6	**C is the correct answer** This is because W_c should have been drawn in the centre of the cube.	**(1)**

9	**The only correct answer is A** ($\frac{50 \times 10^3 \times 2.3}{13}$) B is not correct because work done should be power × time C is not correct because the answer is inverted D is not correct because work done should be power × time and the answer is inverted	**1**

3	**The only correct answer is C (acceleration is a vector and work done is a scalar)** A is not correct because acceleration is a vector B is not correct because acceleration is a vector and work done is a scalar D is not correct because work done is a scalar	**1**

10	**10. The only correct answer is B** ***A*** *is incorrect as* E_{grav} *is a maximum on release and not 0.* *C is incorrect as* E_{grav} *is a maximum on release and the shape of the graph is incorrect.* ***D*** *is incorrect as this is the graph for* E_{grav} *against vertical distance and not displacement.*	**(1)**

10	**D is the correct answer** A is incorrect because *mg* has the wrong direction B is incorrect because *mg* and *ma* have the wrong directions C is incorrect because *ma* has the wrong direction	**1**

10	**The only correct answer is D** (90*g*) A is not correct because by conserving energy, the expression for speed in metres per second should be $\sqrt{2 \times g \times (75 - 30)}$ B is not correct because by conserving energy, the expression for speed in metres per second should be $\sqrt{2 \times g \times (75 - 30)}$ C is not correct because by conserving energy, the expression for speed in metres per second should be $\sqrt{2 \times g \times (75 - 30)}$	**1**

1	**The only correct answer is D m s^{-2}**	**1**
	A *is not correct because s is the unit for time which is scalar* ***B*** *is not correct because* m^3 *is the unit for volume which is scalar* ***C*** *is not correct because m* s^{-1} *is the unit for both speed and velocity so is both scalar and vector*	

2	**The only correct answer is B 60 m**	**1**
	A *is not correct because 30 m is the radius and half the displacement* ***C*** *is not correct because* 30π *is half the circumference of the inside of the track. It is the distance travelled and not the displacement* ***D*** *is not correct because* 60π *is the circumference of the inside of the track and is double the distance travelled*	

6	**6. The only correct answer is C** ***A*** *is not correct as the diameter, and not the radius, was substituted into the equation for the cross-sectional area of the cylinder.* ***B*** *is not correct as the '2' was not squared when the diameter /2 was substituted for the radius into the equation for the cross-sectional area of the cylinder.* ***D*** *is not correct as an incorrect equation for the cross-sectional area of the cylinder was used.*	**(1)**

2	**The correct answer is C (decreasing acceleration)** A is incorrect because constant acceleration has a straight line B is incorrect because displacement is increasing D is incorrect because displacement is increasing	**1**

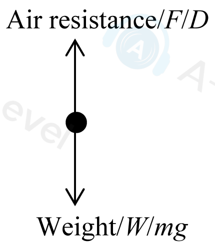
14(a)	Maximum value of weight/force for which weight/force is proportional to extension **Or** Point beyond which Hooke's Law no longer applies **Or** Point beyond which graph line ceases to be straight **Or** Point beyond which weight/force is no longer proportional to extension	**(1)**	**1**
14(b)(i)	Use of large triangle to determine gradient Gradient = 18 500 ($N m^{-1}$) (sf range 18 - 19, no ue) <u>Example of calculation</u> gradient = 37 N ÷ (2 × 10^{-3} m) = 18 500 ($N m^{-1}$)	**(1)** **(1)**	**2**
14(b)(ii)	Rearranges E = stress / strain to get $E = \text{gradient} \times \frac{x}{A}$ **Or** Rearranges E = stress / strain to get $\text{gradient} = \frac{A}{x}E$ Use of $A = \pi r^2$ Young modulus = 2 × 10^{11} Pa (allow ecf from (b)(i)) <u>Example of calculation</u> $A = \pi \times (2.8 \times 10^{-4})^2 = 2.46 \times 10^{-7}\ m^2$ $E = 1.85 \times 10^4\ N\ m^{-1} \times 2.6\ m \div 2.46 \times 10^{-7}\ m^2 = 1.95 \times 10^{11}$ Pa	**(1)** **(1)** **(1)**	**3**
14(c)	Use of $\sigma = \frac{F}{A}$ Determines maximum safe load **Or** Determines maximum stress **Or** Determines minimum cross section Valid conclusion by comparison with student's calculation <u>Example of calculation</u> $\sigma_{max} = \frac{W_{max}}{A}$ $4.80 \times 10^8\ Pa = \frac{W_{max}}{2.46 \times 10^{-7} m^2}$ $W_{max} = 480 \times 10^6\ Pa \times 2.46 \times 10^{-7}\ m^2 = 118\ N > 100$ N so yes	**(1)** **(1)** **(1)**	**3**
	Total for question 14		**9**

<table>
<tr><th>Question Number</th><th>Answer</th><th>Mark</th></tr>
<tr><td>18(a)(i)</td><td>
Explanation

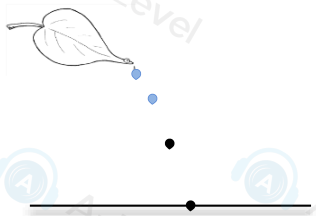
- Terminal velocity is the constant/maximum velocity the rain reaches
Or terminal velocity is the velocity when acceleration = 0 (1)
- When weight = Drag (+ upthrust)
Or when forces is equilibrium
Or when resultant force = 0
(accept when the total upward force = total downward force) (1)

Diagram

- Weight and air resistance (and upthrust) only drawn with correct directions (arrowed lines must touch dot, and labels included) (1)
- Arrow lengths of weight and air resistance same length (1)
(if upthrust drawn, upthrust line + drag line = weight line)
(MP4 dependent on MP3)



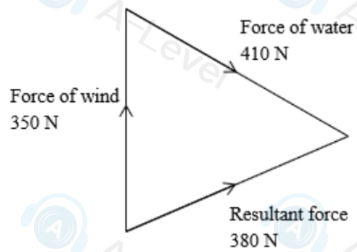
</td><td>4</td></tr>
</table>

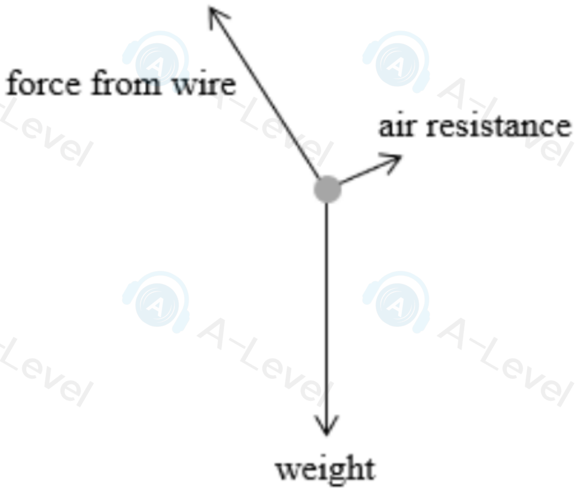
18(a)(ii)	• Use of $A = \pi r^2$ **and** $V = \frac{4}{3}\pi r^3$ • Use of $\rho = \frac{m}{V}$ **and** $W = mg$ • Use of $W = F$ • $v = 6.5 - 7.0 \text{ m s}^{-1}$ <u>Example of calculation</u> $A = \pi \times (0.002)^2 = 1.26 \times 10^{-5} \text{ m}^2$ $V = \frac{4}{3}\pi \times (0.002 \text{ m})^3 = 3.35 \times 10^{-8} \text{ m}^3$ $m = 1000 \text{ kg m}^{-3} \times 3.35 \times 10^{-8} \text{ m}^3 = 3.35 \times 10^{-5} \text{ kg}$ $W = 3.35 \times 10^{-5} \text{ kg} \times 9.81 \text{ N kg}^{-1} = 3.29 \times 10^{-4} \text{ N}$ $3.29 \times 10^{-4} \text{ N} = 0.45 \times 1.2 \text{ kg m}^{-3} \times 1.26 \times 10^{-5} \text{ m}^2 \times v^2$ $3.29 \times 10^{-4} \text{ N} = 6.80 \times 10^{-6} \times v^2$ $v = 6.96 \text{ m s}^{-1}$	(1) (1) (1) (1)	**4**
18(b)(i)	• Vertical displacement increasing • Horizontal displacement constant (same as first two drops) (Mark all added drops but there must be a minimum of 2 additional drops to award MP1 &2) 	(1) (1)	**2**
18(b)(ii)	• Use of $s = ut + \frac{1}{2}at^2$ with $u = 0$ (accept use of t = 0.2 s, 0.25 s, 0.75 s, 1.0 s) • See 0.8 s for the time since the drop left the leaf • $s = 3.1 \text{ m}$ <u>Example of calculation</u> $s = \frac{1}{2} \times 9.81 \text{ N kg}^{-1} \times (0.8 \text{ s})^2 = 3.14 \text{ m}$	(1) (1) (1)	**3**
	Total for question 18		**13**

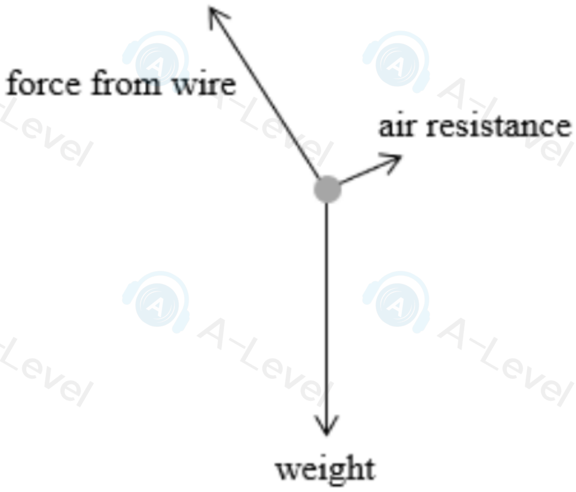
Question Number	Answer		Mark
16(a)	Compares ≈40 (MPa) (compression) with ≈10 (MPa) (tension) Breaking/fracture/ultimate stress/force (much) greater under compression **Or** Breaking/fracture/ultimate stress is 40 MPa under compression, and 10 MPa under tension. **Or** Breaking/fracture/ultimate stress is 30 MPa greater under compression. (If no other mark scored, allow 1 mark for greater energy absorbed/stored under compression)	(1) (1)	**(2)**
16(b)	Breaking stress = 5.00 to 5.10 ($\times 10^8$ Pa) Use of $\sigma = F/A$ $F = 8.0/8.1 \times 10^5$ N <u>Example of calculation</u> $A = \pi \times (2.25 \times 10^{-2}\text{ m})^2 = 1.59 \times 10^{-3}\text{ m}^2$ $F = 1.59 \times 10^{-3}\text{ m}^2 \times 5.05 \times 10^8\text{ Pa} = 8.03 \times 10^5\text{ N}$	(1) (1) (1)	**(3)**
16(c)(i)	Concrete can withstand high(er) stress/force under compression **Or** Concrete is strong(er) under compression The concrete remains under compression when tensile force applied. **Or** Applied/tensile force first has to overcome the compression **Or** When tensile force applied, concrete is still under compression The steel/rods take (some of) the force/stress **Or** The force/stress causes deformation of the steel Steel can withstand a large(r) tensile force/stress **Or** Steel is strong(er) under tension **Or** Ultimate tensile stress of steel is large(r)	(1) (1) (1) (1)	**(4)**
16(c)(ii)	(When force removed) the rod will not return to its original length/shape **Or** The rod will be permanently/plastically deformed the concrete will not compress (as much) **Or** The compression force will be less/zero	(1) (1)	**(2)**
	Total for question 16		**11**

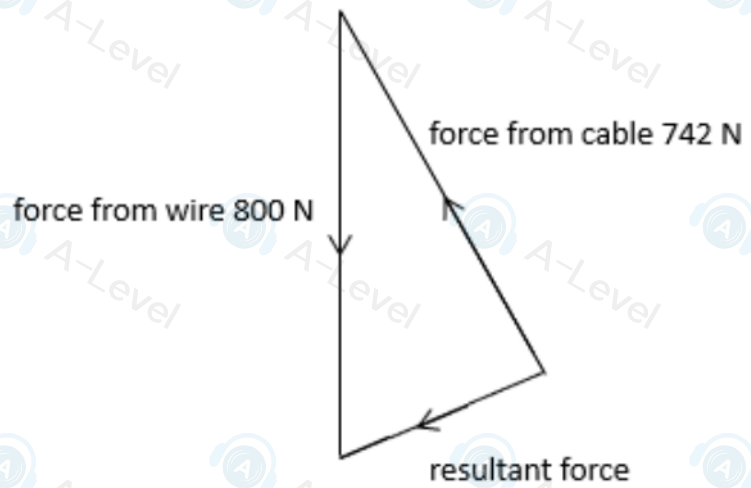
14(a)	The ball fell a smaller distance (during each flash of the laboratory strobe) **Or** Each image of the ball would be smaller (using the laboratory strobe) The uncertainty was less (with the laboratory strobe) MP2 dependent on MP1	**(1)** **(1)**	**2**
14(b)(i)	(allow *a* for *g* throughout) $s = (ut+)\frac{1}{2}gt^2$ **and** *g* is constant Comparison of $s = \frac{1}{2}gt^2\ (+ut)$ with $y = mx\ (+c)$ **Or** *s* is proportional to t^2 so the gradient of graph is constant	**(1)** **(1)**	**2**
14(b)(ii)	Use of $s = \frac{1}{2}at^2$ and a pair of corresponding values from the graph **Or** Pair of corresponding values from the graph used to determine gradient $g = 10.0\ \mathrm{m\ s^{-2}}$ (allow answers in the range $9.8\ \mathrm{m\ s^{-2}}$ to $10.1\ \mathrm{m\ s^{-2}}$) (dependent on MP1) (answer must be consistent with their calculation) <u>Example of calculation</u> $\frac{\Delta h}{\Delta t^2} = \frac{0.30}{0.060} = 5.00$ $g = 5.00\ \mathrm{m\ s^{-2}} \times 2 = 10.00\ \mathrm{m\ s^{-2}}$	**(1)** **(1)**	**2**
	Total for question 14		**6**

14(a)	The ball fell a smaller distance (during each flash of the laboratory strobe) **Or** Each image of the ball would be smaller (using the laboratory strobe) The uncertainty was less (with the laboratory strobe) MP2 dependent on MP1	**(1)** **(1)**	**2**
14(b)(i)	(allow *a* for *g* throughout) $s = (ut+)\frac{1}{2}gt^2$ **and** *g* is constant Comparison of $s = \frac{1}{2}gt^2\ (+ut)$ with $y = mx\ (+c)$ **Or** *s* is proportional to t^2 so the gradient of graph is constant	**(1)** **(1)**	**2**
14(b)(ii)	Use of $s = \frac{1}{2}at^2$ and a pair of corresponding values from the graph **Or** Pair of corresponding values from the graph used to determine gradient $g = 10.0\ \text{m s}^{-2}$ (allow answers in the range $9.8\ \text{m s}^{-2}$ to $10.1\ \text{m s}^{-2}$) (dependent on MP1) (answer must be consistent with their calculation) <u>Example of calculation</u> $\frac{\Delta h}{\Delta t^2} = \frac{0.30}{0.060} = 5.00$ $g = 5.00\ \text{m s}^{-2} \times 2 = 10.00\ \text{m s}^{-2}$	**(1)** **(1)**	**2**
	Total for question 14		**6**

Question Number	Answer		Additional Guidance	Mark
12	Triangle of correct shape drawn, with at least two sides labelled Vector triangle drawn with at least two sides labelled and arrows in correct directions Magnitude of resultant force = 380 N (allow 370 N to 390 N) Angle of resultant force from north = 68° (allow 66° – 70°)	(1) (1) (1) (1)	<u>Example diagram</u>  	4
	Total for question 12			4

19(a)	Arrow to the left and upwards labelled force from wire / harness Arrow vertically downwards labelled weight / W / mg Arrow to right (and slightly upward) labelled (viscous) drag / D or labelled air resistance <u>Example diagram</u>  	**(1)** **(1)** **(1)**	**3**
19(b)(i)	Appropriate trigonometry used 742 (N) <u>Example of calculation</u> $R = 2 \times 1\,200\text{ N} \times \cos(72°) = 741.6\text{ N}$	**(1)** **(1)**	**2**

19(a)	Arrow to the left and upwards labelled force from wire / harness Arrow vertically downwards labelled weight / W / mg Arrow to right (and slightly upward) labelled (viscous) drag / D or labelled air resistance <u>Example diagram</u>  	**(1)** **(1)** **(1)**	**3**
19(b)(i)	Appropriate trigonometry used 742 (N) <u>Example of calculation</u> $R = 2 \times 1\,200\text{ N} \times \cos(72°) = 741.6\text{ N}$	**(1)** **(1)**	**2**

19(b)(ii)	Straight line at least 8 cm long representing force from wire (800 N), with label Vector triangle drawn with at least two sides labelled, and resultant force on shortest side All 3 arrows in correct relative directions (dependent on MP2) Resultant force = 400 N (Range from 390 to 410) <u>Example diagram</u>  	**(1)** **(1)** **(1)** **(1)**	**4**
19(c)	(most) E_{grav} transferred to E_{k} and mass is in both equations (So final) speed does not depend on mass of person **Or** (So final) speed only depends on change in height **Or** (So final) speed = $\sqrt{2g\Delta h}$ (and g is constant) (assuming) work done against resistive forces is negligible	**(1)** **(1)** **(1)**	**3**
	Total for question 19		**12**