



Cowen
Physics

OCR Physics A

Work, Energy and Power

Exam Pack

- 4 (a) (i) State what is meant by the *force constant* of a wire.

.....
 [1]

- (ii) A student is investigating wires **A** and **B** made from the same material. The wires have the same length. Wire **A** is thicker than wire **B**.
 Explain which of these wires has a greater value of force constant.

.....

 [2]

- (b) A compression spring is attached to a block of metal. The block and the spring fall vertically towards the horizontal ground as shown in Fig. 4.1.

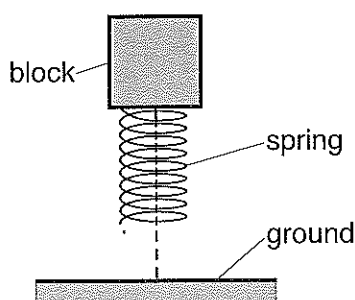


Fig. 4.1

The spring has negligible mass.

At time $t = 0$ the spring touches the ground. Fig. 4.2 shows the variation of the compression x of the spring with time t .

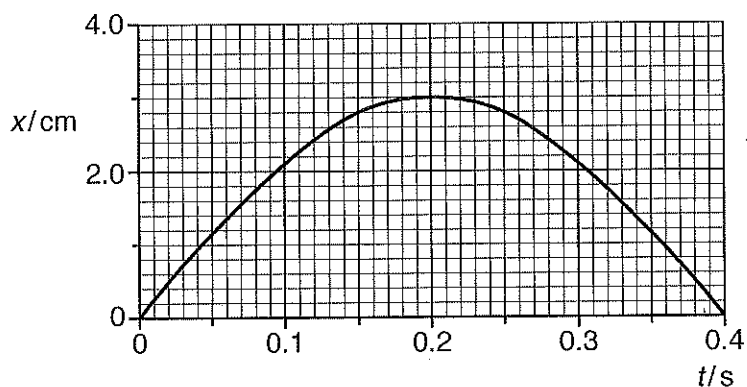


Fig. 4.2

- (i) Explain how you can use the graph in Fig. 4.2 to determine the maximum speed of the block.

.....
.....
.....
..... [2]

- (ii) The force constant of the spring is 24 N m^{-1} .
Use Fig. 4.2 to determine the maximum elastic potential energy E for the spring between $t = 0$ and 0.4 s .

$E = \dots\dots\dots \text{ J [3]}$

- (iii) Describe the energy changes of the block and the spring from $t = 0$ to $t = 0.2 \text{ s}$.

.....
.....
.....
.....
.....
.....
.....
..... [3]

Question	Answer	Marks	Guidance
4 a	i force constant = force/extension or force per (unit) extension	B1	Allow tension instead of force and compression instead of extension Allow: equation using symbols if meanings are stated
	ii For the <u>same</u> force A has a smaller extension Wire A has the greater force constant	M1 A1	Alternative: For the <u>same</u> extension A has the greater force / Use of Young modulus = stress/strain to show $k \propto A$ M1 Wire A has greater force constant A1
b	i The gradient of graph / tangent (to graph) is equal to the speed Draw a <u>tangent</u> to the graph at $t = 0$ s and find its gradient	B1 B1	Allow any t between 0.0 and 0.04 s
	ii $E = \frac{1}{2} kx^2$ and $x = 3.0$ cm (from Fig. 4.2) $E = \frac{1}{2} \times 24 \times 0.03^2$ $E = 1.1 \times 10^{-2}$ (J)	C1 C1 A1	Allow 2 marks for 110 (J); cm not converted into m
	iii The GPE and KE of the <u>block</u> decreases The <u>strain/elastic potential energy</u> in the spring increases / (KE and GPE) energy transferred /converted to <u>EPE</u> in the spring At $t = 0.2$ s, the block has <u>no KE</u> and the spring has <u>maximum strain/elastic potential</u> energy	B1 B1 B1	Ignore any reference to the GPE and KE of the spring since it has negligible mass Ignore reference to GPE of block at $t = 0.2$ s
	Total	11	

Answer **all** the questions.

1 (a) Define *power*.

.....
 [1]

(b) Fig. 1.1 shows a small electric motor used to lift an object.

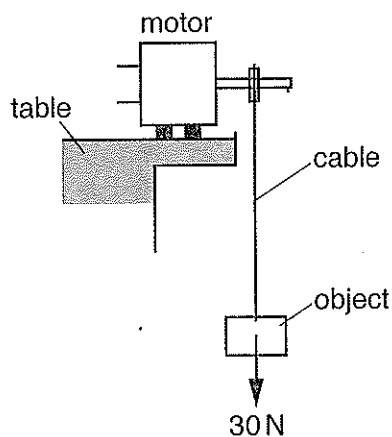


Fig. 1.1

The weight of the object is 30 N. The efficiency of the motor is 5.0%. The motor lifts the object vertically at a constant speed of 8.4 cm s⁻¹.

(i) State the tension in the cable. Justify your answer.

.....

 [2]

(ii) Calculate the rate at which work is done in lifting the object vertically against the force of gravity.

rate of work done =Js⁻¹ [2]

(iii) Calculate the input power to the electric motor.

power = W [1]

(iv) Explain why the tension in the cable is different when the object is accelerating upwards.

.....
.....
.....
.....
..... [2]

Question	Answer	Marks	Guidance
1 a	Power is the rate of work done / power is the rate of energy transfer	B1	Allow: power = energy/time or energy per (unit) time or power = work/time Allow: equation using symbols if meanings are stated Ignore any reference to units
b	i (The tension is) equal to the weight / 30 N Since object has constant speed / no acceleration the <u>net</u> / <u>resultant</u> force on the object is zero.	B1 B1	
ii	rate of work done = 30×0.084 rate of work done = $2.5 \text{ (J s}^{-1}\text{)}$	C1 A1	Allow 1 mark for $252 \text{ (J s}^{-1}\text{)}$; cm not converted into m
iii	input power = $2.5/0.05$ input power = 50 (W)	B1	Possible ecf from ii
iv	The tension would be greater than 30 N / weight of object Explanation in terms of resultant / net upward force (F) = ma	B1 B1	Allow tension would be larger Not acceleration causes a (resultant/net) force
	Total	8	

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

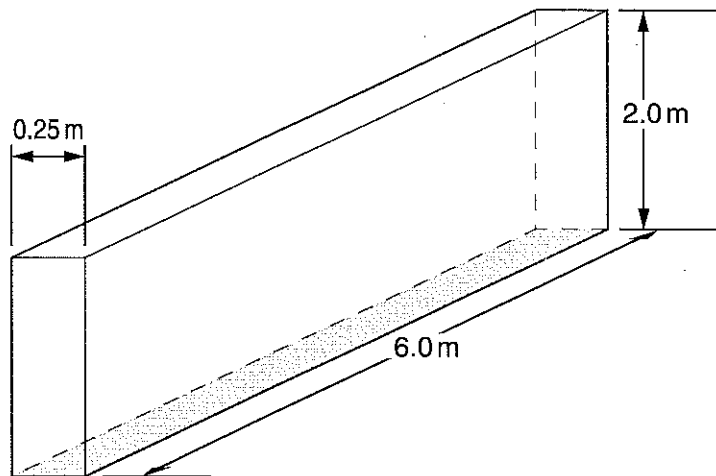


Fig. 3.1

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]

Question	Expected Answers	Marks	Additional Guidance
3 a	$V = 6 \times 2 \times 0.25$ $\rho = m / V$ $m = 3 \times 2500$ $= 7500 \text{ (kg)}$	C1 A1	In any form
b	$P = F / A$ $= [7500 \times 9.8(1)] / (6 \times 0.25)$ $= 4.9 \times 10^4 \text{ (Pa)}$	C1 C1 A1	Wrong formula used (e.g. $P = \text{Mass} / A$) then 0/3 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 No ECF for incorrect area used.
	Total	5	

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

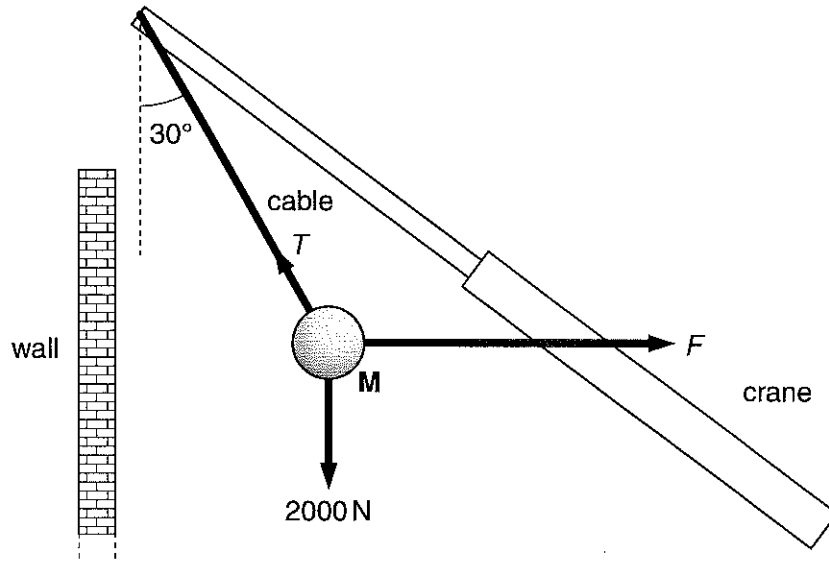


Fig. 4.1

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 $F = \dots\dots\dots$ N [3]

[Turn over

(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.

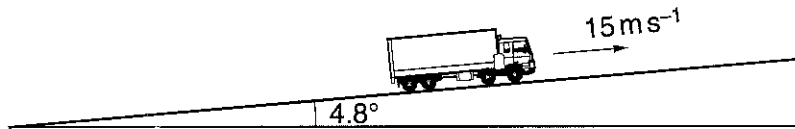


Fig. 5.1

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

(a) Show that the component of the weight of the lorry down the slope is $2.0 \times 10^4 \text{ N}$.

[1]

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

rate of work done = J s^{-1} [2]

(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]

Question	Expected Answers	Marks	Additional Guidance
4 a	<p>Either: Resolve horizontally $F = T \cos 60$ Resolve vertically $2000 = T \sin 60$ $F = 1155 \text{ (N)}$</p> <p>Or correct triangle of forces</p> <p>correct trig. statement $F = 1155 \text{ (N)}$</p> <p>Or correct scale diagram Scale given $F = 1155 \text{ (N)}$</p>	<p>C1 C1 A1</p> <p>C1</p> <p>C1 A1</p> <p>C1 C1 A1</p>	<p>Allow answers to two SF (1200)</p> <p>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).</p> <p>Allow answers to two SF (1200)</p> <p>As above (for triangle of forces)</p> <p>Allow answers from 1100 to 1200 (N)</p>
b	<p>i Larger mass, weight, larger angle or larger force F</p> <p>Greater kinetic energy (change) or greater momentum (change)</p> <p>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 $F=ma$</p>	<p>B1</p> <p>B1</p>	<p>Not longer cable</p> <p>Do not accept It hits with greater force on its own</p> <p>Do not accept travels with greater acceleration hence force is larger using $F=ma$.</p>
	Total	5	

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

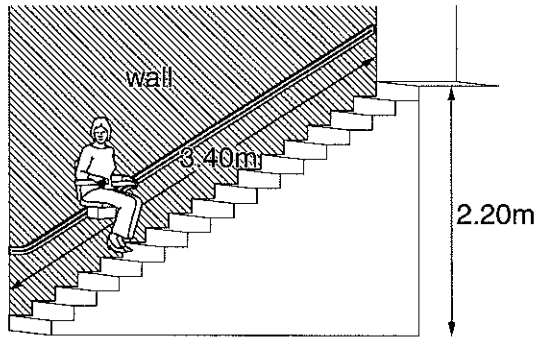


Fig. 3.1

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]

Question 3	Expected Answers	Marks	Additional Guidance
(a)	Potential energy = mgh = 930×2.2 = 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 = $930 \sin 40.3$ = 602 (N) [601.5]	A1	
(ii)	power = $(601.5 \times 3.4) / 42$ 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]

- (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]

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 $W = Fs$	B1	Allow d / x instead of s
2	and $F = ma$	B1	Allow equations in words
(ii)	$W = m \times a \times s$ allow $W / s = ma$ $a = (v-u) / t$ and $s = [(u + v)/2] \times t$ or $a \times s = (v^2 - u^2) / 2$ $W = m \times (v-u) / t \times [(v+u)/2] \times t$ and $v=0$ Or $W = m \times (v^2 - u^2) / 2$ and $v = 0$ $W = \frac{1}{2} mu^2$	B1	need W in answer line or somewhere $W = KE(\text{lost})$
(iii)	Distance is proportional to (velocity) ²	B1	need u here or initial velocity defined as v if v given
(c) (i)	$F \times s = \frac{1}{2} mu^2$ $F = 0.5 \times 1550 \times (13.3)^2 / 25$ $= 5500 \text{ (5483) (N)}$	C1 A1	note calculating acceleration = 3.54 scores this mark allow 5480 (m) note using 1500 (-1) gives 5300 (N)
(ii)	100 (m)	B1	allow double the speed causes four times distance etc
	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 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]

- (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]

Question		Expected Answers	Marks	Additional Guidance
4	(a)	work done = force \times distance <u>moved</u> in the direction of the force	M1 A1	Allow: 'displacement' instead of 'distance' Allow: 1 mark for 'force \times 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) $\approx 3.0 \times 10^4$ (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) total drive time = $\frac{18 \times 46 \times 10^6 \times 0.25}{15000}$ (= 1.38×10^4 s) total drive distance = $1.38 \times 10^4 \times 30$ = 4.1×10^5 (m)	C1 C1 A1	Allow: 'input energy' = $18 \times 46 \times 10^6$ (= 8.28×10^8 J) This C1 mark can also be scored using: 'distance = $2.07 \times 10^8 / 500$ ' Possible ecf from iii 1. Allow: Bald 4.1×10^5 (m) scores 3/3 2/3 for 1.66×10^5 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.

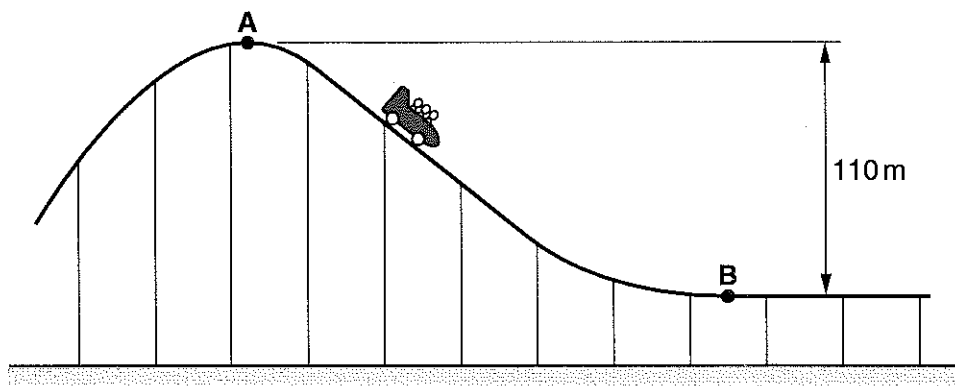


Fig. 4.1

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 m 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 4000 kg.

(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]

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

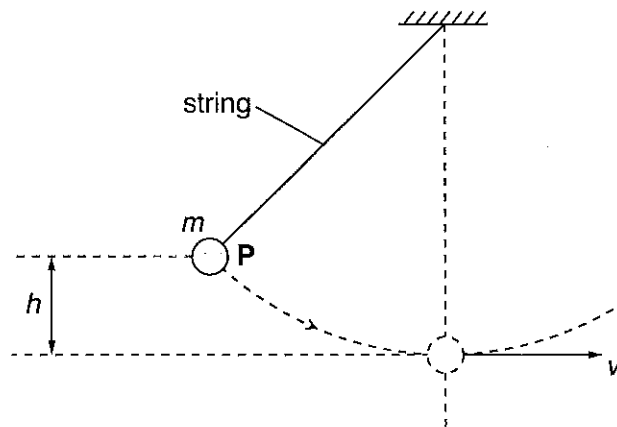


Fig. 5.1

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]

(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 $1.2 \times 10^{-2} \text{ m}$ over a surface area of $2.0 \times 10^7 \text{ m}^2$ during a time of 900 s. The rain falls from an average height of $2.5 \times 10^3 \text{ m}$. The density of rainwater is $1.0 \times 10^3 \text{ kg m}^{-3}$. 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 $2.4 \times 10^8 \text{ kg}$.

[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]

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)	$m = \rho V$ $m = 1.0 \times 10^3 \times (1.2 \times 10^{-2} \times 2.0 \times 10^7)$ mass of water = 2.4×10^8 (kg)	C1 C1 A0	Allow any subject for the density equation
(ii)	loss in potential energy = $2.4 \times 10^8 \times 9.81 \times 2.5 \times 10^3$ 30% of GPE = $0.3 \times 5.89 \times 10^{12}$ (= 1.77×10^{12}) power = $\frac{1.77 \times 10^{12}}{900}$ 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: $\frac{5.89 \times 10^{12}}{900}$ (= 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.

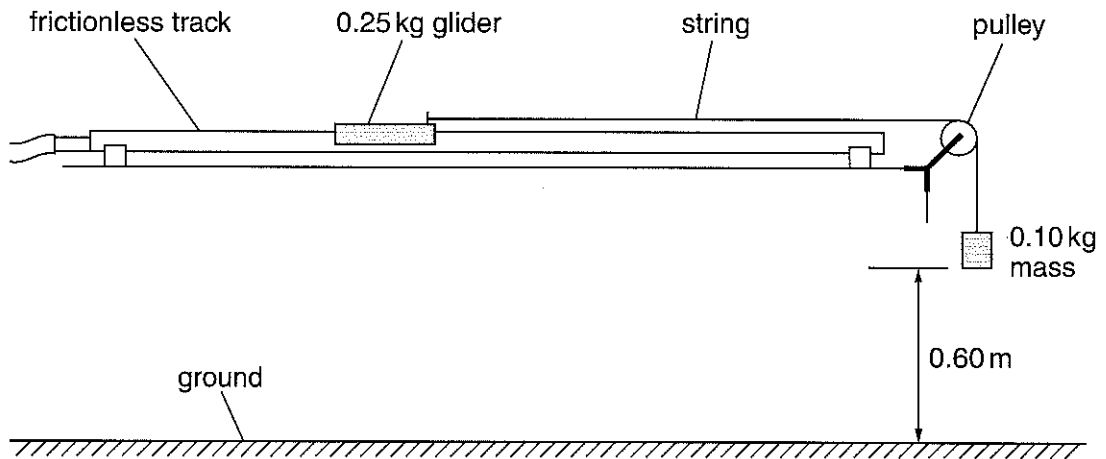


Fig. 6.1

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 ms^{-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]

- (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]

G481

Mark Scheme

June 2011

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 $v = 1.833$ or $v = 1.83$ $v = 1.8$ (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	KE 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]

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

[2]

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

force = N [3]

[Total: 10]

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

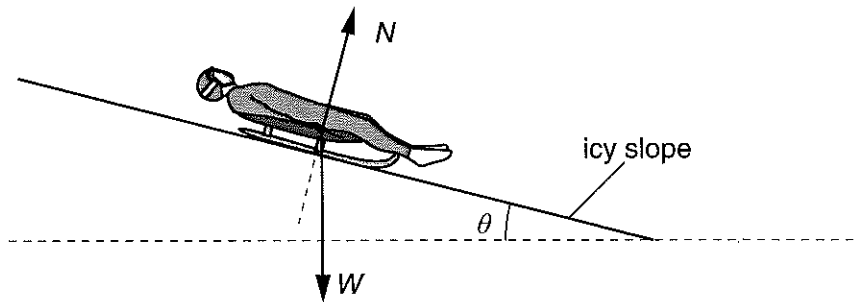


Fig. 3.1

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]

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

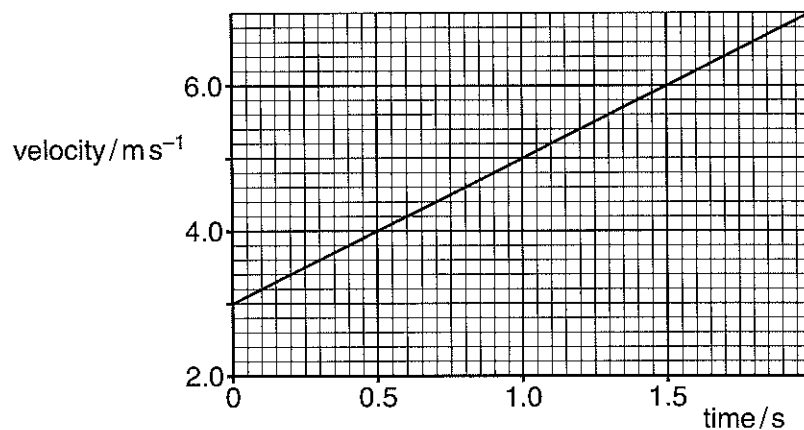


Fig. 3.2

- (i) Use Fig. 3.2 to determine

- 1 the acceleration of the sledge and rider down the slope

acceleration = ms⁻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 ms^{-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]

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 \times distance <u>moved</u> in direction of force	M1 A1	Allow: 'force \times 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: $W \sin \theta$ or $mg \sin \theta$ Not: 'component of gravity' Allow: <u>Resultant</u> of W and N
	(d) (i)	1 acceleration = gradient $a = (v - u) / t$ $a = 3.0 / 1.5$ $a = 2.0 \text{ (m s}^{-2}\text{)}$ 2 $a = g \sin \theta$ $\sin \theta = 2.0 / 9.81$ $\theta = 12^\circ$	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 $a = (-) 4.29 \text{ (m s}^{-2}\text{)}$ $m = 510/4.29$ 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.

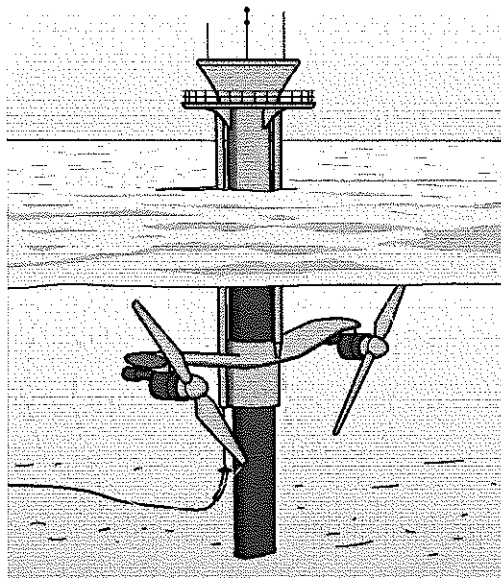


Fig. 7.1

When operating, $9.7 \times 10^5 \text{ kg}$ of seawater travelling at a speed of 3.0 ms^{-1} passes through each turbine every second. Each turbine generates $1.2 \times 10^6 \text{ W}$ 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 $4.4 \times 10^6 \text{ W}$.

[2]

(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 ms^{-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

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 =) $\frac{1}{2} \times 9.7 \times 10^6 \text{ (kg s}^{-1}\text{)} \times 3.0^2$ (power =) $4.365 \times 10^6 \text{ (W)}$	C1 C1 A0	Allow: 1 mark for a bald answer of 4.37×10^6 since this is a 'show' question
(c)	efficiency = $\frac{1.2}{4.4} \times 100$ 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 =) $9.7 \times 10^5 / 1030$ or 941.7 mass per second = density \times volume per second $9.7 \times 10^5 = 1030 \times (3.0 \times \pi \times r^2)$ $r^2 = \frac{9.7 \times 10^5}{1030 \times 3\pi}$ 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: <ul style="list-style-type: none"> • 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.

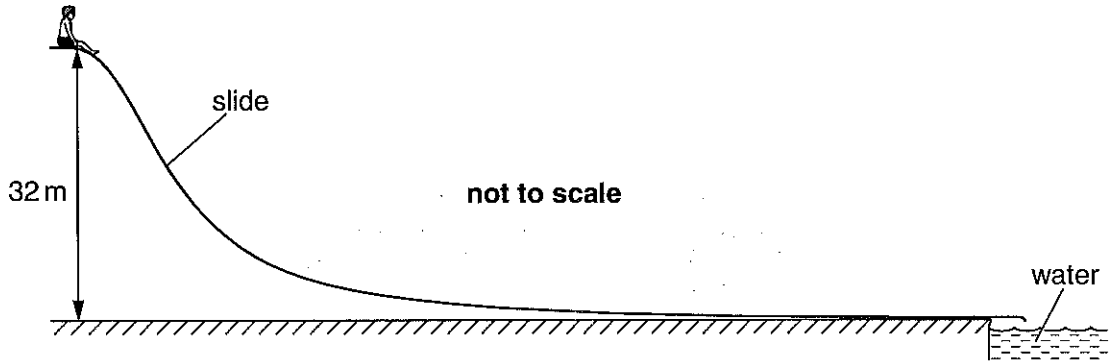


Fig. 6.1

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 ms^{-1} .

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

kinetic energy = J [2]

- (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]

Question		Answer	Marks	Guidance
6	(a)	work done = force \times distance <u>moved</u> in the direction of force	B1	Allow: work done = force \times displacement in direction of force
	(b) (i)	mass = $700/9.81$ or mass = 71.4 (kg) kinetic energy = $\frac{1}{2} \times 71.4 \times 15^2$ kinetic energy = 8.0×10^3 (J)	C1 A1	Note: Answer to 3 sf is 8.03×10^3 (J) Note: ' $\frac{1}{2} \times 700 \times 15^2 = 7.9 \times 10^4$ ' 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

$$E_p = \dots\dots\dots \text{ J [1]}$$

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

$$\text{output power} = \dots\dots\dots \text{ W [1]}$$

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

$$\text{input power} = \dots\dots\dots \text{ W [1]}$$

[Total: 4]

Question		Answer	Marks	Guidance
6	(a)	(1 watt is equal to) 1 joule (of energy transferred) <u>per</u> second	B1	Allow: (1) J s ⁻¹ Not: '1 J (of energy transferred) <u>in</u> 1 s' because the <u>per</u> or <u>rate</u> 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 $E_k = \frac{1}{2}mv^2$.

[3]

(b) The braking distance of an empty van travelling at a steady speed on a level road is 50m. 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]

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) $v^2 = 2ax$ Use of $v^2 = 2ax$ and $E_k = max$ to show $KE = \frac{1}{2}mv^2$	B1 B1 B1	Note: This mark is for substituting ' ma ' into the equation ' Fx ' Note: This B1 mark is for manipulation of equations leading to $KE = \frac{1}{2}mv^2$ Allow full credit for alternative approaches
	(b)		The (braking) distance is more (than 50m) $KE = Fx$ Correct reasoning for longer braking distance, eg: (KE increases and) $x \propto KE$ Or The (braking) distance is more (than 50m) The van has smaller deceleration (for the same force) Correct reasoning for longer braking distance in terms of $v^2 = u^2 + 2as$	B1 B1 B1 B1 B1 B1	Alternative: $Fx = \frac{1}{2}mv^2$ B1 Correct reasoning for longer braking distance, eg: $x \propto m$ B1 Allow: smaller acceleration 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 ms^{-1} towards the ground from a height of 2.8 m . The ball hits the ground and rebounds at a speed of 12 ms^{-1} , as shown in Fig. 4.1. Assume air resistance has negligible effect on the motion of the ball.

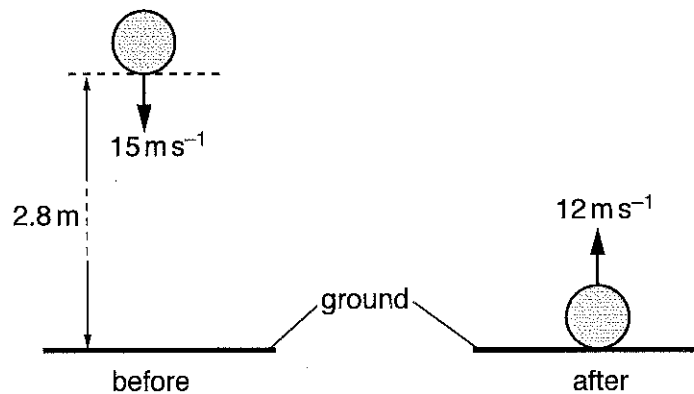


Fig. 4.1

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

speed = ms^{-1} [2]

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

energy transferred = J [3]

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 =) $\frac{1}{2} \times 0.20 \times 16.7^2$ or (initial energy =) $0.20 \times 9.81 \times 2.8 + \frac{1}{2} \times 0.20 \times 15^2$ (final energy =) $\frac{1}{2} \times 0.20 \times 12^2$ 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 ($\frac{1}{2} \times 0.20 \times 15^2$) and the final KE ($\frac{1}{2} \times 0.20 \times 12^2$)
		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 <u>one</u> from: <ul style="list-style-type: none"> • Mass obtained using a balance / scales • Weight / load obtained using a newtonmeter / spring balance • Distance / height obtained using a ruler / metre stick / measuring tape Time obtained using a clock / (stop)watch / timer or light-gate <u>and</u> timer or light-gate <u>and</u> data-logger (output power =) 'mass \times g \times distance'/time or 'weight \times distance/time' or 'weight \times speed' input power = output power/0.15	B1 B1 B1 B1	✎ The term clock / (stop)watch / timer /data-logger must be spelled correctly to gain this mark Allow symbols, e.g <i>mgh/t</i> , <i>Wh/t</i> and <i>Wv</i>
Total	4		