9	**The only correct answer is D 80 × g × 450 × sin25°** *A is not correct because incorrect use of trigonometry to determine the vertical distance travelled* *B is not correct because incorrect use of trigonometry to determine the vertical distance travelled* *C is not correct because this expression uses the horizontal distance travelled which is 450 × cos25° and not the vertical distance travelled*	**1**

8	**C is the correct answer** This is because the power needed is equal to the gravitational energy supplied per second (*mgh*) plus the kinetic energy given to the water per second ($\frac{1}{2}mv^2$).	**(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**

5	**C** **Gain in gravitational potential energy: same for P and Q** **Power developed: greater for P than Q** Incorrect Answers: A – incorrect gain in GPE but correct power developed B – incorrect gain in GPE and incorrect power developed D – correct gain in GPE but incorrect power developed	**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)**

3	**A** ***Fd***	**1**
	Incorrect Answers: (all due to incorrect variables selected from information given) B – *Ft* is the impulse on the block due to the applied force *F* C – *Fv* is the power developed by the block D – *mgd* would be the work done had the block moved a distance *d* due to the gravitational force and not the applied force *F*	

2	**C is the correct answer** A is incorrect because it takes no account of the k.e. B is incorrect because the energy dissipated would be greater than the original energy D is incorrect because the energy dissipated could not be negative	**(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)**

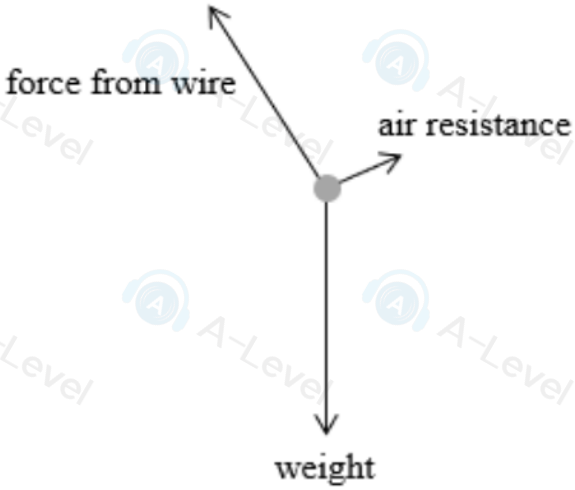
D is not correct as the anomalous point (4.50) has not been ignored.

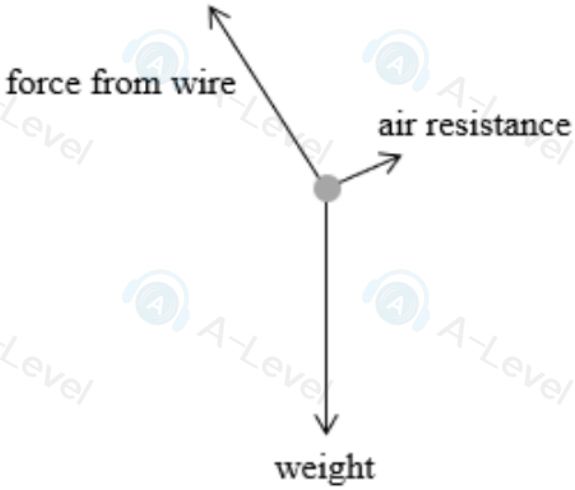
4	**D is the correct answer** This is because the area under a stress-strain graph is the work done per unit volume, but the area under the other 3 graphs represents work done.	**(1)**

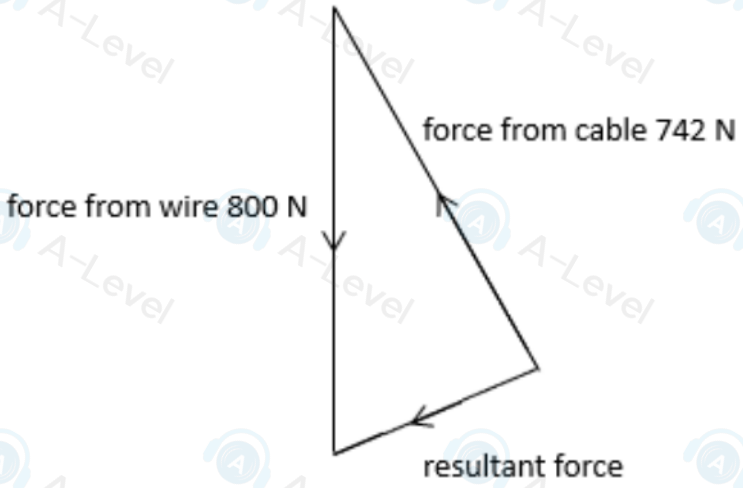
Question Number	Answer		Mark
15(a)(i)	Use of $v^2 = u^2 + 2as$ with $u = 0$ **Or** use of $t = s$/average velocity and $v = u + at$ with $u = 0$	(1)	
	The final velocity in m s^{-1} **Or** distance in km	(1)	
	$a = 2.8 \times 10^5$ m s^{-2} **Or** 280 km s^{-2}	(1)	**3**
	Example of calculation $(11 \times 10^3 \text{ m s}^{-1})^2 = 0^2 + (2 \times a \times 220 \text{ m})$ $a = 275\,000$ 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**
	Example of calculation $E_k = ½ \times 1500 \text{ kg} \times (11 \times 10^3 \text{ m s}^{-1})^2 = 9.075 \times 10^{10}$ J Energy to be supplied by fuel = $2 \times 9.075 \times 10^{10}$ J = 1.815×10^{11} J Mass of fuel required = 1.815×10^{11} J/3×10^6 J kg^{-1} = 6.05×10^4 kg		
***15(b)**	**(QWC – work must be clear and organised in a logical manner using technical terminology where appropriate)** Gas 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
14(a)(i)	• Use of $\rho = \frac{m}{V}$ • Use of $A = \pi r^2$ • Use of volume in 1 second = cross section area × speed • Speed = 37.1 (m s^{-1}) Example of calculation $\frac{V}{t} = \frac{300 \text{ kg s}^{-1}}{1030 \text{ kg m}^{-3}} = 0.291 \text{ m}^3\text{s}^{-1}$ $A = \pi \times 0.05^2 = 7.85 \times 10^{-3}$ m^2 Speed = 0.291 m^3 s^{-1}/ 7.85×10^{-3} m^2 = 37.1 m s^{-1}	(1) (1) (1) (1)	4
14(a)(ii)	• Use of $p = mv$ • Rate of change of momentum = 1.1×10^4 kg m s^{-2} (ecf from (a)(i)) Example of calculation mass × speed = 300 kg ×37.1 m s^{-1} = 1.11×10^4 kg m s^{-2}	(1) (1)	2
14(b)	• Pump applies a (forward) force to the water. • By Newton 3, water applies an (equal and) opposite/backward force to the pump **Or** By Newton 3, water applies a force to the pump in the opposite direction to the (flow of) water.	(1) (1)	2
14(c)	• Initially (speed is constant because) drag force = forward force • Turning on pump gives resultant force backwards, so boat slows. • Drag force becomes less (as boat slows) until forces balance again.	(1) (1) (1)	3
	Total for question 14		**11**

Question Number	Answer		Mark
17(a)(i)	Use of fall factor = $\frac{\text{height fallen before the rope begins to stretch}}{\text{total unstretched length of rope}}$	**(1)**	
	Use of $\varepsilon = \frac{\Delta x}{x}$ with x = 15.0 m	**(1)**	
	Use of $E_{grav} = mg\Delta h$	**(1)**	
	Use of $E_{grav} = E_{el}$ with their Δx	**(1)**	
	F_{max} = 14 000 (N)	**(1)**	**5**
	Example of calculation Height fallen = 15.0 m × 0.8 = 12 m Δx = 0.09 × 15.0 m = 1.35 m E_{grav} = 71 kg × 9.81 N kg^{-1} × 12 m = 8358 J (from fall) E_{grav} = 71 kg × 9.81 N kg^{-1} × 1.35 m = 940.3 J (from extension) 8358 J + 940.3 J = ½ × F_{max} × 1.35 m F_{max} = 13 775 N		
17(a)(ii)	• This would not be a good idea, as the climber would reach a higher velocity (just before the rope stretches)	**(1)**	
	• (Hence) the climber's deceleration/force (as the rope stretches) would be greater	**(1)**	**2**
17(b)	**Max 6**		
	• Use of area under the graph to determine the stored energy	**(1)**	
	• Energy = 800 J (new)	**(1)**	
	• Energy = 700 J (old)	**(1)**	
	• The old rope would absorb/store less energy	**(1)**	
	• Use of $F = k\Delta x$ to determine k (accept gradient of a tangent)	**(1)**	
	• Calculation of k for both ropes at same applied force	**(1)**	
	• The old rope is not as stiff as the new rope **Or** The old rope extends more	**(1)**	
	• The old rope would break at a smaller applied force/stress	**(1)**	**6**
	Total for question 17		**13**

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 Example diagram  	**(1)** **(1)** **(1)**	**3**
19(b)(i)	Appropriate trigonometry used 742 (N) Example of calculation $R = 2 \times 1\,200\ \text{N} \times \cos(72°) = 741.6\ \text{N}$	**(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 Example diagram  	**(1)** **(1)** **(1)**	**3**
19(b)(i)	Appropriate trigonometry used 742 (N) Example of calculation $R = 2 \times 1\,200\ \text{N} \times \cos(72°) = 741.6\ \text{N}$	**(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)**	**4**
	Example diagram 		
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**