2	**The only correct answer is B (Useful power output is constant; total energy output increases.)** A is not correct because total energy output would increase with time C is not correct because useful power output is constant D is not correct because useful power output is constant and total energy output would increase with time	1

10	**C is the correct answer** A is incorrect because time is not speed/distance B is incorrect because time is not speed/distance D is incorrect because the powers of ten are incorrect	**(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

2	**C is the correct answer as 1 kWh = 1000 W × 3600 s = 3.6× 10^6 J** A is not the correct answer as 0.28 J= $\frac{1000\ \text{W}}{3600\ \text{J}}$ B is not the correct answer as 0.28 W= $\frac{1000\ \text{W}}{3600\ \text{J}}$ and the unit should be J and not W D is not the correct answer as the unit should be J and not W.	**(1)**

6	**The only correct answer is C ($\frac{5000}{42\times0.63}$)** A is not correct because the useful output power should not be inverted B is not correct because the useful output power should not be inverted and should be divided by 0.63 D is not correct because the useful output power should be divided by 0.63	1

D is incorrect because the displacement should be doubled

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)**

9	**The only correct answer is A ($\frac{50\times10^3\times2.3}{13}$)** 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

4	**C is the correct answer as efficiency** $= \frac{\text{useful energy output}}{\text{total energy input}} = \frac{200\text{ N} \times 4\text{ m}}{90\text{ N} \times 10\text{ m}}$ 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)**

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	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**

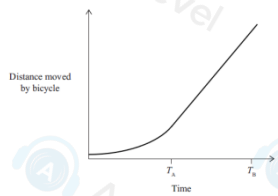
8	**B to the left of O**	**1**
	Incorrect Answers: the centre of mass has moved to the left of O. The right-hand half has double the density but half the diameter so the weight is $(2 \times \frac{1}{(2)^2} =) \frac{1}{2}$ the original weight. The pivot needs to be placed under the centre of gravity for the rod to balance. A – O is no longer the position of the centre of gravity C – The centre of gravity is to the left of O and not the right D – There is a balance point but, so that there is equal weight either side of the centre of gravity, its position has moved to the left	

8	**D is the correct answer** A is not the correct answer as it gives units of J^{-1} which is not a unit for energy. B is not the correct answer for the same reason that A is not. C is not the correct answer as $68 \neq 68\%$.	**(1)**

10	**The only correct answer is A** ($\frac{Fx}{y} + F$) B is not correct because $W = \frac{Fx}{y} + F$ C is not correct because $W = \frac{Fx}{y} + F$ D is not correct because $W = \frac{Fx}{y} + F$	1

4	**D is the correct answer** A is not correct because the initial power output should be a constant greater than zero, and the power output whilst going uphill should be constant B is not correct because whilst going uphill the power output should be constant C is not correct because the power output should increase	1

Question Number	Answer	Additional Guidance	Mark
20(a)	In equilibrium, total clockwise moment = total anticlockwise moment **Or** In equilibrium, sum of all moments (about any point) = 0 **Or** In equilibrium, resultant moment (about any point) = 0 **(1)**	Clockwise moment = anticlockwise moment is insufficient.	1
20(b)(i)	The weight causes a clockwise moment (about the pivot) **(1)** So the direction (of the moment provided by the motor) is anticlockwise (dependent on MP1) **(1)**		2
20(b)(ii)	The motor needs to provide a smaller moment **(1)** So a smaller force is needed (which moves through the same distance) **(1)** So the work done decreases (dependent on MP1 or MP2) **(1)**		3
20(b)(iii)	Determines distance from pivot to centre of gravity of section of bridge **(1)** Use of Moment of force = Fx **(1)** Use of principle of moments **(1)** Moment produced by motor = 8.4×10^7 Nm **(1)**	<u>Example calculation</u> Distance from pivot to centre of gravity of section $= 33\text{ m} - \frac{33\text{ m} + 12\text{ m}}{2}$ $= 10.5\text{ m}$ $4.0 \times 10^6\text{ N} \times 11\text{ m}$ + moment produced by motor $= 1.2 \times 10^7\text{N} \times 10.5\text{ m} + 71 \times 10^3\text{ N} \times 28\text{ m}$ Moment produced by motor = 8.40×10^7 Nm	4
	Total for question 20		10

Question Number	Answer	Additional Guidance	Mark
18(a)	Gradient increasing between 0 s and T_A **(1)** Straight line with positive gradient between T_A and T_B **(1)**	graph does not have to start from origin <u>Example diagram</u>  	2

***18(b)**	This question assesses a student's ability to show a coherent and logically structured answer with linkages and fully-sustained reasoning. Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning. The following table shows how the marks should be awarded for indicative content. IC points / IC mark / Max linkage mark / Max final mark 6 / 4 / 2 / 6 5 / 3 / 2 / 5 4 / 3 / 1 / 4 3 / 2 / 1 / 3 2 / 2 / 0 / 2 1 / 1 / 0 / 1 0 / 0 / 0 / 0 The following table shows how the marks should be awarded for structure and lines of reasoning. Number of marks awarded for structure of answer and sustained line of reasoning Answer shows a coherent and logical structure with linkages and fully sustained lines of reasoning demonstrated throughout: 2 Answer is partially structured with some linkages and lines of reasoning: 1 Answer has no linkages between points and is unstructured: 0	**Indicative content** IC1 In stage A, the kinetic energy increases IC2 (and kinetic energy is proportional to speed squared, so) in stage A, the useful power output increases IC3 In stage B, the gravitational potential energy increases (and kinetic energy is constant) **Or** In stage B, work is done against gravity (and kinetic energy is constant) IC4 And in stage B the gradient of the slope increases so power output increases IC5 In stage C gravitational potential energy increases **and** kinetic energy decreases IC6 So in stage C the useful power output of the person is zero	**6**
	Total for question 18		**8**

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**

Question Number	Answer	Mark
12(a)	Use of $(\Delta)E_{grav} = Fd$ **Or** Use of $E_k = (\Delta)E_{grav}$ **AND** Use of $v^2=u^2+2as$ with $a = -\frac{F}{m}$ (1) Gradient = $\frac{mg}{F}$ **Or** $\frac{d}{h} = \frac{mg}{F}$ (1) Example of calculation $mgh = Fd$ $\frac{d}{h} = \frac{mg}{F}$	**(2)**
12(b)	$u = \sqrt{2gh}$ (1) (Do not allow if suvat used with $a=g$) Use of $p = mv$ (1) $m_1u = (m_1 + m_2)\,v$ (either seen or used) (Do not allow if there is an m_2u term unless $u=0$) (1) Some working leading to the correct expression **AND** statement that the student is correct. (1) Example of calculation $mgh = ½\,mv^2$ $v = \sqrt{2gh}$ $m\sqrt{2gh} = 2mv$ $v = \frac{\sqrt{2gh}}{2} = \sqrt{\frac{gh}{2}}$	**(4)**
	Total for question 12	**6**