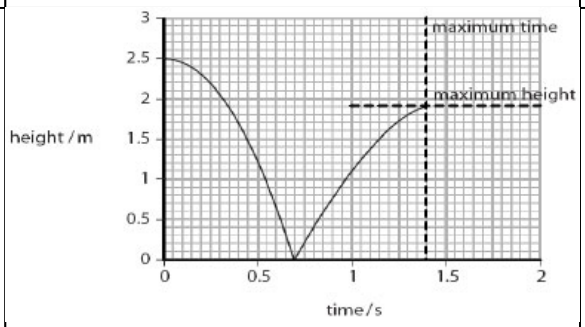
Mark Scheme

Q1.

	Answer	Acceptable answers	Mark
(i)	2.5 (m)	Allow answers between (and including) 2.45 & 2.55	**(1)**
(ii)	0.7 (s)	Allow answers between (and including) 0.68 & 0.72	**(1)**
(iii)	 line: same shape as original (1) peak at 1.9 m (1) time taken < 0.7 s (1)	Ignore any part of the graph after the peak	**(3)**
(iv)	An explanation linking: energy lost (1) in collision with ground / air resistance (1)	Inelastic collision worth (2) as sound or heat	**(2)**

Q2.

Question number	Answer	Additional guidance	Mark
(a)(i)	Calculating the mean (1) 18.36 Rounding to 2 s.f. (1) 18 (cm)	award full marks for correct numerical answer without working	(2)

Question number	Answer	Additional guidance	Mark
(a)(ii)	Rearrangement (1) $t = \sqrt{\frac{\text{distance}}{500}}$ Substitution and answer (1) time = 0.17 (s)	award full marks for correct numerical answer without working allow answers which round to 0.17, e.g. 0.1673	(2)

Question number	Answer	Additional guidance	Mark
(b)	An explanation that combines identification via a judgement (1 mark) to reach a conclusion via justification/reasoning (1 mark): • 25.5 is an anomalous result (1) • (because) it is much further away from the mean than the other results (1)	ignore 19	(2)

Question number	Answer	Mark
(c)	• Take more readings (1) • Idea that a third student should also measure the reaction time (1)	(2)

Question number	Answer	Additional guidance	Mark
(d)	An answer that combines the following points to provide a logical description of the plan/method/experiment: • using a larger group of students/large population of students (1) • and measure how their reaction time varies with age/height (1)	allow any suitable variable	(2)

Q3.

	Answer	Acceptable answers	Mark
	A 600 kg m/s		**(1)**

Q4.

	Answer	Acceptable answers	Mark
(a)	**C** when the bungee cord is stretched the most		**(1)**
(b)	**A** 600 kg m/s		**(1)**
(c)(i)	Substitution: (1) 60 × 10 × 50 or 600 × 50 Evaluation: (1) 30 000 Unit: (1) J / Nm	 give two marks for correct answer no working j / joule 30 kJ for full marks	**(3)**
(c)(ii)	After falling 50 m / when the cord becomes straight/when cord starts to stretch	tension starting to increase at terminal velocity ignore maximum velocity/speed	**(1)**
(c)(iii)	An explanation linking any two of not all GPE is transferred to KE (1)	 not all GPE goes to KE	**(2)**

	some {of the GPE transfers to thermal energy /work is done} (1) due to drag (1)	maximum energy is same (value) as GPE before falling /speed does not reach the speed at which he should fall some lost as heat/sound (of rope or movement through air) (air) resistance / friction ignore wind		

Q5.

Question number	Answer	Additional guidance	Mark
(i)	substitution (1) (force =) $\frac{8.7}{0.35}$ evaluation (1) 25 (N)	use of force = $\frac{\text{change in momentum}}{\text{time}}$ allow numbers that round to 25 e.g 24 .8571 award full marks for correct answer without working.	**(2)** **AO2**

Question number	Answer	Additional guidance	Mark
(ii)	(magnitude) 25 (N) (1) (direction) down(wards)/ towards floor (1)	ecf from i allow arrow drawn pointing down "south"	**(2)** **AO3**

Q6.

Question number	Answer	Additional guidance	Mark
(i)	substitution (1) 371 = (64.5+ m) x 3.5 rearrangement (1) m+64.5 = 371 / 3.5 evaluation of total mass (1) m+64.5 = 106 (kg) evaluation of woman's mass (1) m = 106-64.5 = 41.5 (kg)	full marks will be awarded for correct numerical answer without working	**(4)**

Question number	Answer	Additional guidance	Mark
(ii)	substitution (1) KE = ½ x 64.5 x 3.5^2 evaluation (1) 395 (J)	allow answers which round to 395 e.g. 395.0625 full marks will be awarded for correct numerical answer without working	**(2)**

Q7.

Question number	Answer	Additional guidance	Mark
(i)	attempt to use correct data from graph or equation (1) substitution (1) (a =) $\frac{26 - 14}{34}$ evaluation to 2 sf (1) 0.35 (m/s^2)	quoting $a = \frac{(\Delta) v}{t}$ or a = gradient (of line) 0.3529... scores mp1 and mp2 $\frac{26}{34}$ scores mp1 independent mark award full marks for correct answer without working.	**(3)** **AO2**

Question number	Answer	Additional guidance	Mark
(ii)	attempt to calculate area under the line (1) calculates EITHER area of triangle OR area of rectangle (1) 204 (m) or 476 (m) evaluation (1) 680 (m)	accept count squares use of $v^2-u^2 = 2ax$ $x = \frac{v^2-u^2}{2a}$ allow ecf from (i) award full marks for correct answer without working award 1 mark for final answer 408 (m)	**(3)** **AO2**

Q8.

	Answer	Additional guidance	Mark
(i)	conversion of time to s (1) (t =) 0.012 **OR** 12×10^{-3} **OR** 1.2×10^{-2} substitution (1) $(F=)\frac{(0.075 \times -15.0) - (0.075 \times 8.2)}{0.012}$ OR $(F=)\frac{(0.075 \times 15.0) - (0.075 \times -8.2)}{0.012}$ OR $(F=)\frac{0.075 \times (15.0 + 8.2)}{0.012}$ evaluation (1) (-)150 (N)	substitution and conversion in either order ignore signs on velocity accept time to any power of ten for substitution mark $(F=)\frac{(1.125) + (0.615)}{0.012}$	**(3)** **AO2**

		145 (N) scores 3 marks 145 (N) to any other power of ten scores 2 marks maximum 42.5 (N) scores 2 marks maximum 42.5 (N) to any other power of ten scores 1 mark maximum 93.75 (N) or 51.25(N) 1.933 scores 1 mark maximum award full marks for correct answer without working	

	Answer	Additional guidance	Mark
(ii)	Any two from: (forces are) equal / same size (1) (forces are) opposite (direction) (1) (forces) act on different bodies (1) same type of force (1)	no marks awarded for answers in terms of energy (forces are) one to the left, one to the right one (force) acts on racket, one acts on ball both are contact forces if no other marks awarded, allow action and reaction (acting) for 1 mark	**(2)** **AO1**

Q9.

Question Number	Answer	Additional guidance	Mark
(i)	substitution in $v^2 - u^2 = 2ax$ (1) $24^2 - 7.6^2 = 2 \times 3 \times x$ rearrangement (1) $(x =) \frac{24^2 - 7.6^2}{6}$ evaluation (1) 86 (m)	accept rearrangement and substitution in either order allow numbers that round to 86 (m) award full marks for the correct answer without working	**(3)**

Question Number	Answer	Additional guidance	Mark
(ii)	recall and substitution (1) $(a = \frac{v - u}{t})$ $3.0 = \frac{24 - 7.6}{t}$ rearrangement (1) $t = \frac{v - u}{a}$ OR $(t =) \frac{24 - 7.6}{3.0}$ evaluation (1) 5.5 (s)	Allow alternative method: average speed = distance / time i.e. 15.8 = 86(.37) / time (t =) 86(.37) / 15.8 allow numbers that round to 5.5 (s) OR numbers that round to 5.4 if using alternative method and distance = 86 award full marks for the correct answer without working no marks for t = d / (v-u) = 86(.37) / (24-7.6) giving 5.3 s as an answer	**(3)**

Q10.

Question number	Answer	Additional guidance	Mark
	Two stage calculation substitution$_1$ (1) $(v^2 - 0 =) 2 \times 10 \times 3.8$ evaluation of v (1) $(v =)$ 8.7 (m/s) substitution$_2$ (1) $0.40 = m \times 8.7$ rearrangement and evaluation (1) $(m =)$ 0.046 (kg)	 use of $v^2 - u^2 = 2ax$ OR $\frac{1}{2} mv^2 = mgh$ 76 allow numbers that round to 8.7 e.g. 8.718 use of $p = mv$ allow numbers that round to 0.046 e.g. 0.04598 award full marks for correct answer without working.	**(4) AO2**

Q11.

Question number	Answer	Additional guidance	Mark
	substitution (1) $(t^2=)\ \frac{2 \times 1.4}{10}$ evaluation (1) $(t =)$ 0.53 (s)	 0.28 allow numbers that round to 0.53 e.g. 0.52915 award full marks for correct answer without working.	**(2)** **AO2**

Q12.

Question Number	Answer	Additional guidance	Mark
	rearrangement (1) $a = \frac{(v^2-)u^2}{2x}$ substitution (1) $a = \frac{(-)15^2}{2 \times 14}$ evaluation (1) deceleration = 8(.04) (m/s^2)	 rearrangement and substitution in either order 225/28 for 2 marks accept – 8(.04) award full marks for the correct answer with no working	**(3)** AO 2 1

Q13.

	substitution: 0.5 × 18 (1) evaluation 9.0 (1)	 9	**(2)**

		give full marks for correct answer no working	

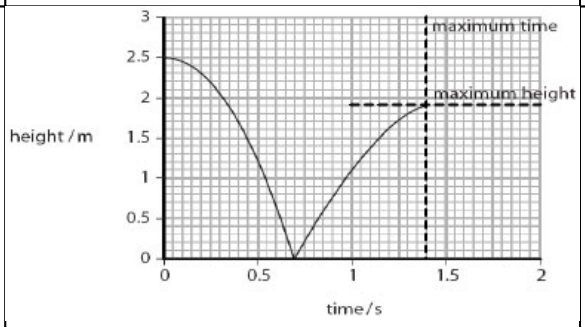
Q14.

Question number	Answer	Additional guidance	Mark
(a)	Rearrangement (1) $m = \frac{f}{a}$ Substitution and conversion (1) $m = \frac{1870}{1.83}$ Answer and rounding to 3 s.f. (1) 1020 (kg)	maximum 2 marks if kN not converted to N award full marks for correct numerical answer without working	**(3)**

Question number	Answer	Additional guidance	Mark
(b)	Rearrangement of $\frac{(v-u)}{t} = a$ (1) $v = u + at$ Substitution (1) $v = 0 + 1.83 \times 16$ Answer (1) 29.3 (m/s)	award full marks for correct numerical answer without working	**(3)**

Question number	Answer	Mark
(c)	Correctly identifies data points from the graph to calculate areas (1) Calculates area under AB (1) 240 m Calculates area under CD (1) 135 m distance travelled at constant speed = 240 m is greater than distance travelled when slowing down = 135 m (1)	**(4)**

Q15.

	Answer	Acceptable answers	Mark
(a)(i)	2.5 (m)	Allow answers between (and including) 2.45 & 2.55	**(1)**
(a)(ii)	0.7 (s)	Allow answers between (and including) 0.68 & 0.72	**(1)**
(a)(iii)	 line: same shape as original (1) peak at 1.9 m (1) time taken < 0.7 s (1)	Ignore any part of the graph after the peak	**(3)**
(a)(iv)	An explanation linking: <u>energy</u> lost (1) in collision with ground / air resistance (1)	Inelastic collision worth (2) as sound or heat	**(2)**
(b)(i)	shown using data Any two from kinetic energy before = 12.5 + 0 (=12.5) (1) kinetic energy after = 4.5 + 8 (=12.5) (1) Kinetic energy is the same before and after the collision (1)	Kinetic energy is conserved/no energy lost	**(2)**
(b)(ii)	cyclotron (1)	named particle accelerator accept CERN	**(1)**

Q16.

Question Number	Answer	Mark
*	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. **AO1 (6 marks)** • momentum = mass × velocity • action and reaction are equal and opposite (N 3) • force of R on Q = -force of Q on R • $\frac{\text{change in momentum of Q}}{\text{time}} = -\frac{\text{change in momentum of R}}{\text{time}}$ • time of collision same for both • change in momentum of Q = - change in momentum of R • no overall change in momentum • R accelerates because of force from Q • transfer of momentum between Q and R	**(6)** AO 1 1

Level	Mark	Descriptor
	0	• No rewardable material.
Level 1	1-2	• An explanation that demonstrates elements of physics understanding, some of which is inaccurate. Understanding of scientific ideas lacks detail. (AO1) Presents an explanation with some structure and coherence. (AO1)
Level 2	3-4	• An explanation that demonstrates physics understanding, which is mostly relevant but may include some inaccuracies. Understanding of scientific ideas is not fully detailed and/or developed. (AO1) • Presents an explanation that has a structure which is mostly clear, coherent and logical. (AO1)
Level 3	5-6	• An explanation that demonstrates accurate and relevant physics understanding throughout. Understanding of the scientific ideas is detailed and fully developed. (AO1) • Presents an explanation that has a well-developed structure which is clear, coherent and logical. (AO1)

Q17.

	Answer	Acceptable answers	Mark

(a)(i)	momentum = 0.03 × 170 (1)	Accept 5.1 seen	**(1)**
(a)(ii)	momentum before = momentum after (1) 5.1 = 0.83 × v (1) v = 6.1 (m/s) (1)	allow 5.0 = 0.80 x v for 1 mark max 5.0 = 0.83 × v v = 6.0 (m/s) allow ecf from (a)(i) give full marks for correct answer, no working	**(3)**
(a)(iii)	Statement to include any two from • kinetic energy is not conserved (1) • (lost ke) appears as heat/sound (1) • momentum is conserved (1)	 ke not conserved / some ke lost no momentum lost	**(2)**
(b)(i)	an explanation linking • momentum (must be) conserved (1) • so must have positive and negative momentum (1)	 photons move in opposite directions indication of movement in opposite directions (e.g. opposite velocities)	**(2)**
(d)(ii)	E = (2 ×) 9.1 × 10^{-31} × [3 × 10^{8}]^{2} (1) = 1.6 × 10^{-13} (J) (1)	8.2 × 10^{-14} (0.82 × 10^{-13}) for 1 mark give full marks for correct answer, no working	**(2)**

Q18.

Question Number	Answer	Additional guidance	Mark
	□ B centripetal force **The only correct answer is B (correct term for circular motion)** **A** is not correct – incorrect term **C** is not correct – incorrect term **D** is not correct – incorrect term		**(1)**

Q19.

Question Number	Answer	Acceptable answers	Mark
(a)(i)	Circular/spiral/circle		**(1)**

Question Number	Answer	Acceptable answers	Mark
(a)(ii)	An explanation linking three of the following. • (fast moving) <u>protons</u> (1) • absorbed by (1) • nuclei (1) • (produces)unstable nuclei (1)	bombard / hit /strike / collide with stable atoms / stable element	**(3)**

Question Number	Answer	Acceptable answers	Mark
(b)(i)	B momentum		**(1)**

Question Number	Answer	Acceptable answers	Mark
(b)(ii)	(Momentum/it)equals mass x <u>velocity</u>	p = m x v kilograms / kg is the mass and metres per second / m/s is the <u>velocity</u> Accept "times" for x	**(1)**

Question Number		Indicative Content	Mark
QWC	*** (b) (iii)**	An explanation including some of the following points Diagram 1 • Moving in opposite directions before collision • inelastic collision • stationary after collision • momentum zero after collision • (therefore) total momentum must have been zero before collision • (therefore) cars were moving at the same speed in opposite directions (assuming cars have equal mass) • both cars had kinetic energy before the collision • KE zero after collision • KE converted into heat, sound, elastic potential energy etc. Diagram 2 • Elastic collision / almost elastic collision • Momentum conserved • Momentum transferred from first to last sphere • KE conserved / almost conserved • (because)last sphere reaches same height as first sphere • Three spheres always have zero momentum • Small amount of energy transferred to sound/heat	**(6)**

Level	**0**	No rewardable content
1	**1 - 2**	• A limited analysis of ONE collision which is given by a correct statement e.g. In collision 1, kinetic energy has been lost OR In collision 2 momentum is transferred from the first to the last sphere. • the answer communicates ideas using simple language and uses limited scientific terminology • spelling, punctuation and grammar are used with limited accuracy
2	**3 - 4**	• a simple analysis of BOTH collisions considering BOTH momentum AND kinetic energy correctly for each one e.g. In collision 1, momentum is conserved and the kinetic energy of the cars changes. In collision 2, momentum and the kinetic energy is conserved. • answer communicates ideas showing some evidence of clarity and organisation and uses scientific terminology appropriately • spelling, punctuation and grammar are used with some accuracy
3	**5 - 6**	• a detailed analysis of BOTH collisions considering momentum AND kinetic energy for each collision correctly for each AND detailed reference to EITHER diagram. e.g. In collision 1, the momentum before and after the collision is zero because momentum is always conserved, but the KE is lost. In collision 2, all the momentum and KE is transferred to the last sphere because it gets to the same height as the first one. • the answer communicates ideas clearly and coherently uses a range of scientific terminology accurately • spelling, punctuation and grammar are used with few errors

(Total marks for question = 12 marks)

Q20.

	Answer	Additional guidance	Mark
(i)	a description using any **four** of the following points in a logical order: measure the mass / weight of the trolley(s) / weigh the trolley(s) (1) determine the speed of trolley A (1) put one light gate (connected to data logger) further down the runway than trolley A and another beyond trolley B (1) trollies A and B stick together (1) measure combined velocity / speed of A and B (1) calculate momentum of trolley A before collision **and** A and B after collision (1) check for equality / velocity after collision is half that before collision (1) repeat **and** take mean / average (1)	 allow determine / find / calculate use (average) speed = distance / time to calculate speed of trolley A may be shown on diagram measure distance and time in appropriate places calculate (total) momentum before and after collision (total) momentum before equals (total) momentum after	**(4)** **AO1**

	Answer	Additional guidance	Mark
(ii)	{compensating for / reducing **effect** of / overcoming / balancing / cancelling **effect** of} friction OR so that trolley A travels at a constant speed / doesn't slow down	do not accept reducing / cancelling friction do not accept so trolley accelerates down slope	(1) AO3

Q21.

Question number	Answer	Additional guidance	Mark
	A description to include: measurement of (relevant) distance (1) measurement of (relevant) time (1) use of speed = $\frac{\text{distance}}{\text{time}}$ (1) detail (1)	 one of distance down slope or distance along bench or length of toy car/card 'record the distance the car travels and time it' scores 2 marks For example: speed down slope × 2 mark distance along bench use a light gate speed gun at the bottom of the slope Repeating AND averaging	(4)

Q22.

Question Number	Answer	Additional guidance	Mark
	A description including: measure appropriate distance (1) measure appropriate time (1) use (average) speed = $\frac{\text{distance}}{\text{time}}$ (1)	 e.g. distance along runway from max height to P e.g. start the watch when trolley stops stop the watch when trolley hits spring accept $s = \frac{d}{t}$	**(3)**

Q23.

	Answer	Acceptable answers	Mark
(a)(i)	B it decreases		**(1)**
(a)(ii)	C it does not change		**(1)**
(b)(i)	horizontal arrow (judge by eye), pointing to the right **anywhere** on the diagram 		**(1)**
(b)(ii)	substitution: (1) 130 000 × 75	give full marks for correct answer, no working	**(2)**

	evaluation: (1) 9 750 000 (kgm/s) (Ns)	Ignore minus sign 9.75×10^6 (kgm/s) (Ns)	
(b)(iii)	9 750 000 kgm/s	same value as answer to (b)(ii) Ignore minus sign	**(1)**
(c)(i)	An explanation linking two of the following: • force is smaller/less (1) • momentum changes more slowly (1) • lower deceleration (1) • use of the formula (1)	pressure is smaller/less slower deceleration force is proportional to rate of change of momentum/F= (mv – mu)/t	**(2)**
(c)(ii)	Any two from: (for loaded aircraft) • has more mass (1) • has more momentum (1) • has more k.e. (1) • higher velocity • brakes need to do more work (1)	accept reverse argument for empty aircraft heavier/more passengers/more cargo higher speed/moving faster	**(2)** **expert**

Total marks for question = 10 marks

Q24.

	Answer	**Acceptable answers**	**Mark**
(a)	kinetic (energy)	Movement (energy) KE	**(1)**
(b)	substitution: 0.6 × 20 (1) evaluation 12 (1) J (1)	give 2 marks for correct answer no working unit is an independent mark joules, Nm, kgm^2/s^2 , Ws	**(3)**
(c)	substitution: 0.5 × 18 (1) evaluation 9.0 (1)	9 give full marks for correct answer no working	**(2)**

	Indicative Content	

QWC	***(d)**	a description including some of the following points: • chemical to kinetic while in his hand • kinetic (gradually) to potential while rising / fr • eventually all potential at 10 m with a little the energy • some mention of conservation of energy • potential (gradually) to kinetic as falls / 10 m-0 • with a little more thermal (heat) energy • at 0 m sound energy • at 0 m thermal (heat) energy

Level	**0**	No rewardable content
1	**1 - 2**	• a limited description which identifies a change in one relevant type energy or a transfer of energy from one form to another e.g. kinetic energy increases OR kinetic energy changes to sound. • the answer communicates ideas using simple language and uses limited scientific terminology • spelling, punctuation and grammar are used with limited accuracy
2	**3 - 4**	• a simple description giving detail of a relevant energy change/transfer e.g. kinetic energy changes into potential energy as it moves upwards OR kinetic energy increases as it falls. • the answer communicates ideas showing some evidence of clarity and organisation and uses scientific terminology appropriately • spelling, punctuation and grammar are used with some accuracy
3	**5 - 6**	• a detailed description of a sequence of relevant energy changes /transfers e.g. kinetic energy is transferred into potential energy as it rises. This then changes back into kinetic energy as it falls back down. • the answer communicates ideas clearly and coherently uses a range of scientific terminology accurately • spelling, punctuation and grammar are used with few errors

Q25.

Question number	Answer	Additional guidance	Mark
(a)(i)	0.45 (s) (1)	Allow any value ≥ 0.4 and ≤ 0.5	**(1)**

Question number	Answer	Additional guidance	Mark
(a)(ii)	An explanation that combines improvement of the experimental procedure (1 mark) and justification/reasoning which must be linked to the improvement (1 mark) • take pictures more frequently (1) • in order to determine exact time of the release. (1)	other responses may be acceptable	**(2)**

Question number	Answer	Additional guidance	Mark
(a)(iii)	Substitution (1) F = 7.26 x 20.6 Evaluation (1) 150 (N)	Accept 149.6 (N) full marks will be awarded for correct numerical answer without working	(2)

Question number	Answer	Additional guidance	Mark
(a)(iv)	Rearrangement (1) v = a x t Substitution (1) v = 23 x 0.48 Evaluation (1) 11 m/s	Accept 11.04(m/s) full marks will be awarded for correct numerical answer without working	(3)

Question number	Answer	Additional guidance	Mark
(b)	Substitution (1) PE = 7.26 x 10 x 1.3 Evaluation (1) 94.4 (J)		(2)

Q26.

Question number	Answer	Additional guidance	Mark
	An explanation linking any four from force(s) associated with change(s) in momentum (use of Newton's second law) (1) detail of momentum changes, involving time (1) time of collision is same for both (1) (therefore) momentum change is the same for both (1) equal and opposite forces mean equal and opposite momentum changes (1) (total) momentum before a collision = (total) momentum after collision (1) (conservation of momentum requires) no external forces acting (1)	$F = \frac{(mv-mu)}{t}$ $F=ma$ $\frac{m_1v_1 - m_1u_1}{t} = -\frac{(m_2v_2 - m_2u_2)}{t}$ with explanation leading to $m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$ for both marks	**(4)** **Exp**

Q27.

Question number	Answer	Additional guidance	Mark
	An explanation that combines up to 3 points of application of knowledge and reasoning/justification • Momentum increased if final velocity can be increased (1) • Distance (while in athlete's hand) is greater (1) • Time whilst subject to force is longer (1) • using the equation F = (mv-mu)/t (1)	Ignore references to shot after it has left the athletes hand accelerating for a longer time use of $v = u + at$ or use of $v^2-u^2 = 2ax$	**(3)**

Q28.

Question number	Answer	Additional guidance	Mark
	An explanation linking three of: acceleration increases (1) as F = ma (1) (and) mass decreases (1) due to burning/using fuel (1)	 independent mark	**(3)** **AO1**

Q29.

Question number	Answer	Additional guidance	Mark
(i)	(students') reaction time (is significant compared with recorded time) (1)	g is really 9.8	**(1)** **AO2**

Question number	Answer	Additional guidance	Mark
(ii)	**One** from use light gates (1) use automatic timer (1) Use time lapse/ stroboscopic photography (1) drop from greater height (1)	 ignore repeats or more people	**(1)** **AO3**

Q30.

	Answer	Additional guidance	Mark
(i)	an explanation linking **two** from: (wet road means) less / no friction (between tyres and road) (1) (wet weather means) increased stopping distance (1) (slower speed means) shorter braking / stopping distance (1) (dry weather / slower speed) reduces possibility of skidding / sliding / idea of losing control / crashing (1)	accept reverse arguments throughout accept (road) more slippery / less grip accept idea of reduced visibility accept braking or thinking distance in this context accept takes longer to slow down / stop ignore harder to brake	**(2)** **AO1**

	Answer	Additional guidance	Mark
(ii)	convert **either** distance or time (1) (31 m =) $\frac{31}{1000}$ (km) or 0.031 (km) **OR** (1 s =) $\frac{1}{3600}$ (h) = $\frac{1}{60\times60}$ (h) or 0.000 28 (h) evaluation (1) (31 m/s =) 110 (km/h)	(130 km =) 130 × 1000 (m) or 130 000 (m) **OR** (1 h =) 60 x 60 (s) or 3600 (s) (130 km/h =) 36(.1) (m/s) accept 111.6 or 112 (km/h) for 2 marks ` accept 1860 m/min and 2167 m/min for 1 mark each award full marks for the correct answer without working	**(2)** **AO2**

	Answer	Additional guidance	Mark
(iii)	select and substitute into distance travelled = average speed x time (1) 46 = 31 x t rearrangement and evaluation (1) (t=) 1.48(3) (s) evaluation given to 2 sf (1) (t =) 1.5 (s)	 $31 = \frac{46}{t}$ $(t =) \frac{46}{31}$ award two marks for the correct evaluation without working any answer written to 2 sf independent mark 1.5 scores 3 marks 1.4 scores 2 marks 1.50 scores 2 marks 0.67 scores 2 marks 1400 scores 2 marks 0.673(9) scores 1 mark 1426 scores 1 mark	**(3)** **AO2**

Q31.

Question number	Answer	Additional guidance	Mark
(i)	An explanation that combines identification - knowledge (1 mark) and reasoning/justification - understanding (1 mark): • unbalanced / resultant force (1) • (provided by) tension in the string / (weight of) metal disc (1)		**(2)**

Question number	Answer	Additional guidance	Mark
(ii)	substitution into speed = d/t (1) 1.15 = d / 0.04 (1) evaluation (1) d = 0.046m = 4.6 cm (1)	full marks will be awarded for correct numerical answer without working	(2)

Question number	Answer	Additional guidance	Mark
(iii)	using $V^2 - u^2 = 2ax$ $V^2 = 1.15^2$ $= 1.3225$ (1) $2 \times a \times x = 2 \times 1.2 \times 0.55$ $= 1.32$ (1)	allow 1.3225 allow solving $V^2 - u^2 = 2ax$ for a	(2)

Q32.

	Answer	Acceptable answers	Mark
(i)	shown using data Any two from kinetic energy before = 12.5 + 0 (=12.5) (1) kinetic energy after = 4.5 + 8 (=12.5) (1) Kinetic energy is the same before and after the collision (1)	Kinetic energy is conserved/no energy lost	(2)
(ii)	cyclotron (1)	named particle accelerator accept CERN	(1)

Q33.

		Indicative Content	

QWC	*	An explanation including some of the following ideas • brakes apply a force to the car • this force from brakes makes the car decelera velocity • a force also acts on the driver • driver decelerates at same rate as the car • does not move with respect to car/ stays in the • moves slightly because belt stretches • small/ no horizontal force acts on the shopping • shopping bag continues at similar/ same veloc • until shopping bag falls off seat / hits dashboa • ideas can be expressed in terms of energy, mo and/or by reference to Newton's laws

Level	**0**	No rewardable content
1	**1 - 2**	• A limited explanation of the difference in decelerations of at least two of the objects Car **(C)**, Shopping **(S)**and Passenger **(P)**mainly describing the effects. E.g. (at start) **C**stops (very quickly) while {**P / S**} carries on moving (for a longer time) OR **S**{carries on at same speed / hits the dashboard} while **P**is {held back / slowed down} (by the seatbelt) • the answer communicates ideas using simple language and uses limited scientific terminology • spelling, punctuation and grammar are used with limited accuracy
2	**3 - 4**	• A simple explanation of the difference in decelerations of at least **two**of the objects Car, Shopping and Passenger, including a reason for at least one of the decelerations. E.g.(at start) **C**stops (very quickly) **because of**friction at the brakes and at the road while {**P / S**} carries on moving (for a longer time) OR **S**{carries on moving (at same speed) / hits the dashboard} while **P**is {held back / slowed down} **because of**stretching force from the seatbelt) • the answer communicates ideas showing some evidence of clarity and organisation and uses scientific terminology appropriately • spelling, punctuation and grammar are used with some accuracy
3	**5 - 6**	• A detailed explanation of the relative decelerations of **C**, **S and P**including mention of the physical principles involved in any two such as that named forces are needed to change given motions. E.g. (The force of) friction is large for **C**to {slow down / stop} quickly but is low for **P**and **S**. {**So / thus / therefore etc**} **P**or **S**carry on at the same speed (initially). **P**decelerates more slowly than **C**{**because / as a result etc**} of the stretching (force) of the seatbelt. OR *The idea of {*Newton's first law / inertia / need for a force to change motion} and the role of friction and {elastic / tension / stretching} force in producing the **three**named decelerations. OR

		Named force needed for a described change in {momentum/kinetic energy} to {stop / slow down} each of the **three** objects. • the answer communicates ideas clearly and coherently uses a range of scientific terminology accurately • spelling, punctuation and grammar are used with few errors	

Q34.

	Answer	**Acceptable answers**	**Mark**
(a) (i)	D the same size as the driving force		**(1)**
(a) (ii)	transposition: (1) {change in) speed= acceleration × time substitution: (1) speed = 12 × 4 evaluation: (1) 48 (m/s) (1)	transposition and substitution can be in either order substitution mark can be scored when incorrectly transposed word/symbol equation is given Give full marks for correct answer no working	**(3)**
(b)	An explanation linking • {acceleration of sports is 2x / time to reach 30 m/s is ½} that of family car / RA (1) • mass of sports car LESS than ½ that of family car or RA (1) (so resultant force required is less)	Attempt to use f = m × a scores one mark e.g. 4200 <u>OR</u> 3600 scores 1 Correct numerical comparison scores both marks e.g. 4200:3600 numerically or in words scores 2 marks	**(2)**

		Indicative Content	
QWC	***(c)**	An explanation including some of the following ideas • brakes apply a force to the car • this force from brakes makes the car decelera velocity • a force also acts on the driver	

			• driver decelerates at same rate as the car • does not move with respect to car/ stays in the • moves slightly because belt stretches • small/ no horizontal force acts on the shopping • shopping bag continues at similar/ same veloc • until shopping bag falls off seat / hits dashboa • ideas can be expressed in terms of energy, mo and/or by reference to Newton's laws
Level	**0**	No rewardable content	
1	**1 - 2**	• A limited explanation of the difference in decelerations of at least two of the objects Car **(C)**, Shopping **(S)**and Passenger **(P)**mainly describing the effects. E.g. (at start) **C**stops (very quickly) while {**P / S**} carries on moving (for a longer time) OR **S**{carries on at same speed / hits the dashboard} while **P**is {held back / slowed down} (by the seatbelt) • the answer communicates ideas using simple language and uses limited scientific terminology • spelling, punctuation and grammar are used with limited accuracy	
2	**3 - 4**	• A simple explanation of the difference in decelerations of at least **two**of the objects Car, Shopping and Passenger, including a reason for at least one of the decelerations. E.g.(at start) **C**stops (very quickly) **because of**friction at the brakes and at the road while {**P / S**} carries on moving (for a longer time) OR **S**{carries on moving (at same speed) / hits the dashboard} while **P**is {held back / slowed down}**because of**stretching force from the seatbelt) • the answer communicates ideas showing some evidence of clarity and organisation and uses scientific terminology appropriately • spelling, punctuation and grammar are used with some accuracy	
3	**5 - 6**	• A detailed explanation of the relative decelerations of **C**, **S and P**including mention of the physical principles involved in any two such as that named forces are needed to change given motions. E.g. (The force of) friction is large for **C**to {slow down / stop} quickly but is low for **P**and **S**. {**So / thus / therefore etc**}**P**or **S**carry on at the same speed (initially). **P**decelerates more slowly than **C**{**because / as a result etc**} of the stretching (force) of the seatbelt. OR *The idea of* {Newton's first law / inertia / need for a force to change motion} and the role of friction and {elastic / tension / stretching} force in producing the **three**named decelerations. OR Named force needed for a described change in {momentum/kinetic energy} to {stop / slow down} each of the **three**objects. • the answer communicates ideas clearly and coherently uses a range of scientific terminology accurately • spelling, punctuation and grammar are used with few errors	

Q35.

Question number	Indicative content	Mark
*	The indicative content below is not prescriptive and candidates are not required to include all of the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. **A01 (6 marks)** • force needed to keep an object moving in a circle • when moving in a circle, direction of velocity changes • must be an acceleration • moving in a straight line with no resultant force at constant velocity **A02 (6 marks)** • the woman changing direction while circling the man • she is changing velocity (but not changing speed) • therefore she is accelerating • this requires a force towards the centre of her orbit • this is a centripetal force • when the man releases the woman, the centripetal force ceases • there is no resultant force on the woman (if friction from the ice can be ignored) • the woman therefore continue in a straight line • she is now travelling at a constant velocity	**(6)**

Level	Mark	Descriptor
	0	No awardable content
Level 1	1-2	• Demonstrates elements of physics understanding, some of which is inaccurate. Understanding of scientific ideas lacks detail. (AO1) • The explanation attempts to link and apply knowledge and understanding of scientific ideas, flawed or simplistic connections made between elements in the context of the question. (AO2)
Level 2	3-4	• Demonstrates physics understanding, which is mostly relevant but may include some inaccuracies. Understanding of scientific ideas is not fully detailed and/or developed. (AO1) • The explanation is mostly supported through linkage and application of knowledge and understanding of scientific ideas, some logical connections made between elements in the context of the question. (AO2)
Level 3	5-6	• Demonstrates accurate and relevant physics understanding throughout. Understanding of the scientific ideas is detailed and fully developed. (AO1) • The explanation is supported throughout by linkage and application of knowledge and understanding of scientific ideas, logical connections made between elements in the context of the question. (AO2)

Q36.

Question Number	Answer	Acceptable answers	Mark
(i)	Substitution $\frac{90}{1000}$ x 3.3 (1) evaluation 0.30 (N) (1)	 A value which rounds to 0.30 eg 0.297 Give full marks for correct answer with no working Ignore power of ten error until evaluation Allow 1 mark for 297 even with no working shown	**(2)**

Question Number		Indicative Content	Mark
QWC	***(ii)**	An explanation demonstrating some of the following: Descriptions of the graph • Accelerates upwards during stage1 • Maximum velocity is reached at the end of stage 1 • Accelerates downwards / decelerates during stage 2 • Accelerates during stage 3 • Comes to rest during stage 4. Interpretations of the shape of the graph • Fuel is burnt creating thrust in stage • Thrust is upwards in stage 1/ • Gravity/weight (is always) a downward force • Fuel runs out at end of stage 1/ has ran out by stage 2 • Still going up during/ max height at end of stage 2 • Starts to fall at start of stage 3 • Negative velocity during stage 3 because it is falling. • Rapid deceleration / collision with the ground during stage 4/end of stage 3 Explanations for changes in velocity • Resultant force upwards/ thrust greater than gravity force during stage 1 • Acceleration non-linear because mass is decreasing / resultant force is increasing • Linear deceleration in stage 2/3 because force of gravity is constant • Resultant downward force/only gravity/ weight is acting during stage 2 and 3 • Large resultant force of impact during stage 4	**(6)**

Level	0	No rewardable content
1	1 - 2	• A limited explanation involving descriptions of the graph. • E.g. The rocket gets faster as it goes up during stage 1. The rocket slows down during stage 2 • the answer communicates ideas using simple language and uses limited scientific terminology • spelling, punctuation and grammar are used with limited accuracy
2	3 - 4	• A simple explanation involving interpretations of the shape of the graph e.g. The rocket's velocity increases during stage 1 because the burning fuel provides a force. The rocket accelerates downwards during stage 3 • the answer communicates ideas showing some evidence of clarity and organisation and uses scientific terminology appropriately • spelling, punctuation and grammar are used with some accuracy
3	5 - 6	• A detailed explanation which includes descriptions and interpretations for the shape of the graph including an explanation. E.g. The rocket's acceleration during stage 1 is increasing because it is losing mass as the fuel is burnt. It then slows down until it reaches maximum height at the end of stage 2 • the answer communicates ideas clearly and coherently uses a range of scientific terminology accurately • spelling, punctuation and grammar are used with few errors

Q37.

Question Number	Answer	Acceptable answers	Mark
(i)	force (1)	If than one word given then 0 marks.	**(1)**

Question Number	Answer	Acceptable answers	Mark
(ii)	B 0.07kg		**(1)**

Question Number	Answer	Acceptable answers	Mark
(iii)	Arrow pointing (vertically) upwards (1) Value of 1.2 (N) (written near to arrow) (1)	Marks are independent of each other	**(2)**

Q38.

Question number	Answer	Additional guidance	Mark
(i)	4.4 m/s ^{2}		(1)

Question number	Answer	Additional guidance	Mark
(ii)	graph (if projected back) does not pass through origin OWTTE (1)	accept not a straight line	(1)

Question number	Answer	Additional guidance	Mark
(iii)	An answer that combines the following points to provide a plan/method: • raise left hand end of runway (1) • (so that) force of gravity on trolley will balance frictional forces (1)	(so that) trolley travels at constant speed when given a small push	(2)

Q39.

	Answer	Acceptable answers	Mark
(a)	Description including 3 of the following: • (Gravitational) potential energy (transferred) to KE(1) • Idea of energy transfer to heat/sound whilst descending (1) • Chemical energy is transferred to heat energy in Andrew (1) • Idea of energy dissipated on stopping (1)	(G)PE (transferred) to KE Allow gravitational energy for GPE Energy transferred to heat because of air resistance/ friction The energy goes to heat as he stops. Energy is transferred to the surroundings	**(3)**
(b)(i)	substitution (1) 67 × 31 evaluation (1) 2077 (kg m/s)	2080, 2100 working backwards using 2000 (v=) 29.85, 30 (m=) 64.52, 65 67 X 31=2000 scores only one mark	**(2)**

(b)(ii)	substitution (1) 2000 ÷ 2.3 evaluation (1) 870 (N)	answer to (b)(i)) ÷ 2.3 900, 869.6, 869.5 903	**(2)**
(b)(iii)	an explanation linking two of the following • Force on Andrew is quite small (1) • Because impact time is long (1) • The acceleration/deceleration is quite small (1) • Because impact distance is far (1)	force is reduced/ less /not as strong slows down/changes momentum gradually acceleration = 1.35 'g' or 13.5 m/s^2 slows down (rate of) change of momentum scores 2 marks	**(2)**

Total question = 8 marks

Q40.

Question number	Answer	Additional guidance	Mark
(i)	**C** 7.7×10^9 kg m/s Only one correct power of 10. The other answers are all distractors involving students misappropriating 'kilos' in some way, either in kilograms or form kilometres		**(1) comp**

Question number	Answer	Additional guidance	Mark
(ii)	rearrangement and substitution (1) $v = \frac{\text{momentum change}}{\text{mass}}$ $= \frac{7.5\ (\times 10^{10})}{8(.0)\ (\times 10^{6})}$ evaluation (1) 9.4×10^{3} / number that rounds to 9.4×10^{3} (m/s)	$v = \frac{p}{m}$ e.g. 9375, 9.375×10^{3} 9400 (m/s) 9.4 km / s award full marks for the correct answer without working award 1 mark for 9.4 to any other power of 10	(2) exp

Q41.

Question number	Answer	Mark
	☒ **B** force Options A, C and D are all scalars.	(1)

Q42.

Question Number	Answer	Additional guidance	Mark
	an explanation linking: use an electronic timer / (1) to eliminate reaction time (1)	 light gate/ data logger there are other options which should be judged to this pattern (e.g. increase distance to reduce effect of reaction time)	**(2)** AO 3 3b

Q43.

Question number	Indicative content	Mark
	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. **AO2 (strand 2) (6 marks)** <u>Determining force</u> • Use of F = (mv - mu)/t or F =ma • mass (of trolley(s)) needed • and times during impact (t) <u>Showing effect of crumple zone</u> • experiment repeated with and without the spring • (note) difference in contact times • use of spring as crumple zone • with spring, time for contact greater, less impact force <u>Precautions or controls</u> • times repeated and average taken • careful controls – same starting position / same angle of slope / release without pushing etc.	**(6)Exp**

Level	Mark	Descriptor
	0	• No awardable content
Level 1	1-2	• The explanation attempts to link and apply knowledge and understanding of scientific enquiry, techniques and procedures, flawed or simplistic connections made between elements in the context of the question. • Lines of reasoning are unsupported or unclear. (AO2)
Level 2	3-4	• The explanation is mostly supported through linkage and application of knowledge and understanding of scientific enquiry, techniques and procedures, some logical connections made between elements in the context of the question. • Lines of reasoning mostly supported through the application of relevant evidence. (AO2)
Level 3	5-6	• The explanation is supported throughout by linkage and application of knowledge and understanding of scientific enquiry, techniques and procedures, logical connections made between elements in the context of the question. • Lines of reasoning are supported by sustained application of relevant evidence. (AO2)

SUMMARY, for guidance			
Level	**Mark**	**Additional Guidance**	**General additional guidance – the decision within levels** e.g. - At each level, as well as content, the scientific coherency of what is stated will help place the answer at the top, or the bottom, of that level.
	0	No rewardable material.	
Level 1	1–2	Additional guidance Elements of physics present i.e. isolated knowledge of techniques and procedures – **two** unconnected statements from any section	Possible candidate responses Use F = (mv - mu)/t Use F = ma keep slope the same repeat and average use spring as crumple zone
Level 2	3–4	Additional guidance Some knowledge of techniques and procedures with a logical connection made in one section and statement from one more section	Possible candidate responses Measurements (difference in contact times) with and without the spring Use F = ma in finding the force
Level 3	5–6	Additional guidance Detailed knowledge of techniques and procedures with logical connections made in two sections and statement from one more section	Possible candidate responses Measure the trolley mass(es)/ velocities/ impact time(s) and use F = ma in finding the force Measurements (difference in contact times) with and without the spring Same starting place for trolley each time.

Q44.

Question number	Answer	Additional guidance	Mark
(a)	An answer that combines the following points of understanding to provide a logical description: • measurement of time between(or at) two positions using suitable timing equipment (1) • measurement of suitable distance along the runway with metre rule (1) • measurement of vertical height to starting position (1) • repeats AND averages AND use of a correct equation (1)	allow stopwatch, light gates minimum is 0.5 m metal tape measure average speed = distance/time OR average speed = (speed at A − speed at B)/2	(4)

Question number	Answer	Additional guidance	Mark
(b)(i)	Substitution of correct data from graph and mass conversion (1) $0.5 \times 0.65 \times (0.61)^2$ Answer (1) 0.12 (J)	maximum of 1 mark if mass in g used allow tolerance of ±0.2 for speed	(2)

Question number	Answer	Additional guidance	Mark
(b)(ii)	• Tangent to the graph at h = 0.1 (1) • Answer in the region 3.5 to 3.6	either seen on graph or suitable pairs of values of Δv and Δh	(2)

Question number	Answer	Mark
(b)(iii)	An answer that combines points of interpretation/evaluation to provide a logical description: • for each change in height, as the height increases the speed of the trolley increases • the greatest change in speed is between the change in height from 0.04 m to 0.9 m	(2)

Question number	Answer	Additional guidance	Mark
(c)	An answer that combines the following points to provide a logical description of the plan/method/experiment: • identifies control variables (1) • uses at least 3 different surfaces (1) • calculates average speed for each surface and repeats (1)	constant height, constant slope, constant starting points and same length of surface	(3)

Q45.

	Answer	Acceptable answers	Mark
(i)	horizontal arrow (judge by eye), pointing to the right **anywhere** on the diagram 		(1)
(ii)	substitution: (1) 130 000 × 75 evaluation: (1) 9 750 000 (kgm/s) (Ns)	give full marks for correct answer, no working Ignore minus sign 9.75×10^6 (kgm/s) (Ns)	(2)
(iii)	9 750 000 kgm/s	same value as answer to (b)(ii) Ignore minus sign	(1)

Q46.

	Answer	Acceptable answers	Mark
(i)	An explanation linking two of the following: • force is smaller/less (1) • momentum changes more slowly (1)	pressure is smaller/less slower deceleration force is proportional to rate of change of	(2)

	• lower deceleration (1) • use of the formula (1)	momentum/F= (mv – mu)/t	
(ii)	Any two from: (for loaded aircraft) • has more mass (1) • has more momentum (1) • has more k.e. (1) • higher velocity • brakes need to do more work (1)	accept reverse argument for empty aircraft heavier/more passengers/more cargo higher speed/moving faster	**(2)** **expert**

Q47.

Question Number	Answer	Additional guidance	Mark
(i)	substitution (1) $\frac{2x2.5}{0.74^2}$ evaluation (1) 9.1(3) (m/s^2)	 $\frac{5}{0.5476}$ award full marks for the correct answer with no working	**(2)** AO 2 1

Question Number	Answer	Additional guidance	Mark
(ii)	(0.74 + 0.69 + 0.81) ÷ 3 (1) 0.7(5) (1)	accept 0.7 or 0.75 award full marks for the correct answer with no working 0.746 or 0.747 or 0.750 scores 1 mark	**(2)** AO 3 2a AO 3 2b

Q48.

	Answer	Acceptable answers	Mark
(i)	momentum = 0.03 × 170 (1)	Accept 5.1 seen	**(1)**
(ii)	momentum before = momentum after (1) 5.1 = 0.83 × v (1) v = 6.1 (m/s) (1)	allow 5.0 = 0.80 x v for 1 mark max 5.0 = 0.83 × v v = 6.0 (m/s) allow ecf from (a)(i) give full marks for correct answer, no working	**(3)**
(iii)	Statement to include any two from • kinetic energy is not conserved (1) • (lost ke) appears as heat/sound (1) • momentum is conserved (1)	 ke not conserved / some ke lost no momentum lost	**(2)**

Q49.

	Answer	Acceptable answers	Mark
(i)	substitution (1) 67 × 31 evaluation (1) 2077 (kg m/s)	 2080, 2100 working backwards using 2000 (v=) 29.85, 30 (m=) 64.52, 65 67 X 31=2000 scores only one mark	**(2)**
(ii)	substitution (1) 2000 ÷ 2.3 evaluation (1) 870 (N)	answer to (b)(i)) ÷ 2.3 900, 869.6, 869.5 903	**(2)**
(iii)	an explanation linking two of the following • Force on Andrew is quite small (1) • Because impact time is long (1) • The acceleration/deceleration is quite small (1) • Because impact distance is far	force is reduced/ less /not as strong slows down/changes momentum gradually acceleration = 1.35 'g' or 13.5 m/s^2 slows down (rate of) change of momentum scores 2 marks	**(2)**

	(1)		

Q50.

Question Number	Answer	Acceptable answers	Mark
(a)	B 		**(1)**

Question Number	Answer	Acceptable answers	Mark
(b)	**A** – 0 N		**(1)**

Question Number	Answer	Acceptable answers	Mark
(c)(i)	Substitution (1) 1.2 = (20 – 13) / t Transposition (1) t = (20-13)/1.2 Evaluation 5.8 (s) (1) substitution and transposition can be in either order	1.2 = 7 / t t = 7/1.2 5.833 (etc) Give full marks for correct answer, no working	**(3)**

Question Number	Answer	Acceptable answers	Mark
(c) (ii)	Substitution 1400 x 1.2 (1) Evaluation 1700 (N) (1)	1680 Allow full marks for correct answer with no working shown	**(2)**

Question Number	Answer	Acceptable answers	Mark
(c) (iii)	An discussion to include three of the following points The tow rope does not have to support the weight of the car (1) Tension is caused by accelerating force (plus frictional forces) (1) Tension is 5700 N (in this situation)(1) Forces could be kept below 12,000N (1) If acceleration is kept small (1) Numerical justification using f = m x a (1)	 forces are horizontal not vertical / only needs to overcome friction Force is needed to accelerate / resultant force is 0 at constant velocity Force to accelerate is 1700N Forces could be kept small If truck is driven gently/slowly	 **(3)**

(Total for Question = 10 marks)

Q51.

Question Number	Answer	Acceptable answers	Mark
(a)(i)	**A**		**(1)**

Question Number	Answer	Acceptable answers	Mark
(a)(ii)	A description to include any two of • Gravitational / potential energy reduces (1) • kinetic energy increases (1) • total energy remains constant (1)	Ignore energy changes resulting from impact with sand GPE reduces KE increases Allow GPE is transferred to KE for 2 mark	**(2)**

Question Number	Answer	Acceptable answers	Mark
(b)	A explanation linking • (work is done) displacing the sand (1) with EITHER • (as) kinetic energy of the ball(s) has been transferred (1) OR • by the force between the ball and the sand (1)	sand moving/ pushing/ blowing upwards OWTTE or ball sinking into sand	**(2)**

Question Number	Answer	Acceptable answers	Mark
(c) (i)	transposition mass = momentum / velocity (1) substitution mass = 0.46 / 6.2 (1) evaluation 0.074 (kg) / 74g (1)	Subst. and transform. either order 1 mark only can be scored for correct substitution after incorrect transposition. Give full marks for correct answer with no working. Answers that round to 0.074 (kg) 0.07 (kg)	**(3)**

Question Number	Answer	Acceptable answers	Mark
(c)(ii)	substitution (impact) force = 0.46 / 0.17 (1) evaluation 2.7 (N) (1)	Give full marks for correct answer with no working. Ignore power of ten error until evaluation Answers which round to 2.7 Allow ECF if candidate has used mass from part (i) in F=m(v-u) / T F= $\frac{6.2 - 0}{0.17}$ X 0.074 (1) = 2.7 (N) (1)	**(2)**

Q52.

Question Number	Answer	Additional guidance	Mark
(i)	a description to include: add weight / mass (1) to the weight hanger (1)	ignore references to friction here by inclining runway allow (component of) gravity to act on trolley	(2) AO 1 2

Question Number	Answer	Additional guidance	Mark
(ii)	a description to include: transfer mass (1) between trolley and hanger (1)	 allow weight(s) for mass mass removed from trolley = mass added to hanger for 2 marks	(2) AO 1 2

Question Number	Answer	Additional guidance	Mark
(iii)	an explanation that links: raise one end of the runway (1) (so that) trolley (not attached to weight hanger) rolls at constant speed / just starts to move / (force of) gravity (on the trolley) balances forces of friction (1)	 credit methods for reducing friction directly (e.g. oil wheels, runway etc.) to reduce (effects of) friction allow credit for identifying magnitude of frictional forces and subtracting or using graph	(2) AO 3 3b

Q53.

	Answer	Additional guidance	Mark
(i)	selection and substitution (1) (a =) $\frac{82\ (-\ 0)}{36}$ evaluation (1) 2.3 (m/s^2)	**note: this is a "show that" question** accept any value that rounds to 2.3 (m/s^2) accept 2.2 (m/s^2) for 1 mark maximum answer of 2 (m/s^2) without a substitution scores 0 marks	**(2)** **AO2**

	Answer	Additional guidance	Mark
(ii)	substitution (1) 82^2 (– 0^2) = 2 x 2.3 x *x* rearrangement (1) (x) = $\frac{82^2\ (-\ 0^2)}{2\times2.3}$ evaluation (1) 1500 (m)	allow substitution and rearrangement in either order accept 2, 2.2, 2.27, 2.3 for "a" throughout (x) = $\frac{v^2\ (-\ u^2)}{2\times a}$ ignore sign accept 1460 (m) allow answers in the ranges: 1460 (m) to 1481 (m) 1520 (m) to 1530 (m) 1680 (m) to 1700 (m) award full marks for correct answer without working	**(3)** **AO2**

	Answer	Additional guidance	Mark
(iii)	one statement from take off aborted (1) mechanical/engine failure (1) acceleration reduced (1) weather related reasons (1) larger mass / heavier plane / extra passengers (1) (longer runway required) for landing (1)	any other sensible suggestion	**(1)** **AO3**

Q54.

Question Number	Answer	Additional guidance	Mark
(i)	single arrow towards centre of the circle applied to the object (1)	judge by eye	**(1)**

Question Number	Answer	Additional Guidance	Mark
(ii)	an explanation including velocity is a vector (1) (because) direction changes (1)	velocity has (magnitude and) direction / velocity is speed in a (certain) direction	**(2)**

Q55.

Question number	Answer	Additional guidance	Mark
(i) CLIP WITH (ii)	acceleration = $\frac{\text{change in velocity}}{\text{time (taken)}}$	$a = \frac{v-u}{t}$ $a = \frac{\Delta v}{t}$ $\frac{v}{t}$ allow correct rearrangements seen here or in bii	**(1) grad**

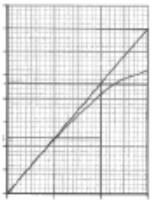
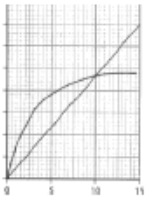
Question number	Answer	Additional guidance	Mark
(ii) CLIP WITH (i)	substitution (1) $\frac{20 - 2}{12}$ evaluation (1) 1.5 (m/s^2)	 $\frac{18}{12}$ -1.5 (m/s^2) award full marks (1 in bi and 2 in bii) for the correct answer without working, award 1 mark if 20-2 or 18 or 2-20 is seen and no other marks are scored If (incorrectly) $a = \frac{v^2 - u^2}{t}$ given in 3bi $a = \frac{20^2 - 2^2}{12}$ OR = 33 scores 1 mark	**(2)**

Q56.

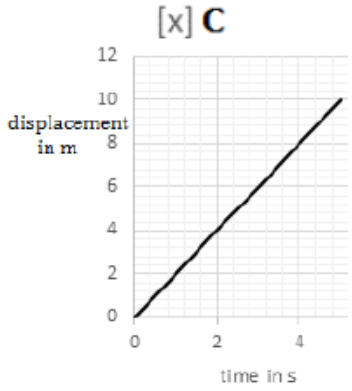
Question Number	Answer	Mark
	C N/kg **is the only correct answer** *A J/kg is not dimensionally the same as m/s²* *B J/kg² is not dimensionally the same as m/s²* *D N/kg² is not dimensionally the same as m/s²*	**(1)** AO 1 1

Q57.

Question number	Answer	Additional guidance	Mark
(i) CLIP WITH GRAPH	distance = area under graph (1) ½ × 7 × 15 (1) 52(.5) (m) (1)	attempt to find area seen on graph correct area(s) identified including calculation 53 (m) allow 7 × 15 or 105 for 1 mark only award full marks for the correct answer with no working	**(3)**

Question number	Answer	Additional guidance	Mark
(ii) CLIP WITH GRAPH H paper	(curve) <u>starting</u> from 0,0 (1) of decreasing gradient (1)	curve can be above or below the line both of these are acceptable  	**(2)**

Q58.

Question number	Answer	Mark
	[x] **C**  A is not correct because it shows a constant velocity of 0.4 m/s B and D are not correct because they show constant acceleration.	**(1)** **AO3**

Q59.

Question Number	Answer	Mark
	A kg m/s ***B*** *is not correct it is mass divided by velocity* ***C*** *is not correct because it is the product of mass and acceleration* ***D*** *is not correct because it is mass divided by acceleration*	**(1)** **AO1**