Question			Answer	Marks	Guidance
1	a		velocity against time	B1	**Not** 'speed' for velocity **Not** time against velocity Ignore units
	b		stress against strain	B1	Ignore units
	c		force / load / tension against length (of wire)	B1	**Not** force against extension **Not** 'weight' for force **Not** 'distance' for length Ignore units
			Total	**3**	

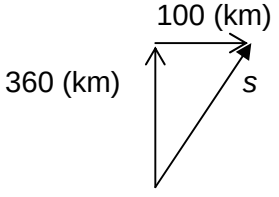
Question			Answers	Marks	Guidance
2	(a)		velocity = rate of <u>change</u> of displacement	B1	**Allow** $v = \frac{\Delta s}{\Delta t}$ where Δs = <u>change</u> in displacement Δt = time (taken) **Allow** displacement travelled/time **Allow** 'velocity = displacement/time' when followed by 'velocity = rate of change of displacement' **Not** 'velocity = displacement/time' or 'distance/time' **Not** mixture of quantity and unit, e.g. change of displacement per second **Not** 'speed in a specific direction'
	(b)	(i)	speed = 70000/3600 KE = $\frac{1}{2} \times 130 \times \left(\frac{70000}{3600}\right)^2$ kinetic energy = 2.5×10^4 (J)	C1 C1 A1	**Note**: speed = 19.4... (m s^{-1}) will score this C1 mark **Note**: Using 19.4 (m s^{-1}) gives 2.446.. $\times 10^4$ (J); hence an answer of 2.4×10^4 (J) will score full marks **Allow** maximum of 2 marks if 19 (m s^{-1}) is used – answer is 2.34… $\times 10^4$ (J) **Allow** 1 mark for ½ × 130 × (70000/60)^2 = 8.84(7) × 10^7 (J) **Note**: No credit for ½ × 130 × v^2 with any other incorrect value for v, including v = 70 and 70000 **Note**: Bald answer of 2.5×10^4 (J) scores full marks **Note**: If the correct equation for KE is written and then the squaring of the speed is omitted, allow ecf as shown below: E = ½ mv^2 = ½ × 130 × 19.4 = 1.3×10^3 (J) ✓× ✓ 2 marks

Question			Answers	Marks	Guidance
	(b)	(ii)	Mass of Mononykus is 1/8 (of the mass of an ostrich) or mass of Mononykus is 16 (kg). Correct reasoning: Volume decreases by (a factor of) 8 **and** density assumed to be the same.	B1 B1	 **Allow** use of V for volume and ρ for density
			Total	**6**	

Question			Answers	Marks	Guidance
3	(a)	(i)	There is only a vertical force / weight is vertical / no horizontal force(s) / acceleration is vertical	B1	**Not** 'horizontal acceleration is zero' – since horizontal velocity is constant is given in the question
		(ii)	1 Correct sketch of the rebound path. 2 The time is the same. For both, the height / vertical distance and (vertical) acceleration are the same.	B1 M1 A1	**Note**: The ball must hit the ground closer to wall. The rebound path should be curved and below the original path. **Allow** $s = \frac{1}{2}at^2$ with *s* and *a* are the same (for both)
	(b)		Drop the ball from a given height **and** measure time of fall. $s = ut + ½\ at^2$ **and** $u = 0$ or $s = ½\ at^2$ (The acceleration of free fall is determined using) $a = 2s/t^2$	B1 B1 B1	 **Allow** $a \equiv g$ and $h \equiv s$ **Note:** *a* must be the subject to gain this B1 mark **Note**: $a = 2s/t^2$ will score the last two B1 marks **Allow** full credit for graphical approach: Drop ball from different heights & measure the times of fall (B1) ; plot a graph of *s* against t^2 (B1) ; $g = 2 \times$ gradient (B1)
	(c)	(i)	Constant deceleration or uniform deceleration or constant negative acceleration or constant rate (of change) of velocity (Momentarily) stops at 1.5 (s) or reaches maximum height at 1.5 (s) Clear idea of returning back. (AW)	B1 B1 B1	**Allow** constant / uniform acceleration / acceleration is 2.66.. ($m\ s^{-2}$) **Allow** 'constant rate of deceleration or acceleration' **Not** 'slowing down' **Allow**: (The ball) goes up and (then) down (the ramp) **Not**: velocity changes sign or direction changes
		(ii)	distance = $½ \times 4.0 \times 1.5$ distance = 3.0 (m)	C1 A1	**Note**: Speed in range 3.0 to 5.0 ($m\ s^{-1}$) and $v \neq 4.0$ ($m\ s^{-1}$), then possible ecf **Allow** 1 sf answer **Allow** full credit for correct use of equation(s) of motion **Special case:** total distance travelled is calculated; allow 1 mark for an answer of 6.0 (m)
			Total	**12**	

Question			Expected Answers	Marks	Additional Guidance
4	a	i	work (done) / (elastic potential) energy	B1	**Not:** heat / gravitational potential energy / kinetic energy
		ii	displacement / distance	B1	
	b		Any <u>two</u> from: • Torque (of a couple) • Moment (of a force) • Work (done) / energy	B1×2	**Not**: 'Couple' for 'torque' **Allow**: PE / KE
			Total	**4**	

5	Expected Answers	Marks	Additional Guidance
a	‘heavy’ and ‘light’ objects / different weights / different masses dropped (from leaning tower of Pisa) / rolled down incline plane Objects have the same <u>acceleration</u> (of free fall) Objects hit ground at same time	B1 B1 B1	**Must use ticks on Scoris to show where the marks are awarded** **Not**: ‘dropping feather’ / ‘vacuum’ / ‘experiment on the Moon’ for this first B1 mark but can score subsequent B1 marks **Not**: ‘fall at the same rate / accelerates at the same rate / same speed’
b(i)	$s = ut + \frac{1}{2}at^2$ <u>and</u> $u = 0$ / $0.600 = \frac{1}{2} \times a \times (0.356)^2$ $a = \frac{2 \times 0.600}{0.356^2}$ $a = 9.47$ (m s^{-2})	C1 C1 A0	**Note**: There are no marks for just an answer, since this is a **‘show’** question **Allow**: 2 marks for correct substitution with ‘a’ the subject or $0.600 = \frac{1}{2} \times a \times (0.356)^2$ followed by $a = 9.469$ (more than 3 sf) **Note:** Using ‘v =.600/0.356’ followed by $a = \Delta v / \Delta t$ = 4.73 scores zero. (Watch out for $4.734 \times 2 = 9.47$)
b(ii)	Air resistance or drag / residual magnetism or ‘sticky’ electromagnet / trapdoor takes time to open	B1	**Not**: ‘Experiment is not done in a vacuum’ / ‘friction/resistance’
b(iii)	A ‘parabola shape’ / graph of increasing positive gradient starting from <u>origin</u> and going through 0.356,0.6	B1	Judge the shape of the graph by eye. A horizontal line from 0.6 must cut the graph within the ‘vertical zone provided by 0.356 s ’ on the time axis
	Total	**7**	

Question			Expected Answers	Marks	Additional Guidance
6	(a)	(i)	Both measured in metre/m	B1	**Allow**: Both have the same unit/Both have 'magnitude' **Not**: Both are distance/length
		(ii)	Distance is a scalar/does not have direction or Displacement is a vector/has direction	B1	**Not**: One is a vector and the other a scalar
	(b)	(i)	time = $\frac{3.6\times10^5}{170}$ time = $2.1(18)\times10^3$ (s) or 2.1×10^3 (s)	B1	**Note**: Answer to 2sf or more is required
		(ii)	Correct vector triangle Eg:  $s^2 = 360^2 + 100^2$ / $s = \sqrt{(360^2 + 100^2)}$ s = 373.6 (km) / 370 (km)	B1 C1 A1	The vector triangle must have at least two labels (360, 100 and s – allow x or d for s). The 'orientation' of the triangle must be as shown. Ignore the direction of the arrows. **Allow**: Full credit can be given for a scale drawing 2 marks if answer in the range (370 – 380) 1 mark if answer in the range (360 – 370) or (380 - 390) **Note**: Bald answer to 2sf or more and no diagram scores 2/3 marks.
			Total	**6**	

Question			Expected Answers	Marks	Additional Guidance
7	(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**	