PRESTON MANOR

Physics Exam Pack

Work, Energy and Power

Name:

Date:

Question / Paper	Mark

3 Fig. 3.1 shows a wall built with a material of average density 2500 kg m^{-3}.

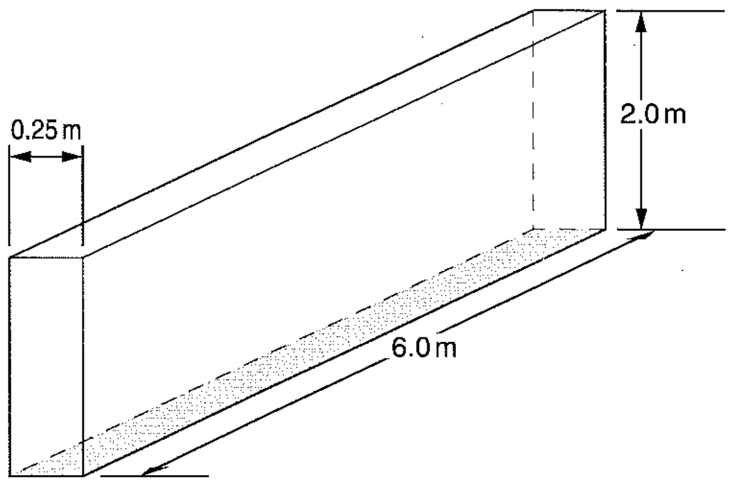

Fig. 3.1

The wall is 6.0 m long, 2.0 m high and 0.25 m wide.

(a) Calculate the mass of the wall.

mass = ... kg [2]

(b) Calculate the pressure the wall exerts on the ground.

pressure = ... Pa [3]

[Total: 5]

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Question			Expected Answers	Marks	Additional Guidance
3	a		V = 6 x 2 x 0.25		
			ρ = m / V	C1	In any form
			m = 3 x 2500		
			= 7500 (kg)	A1	
	b		P = F / A	C1	Wrong formula used (e.g. P = Mass / A) then 0/3
			= [7500 x 9.8(1)] / (6x 0.25)	C1	ECF for the mass from part (a) Penalise for g = 10 if not penalised previously. If no g used then cannot score last two marks
			= 4.9 x 10^4 (Pa)	A1	No ECF for incorrect area used.
			Total	**5**	

4 Fig. 4.1 shows a method used to knock down walls.

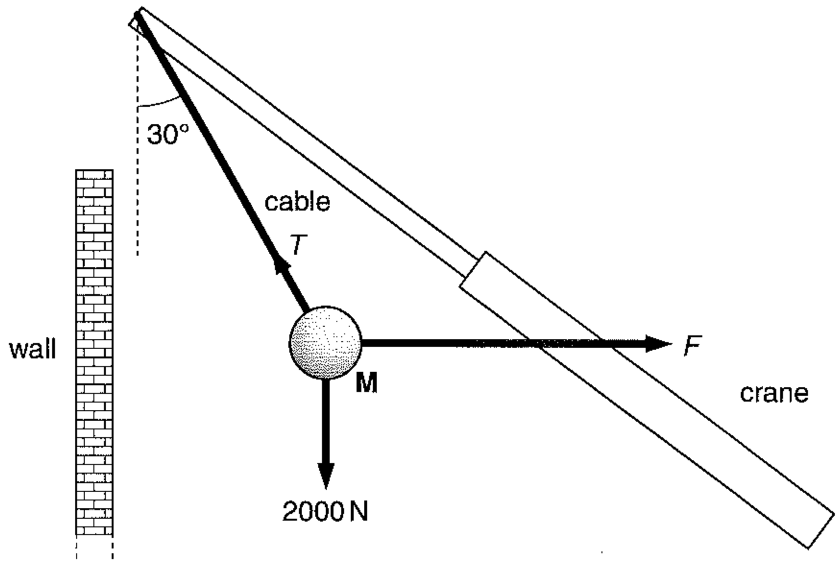

Fig. 4.1

M is a heavy steel ball suspended by a cable in which the tension is *T*. The ball is pulled to one side by a horizontal force *F* until the cable is at 30° to the vertical. It is then released so that it swings into the wall. The weight of the ball **M** is 2000 N.

(a) Determine the force *F* by using a triangle of forces **or** a scale diagram of the forces **or** by resolving forces.

force *F* = ... N [3]

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(b) State and explain one change that could be made to this method to cause more damage to the wall.

....

....

....

....

....[2]

[Total: 5]

5 Fig. 5.1 shows a lorry travelling up a slope.

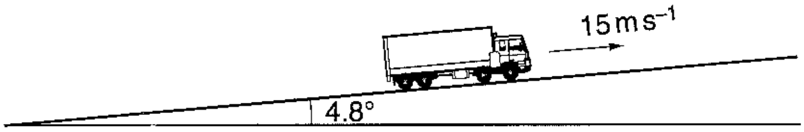

Fig. 5.1

The angle of the slope is 4.8° with the horizontal and the weight of the lorry is 2.4×10^5 N. A resistive force of 1.2×10^4 N down the slope acts on the lorry as it travels up the slope at a constant speed of $15\,\text{m}\,\text{s}^{-1}$.

(a) Show that the component of the weight of the lorry down the slope is 2.0×10^4 N.

[1]

(b) Calculate the rate at which the lorry does work against the resistive force.

rate of work done = ... $\text{J}\,\text{s}^{-1}$ [2]

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(c) Calculate the power developed by the lorry as it travels up the slope.

power = ... W [2]

(d) Calculate the rate of gain of potential energy of the lorry.

rate of gain of potential energy = ... unit .... [3]

(e) State and explain how the braking distance of the lorry up the slope compares with that on a horizontal road at the same speed.

....

....

....[1]

[Total: 9]

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Question			Expected Answers	Marks	Additional Guidance
4	a		**Either:** **Resolve horizontally F = T cos60** **Resolve vertically 2000 = Tsin60** **F = 1155 (N)**	 **C1** **C1** **A1**	 Allow answers to two SF (1200)
			Or correct triangle of forces	**C1**	Basic shape (30, 60 and 90), two forces labelled (arrows not needed). Give this mark even if 30 and 60 reversed (this gives 3464N and would gain 1 mark max).
			correct trig. statement **F = 1155 (N)**	**C1** **A1**	 Allow answers to two SF (1200)
			Or correct scale diagram **Scale given** **F = 1155 (N)**	**C1** **C1** **A1**	As above (for triangle of forces) Allow answers from 1100 to 1200 (N)
	b	i	**Larger mass, weight, larger angle or larger force F**	**B1**	Not longer cable
			Greater kinetic energy (change) or greater momentum (change)	**B1**	Do not accept It hits with greater force on its own
			Allow greater speed <u>at the point of collision</u> /where <u>it hits the wall</u> or mass is larger hence force <u>on wall</u> is larger using F=ma		Do not accept travels with greater acceleration hence force is larger using F=ma.
			Total	**5**	

Question			Expected Answers	Marks	Additional Guidance
5	a	i	$W_c = 2.4 \times 10^5 \times \sin 4.8$	M1	Allow W x sin 4.8
			$= 2.0 \times 10^4$	A0	
	b		W = F x d		
			W / t = F x v		
			= 12000 x 15	C1	
			= 180000 ($J\ s^{-1}$)	A1	
	c		P = W / t P = F x v	C1	
			$P = 3.2 \times 10^4 \times 15$		
			= 480000 (W)	A1	
	d		pe / t = 480000 – 180000	C1	Do not give a mark for PE = mgh on its own. Do not give a mark for W/t or mgh/t on their own
			= 300000	A1	
			allow alternative method of determining the vertical height moved in one second and use of mgh		
			e.g. h = 15 sin4.8 = 1.255	C1	Do not give a mark for W/t or mgh/t on their own
			W/t = mgh/t = $2.4 \times 10^5 \times 1.255$ = 300000	A1	
			unit: W or $J\ s^{-1}$	B1	Allow $kJ\ s^{-1}$ / kW if consistent with numbers used Allow $N\ m\ s^{-1}$ but not $kg\ m^2\ s^{-3}$

Question			Expected Answers	Marks	Additional Guidance
	e		**less**	**M0**	
			Component of weight acts down the slope	**A1**	Weight / force of gravity helps the braking (AW) (not gravity helps braking) Some KE is converted to PE and hence less work has to be done by the braking force
			Total	**9**	

3 Fig. 3.1 shows a stair lift that takes a woman up a flight of stairs.

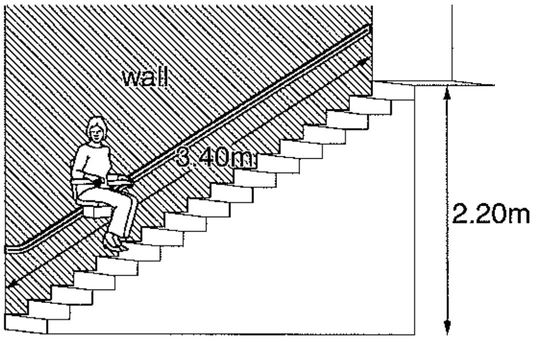

Fig. 3.1

The total weight of the woman and the chair is 930 N. The height gained is 2.20 m and the distance travelled by the woman is 3.40 m.

(a) Calculate the gain in gravitational potential energy of the woman and the chair.

potential energy = ... J **[2]**

(b) Define *power*.

....

.... **[1]**

(c) The lift travels up a slope at an angle of 40.3° to the horizontal in a time of 42.0 s.
Calculate

(i) the component of the weight of the woman and chair down the slope

component = ... N **[1]**

(ii) the power required to lift the woman and chair to the top of the stairs.

power = ... unit .... **[3]**

[Total: 7]

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Question 3			Expected Answers	Marks	Additional Guidance
(a)			Potential energy = mgh = 930 x 2.2 = 2046 (J)	C1 A1	PE = Wgh scores zero
(b)			power = work done / time or = energy (transformed) / time	B1	Do not allow work done over time If symbols are used they need to be defined
(c)	(i)		weight component = 930 sin40.3 = 602 (N) [601.5]	A1	
	(ii)		power = (601.5 x 3.4) / 42 or 2046 / 42 = 48.7 unit: W	C1 A1 B1	Note ecf from (a) or (c)(i) Allow $J\ s^{-1}$
			Total	7	

3 **(a)** Define

(i) the *newton*

....

.... [1]

(ii) *work done by a force*.

....

.... [1]

(b) A car of mass m is travelling at a speed u. A constant braking force F is applied until the car comes to rest. The car travels a distance s after the force is applied.

(i) Write equations for

1 the work done by the force F

2 the relationship between the force F and acceleration a.

[1]

(ii) Use the equations in **(i)** to show that the work done bringing the car to rest equals the loss in kinetic energy of the car.

[3]

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(iii) Hence describe the relationship between the braking distance and the velocity of a car.

....

....

.... **[1]**

(c) **(i)** A car of mass 1550 kg has a braking distance of 25.0 m when travelling at 13.3 m s^{-1}. Calculate the average braking force acting on the car.

force = ... N **[2]**

(ii) Deduce the braking distance when the car is travelling at 26.6 m s^{-1} and the same braking force is applied.

distance = ... m **[1]**

[Total: 10]

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Question 3			Expected Answers	Marks	Additional Guidance
(a)	(i)		**A newton is the <u>force</u> that causes a (mass of) one <u>kilogram</u> to <u>accelerate</u> at one m s^{-2}**	B1	not just 1 kg m s^{-2}
	(ii)		**Work equals the force multiplied by the distance moved <u>in the direction of the force</u>**	B1	force x displacement in line of force
(b)	(i)	1	**W = Fs**		Allow d / x instead of s
		2	**and F = ma**	B1	Allow equations in words
	(ii)		**W = m x a x s allow W / s = ma**	B1	need W in answer line or somewhere W = KE(lost)
			a = (v-u) / t and s = [(u + v)/2] x t or a x s = $(v^2 - u^2)$ / 2		
			W = m x (v-u) / t x [(v+u)/2] x t and v=0 Or W = m x $(v^2 - u^2)$ / 2 and v = 0	B1	
			<u>W</u> = ½ mu^2	B1	need u here or initial velocity defined as v if v given
	(iii)		**Distance is proportional to $(velocity)^2$**	B1	allow double the speed causes four times distance etc
(c)	(i)		**F x s = ½ mu^2 F = 0.5 x 1550 x $(13.3)^2$ / 25 = 5500 (5483) (N)**	C1 A1	note calculating acceleration = 3.54 scores this mark allow 5480 (m) note using 1500 (-1) gives 5300 (N)
	(ii)		**100 (m)**	B1	
			Total	**10**	

4 **(a)** Define *work done* by a force.

....

.... **[2]**

(b) Define *power*.

....

.... **[1]**

(c) Explain why the efficiency of a mechanical device can never be 100%.

....

.... **[1]**

(d) A car has a total mass of 810 kg. Its speed changes from zero to $30\,\mathrm{m\,s^{-1}}$ in a time of 12 s.

(i) Calculate the change in the kinetic energy of the car.

change in kinetic energy = ... J **[2]**

(ii) Calculate the average power generated by the car engine. Assume that the power generated by the engine of the car is entirely used in increasing the kinetic energy of the car.

power = ...W **[1]**

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(iii) The actual efficiency of the car is 25%. The car takes 18 kg of petrol to fill its tank. The energy provided per kilogram of petrol is 46 MJ kg^{-1}. The drag force acting on the car at a constant speed of 30 m s^{-1} is 500 N.

1 Calculate the work done against the drag force per second.

work done per second = ... J s^{-1} **[1]**

2 Calculate the total distance the car can travel on a full tank of petrol when travelling at a constant speed of 30 m s^{-1}.

distance = ... m **[3]**

[Total: 11]

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Question			Expected Answers	Marks	Additional Guidance
4	(a)		work done = force × distance <u>moved</u> in the direction of the force	M1 A1	**Allow**: 'displacement' instead of 'distance' **Allow**: 1 mark for 'force × distance in the direction of the force' **Not**: work done = energy transfer
	(b)		power = work (done)/time or power = energy/time or power = rate of work done	B1	**Not** Mixture of quantities and units, e.g: 'energy per second'
	(c)		This is because of heat/thermal energy/friction	B1	**Not** sound/vibrations
	(d)	(i)	$E_k = \frac{1}{2}mv^2$ / $E_k = \frac{1}{2} \times 810 \times 30^2$ $E_k = 3.645 \times 10^5$ (J) or 3.65×10^5 (J)	C1 A1	**Note**: Bald answer 3.645×10^5 (J) or 3.6×10^5 (J) scores 2/2 marks **Allow**: 1 mark for wrongly rounded answer of 3.7×10^5 (J)
		(ii)	power = $\frac{3.65 \times 10^5}{12}$ power = 3.04×10^4 (W) ≈ 3.0×10^4 (W)	B1	Possible ecf
		(iii) 1.	work done = 500 × 30 work done = 15000 (J s^{-1})	B1	
		2.	'output energy' = $18 \times 46 \times 10^6 \times 0.25$ (= 2.07×10^8 J)	C1	**Allow**: 'input energy' = $18 \times 46 \times 10^6$ (= 8.28×10^8 J)
			total drive time = $\frac{18 \times 46 \times 10^6 \times 0.25}{15000}$ (= 1.38×10^4s)	C1	This C1 mark can also be scored using: 'distance = $2.07 \times 10^8/500$' Possible ecf from **iii 1.**
			total drive distance = $1.38 \times 10^4 \times 30$ = 4.1×10^5 (m)	A1	**Allow**: Bald 4.1×10^5 (m) scores 3/3 2/3 for 1.66×10^6 m if 25% efficiency is not used 2/3 if 30 kW from **ii** is used; answer 2.0 or 2.1×10^5 (m)
			Total	**11**	

4 **(a)** Define *work done* by a force.

In your answer, you should use appropriate technical terms, spelled correctly.

....

.... **[1]**

(b) Fig. 4.1 shows a side view of a roller coaster.

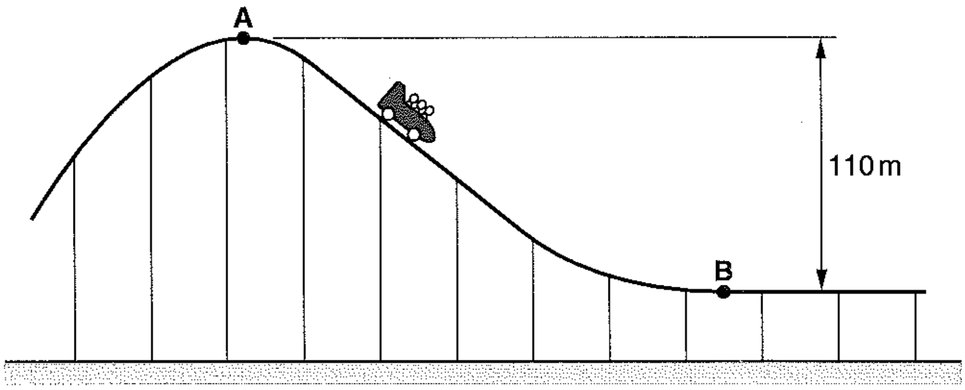

Fig. 4.1

The carriage and its passengers start at rest at **A**. At **B**, the bottom of the ride, the maximum speed of the carriage is $20\,\text{m}\,\text{s}^{-1}$. The vertical distance between **A** and **B** is 110m. The length of the track between **A** and **B** is 510m. The mass of the carriage and the passengers is 4000kg.

(i) Complete the sentence below.

In your answer, you should use appropriate technical terms, spelled correctly.

As the carriage travels from **A** to **B**, ... energy

is transferred to .... energy and heat. **[2]**

(ii) By considering this energy transfer from **A** to **B**, determine the average frictional force acting on the carriage and passengers between **A** and **B**.

force = ... N **[3]**

[Total: 6]

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Q 4	Expected Answers	Marks	Additional Guidance
a	✎work done = force × distance <u>moved</u> / <u>travelled</u> (in direction of force) **The term *distance / displacement* to be included and spelled correctly to gain mark**	B1	**Note:** Must have reference to 'distance moved / travelled' **Allow**: 'work done = force × displacement' **Must use tick or cross on Scoris to show if the mark is awarded**
b(i)	<u>gravitational</u> potential ✎ kinetic **The term *kinetic* to be included and spelled correctly to gain the second B1 mark**	B1 B1	**Not**: 'potential' on its own **Note:** Ignore any reference to sound **Must use ticks on Scoris to show where the marks are awarded**
b(ii)	(GPE =) 4000 × 9.81 × 110 / (GPE =) 4.32×10^6 **or** (KE =) ½ × 4000 × 20^2 / (KE =) 8.0×10^5 Work done = $(4000 \times 9.81 \times 110) - (\frac{1}{2} \times 4000 \times 20^2)$ force = $\frac{3.516 \times 10^6}{510}$ force = 6.9×10^3 (N)	C1 C1 A1	 **Allow**: 2 marks if second line is written or $3.5(16) \times 10^6$ (J) is quoted **Allow**: 3 marks for a bald answer of 6.9×10^3 (N)
	Total	**6**	

5 **(a)** State the principle of conservation of energy.

....

.... [1]

(b) Describe one example where elastic potential energy is stored.

.... [1]

(c) Fig. 5.1 shows a simple pendulum with a metal ball attached to the end of a string.

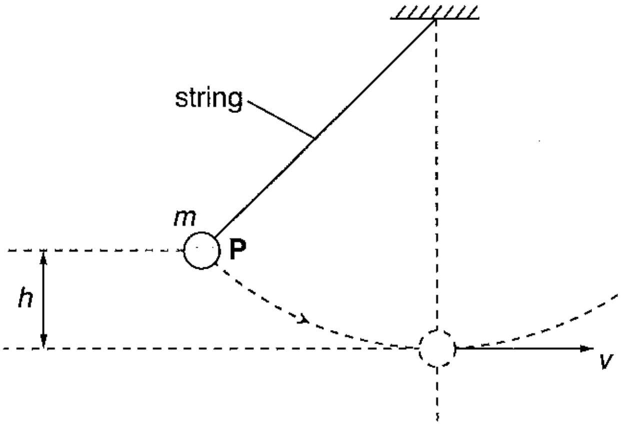

Fig. 5.1

When the ball is released from **P**, it describes a circular path. The ball has a maximum speed v at the bottom of its swing. The vertical distance between **P** and bottom of the swing is h. The mass of the ball is m.

(i) Write the equations for the change in gravitational potential energy, E_p, of the ball as it drops through the height h and for the kinetic energy, E_k, of the ball at the bottom of its swing when travelling at speed v.

E_p =

E_k = [1]

(ii) Use the principle of conservation of energy to derive an equation for the speed v. Assume that there are no energy losses due to air resistance.

[2]

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(d) Some countries in the world have frequent thunderstorms. A group of scientists plan to use the energy from the falling rain to generate electricity. A typical thunderstorm deposits rain to a depth of 1.2×10^{-2} m over a surface area of 2.0×10^{7} m^2 during a time of 900 s. The rain falls from an average height of 2.5×10^{3} m. The density of rainwater is 1.0×10^{3} kg m^{-3}. About 30% of the gravitational potential energy of the rain can be converted into electrical energy at the ground.

(i) Show that the total mass of water deposited in 900 s is 2.4×10^{8} kg.

[2]

(ii) Hence show that the average electrical power available from this thunderstorm is about 2 GW.

[3]

(iii) Suggest one problem with this scheme of energy production.

....

.... **[1]**

[Total: 11]

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Question			Expected Answers	Marks	Additional Guidance
5	(a)		Energy cannot be created or destroyed; it can only be transferred/transformed into other forms or The (total) energy of a system remains constant or (total) initial energy = (total) final energy (AW)	B1	**Allow**: 'Energy cannot be created / destroyed / lost'
	(b)		Any suitable example of something strained (eg: stretched elastic band)	B1	
	(c)	(i)	$E_p = mgh$ and $E_k = \frac{1}{2}mv^2$ (Allow Δh for h)	B1	**Not**: $E_k = mgh$
		(ii)	$mgh = \frac{1}{2}mv^2$ $v^2 = 2gh$ or $v = \sqrt{2gh}$	B1 B1	
	(d)	(i)	$m = \rho V$ $m = 1.0\times10^3 \times (1.2\times10^{-2} \times 2.0\times10^7)$ mass of water = 2.4×10^8 (kg)	C1 C1 A0	**Allow** any subject for the density equation
		(ii)	loss in potential energy = $2.4\times10^8 \times 9.81 \times 2.5\times10^3$ 30% of GPE = $0.3 \times 5.89 \times 10^{12}$ (=1.77×10^{12}) power = $\frac{1.77\times10^{12}}{900}$ power = $1.9(63) \times 10^9$ (W) (≈ 2 GW)	C1 C1 C1 A0	**Allow** 1 mark for '5.89×10^{12} (J)' **Allow** 2 marks for '1.77×10^{12} (J)' **Note**: $\frac{5.89\times10^{12}}{900}$ (= 6.5 GW) scores 2 marks
		(iii)	Any correct suitable suggestion; eg: the energy supply is not constant/ cannot capture all the rain water / large area (for collection)	B1	**Note**: Do not allow reference to 'inefficiency' / 'cost'
			Total	**11**	

6 **(a)** State the principle of *conservation of energy*.

....

....

.... **[1]**

(b) Fig. 6.1 shows a glider on a horizontal frictionless track.

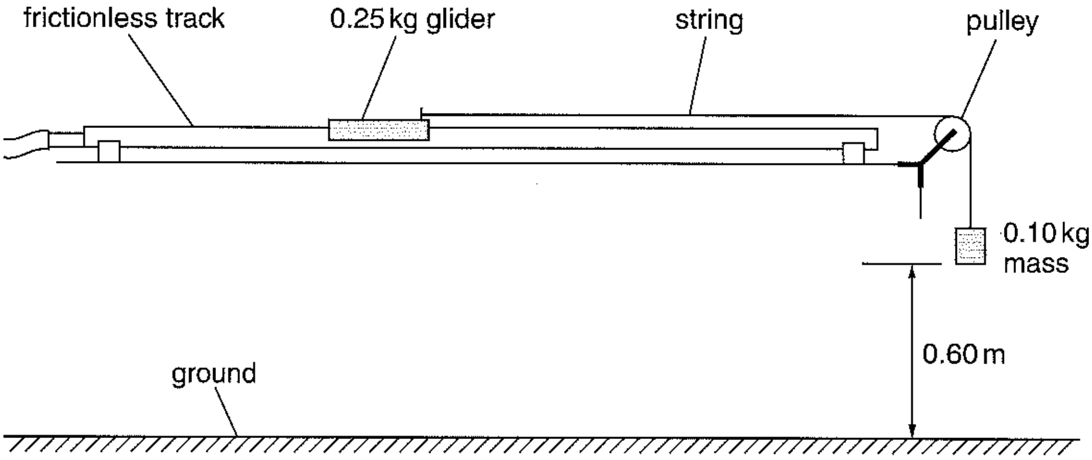

Fig. 6.1

The mass of the glider is 0.25 kg. One end of a string is fixed to the glider and the other end to a 0.10 kg mass. The 0.10 kg mass is held stationary at a height of 0.60 m from the ground. The pulley is more than 0.60 m away from the front of the glider. When the 0.10 kg mass is released, the glider has a constant acceleration of 2.8 m s^{-2} towards the pulley. The 0.10 kg mass instantaneously comes to rest when it hits the ground.

(i) Calculate the loss in potential energy of the 0.10 kg mass as it falls through the distance of 0.60 m.

loss in potential energy = ... J **[1]**

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(ii) The glider starts from rest. Show that the velocity of the **glider** after travelling a distance of 0.60 m is about 1.8 m s^{-1}.

[2]

(iii) Calculate the kinetic energy of the **glider** at this velocity of 1.8 m s^{-1}.

kinetic energy = ... J **[2]**

(iv) Explain why the answer to **(b)(iii)** is not the same as **(b)(i)**.

....

.... **[1]**

[Total: 7]

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Question			Expected Answers	Marks	Additional Guidance
6	a		Energy can neither be created nor destroyed (but it can be transformed from one form to another) or Total energy of a closed system remains constant	B1	
	b	i	loss in PE = $0.10 \times 9.81 \times 0.60$ = 0.59 (J) or 0.589 (J)	B1	
		ii	$v^2 = 2as$ / $v^2 = 2 \times 2.8 \times 0.60$ / $v^2 = 3.36$ $v = \sqrt{2 \times 2.8 \times 0.60}$ or $v = 1.8\underline{33}$ or $v = 1.8\underline{3}$ $v = 1.8$ (m s^{-1})	M1 M1 A0	
		iii	(KE =) $\frac{1}{2}mv^2$ / (KE =) $\frac{1}{2} \times 0.25 \times 1.8^2$ kinetic energy = 0.405 (J) or 0.41 (J)	C1 A1	Possible ecf from **(b)(ii)** **Note**: The answer is 0.42 (J) when 1.83 m s^{-1} is used **Allow:** 1 mark for 0.162 (J) if 0.10 kg mass is used or for 0.567 (J) if 0.35 kg is used
		iv	<u>KE</u> of 0.10 kg mass is not taken into account (AW)	B1	**Not:** 'There is friction'
			Total	7	

2 **(a)** State the *principle of conservation of energy.*

....

.... [1]

(b) Define *work done* by a force and state its unit.

definition ....

....

....

unit .... [3]

(c) Fig. 2.1 shows a crater on the surface of the Earth.

Fig. 2.1

The crater was formed by a meteor impact about 50,000 years ago. The meteor was estimated to have a mass of 3.0×10^8 kg with an initial kinetic energy of 8.4×10^{16} J just before impact.

(i) State one major energy transformation that took place during the impact of the meteor with the Earth.

....

.... [1]

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(ii) Show that the initial impact speed of the meteor was about $2.0 \times 10^4\,m\,s^{-1}$.

[2]

(iii) The crater is about 200 m deep. Estimate the average force acting on the meteor during the impact.

force = ... N **[3]**

[Total: 10]

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Question			Answers	Marks	Guidance
2	(a)		total energy of a (closed) system remains constant or Energy cannot be created or destroyed (it can only be transferred into other forms) or total initial energy = total final energy	B1	**Not**: 'Energy cannot be created / destroyed / lost'
	(b)		work done = force × distance moved in the direction of the force Unit: N m or J	M1 A1 B1	**Allow**: 'force × displacement' for the M1 mark **Note**: The unit mark is an independent mark
	(c)	(i)	kinetic energy → heat	B1	**Not**: friction / deformation / sound / KE of dust / KE of Earth
		(ii)	($E = \frac{1}{2}mv^2$) $8.4 \times 10^{16} = \frac{1}{2} \times 3.0 \times 10^8 \times v^2$ $v^2 = \frac{2 \times 8.4 \times 10^{16}}{3.0 \times 10^8}$ or $v = \sqrt{\frac{2 \times 8.4 \times 10^{16}}{3.0 \times 10^8}}$ ($v = 2.37 \times 10^4$ m s^{-1})	 C1 C1 A0	**Note**: This mark is for correct substitution **Allow**: 2 marks for $v^2 = 5.6 \times 10^8$ **Allow**: 1 mark for a bald answer of 2.4×10^4
		(iii)	$8.4 \times 10^{16} = F \times 200$ $F = \frac{8.4 \times 10^{16}}{200}$ force = 4.2×10^{14} (N)	C1 C1 A1	Possible ecf **Allow**: $a = (-)\frac{u^2}{2s}$ $a = (-)\frac{(2.37 \times 10^4)^2}{2 \times 200}$ or $a = (-)\frac{(2 \times 10^4)^2}{2 \times 200}$ C1 $a = 1.4 \times 10^6$ (m s^{-2}) or $a = 1.0 \times 10^6$ (m s^{-2}) C1 $F = 3.0 \times 10^8 \times 1.4 \times 10^6$ or $F = 3.0 \times 10^8 \times 1.0 \times 10^6$ force = 4.2×10^{14} (N) or force = 3.0×10^{14} (N) A1
			Total	**10**	

3 **(a)** Define *velocity*.

....

.... [1]

(b) Define *work done* by a force.

....

.... [2]

(c) Fig. 3.1 shows a rider on a sledge sliding down an icy slope.

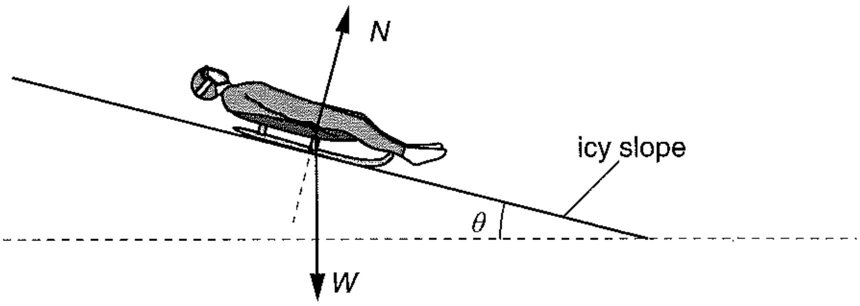

Fig. 3.1

The frictional forces acting on the sledge and the rider are negligible. The normal contact force N and the total weight W of the sledge and rider are shown.

(i) Explain why the force N does no work on the sledge as it slides down the slope.

....

.... [1]

(ii) State and explain the force that causes the sledge and rider to accelerate down the slope.

....

.... [1]

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(d) Fig. 3.2 shows the velocity against time graph for the sledge and rider in **(c)** sliding down the icy slope.

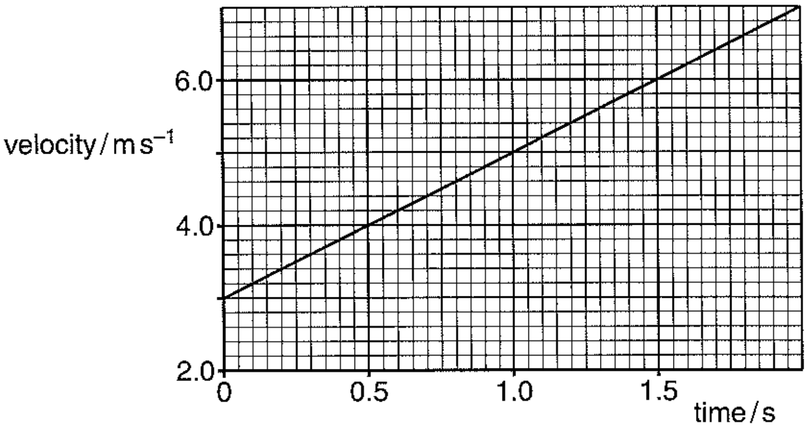

Fig. 3.2

(i) Use Fig. 3.2 to determine

1 the acceleration of the sledge and rider down the slope

acceleration = ... m s^{-2} **[2]**

2 the angle made by the slope to the horizontal.

angle = ... ° **[2]**

(ii) The sledge crashes into a foam barrier at the bottom of the slope.

The velocity of the sledge just before the impact is $15\,m\,s^{-1}$. The sledge and rider take 3.5 s to stop. The average decelerating force on the sledge and rider is 510 N.

Calculate the total mass of the sledge and rider.

mass = ... kg **[3]**

[Total: 12]

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Question			Answer	Marks	Guidance
3	(a)		velocity = rate of change of <u>displacement</u>	B1	**Allow**: Equation if labels are defined **Not**: velocity = displacement/time **Not**: A mixture of quantity and unit, e.g: 'change in displacement per second'
	(b)		work done = force × distance <u>moved</u> in direction of force	M1 A1	**Allow**: 'force × displacement' for the M1 mark
	(c)	(i)	It is at right angles to motion	B1	**Allow:** It is at right angles to slope / sledge
		(ii)	The component of the weight / *W* / *mg* (down the slope)	B1	**Allow:** *W* sinθ or *mg*sinθ **Not**: 'component of gravity' **Allow:** <u>Resultant</u> of *W* and *N*
	(d)	(i)	1 acceleration = gradient / $a = (v-u)/t$ a = 3.0/1.5 a = 2.0 (m s^{-2}) 2 $a = g\sin\theta$ $\sin\theta = 2.0/9.81$ θ = 12°	C1 A1 C1 A1	 **Allow**: 1 sf answer Possible ecf from incorrect value of acceleration *a* Answer to 3 sf is 11.8° **Note**: Using 10 m s^{-2} gives an answer of 11.5° - award 2 marks
		(ii)	*a* = (-) 15/3.5 or *a* = (-) 4.29 (m s^{-2}) $m = 510/4.29$ mass = 120 (kg)	C1 C1 A1	**Ignore** sign Answer to 3 sf is 119 (kg)
			Total	**12**	

7 Fossil fuels will eventually run out. This has led to scientists looking for alternative sources of energy. Tidal stream systems use the kinetic energy of seawater to generate electrical energy during the incoming and outgoing tides. Fig. 7.1 shows a twin-turbine system in which flowing seawater turns the turbine blades.

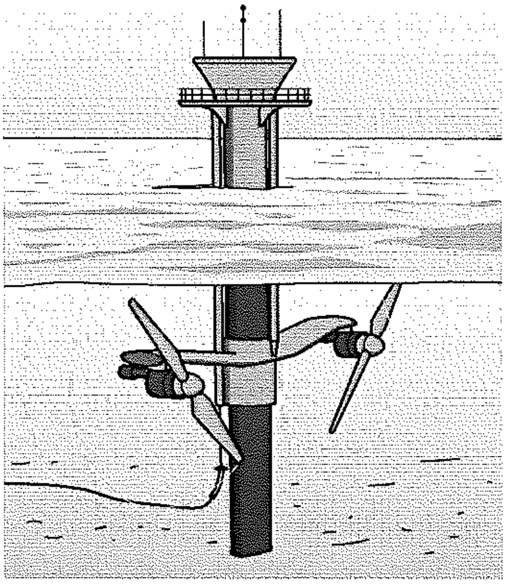

Fig. 7.1

When operating, 9.7×10^5 kg of seawater travelling at a speed of $3.0\,\text{m}\,\text{s}^{-1}$ passes through each turbine every second. Each turbine generates 1.2×10^6 W of electrical power.

(a) Define *power*.

....

.... **[1]**

(b) The input power to each turbine is the kinetic energy of the seawater that flows through each turbine in one second.

Show that the input power to each turbine is 4.4×10^6 W.

[2]

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(c) Calculate the percentage efficiency of each turbine.

efficiency = ... % **[1]**

(d) In one second, a cylinder of seawater of mass 9.7×10^5 kg passes through each turbine at a speed of $3.0\,m\,s^{-1}$. Calculate the radius of each turbine. The density of seawater is $1030\,kg\,m^{-3}$.

radius = ... m **[3]**

(e) Tidal stream systems require less space than conventional wind turbines that are found in windy regions of this country.

(i) Explain why a tidal stream turbine system of identical size to a wind turbine system will produce greater power for the same water or wind speed.

....

....

.... **[1]**

(ii) Suggest one further advantage of tidal stream systems over conventional wind farms.

....

.... **[1]**

[Total: 9]

END OF QUESTION PAPER

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Question			Answer	Marks	Guidance
7	(a)		power = work done/ time or energy/time or 'rate of work done'	B1	
	(b)		power = KE/time Using $\frac{1}{2}mv^2$ (power =) ½ × 9.7 × 10^5 (kg s^{-1}) × 3.0^2 (power =) 4.365 × 10^6 (W)	C1 C1 A0	**Allow**: 1 mark for a bald answer of 4.37 × 10^6 since this is a 'show' question
	(c)		efficiency = $\frac{1.2}{4.4}$ × 100 efficiency = 27 %	B1	**Note**: Answer to 3 sf is 27.3% if 4.4 × 10^6 is used **Note**: Answer is 27.5% if 4.365 × 10^6 is used **Not**: 0.27
	(d)		(volume per second =) 9.7 × 10^5/1030 or 941.7 mass per second = density × volume per second 9.7 × 10^5 = 1030 × (3.0 × π × r^2) $r^2 = \frac{9.7 \times 10^5}{1030 \times 3\pi}$ radius = 10 (m)	C1 C1 A1	**Allow** any subject **Allow**: 2 marks for 100 (m); answer not square rooted
	(e)	(i)	water has greater density or water has greater mass / KE for the <u>same volume</u>	B1	
		(ii)	Any <u>one</u> from: • Not an eyesore / cannot be seen • Not noisy • Predictable energy (with in and out tides) • Do not occupy space on the land	B1	**Allow** other sensible suggestions
			Total	**9**	

6 **(a)** Define *work done* by a force.

....

.... **[1]**

(b) Fig. 6.1 shows a water slide.

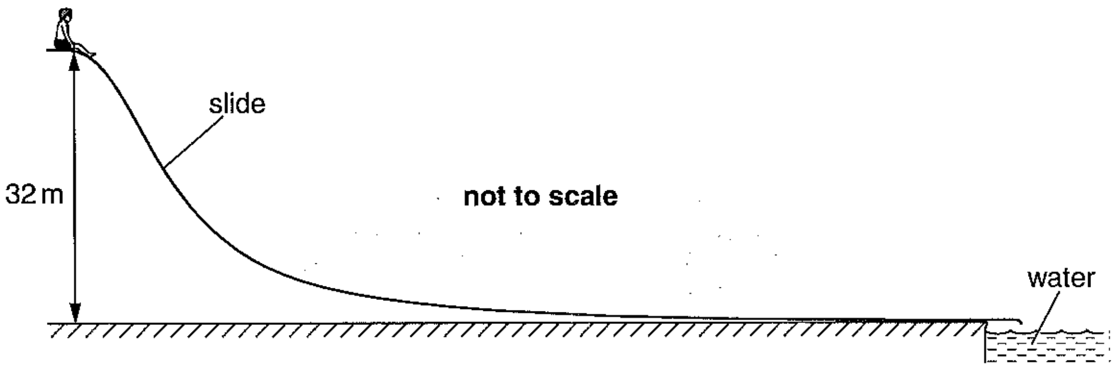

Fig. 6.1

The top of the slide is 32 m above the bottom of the slide. The total distance along the slide is 120 m. A person of weight 700 N, initially at rest at the top, slides down. His speed at the end of the slide is $15\,\mathrm{m\,s^{-1}}$.

(i) Calculate his kinetic energy at the end of the slide.

kinetic energy = ... J **[2]**

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(ii) Calculate the average resistive force acting on him as he travels down to the end of the slide.

average resistive force = ... N **[3]**

[Total: 6]

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Question			Answer	Marks	Guidance
6	(a)		work done = force × distance moved in the direction of force	B1	**Allow**: work done = force × displacement in direction of force
	(b)	(i)	mass = 700/9.81 or mass = 71.4 (kg) kinetic energy = ½ × 71.4 × 15^2 kinetic energy = 8.0×10^3 (J)	C1 A1	 **Note**: Answer to 3 sf is 8.03×10^3 (J) **Note**: '½ × 700 × 15^2 = 7.9×10^4' scores zero **Allow**: 1 sf answer
		(ii)	GPE = *mgh* 700 × 32 / 2.24×10^4 (J) work done = $2.24 \times 10^4 - 8.03 \times 10^3$ resistive force = $\frac{1.44 \times 10^4}{120}$ resistive force = 120 (N)	 C1 C1 A1	 Possible ecf **Note**: Dividing the work done by 32 (m) gives 450 (N). This answer scores 2 marks.
			Total	**6**	

6 **(a)** Power can be measured in watts. Define the *watt*.

....

.... **[1]**

(b) An electric motor-driven crane is used to raise a load of bricks of mass 700 kg through a vertical height of 8.5 m in a time of 45 s. The efficiency of the motor-driven crane is 30%. Calculate

(i) the gravitational potential energy E_p gained by the bricks

E_p = ... J **[1]**

(ii) the output power of the motor-driven crane

output power = ... W **[1]**

(iii) the input power to the motor-driven crane.

input power = ... W **[1]**

[Total: 4]

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Question			Answer	Marks	Guidance
6	(a)		(1 watt is equal to) 1 joule (of energy transferred) per second	B1	**Allow**: (1) J s^{-1} **Not**: '1 J (of energy transferred) in 1 s' because the per or rate idea is not clear **Note**: Do not allow mixture of quantity and unit. Eg: '1 J per unit time' or 'energy per second'
	(b)	(i)	$E_p = 700 \times 9.81 \times 8.5$ $E_p = 5.8(4) \times 10^4$ (J)	B1	
		(ii)	output power = $\frac{5.84 \times 10^4}{45}$ output power = 1.3×10^3 (W)	B1	Possible ecf from **(i)**
		(iii)	input power = $1.3 \times 10^3/0.3$ input power = 4.3×10^3 (W)	B1	Possible ecf from **(ii)**
			Total	**4**	

7 **(a)** A car of mass m is at rest. A constant net force F acts on the car and it moves a distance x in the direction of the force. The final velocity of the car is v.

(i) Write down the equation

1 for the work done by the force F

2 relating force F and acceleration a.

[1]

(ii) Hence show that the kinetic energy of the car is given by the equation $E_k = ½mv^2$.

[3]

(b) The braking distance of an empty van travelling at a steady speed on a level road is 50 m. The van is now fully loaded with goods and travels at the same speed on the same road.

Explain whether or not the braking distance would be the same. Assume that the driver applies the same braking force.

....

....

....

....

....

....

.... **[3]**

[Total: 7]

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Question			Answer	Marks	Guidance
7	(a)	(i)	(work done =) Fx and $F = ma$ (Allow any subject)	B1	**Allow**: d or s instead of x
		(ii)	(E_k =) max or (work done =) max (Allow any subject)	B1	**Note**: This mark is for substituting 'ma' into the equation 'Fx'
			$v^2 = 2ax$	B1	
			Use of $v^2 = 2ax$ and $E_k = max$ to show KE = ½ mv^2	B1	**Note**: This B1 mark is for manipulation of equations leading to KE = ½ mv^2 **Allow** full credit for alternative approaches
	(b)		The (braking) distance is more (than 50m)	B1	
			KE = Fx	B1	Alternative: Fx = ½ mv^2 B1
			Correct reasoning for longer braking distance, eg: (KE increases and) $x \propto$ KE	B1	*Correct reasoning for longer braking distance, eg:* $x \propto m$ B1
			Or		
			The (braking) distance is more (than 50m)	B1	
			The van has smaller deceleration (for the same force)	B1	**Allow**: smaller acceleration
			Correct reasoning for longer braking distance in terms of $v^2 = u^2 + 2as$	B1	**Allow**: Correct reasoning for longer distance in terms of equations of motion
			Total	**7**	

4 **(a)** An object falling towards the ground has both kinetic energy and gravitational potential energy.

Explain what is meant by *gravitational potential energy* without using an equation.

....

.... **[1]**

(b) A ball of mass 0.20 kg is thrown vertically downwards at a speed of $15\,m\,s^{-1}$ towards the ground from a height of 2.8 m. The ball hits the ground and rebounds at a speed of $12\,m\,s^{-1}$, as shown in Fig. 4.1. Assume air resistance has negligible effect on the motion of the ball.

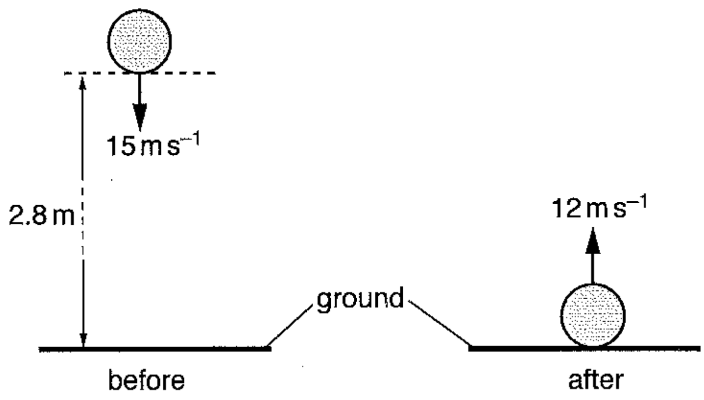

Fig. 4.1

(i) Calculate the speed of the ball just before it hits the ground.

speed = ... $m\,s^{-1}$ **[2]**

(ii) Calculate the energy transferred to the ground during the impact.

energy transferred = ... J **[3]**

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(iii) The time of impact of the ball with the ground is 0.065 s.

Calculate the magnitude of the average force exerted by the ground on the ball during the impact.

force = ... N **[2]**

5 A student wants to carry out an experiment to determine the input power to a small electric motor without using electrical meters. The motor is used to lift light loads. The efficiency of the motor is 15%. Describe how this student can determine the input power to the motor. Your description should include:

- the measurements taken
- the instruments used to take the measurements
- how the measurements are used to determine the input power to the motor.

In your answer, you should use appropriate technical terms, spelled correctly.

....

....

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....

....

....

....

....

....

.... **[4]**

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Question			Answer	Marks	Guidance
4	a		GPE linked to 'position' / height (in a gravitational field)	B1	**Allow**: GPE linked to an object 'raised' / 'lowered' (on the Earth)
	b	i	$v^2 = u^2 + 2as$ $v^2 = 15^2 + (2 \times 9.81 \times 2.8)$ or $v = \sqrt{280}$ speed = 17 (m s^{-1})	 C1 A1	**Allow** other correct methods **Note**: Answer is 16.7 m s^{-1} to 3sf
		ii	(initial energy =) ½ × 0.20 × 16.7^2 or (initial energy =) 0.20 × 9.81 × 2.8 + ½ × 0.20 × 15^2 (final energy =) ½ × 0.20 × 12^2 energy lost = 14 (J)	C1 C1 A1	Possible ecf from **b(i)** **Special case:** 1 mark for 8.1 (J); the difference in the initial KE (½ × 0.20 × 15^2) and the final KE (½ × 0.20 × 12^2)
		iii	change in velocity = 17 + 12 (= 29 m s^{-1}) or 16.7 + 12 (= 28.7 m s^{-1}) *F* = *ma* force = $0.20 \times \frac{29}{0.065}$ or force = $0.20 \times \frac{28.7}{0.065}$ force = 89 (N) or force = 88 (N)	C1 A1	Possible ecf from **(b)(i)** **Allow** 1 mark for 'force = $0.20 \times \frac{(b)(i) - 12}{0.065}$' calculated with an answer.
			Total	**8**	

Question			Answer	Marks	Guidance
5			Any one from: • Mass obtained using a balance / scales • Weight / load obtained using a newtonmeter / spring balance • Distance / height obtained using a ruler / metre stick / measuring tape	B1	
			Time obtained using a clock / (stop)watch / timer or light-gate and timer or light-gate and data-logger	B1	✐ The term **clock / (stop)watch / timer /data-logger** must be spelled correctly to gain this mark
			(output power =) 'mass × g × distance'/time or 'weight × distance/time' or 'weight × speed'	B1	**Allow** symbols, e.g *mgh/t*, *Wh/t* and *Wv*
			input power = output power/0.15	B1	
			Total	**4**	