bald 7200 (m) scores 2 marks **Allow**: 1 mark for 's = (6 × 2400) + ½ × 0.0025 × 2400^2 = 21600 (m)'
	(iii)	Correct shape of curve of decreasing gradient starting from 0,0 Graph passes through 40, 7.2	M1 A1	 Possible e.c.f. from **(b)(ii)** **Allow** the A1 mark if x is between 5-10 km at 40 min
(c)	(i)	It has (constant) acceleration / It accelerates (down the ramp)	B1	**Allow**: Its velocity / speed increases
	(ii)	The time taken by ball to travel between (successive) bells is the same / 'same as first trolley' / 'there is no change' (AW) Acceleration is independent of mass / acceleration is the same (for the heavier trolley) (AW)	B1 B1	
		Total	**11**	

3)

d(i)	Mention of weight or drag	B1	**Allow:** (air) resistance / (air) friction for 'drag' **Not:** 'gravity' for 'weight' **but** 'force of gravity' is fine
	Net / total / resultant force (on drop) is zero 'upward force = downward force' / 'weight = drag' / 'weight balances drag'	B1	**Not**: 'acceleration = 0' since question requires answer in terms of forces **Not**: 'All forces are equal' **Note**: 'weight = drag' / 'weight balances drag' scores 2 marks
(ii)1	A downward line / arrow (from the raindrop) leaning to the right	B1	**Note**: Answer **must** be on Fig. 1.2 Judge by eye – the angle is not important
(ii)2	$v^2 = 1.5^2 + 4.0^2$ velocity = 4.27 (m s^{-1}) ≈ 4.3 (m s^{-1})	C1 A1	**Allow**: 2 marks for a scale drawing with value in the range 4.1 to 4.5. If value in the range 4.0 to 4.1 or 4.5 to 4.6 then give 1 mark **Allow**: 2 marks for a bald answer of 4.3 (m s^{-1})

4)

(a)	(i)	*a* = gradient/slope (of the line)	B1	**Allow**: *a* = change in velocity/time or 'rate of change of velocity' **Allow**: Correct equation plus labels; $a = (v-u)/t$; *v* = final velocity, *u* = initial velocity and *t* = time **Note**: The term *gradient/slope/change/ initial* to be included and spelled correctly to gain mark
	(ii)	*s* = area (under the graph)	B1	
(b)		area of 'rectangle' = '*ut*' area of 'triangle' = $\frac{1}{2} \times t \times (v-u)$ area of 'triangle' = $\frac{1}{2} \times t \times at$	M1 M1	**Note**: The second M1 mark is **not** for '½ at^2' but for ' ½ × *t* × *at*' **Allow**: 'Area of trapezium method': $s = \frac{1}{2}(u+v)t$ and $v = u + at$ M1 Correct substitution leading to correct answer M1 **Note**: Substitution method starting with $v^2 = u^2 + 2as$ scores zero
(c)	(i)	$32 = \frac{1}{2} \times a \times 2.8^2$ $a = \frac{32 \times 2}{2.8^2}$ *a* = 8.16 (m s^{-2}) or 8.2 (m s^{-2})	C1 A1	**Note**: The C1 mark is for substitution into the equation given in **(b)** with *u* = 0 **Note**: Bald answer of 8.16 (m s^{-2}) or 8.2 (m s^{-2}) scores 2/2 marks Bald 8 (m s^{-2}) scores 1/2
	(ii)	Drag/air resistance/air friction (makes the time longer)	B1	**Not:** 'Reaction time'/'wind'
		Total	**7**	

5)

d(i)	Mention of weight or drag	B1	**Allow:** (air) resistance / (air) friction for 'drag' **Not:** 'gravity' for 'weight' **but** 'force of gravity' is fine
	Net / total / resultant force (on drop) is zero 'upward force = downward force' / 'weight = drag' / 'weight balances drag'	B1	**Not**: 'acceleration = 0' since question requires answer in terms of forces **Not**: 'All forces are equal' **Note**: 'weight = drag' / 'weight balances drag' scores 2 marks
(ii)1	A downward line / arrow (from the raindrop) leaning to the right	B1	**Note**: Answer **must** be on Fig. 1.2 Judge by eye – the angle is not important
(ii)2	$v^2 = 1.5^2 + 4.0^2$ velocity = 4.27 (m s^{-1}) ≈ 4.3 (m s^{-1})	C1 A1	**Allow**: 2 marks for a scale drawing with value in the range 4.1 to 4.5. If value in the range 4.0 to 4.1 or 4.5 to 4.6 then give 1 mark **Allow**: 2 marks for a bald answer of 4.3 (m s^{-1})

6)

a	i	Length from **A** to **B** = 8.0 (cm) displacement = 400 (km) or time = 1500 (s) average velocity = $400 \times 10^3/1500$ average velocity = 270 (m s^{-1})	C1 C1 A1	**Allow** ± 0.1 cm Possible ecf within the calculation for an incorrect value for length **AB**. **Note** no credit if distance is used.
	ii	(The average speed is different because) the <u>distance</u> (travelled) is different / not the same / greater than the <u>displacement</u>	B1	
b	i	distance = $2 \times \pi \times 4.2 \times 10^8$ speed = $\frac{2\times\pi\times4.2\times10^8}{1.5\times10^5}$ speed = 1.8×10^4 (m s^{-1})	C1 A1	 **Note**: Answer to 3 sf is 1.76×10^4 (m s^{-1}) **Not** 5600π (m s^{-1})
	ii	($0 = u^2 - 2as$) $(1.3\times10^3)^2 = 2\times a\times470\times10^3$ (Any subject) $a = \frac{(1.3\times10^3)^2}{2\times470\times10^3}$ (*a* must be the subject) acceleration = 1.8 (m s^{-2})	C1 C1 A1	**Allow** full credit for '$mgh = ½\ mu^2$' approach **Ignore** signs **Allow**: 2 marks for 1.8×10^n; $n \neq 0$
		Total	**9**	

7)

(a)	(Acceleration =) rate of change of <u>velocity</u>	B1	**Allow**: Equations $a = \frac{v-u}{t}$ and $a = \frac{\Delta v}{t}$ as long as labels, *v*, *u*, Δv and *t* are defined. **Not**: 'speed' instead of 'velocity'
(b)	It has <u>direction</u> (and magnitude)	B1	**Must use ticks on Scoris to show where the marks are awarded** '***direction***' must be spelled correctly to gain the mark.
(c)(i)	**1** Increasing acceleration **2** Constant deceleration	B1 B1	**Not:** answers using rate of acceleration - for either mark **Not**: Constant acceleration **Allow**: constant negative acceleration **Allow:** uniform /steady deceleration
(c)(ii)	The area under the graph from $t = 0$ to $t = 2$ s is smaller (AW)	B1	
(d)	$s = \frac{1}{2}(v+u)t$ $0.020 = \frac{1}{2}(0.26)\times t$ time = 0.15 (s)	 C1 A1	Arriving at an acceleration of 1.69 m s^{-2} and no further works scores zero. **Allow**: Alternative approaches **Note**: Answer to 3 sf is 0.154 (s) **Note**: '0.020/0.26 = 0.77 (s)' scores zero
	Total	**7**	

8)

(d)	(i)	1 acceleration = gradient / $a = (v-u)/t$ a = 3.0/1.5 a = 2.0 (m s^{-2}) 2 $a = g\sin\theta$ $\sin\theta = 2.0/9.81$ $\theta = 12°$	C1 A1 C1 A1	 **Allow**: 1 sf answer Possible ecf from incorrect value of acceleration *a* Answer to 3 sf is 11.8° **Note**: Using 10 m s^{-2} gives an answer of 11.5° - award 2 marks
	(ii)	a = (-) 15/3.5 or a = (-) 4.29 (m s^{-2}) $m = 510/4.29$ mass = 120 (kg)	C1 C1 A1	**Ignore** sign Answer to 3 sf is 119 (kg)

9)

(a)		Difference: Velocity / vector has direction (and speed does not) or speed / scalar does not have direction (velocity has) Similarity: Both have the same unit / both have m s^{-1} (as the unit) / both have magnitudes	B1 B1	**Not** 'velocity is a vector / speed is a scalar' since it is stated in the question
(b)	**(i)**	distance = $2 \times \pi \times 0.60$ (= 3.77 m) / speed = $\frac{3.77}{12}$ speed = 0.31 (m s^{-1})	C1 A1	**Note**: Answer to 3 sf is 0.314 (m s^{-1})
	(ii)	$s^2 = 0.60^2 + 0.60^2$ s = 0.85 (m)	C1 A1	**Note**: Answer to 3 sf is 0.849 (m) **Note**: 0.72 scores 1 mark (square root omitted)
	(iii)	The (change in) displacement is zero	B1	
	(iv)	The direction changes (even though the magnitude is the same)	B1	
		Total	**8**	

10)

(a)		$W = mg$ weight $= 1.50 \times 9.81 = 14.72$ (N) or 14. 7 (N) or 15 (N)	B1	**Allow**: Use of 9.8 (m s^{-2}) **Allow**: Bald 15 (N); but **not** '1.50 × 10 = 15(N)'
(b)	**(i)**	Net / resultant force (on **B**) is less / (net) force (on **B**) is less than its weight / there is tension (in the string) / there is a vertical / upward / opposing force (on **B**)	B1	**Note**: Must have reference to force
	(ii)	$s = ut + \frac{1}{2}at^2$ and $u = 0$ $1.40 = \frac{1}{2} \times 1.09 \times t^2$ t = 1.60 (s)	C1 C1 A1	**Allow**: 2 marks for 1.75/1.09' if answer from **(iii)** is used **Allow**: 2 sf answer **Allow**: 2 marks if **2.80 m** is used; time = 2.27 (s)
	(iii)	$v^2 = 2 \times 1.09 \times 1.40$ / $v = 0 + 1.09 \times 1.60$ v = 1.75 (m s^{-1}) / v = 1.74 (m s^{-1})	C1 A1	Possible ecf **Allow**: 1.7 or 1.8 (m s^{-1})
	(iv)	change in velocity = 2.47 + 1.50 (= 3.97 m s^{-1}) acceleration = $\frac{3.97}{0.030}$ acceleration = 132 (m s^{-2})	C1 A1	Ignore sign for change in velocity **Allow**: 130 (m s^{-2}) --- **Special case:** acceleration = $\frac{2.47 - 1.50}{0.030} = 32.3$ or 32 (m s^{-2}) scores 1 mark
		Total	**9**	

11)

(a)		The mass (of the electron) increases as its speed approaches c / speed of light / 3×10^8 m s^{-1}	M1 A1	**Not**: mass 'changes' / 'electron becomes heavier'
(b)	**(i)**	A line with correct arrow in the y direction has length of 14 to 16 'small squares' A line with correct arrow in the x direction has length of 24 to 26 'small squares'	B1 B1	**Note**: If correct arrows are not shown, then maximum mark is 1
	(ii)	component = $(8.0 \cos 31 =) 6.86$ (m s^{-1}) or 6.9 (m s^{-1})	B1	**Allow**: 6.85 as BOD