

WJEC A-LEVEL PHYSICS • UNIT 1

PHYSICS



EXAM QUESTION PACK

1.3 DYNAMICS

SCORE

/

PERCENTAGE

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STEMUP

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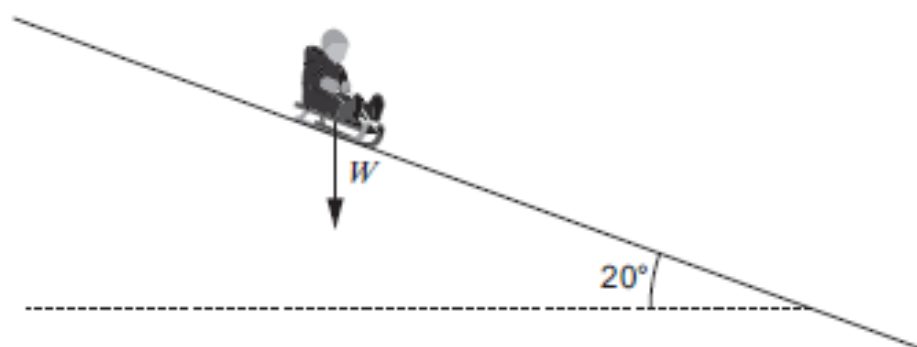
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1.

1. Matthew is sliding down a snow-covered slope on a sledge. The total mass of Matthew and the sledge is 62 kg.



- (a) On the diagram the arrow represents the total weight, W , of Matthew and the sledge. Add two more arrows to show the normal contact force on the sledge and the frictional force on the sledge. [1]

- (b) (i) Show that the component of W parallel to the slope is approximately 200 N. [2]

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- (ii) Calculate the magnitude of the normal contact force. [2]

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- (c) The sledge's acceleration just after it has started moving is measured to be 2.5 ms^{-2} . Matthew believes that, starting from rest, it will take him less than 9.0 s to slide 100 m down the slope. Evaluate whether or not he is correct, commenting on whether or not your calculation is conclusive. [3]

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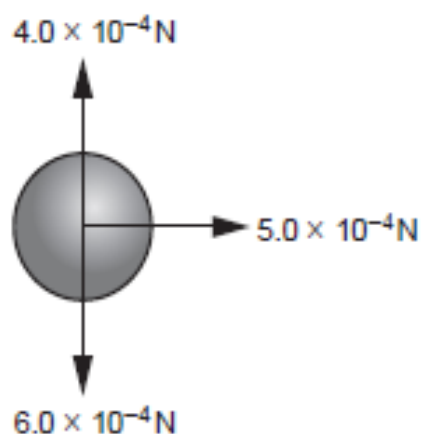
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2. (a) The forces acting on a hailstone falling in a horizontal cross-wind can be represented as in the diagram.



- (i) Calculate the magnitude and direction of the resultant force acting on the hailstone. [3]

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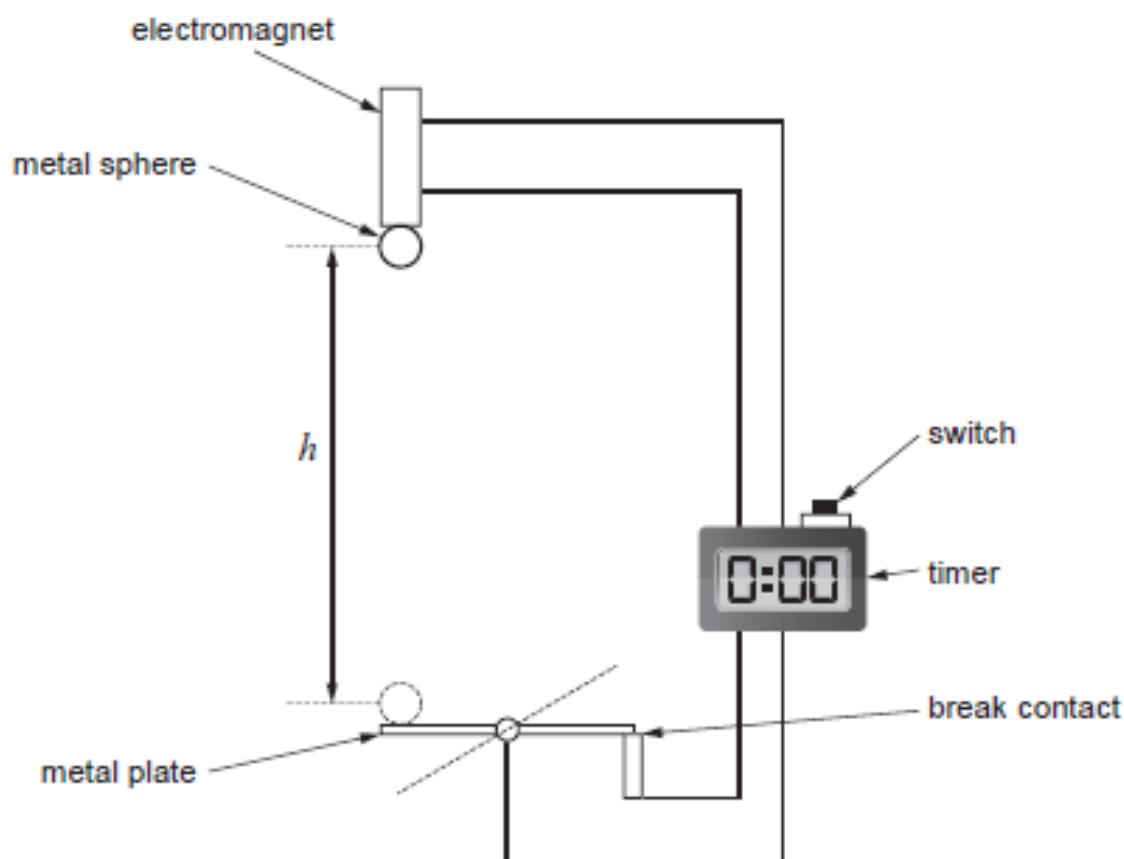
- (ii) At a later time, the wind has stopped blowing and the hailstone falls at terminal velocity. In terms of forces, explain why the hailstone is at terminal velocity. [1]

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(b) Aled uses the following apparatus to measure the acceleration of free-fall, g .



When the switch is pressed, it starts the timer and disconnects the electromagnet, almost instantly releasing the metal sphere. When the sphere hits the metal plate it breaks the circuit, stopping the timer. The time taken for the metal sphere to fall through a range of different heights, h is measured.

- (i) Aled is told that there is a very small time delay between the switch being pressed and the ball being released. This is a systematic error. The manufacturer states that the time delay is 0.05 s. State how Aled should account for the systematic error when taking readings. [1]

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- (ii) Aled records his corrected results (i.e. with the systematic error accounted for) in the table below. Complete the row for time squared, t^2 giving your answers to an appropriate number of significant figures. [2]

Drop height, h/m	0.40	0.80	1.20	1.60	2.00
Corrected time, t/s	0.27	0.41	0.48	0.58	0.64
Corrected time squared, t^2/s^2					

- (iii) The following relationship is used to find a value for g :

$$g = \frac{2h}{t^2}$$

Show how this relationship is obtained from an appropriate equation of accelerated motion. [2]

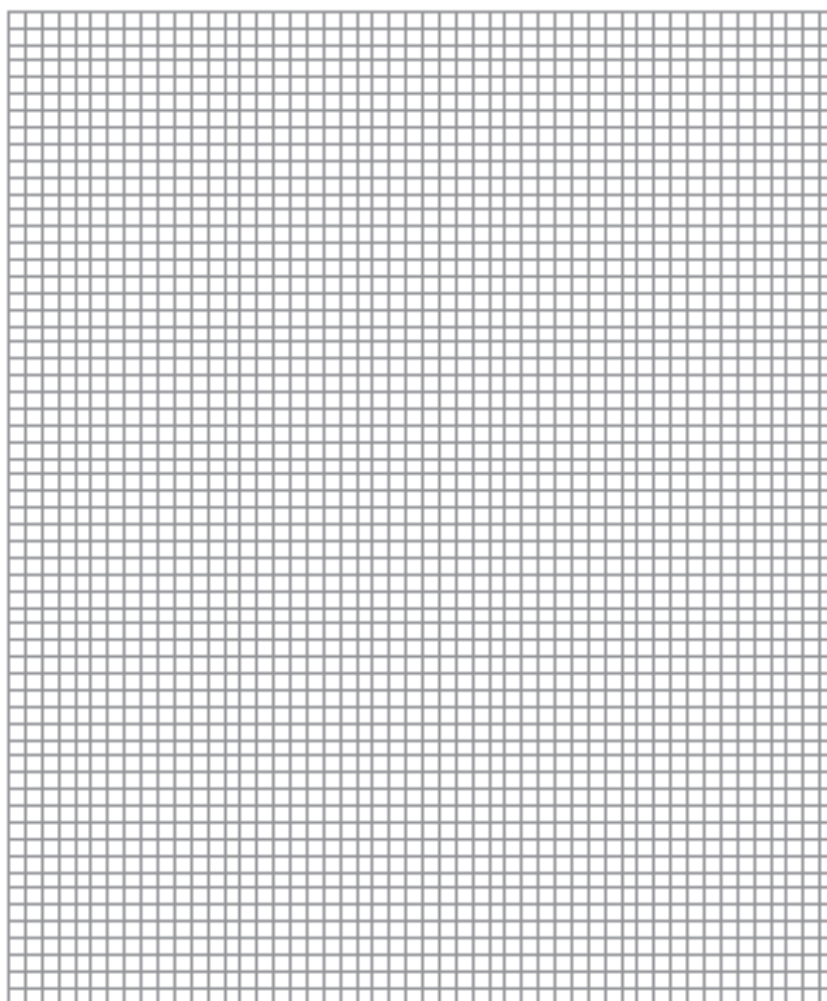
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- (iv) On the grid below, plot a graph of h (vertical axis) against t^2 (horizontal axis) and draw a line of best fit. [4]



- (v) Use your graph to determine a value for g . [3]

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- (c) Discuss to what extent your graph agrees with the equation in (b)(iii). [3]

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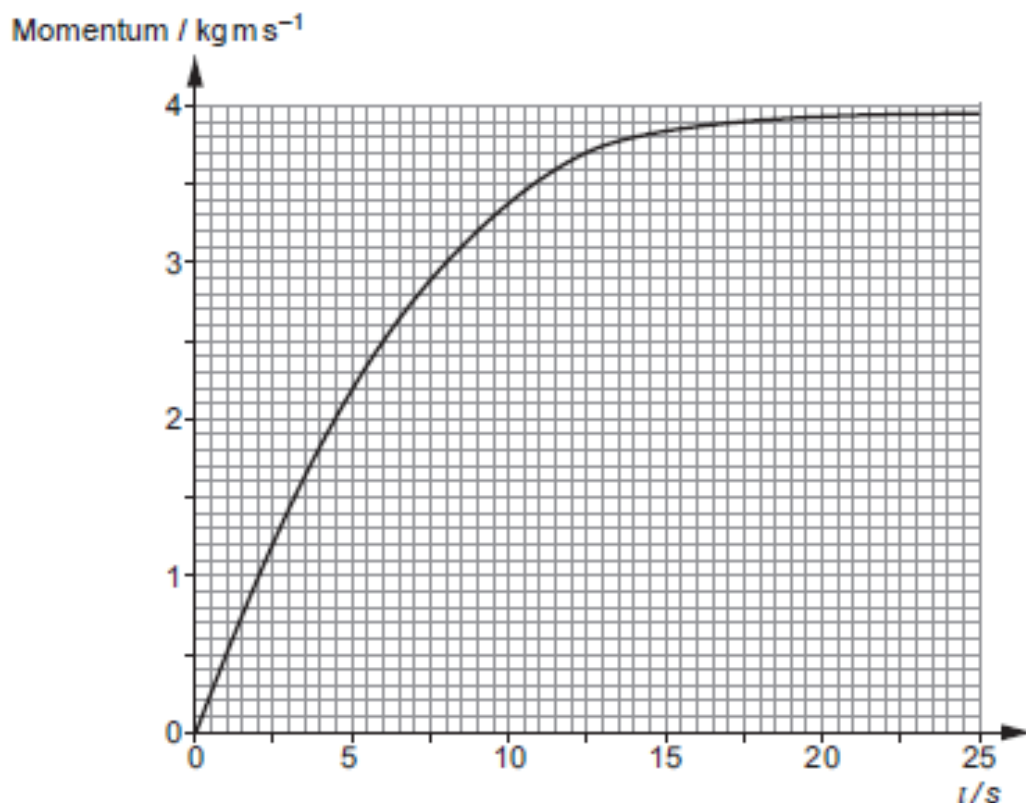
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3.

(a) State Newton's second law of motion in terms of *momentum*.

[2]

(b) A momentum-time graph is plotted below for an object of mass 0.050 kg dropped (at time $t = 0$) from the top of a high cliff.

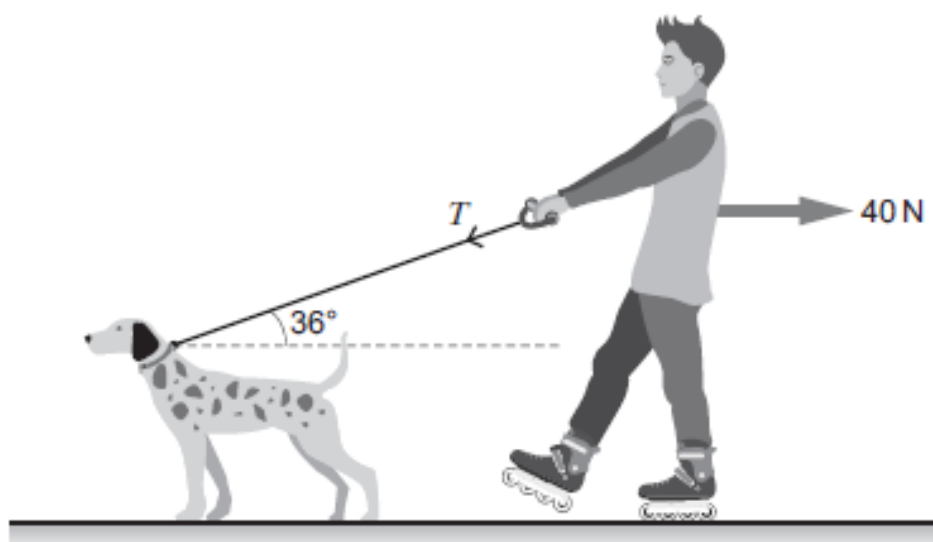


(i) Show clearly that the resultant force on the object at $t = 10$ s is approximately 0.15 N. [3]

(ii) Deduce the magnitude of the force of air resistance on the object at $t = 10$ s. [2]

(iii) State the magnitude of the force of air resistance on the body when it has reached its terminal velocity. [1]

4. (a) The diagram shows a roller-skater being pulled along a horizontal road at constant velocity. The total resistive force to the skater's motion is 40 N.



Show that the tension, T , in the dog lead is approximately 50 N.

[2]

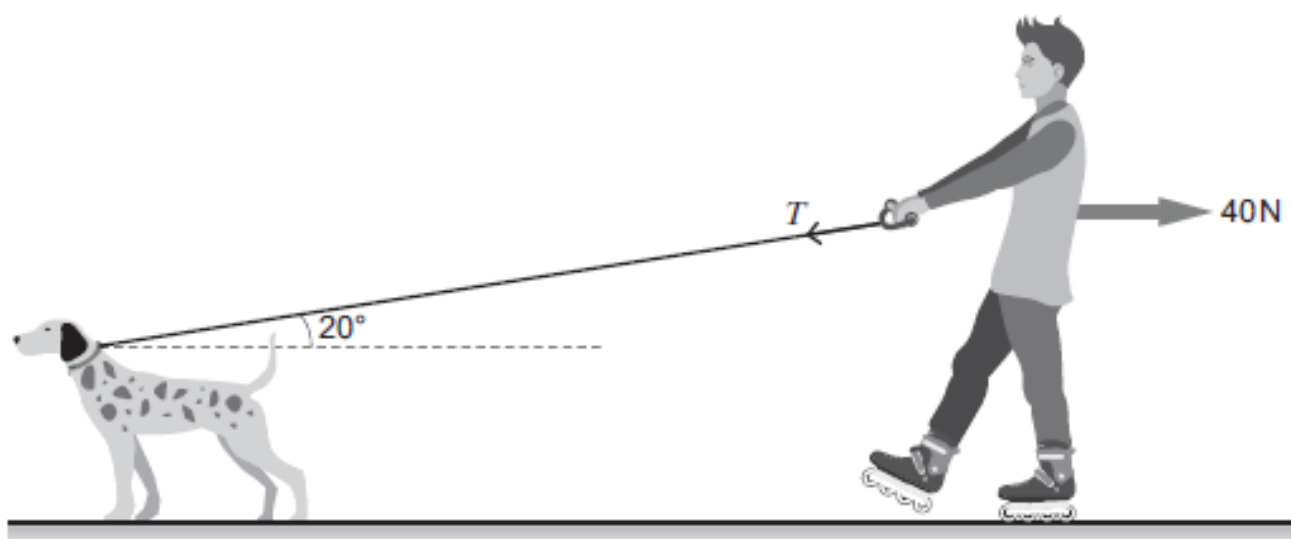
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- (b) Later, the roller-skater, moving at the same velocity as in part (a), extends the dog lead as shown in the diagram below.



- (i) Assuming that the tension, T , is the same as in part (a), explain why the roller-skater initially accelerates.

[1]

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- (ii) Calculate this initial acceleration, given that the mass of the roller-skater is 35 kg. [3]

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- (c) The roller-skater believes that the dog's rate of doing work is the same, regardless of the length of the dog lead. Use information from (a) and (b) to investigate whether or not this claim is correct. [3]

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5. (a) A law of motion can be expressed as:

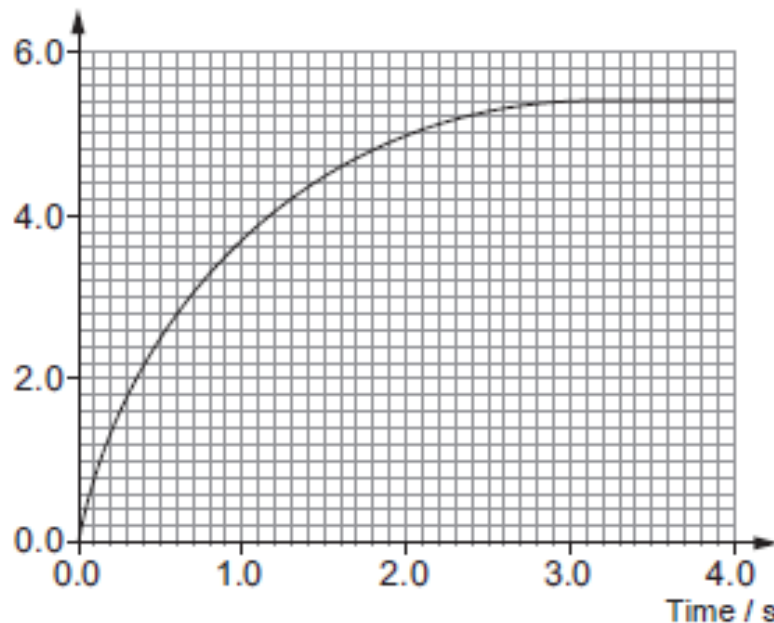
$$\text{resultant force} = \frac{\text{change in momentum}}{\text{time}}$$

State the name of the law.

[1]

- (b) The graph shows how the momentum of a spacecraft varies with time.

Momentum / 10^3 kg m s^{-1}



- (i) By drawing a suitable tangent, show that the resultant force on the spacecraft at $t = 1.0 \text{ s}$ is approximately 2 kN . [2]

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- (ii) Hence show that the mass of the spacecraft is approximately 5000 kg , given that its acceleration at $t = 1.0 \text{ s}$ is 0.4 m s^{-2} . [1]

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- (iii) Label, with the letter P, a point on the graph where the resultant force on the spacecraft is zero. [1]

- (c) At $t = 4.0\text{ s}$ the spacecraft 'docks' (collides) with another stationary spacecraft of mass $7\,000\text{ kg}$. They join on impact.

(i) State the principle of conservation of momentum. [2]

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(ii) Calculate the velocity of both spacecraft after colliding. [3]

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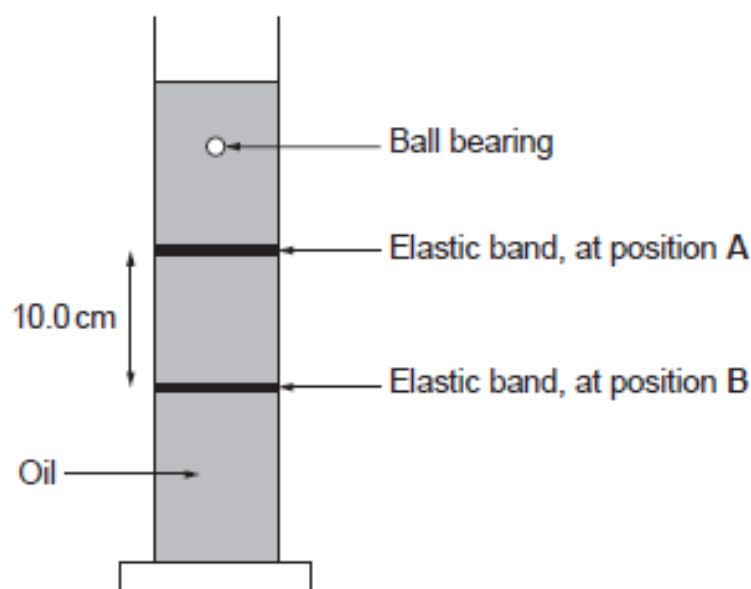
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6. Emma investigates the viscosity of oil by measuring the terminal velocities of a number of different sized ball bearings as they move through it. She uses the following apparatus.



- (a) (i) Once released, a ball bearing attains terminal velocity before it reaches the elastic band at position A. Explain what is meant by terminal velocity. [1]

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- (ii) At terminal velocity the two main forces acting on the ball bearing are its weight and the drag of the oil. According to Newton's third law, for each of these forces there is a corresponding equal and opposite force. Identify each of these forces and the body upon which it acts. [2]

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- (b) Emma measures the time it takes the ball bearings to fall from the elastic band at position A to the elastic band at position B. She carries out each measurement twice, and obtains the following results. The distance between the two elastic bands is 10.0 cm. The uncertainty in this distance can be considered negligible when calculating the uncertainty in the terminal velocity.

Ball bearing		Time to fall			Terminal velocity	
Diameter, d/cm	(Diameter) ² , d^2/cm^2	Reading 1 /s	Reading 2 /s	Mean/s	Velocity, $v/\text{cm s}^{-1}$	Uncertainty, $\Delta v/\text{cm s}^{-1}$
0.24	0.058	14.0	14.6	14.3		± 0.01
0.32	0.10	8.0	8.6	8.3		± 0.05
0.40	0.16	5.3	5.9		1.8	$\pm$
0.48	0.23	3.6	4.1		2.6	$\pm$
0.64	0.41	2.2	1.9	2.1	4.8	± 0.3

Complete the table. *Space has been left for any calculations if needed.*

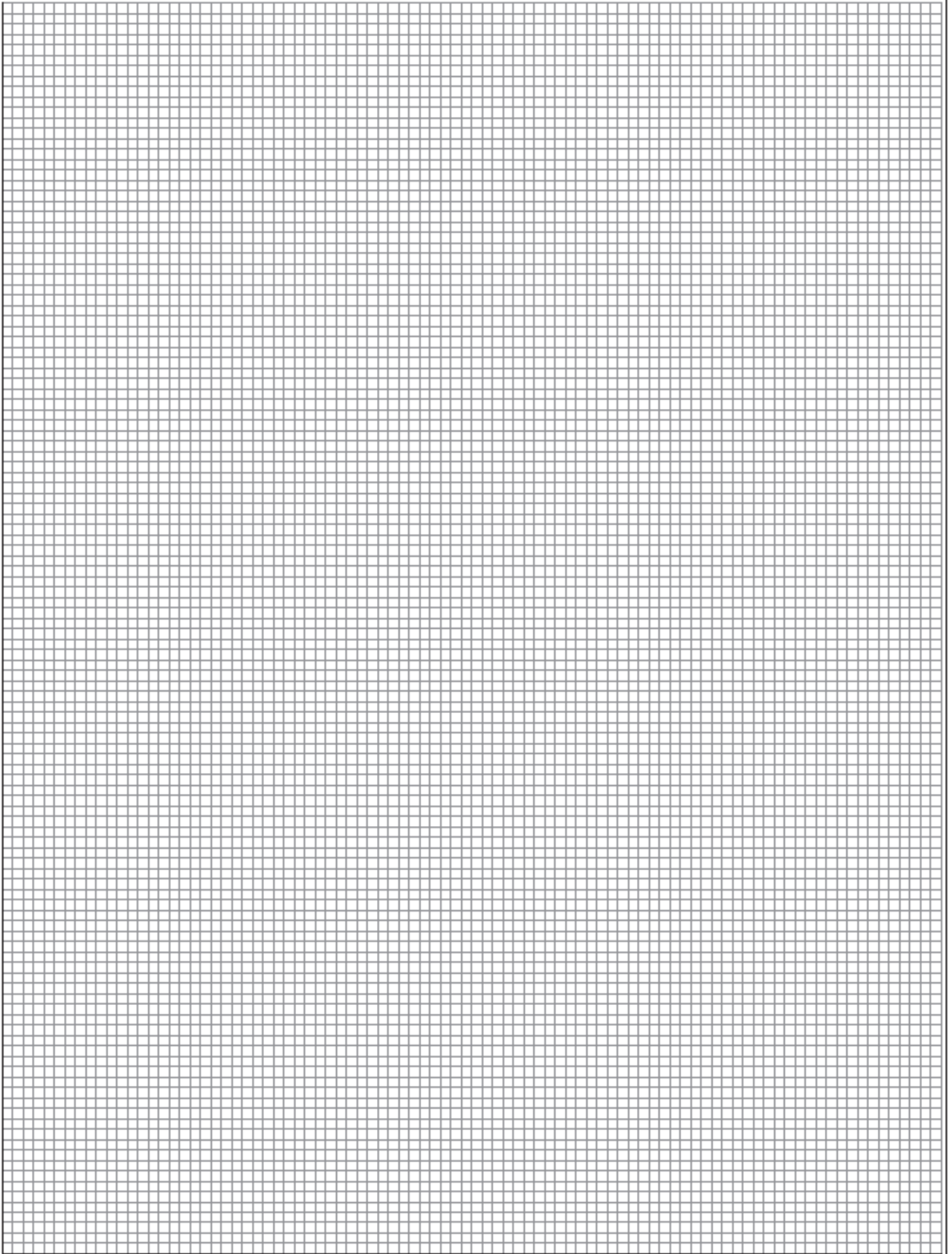
[4]

- (c) (i) Emma's friend, Fiona, thinks that the terminal velocity, v , is directly proportional to the square of the diameter, d , of the ball bearing,

$$v \propto d^2.$$

Plot a suitable graph to check whether Fiona is correct.

[4]



(ii) Evaluate whether or not Fiona is correct.

[2]

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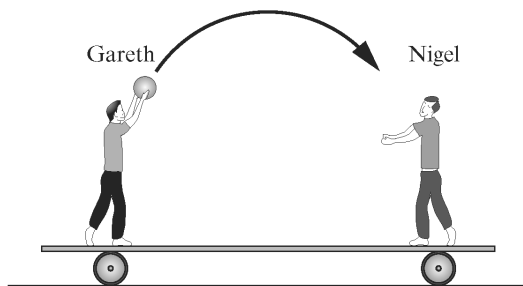
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7. Two boys stand each end of a trolley as shown. The trolley is initially at rest and can move without resistance on a horizontal surface.



- (a) (i) Define acceleration. [1]

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- (ii) Gareth takes 0.80s to throw a ball from rest to a speed of 6.0ms^{-1} . Calculate the acceleration of the ball. [2]

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- (b) Describe and explain in terms of forces, the motion of **the trolley** from the instant the ball is released by Gareth until after it is caught by Nigel. [4]

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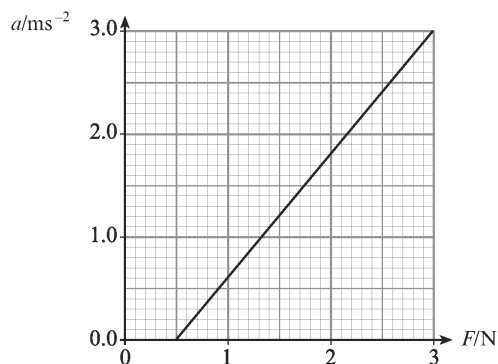
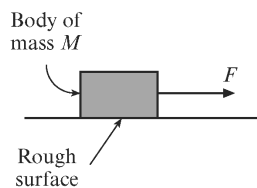
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8.

A body of mass M is placed on a rough surface and a horizontal force, F , is applied to it as shown. Data-logging apparatus is used to determine the acceleration of the body for different values of F . The results are shown in the graph.



- (a) (i) Explain why the acceleration of the body is 0 when the applied force F is less than 0.5 N. [1]

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- (ii) Use your graph to determine the value of M . [3]

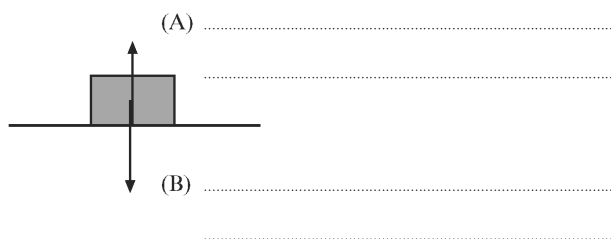
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- (b) (i) Label forces (A) and (B) also acting on the body. [2]



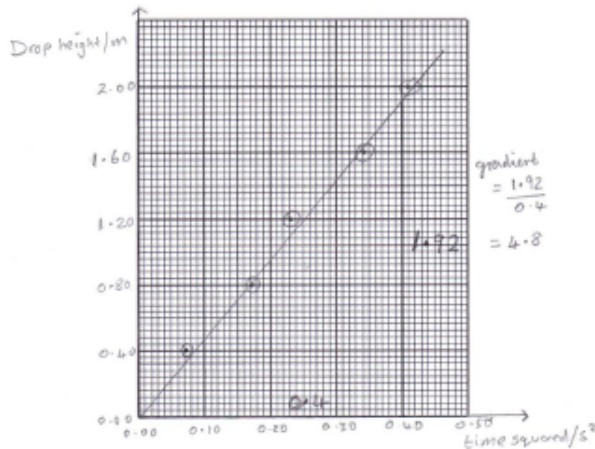
- (ii) State the Newton third law reaction to force (B) and the body upon which it acts. [2]

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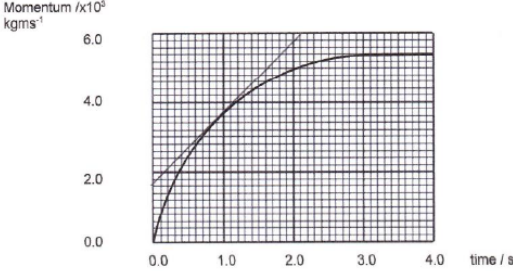
Marking Scheme

Question			Marking details	Marks available				Maths	Prac
				AO1	AO2	AO3	Total		
1	(a)		Normal force and frictional force shown by arrows in correct directions. Labelling not required nor 'correct' positions, length irrelevant	1			1		
	(b)	(i)	Multiplication of m by $9.81 \text{ [N kg}^{-1}\text{]}$ apparent (1) Multiplication by $\cos 70^\circ$ or $\sin 20^\circ$ apparent (1) [$\rightarrow 208 / 210 \text{ N}$]	1	1		2	1	
		(ii)	[Because no acceleration normal to surface] $N = W \cos 20^\circ$ or by implication (1) $N = 570 \text{ N}$ or 572 N [Accept 571 N] (1)		2		2	2	
	(c)		Correct use of $x = \frac{1}{2}at^2$ (1) One of: 101 m in 9.0 s or $8.9[4] \text{ s}$ for 100 m or 100 m in 9.0 s requires an acceleration of 2.47 m s^{-2} (1) Calculation predicts that he is right, but not decisive [or actually the wrong prediction] owing to [increasing] air resistance, or unevenness of snow or not enough s.f. in data or recognition that acceleration may not be uniform (1)			3	3	2	
			Question 1 total	2 2	3	3	8	5	0

Question			Marking details	Marks available				Maths	Prac																		
				AO1	AO2	AO3	Total																				
2	(a)	(i)	Magnitude of vertical force = 2.0×10^{-4} (N) (1) [Direction not required here] Application of Pythagoras and correct overall magnitude determined i.e. $R^2 = (2.0 \times 10^{-4})^2 + (5.0 \times 10^{-4})^2$ $R = 5.4 \times 10^{-4}$ (N)[accept 5.38 or 5.39] (1) No ecf $\theta = 21.8^\circ$ [tolerance of rounding errors] below horizontal [allow 112° , 22° South of E...] stated or clearly shown in diagram [accept 68.2° to the vertical stated or shown] ecf on R (1)		3		3	3																			
		(ii)	Air resistance and force due to gravity [or weight] are equal [or air resistance = 6.0×10^{-4} N] hence no resultant force [accept forces balanced /cancel / no acceleration]	1			1																				
	(b)	(i)	Subtract ...0.05 [from readings (of time)] / the time delay / ...it			1	1		1																		
		(ii)	<table border="1"><tr><td>Drop height h, (m)</td><td>0.40</td><td>0.80</td><td>1.20</td><td>1.60</td><td>2.00</td></tr><tr><td>Corrected time t, (s)</td><td>0.27</td><td>0.41</td><td>0.48</td><td>0.58</td><td>0.64</td></tr><tr><td>Corrected time squared t^2, (s²)</td><td>0.07(3)</td><td>0.17</td><td>0.23</td><td>0.34</td><td>0.41</td></tr></table> All values of t^2 calculated correctly (1) [award this mark, even if sig figs incorrect] To 2 sig. fig. [Allow 1 sf on first answer] [see table] (1)	Drop height h , (m)	0.40	0.80	1.20	1.60	2.00	Corrected time t , (s)	0.27	0.41	0.48	0.58	0.64	Corrected time squared t^2 , (s ²)	0.07(3)	0.17	0.23	0.34	0.41		2		2	2	2
Drop height h , (m)	0.40	0.80	1.20	1.60	2.00																						
Corrected time t , (s)	0.27	0.41	0.48	0.58	0.64																						
Corrected time squared t^2 , (s ²)	0.07(3)	0.17	0.23	0.34	0.41																						
		(iii)	$x = ut + \frac{1}{2}at^2$ identified (1) Explanation that: $[x = h]$, $u = 0$ and $a = g$ [or by implication] (1) No algebra required	1	1		2																				
		(iv)	Suitable scale and both axes labelled correctly with appropriate units: [drop] height $[h]$ / m and time squared $[t^2]$ / s ² [or $(t / s)^2$] (1) Allow ecf from table All 5 points plotted correctly $\pm \frac{1}{2}$ small square division (2) If 4 points plotted correctly $\pm \frac{1}{2}$ small square division (1) If 3 or less points plotted correctly $\pm \frac{1}{2}$ small square division (0) Appropriate line of best fit [through origin] (1) ecf 		4		4	4	4																		
		(v)	Suitable triangle shown on graph [or two points on line implied in calculation] with $\Delta h \geq 1.0$ m [or two appropriate points shown on line] See above (1) Gradient calculated correctly [Accept 4.6 to 5.0] (1) $g = 2 \times \text{gradient}$ [Allow ecf] (1) 2nd and 3rd mark can be awarded even if first mark withheld. [Allow final mark for correct answers using data points rather than gradient]			3	3	2	3																		
	(c)		Straight line / $h \propto t^2$ / linear graph (1) Through [or close to] origin (1) g close to accepted value / 9.81 or low degree of scatter / points close to line of best fit [accept relevant comment based upon candidate's graph] (1)			3	3		3																		
			Question 2 total	2	10	7	19	11	13																		

3.	Question		Marking details	Marks available				Maths	Prac
				AO1	AO2	AO3	Total		
3	(a)		Rate of change of momentum proportional to [or equals] force(1) Context or detail: either resultant force [..... body's rate of change of momentum] or and takes place in the direction of the [resultant] force (1)	1					
				1			2		
	(b)	(i)	Tangent drawn at $t = 10.0$ s (tolerate errors of judgement) (1) Clear calculation of gradient (1) Resultant force = $0.15 [\pm 0.03]$ N Accept 3sf (1)		3		3	2	
		(ii)	Resultant force = weight – air resistance (or equivalent) used (1) 0.34 N or 0.35 N ecf (1)		1 1		2	1	
		(iii)	0.49 N [accept 0.5 N or 0.50 N] [accept '= weight']	1			1		
			Question 3 total	4	4	0	8	3	0

4.	Question		Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
4	(a)		$\frac{40}{T} = \cos 36^\circ$ (1) $T = 49.4$ [N] seen [1] Alternative: Resistive force = $50 \cos 36^\circ$ [1] = 40.5 [N] seen [1] Alternative: $\theta = \cos^{-1} \left(\frac{40}{50} \right)$ [1] $\theta = 36.9^\circ$ [1]	1	1		2	2	
	(b)	(i)	Horizontal component of tension increased and consequence i.e. reference to unbalanced forces (e.g. forward force > than resistive force) Accept greater horizontal resultant force [from dog]		1		1		
		(ii)	$\Sigma F = 49.4 \cos 20^\circ - 40$ [= 6.4 N] [1] $a = \frac{6.4}{35}$ ecf on ΣF [1] $a = 0.18$ [ms ⁻²] [1] N.B. If 50 N used then $\Sigma F = 7$ N and $a = 0.2$ [ms ⁻²]	1	1 1		3	3	
	(c)		Rate of doing work = $F_H \times v$ or $F_H \times \frac{d}{t}$ [1] accept answers based on work done i.e. work = $F_H \cos \theta$ or $W = F_H x$ 1x[1] for one of: F_H has increased [v has increased – award mark if no reference made to v or $\frac{d}{t}$ here] ✓ $\cos \theta$ increased ✓ - as v increases drag increases, so more work is done against drag (per unit distance and time) ✓ Therefore P increased / claim is incorrect [1] accept answer based on work rather than rate of doing work			3	3		
			Question 4 total	2	4	3	9	5	0

5.	Question		Marking details	Marks available				Maths	Prac
				AO1	AO2	AO3	Total		
5	(a)		Newton's 2 nd Law	1			1		
	(b)	(i)	 Suitable tangent at $t = 1.0 [\pm 0.1] \text{ s}$ seen $[\Delta t \geq 1.0 \text{ s}]$ (1) Appropriate [with $\Delta t \geq 1.0 \text{ s}$] values taken from tangent and manipulated correctly to show $F_{\text{resultant}} \approx 2000 \text{ N}$ (1) [ecf on tangent in range $1.7 - 2.3 \text{ kN}$]		2		2	2	
		(ii)	$m = 2000$ (or own value from (i)) $\div 0.4$ (= 5000 kg)		1		1	1	
		(iii)	P labelled on line at $t \geq 3.0 \text{ s}$	1			1		
	(c)	(i)	The vector sum of the momenta of bodies in a system stays constant (even if forces act between the bodies), ... (1) provided there is no external / resultant force / in an isolated system (1) Accept: The total momentum before a collision is equal to the total momentum after a collision..... (1) provided there is no external / resultant forces act / in an isolated system (1)	2			2		
		(ii)	Momentum before collision = $5.4 \times 10^3 \text{ (Ns)}$ (1) [from graph] Momentum after collision = (5000 or ans to (b)(ii)+ 7000) v (1) $v = 0.45 \text{ (m s}^{-1}\text{)}$ (1) [ecf on value from graph, including slips in power of 10]	1	1 1		3	3	
			Question 5 total	5	5	0	10	6	0

6.	Question		Marking details	Marks available				Maths	Prac
				AO1	AO2	AO3	Total		
6	(a)	(i)	Constant / steady velocity no resultant / overall force acting	1			1		
		(ii)	Ball bearing attracted to (centre of) the earth and the earth attracted to the ball bearing/ w.t.t.e. (1) Ball bearing pushing down on the oil and the oil pushing up on the ball bearing / w.t.t.e. (1)			2	2		
	(b)		Mean time i.e. 5.6 and 3.9 (1) Velocity i.e. 0.699 or 0.70 and 1.2 or 1.20 (1) Uncertainty i.e. 0.1 and 0.2 (1) All s.f. consistent in all columns (accept first velocity value (i.e. 0.699 or 0.70) to 2/3 s.f.) (1)		4		4	4	4
	(c)	(i)	Scale suitable with at least half of the paper used (1) Axis labelled with units (1) All points plotted correctly with error bars for v except first value (1) Suitable line of best fit (1)		4		4	3	4
		(ii)	Any 2 $\times$ (1) from: - Straight line graph / constant positive gradient - Through the origin - Line of best fit through all the error bars / close to all points			2	2	2	2
			Question 6 total	1	8	4	13	9	10

7.	(a)	(i)	Rate of change of velocity or $\frac{v-u}{t}$ or change in velocity / time taken	1
		(ii)	($u = 0$) (1) [or by impl.] Acceleration = $\frac{6.0}{0.8} = 7.5 \text{ m s}^{-2}$ (1) UNIT mark	2
	(b)		After release there are no [horizontal] forces acting [on the trolley] (1) so it travels with constant speed [to the left] (1). When Nigel catches it there is a force on the trolley to the right / towards Nigel (1) which causes the trolley to decelerate/ slow down/ stop moving [to rest] (1)	4
8.	(a)	(i)	To overcome the frictional / drag force or because the applied force is insufficient.	1
		(ii)	$\frac{1}{\text{gradient}}$ attempted (1); Correct substitution, e.g. $\frac{3.0-0.5}{3.0}$ (1) $m = 0.8(3) \text{ kg ((unit))}$ (1)	3
	(b)	(i)	A = contact force of surface on body [accept <u>normal</u> reaction](1) B = gravitational force of Earth on body (1) [accept: weight / mg]	2
		(ii)	<u>Gravitation force of body (mass)</u> (1) on Earth (1)	2
				[8]

Examiner's Comments

1. There are no examiner comments available for this question
2. There are no examiner comments available for this question
3. There are no examiner comments available for this question
4. There are no examiner comments available for this question
5. There are no examiner comments available for this question
6. There are no examiner comments available for this question

7. Mean Mark: $3.3/7 = 48\%$

- (a) (i) & (ii) Minority of candidates defined acceleration incorrectly as 'rate of change of velocity per unit time'. Definitions in terms of speed were not accepted also. The calculation was generally successful though some candidates lost a mark for incorrect or missing units.
- (b) The vast majority of candidates gave a lengthy (often correct) description of what happened up to the moment Gareth released the ball but failed to mention what happened when it was in flight. Many thought that Nigel catching the ball would move the trolley to the right. The direction of the force when Nigel caught the ball was often omitted or just eluded to but not actually stated clearly enough to gain the mark. Changes in weight and references to vertical forces appeared on the weaker candidates' papers. Only a handful of 4 mark answers were seen and these tended to be the most succinct.

This comment originally referred to question 3 on paper 1321/01 (12/01/2012)

8. (a) (i) This was poorly answered. A large number of candidates did not realise that until the frictional force was overcome, there could be no acceleration.
- (ii) Only the more able candidates realised that the reciprocal of the gradient gave the value of the mass of the object. The majority of candidates attempted to use $M = F/a$, using the coordinates of one point read from the graph.
- (b) (i) The idea of force A being the contact force exerted by a supporting body on a mass placed on it was not well understood. The term 'normal reaction' was accepted, but the much looser term, 'reaction' was not. Although it would have been nice to see a more precise explanation, credit was given for describing force B in general terms e.g weight, mg etc.
- (ii) Newton's Third Law is not well understood, and it was rare to see an answer that was anywhere close to what was expected. Only a handful of candidates attributed the Newton third law reaction to force B as being the **pull/force of the body (1 mark) on the Earth (1 mark)**.

This comment originally referred to question 4 on paper 1321/01 (12/01/2011)