3	**D is the correct answer** A is not the correct answer as would be difference in velocities of cars descending to ground from standing starts at P and Q and is out by factor of √2 B is not the correct answer as would be difference in velocities of cars descending to ground from standing starts at P and Q C is not the correct answer as is out by a factor of √2	**(1)**

8	**A is the correct answer as E_{grav} decreases at an increasing rate as the ball accelerates towards the ground and increases at a decreasing rate as the ball decelerates away from the ground after the bounce** B is not the correct answer as E_{grav} increases as the height of the ball above the ground decreases and decreases as height of the ball above the ground increases. C is not the correct answer as the graph does not show the change in as E_{grav} at an increasing and decreasing rate as in response A, as the height of the ball above the ground changes D is not the correct answer as E_{grav} increases as the height of the ball above the ground decreases and decreases as the height of the ball above the ground increases.	**(1)**

5	**B is the correct answer** A is incorrect because the CW moment of the force could balancethe ACW moment of the weight C is incorrect because the CW moment of the force could balance theACW moment of the weight D is incorrect because the CW moment of the force could balance the ACW moment of the weight	**1**

2	**The only correct answer is A (The resultant force is zero and the resultant moment is zero)** B is not correct because the resultant moment should be zero C is not correct because the resultant force should be zero D is not correct because the resultant force should be zero and the resultant moment should be zero	**1**

4	**C is the correct answer as efficiency** $= \frac{\textbf{useful energy output}}{\textbf{total energy input}} = \frac{\textbf{200 N} \times \textbf{4 m}}{\textbf{90 N} \times \textbf{10 m}}$ A is not the correct answer as this is the total energy input divided by the useful energy output B is not the correct answer as this is the useful energy output divided by the total of the energy output and the energy input D is not the correct answer as this is the total energy input divided by the total of the energy output and the energy input	**(1)**

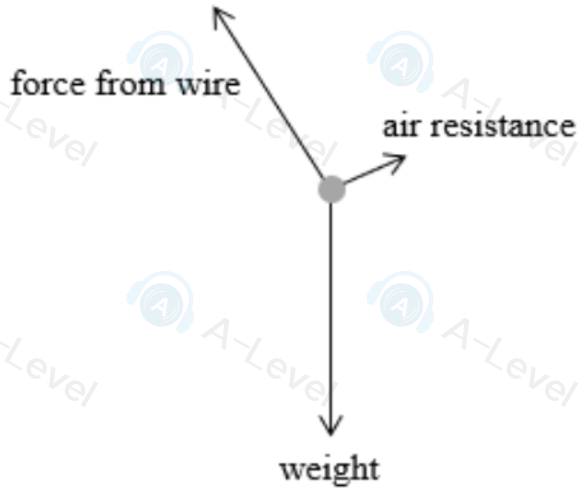
5	The only correct answer is **B** A is not correct because Q has the same change in E_{grav}. C is not correct because R is lifted a smaller distance. D is not correct because R has the smallest change in E_{grav}.	**1**

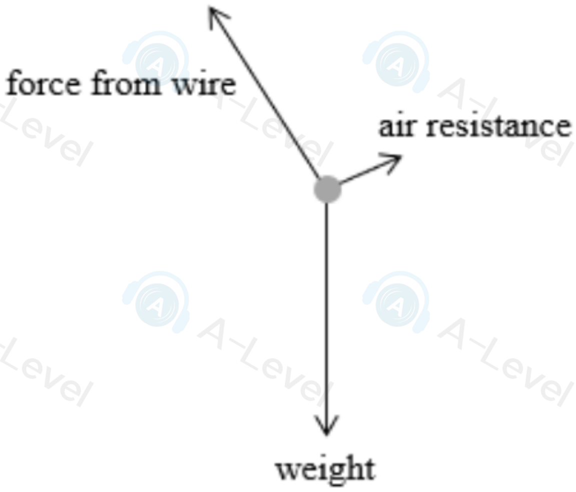
6	The only correct answer is **D** The work done is the area to the left of the line on the graph. A is not correct because it is the work done for a constant force. B is not correct because it is the work that would be done if the spring obeyed Hooke's law. C is not correct because it represents the area under the line on the graph.	**1**

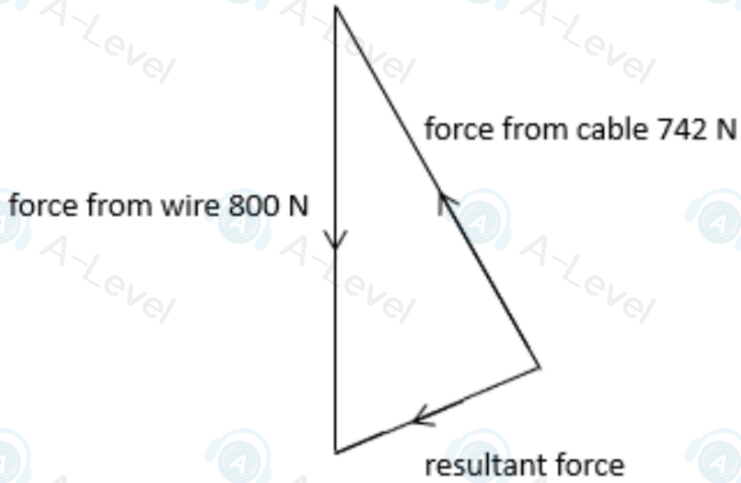
10	**10. The only correct answer is B** *A is incorrect as E_{grav} is a maximum on release and not 0.* *C is incorrect as E_{grav} is a maximum on release and the shape of the graph is incorrect.* *D is incorrect as this is the graph for E_{grav} against vertical distance and not displacement.*	**(1)**

Question Number	Answer		Mark
15(a)(i)	Use of $v^2 = u^2 + 2as$ with $u = 0$ **Or** use of $t = s$/average velocity and $v = u + at$ with $u = 0$	(1)	
	The final velocity in m s^{-1} **Or** distance in km	(1)	
	$a = 2.8 \times 10^5$ m s^{-2} **Or** 280 km s^{-2}	(1)	**3**
	<u>Example of calculation</u> $(11 \times 10^3 \text{ m s}^{-1})^2 = 0^2 + (2 \times a \times 220 \text{ m})$ $a = 275\,000$ m s^{-2}		
15(a)(ii)	Use of $E_k = ½\, mv^2$ with $m = 1500$ kg	(1)	
	Correct use of 50% e.g. $(2 \times E_k)$ or $(0.5 \times 3 \times 10^6)$	(1)	
	Use of mass of fuel = kinetic energy/energy per kg of fuel	(1)	
	Mass of fuel required = 6.1×10^4 kg	(1)	**4**
	<u>Example of calculation</u> $E_k = ½ \times 1500 \text{ kg} \times (11 \times 10^3 \text{ m s}^{-1})^2 = 9.075 \times 10^{10}$ J Energy to be supplied by fuel = $2 \times 9.075 \times 10^{10} \text{ J} = 1.815 \times 10^{11}$ J Mass of fuel required = $1.815 \times 10^{11} \text{ J}/3 \times 10^6 \text{J kg}^{-1} = 6.05 \times 10^4$ kg		
***15(b)**	**(QWC – work must be clear and organised in a logical manner using technical terminology where appropriate)**		
	<u>Gas</u> is ejected forwards	(1)	
	By N3, there is a backward/opposite force/push (on the capsule).	(1)	
	There is a (backwards) resultant force (on the capsule)	(1)	
	By N1/N2, there is an acceleration	(1)	
	Force/acceleration is in opposite direction to motion, so a deceleration **Or** force/acceleration is in opposite direction to motion, so negative acceleration	(1)	**5**
	(accept upwards and downwards for forwards and backwards)		
	Total for question 13		**12**

Question Number	Answer		Mark
13(a)	• Use of $\Sigma F = 0$, seen or implied • $F = 11$ N • Use of moment of force = Fx (with any corresponding force and known distance from an end, A or midpoint) • Use of the principle of moments • $x = 0.86$ m <u>Example of calculation</u> $F_A + F_B = 8.5\text{ N} + 14\text{ N} = 22.5\text{ N}$ $F_A = F_B$ $2F = 22.5\text{ N}$ $F = 11.25\text{ N}$ if moments taken from the left end $(11.25\text{ N} \times 0.15\text{ m}) + (11.25\text{ N} \times x) = (8.5\text{ N} \times 0.35\text{ m}) + (14\text{ N} \times 0.60\text{ m})$ $x = 0.861$ m if moments taken from midpoint $(11.25\text{ N} \times 0.45\text{ m}) = (11.25\text{ N} \times x) + (8.5\text{ N} \times 0.25\text{ m})$ $x = 0.261$ m so distance = 0.261 m + 0.6 m = 0.861 m if moments taken from A $(8.5\text{ N} \times 0.20\text{ m}) + (14\text{ N} \times 0.45\text{ m}) = (11.25\text{ N} \times x)$ $x = 0.711$ m so distance = 0.711 + 0.15 m = 0.861 m	(1) (1) (1) (1) (1)	5
13(b)	The moment (of B) must be the same For a smaller distance (from the left end of the shelf), the (normal contact) force must increase	(1) (1)	2
	Total for question 13		**7**

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 **(1)** Vector triangle drawn with at least two sides labelled, and resultant force on shortest side **(1)** All 3 arrows in correct relative directions (dependent on MP2) **(1)** Resultant force = 400 N (Range from 390 to 410) **(1)** <u>Example diagram</u> 		**4**
19(c)	(most) E_{grav} transferred to E_k and mass is in both equations **(1)** (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) **(1)** (assuming) work done against resistive forces is negligible **(1)**		**3**
	Total for question 19		**12**

Question Number	Answer	Mark
16(a)	Resultant force is zero **(1)** Resultant moment (about any point) is zero **(1)**	2

Question Number	Answer		Mark
16(a)	Resultant force is zero	(1)	
	Resultant moment (about any point) is zero	(1)	2
16(b)	Use of Moment of force $= Fx$	(1)	
	Use of principle of moments with dish in original position	(1)	
	Uses total weight = weight of rice + weight of dish to determine weight of one portion of rice	(1)	
	Use of principle of moments with dish in new position **Or** Calculates clockwise moment with 3 portions of rice in new position **and** calculates anticlockwise moment of weight of beam	(1)	
	Dish contains 8.2 portions of rice	(1)	
	Comparison with 3 portions **and** consistent conclusion	(1)	6
	<u>Example calculation</u> Moment of weight of beam = $3.1 \text{ N} \times 0.08 \text{ m} = 0.248 \text{ N m}$ $0.248 \text{ N m} = (\text{weight of dish and rice}) \times 0.25 \text{ m}$ Weight of dish and rice $= \dfrac{0.248 \text{ N m}}{0.25 \text{ m}} = 0.992 \text{ N}$ Weight of one portion of rice = 0.992 N – 0.64 N = 0.352 N 0.248 N m = (portions × 0.352 N + 0.64 N) × 0.07 m Number of portions $= \dfrac{\frac{0.248 \text{ N m}}{0.07} - 0.64 \text{ N}}{0.352 \text{ N}} = 8.247$ The dish contains 8.2 portions, not 3 portions of rice		
	Total for question 16		**8**

18(a)	No resultant force No resultant moment (about any point)	**(1)** **(1)**	**2**
18(b)	The point at which the weight of an object is considered to act	**(1)**	**1**
18(c)(i)	Use of $W = mg$ Horizontal distance from edge of door to centre of gravity identified as $\frac{w}{2}$ Use of moment of force $= Fx$ Use of clockwise moment = anticlockwise moment Horizontal component of force of hinge Y on door = 37.5 (N) **OR** Use of $W = mg$ Use of tan θ with dimensions of door Use of vertical component of force of hinge Y on door = W/2 Use of tan θ with vertical and horizontal components of force of hinge Y on door Horizontal component of force of hinge Y on door = 37.5 (N) <u>Example of calculation</u> $W = 14.4 \text{ kg} \times 9.81 \text{N kg}^{-1} = 141 \text{ N}$ $141 \text{ N} \times \frac{0.85 \text{ m}}{2} = F_{\text{horizontal}} \times 1.60 \text{ m}$ $F_{\text{horizontal}} = \frac{60.0 \text{ N m}}{1.60 \text{ m}} = 37.5 \text{ N}$	**(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)**	**5**

18(a)	No resultant force No resultant moment (about any point)	**(1)** **(1)**	**2**
18(b)	The point at which the weight of an object is considered to act	**(1)**	**1**
18(c)(i)	Use of $W = mg$ Horizontal distance from edge of door to centre of gravity identified as $\frac{w}{2}$ Use of moment of force $= Fx$ Use of clockwise moment = anticlockwise moment Horizontal component of force of hinge Y on door = 37.5 (N) **OR** Use of $W = mg$ Use of tan θ with dimensions of door Use of vertical component of force of hinge Y on door = W/2 Use of tan θ with vertical and horizontal components of force of hinge Y on door Horizontal component of force of hinge Y on door = 37.5 (N) <u>Example of calculation</u> $W = 14.4 \text{ kg} \times 9.81 \text{N kg}^{-1} = 141 \text{ N}$ $141 \text{ N} \times \frac{0.85 \text{ m}}{2} = F_{\text{horizontal}} \times 1.60 \text{ m}$ $F_{\text{horizontal}} = \frac{60.0 \text{ N m}}{1.60 \text{ m}} = 37.5 \text{ N}$	**(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)** **(1)**	**5**

18(c)(ii)	Use of appropriate trigonometry to determine θ $\theta = 28°$ (allow ecf from 18(c)(i)) (show that answer gives 30°) Use of Pythagoras' theorem to determine F **Or** Use of appropriate trigonometry to determine F F = 80 N (allow ecf from 18(c)(i)) (show that answer gives 81 N) <u>Example of calculation</u> $\theta = \tan^{-1}\left(\frac{37.5}{\left(\frac{141}{2}\right)}\right) = 28.0°$ $F = \sqrt{(37.5\text{ N})^2 + \left(\frac{141\text{ N}}{2}\right)^2} = 80.0\text{ N}$	(1) (1) (1) (1)	4
18(c)(iii)	Moment of weight of door (about X) remains the same. **Or** $mg \times \frac{w}{2} = F_{\text{horizontal}} \times L$ (and m, g and w remain the same). (So) horizontal (component of) force increases (when L decreases). Vertical (component of) force remains the same. **Or** Each hinge still holds half the weight of the door. (So) F increases and θ increases.	(1) (1) (1) (1)	4
	Total for question 18		**16**