Energy Concepts

Question Paper

Level	Pre U
Subject	Physics
Exam Board	Cambridge International Examinations
Topic	Energy Concepts
Booklet	Question Paper

Time Allowed: **40 minutes**

Score: **/33**

Percentage: **/100**

Grade Boundaries:

1 Water is pumped through a car engine in order to keep it at a constant temperature. The pump stops working and the engine transfers energy to the water in the engine block at a rate of 100 kW. The volume of water in the engine block is 6.0×10^{-3} m^3.

At what rate does the temperature of the water rise?
Water has a specific heat capacity of 4200 J kg^{-1} K^{-1} and a density of 1000 kg m^{-3}.

A 0.0040 K s^{-1} **B** 0.25 K s^{-1} **C** 4.0 K s^{-1} **D** 24 K s^{-1}

2 Before the invention of the modern refrigerator, ice was manufactured industrially and delivered to households. One method used the evaporation of ammonia.

Energy was required to make the ammonia evaporate and 75 % of this energy came from liquid water at 0 °C, turning the water into ice.

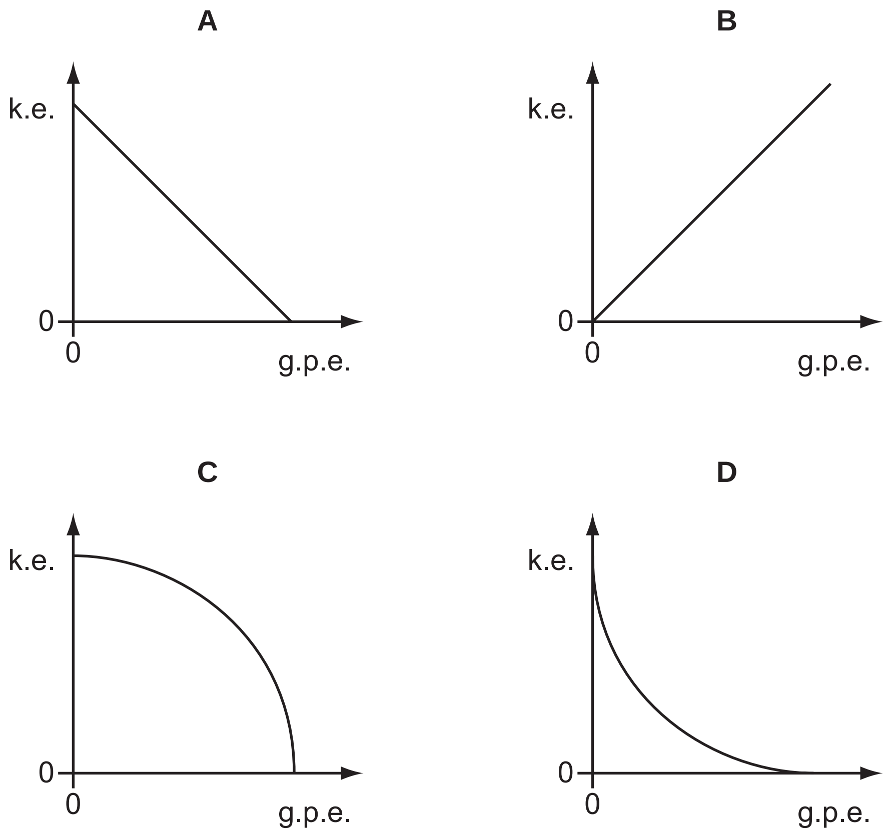
In six hours 8.0×10^4 kg of ice was produced. At what rate did the ammonia need to be evaporated?
The specific latent heat of fusion of water is 330 kJ kg^{-1}.
The specific latent heat of vaporisation of ammonia is 1370 kJ kg^{-1}.

A 0.67 kg s^{-1} **B** 1.2 kg s^{-1} **C** 12 kg s^{-1} **D** 20 kg s^{-1}

Space for working

3 An apple is released from rest and falls freely under gravity.

Which graph shows how the kinetic energy (k.e.) of the apple varies with its gravitational potential energy (g.p.e.)? Ignore air resistance.



Space for working

4 An electric motor is 40% efficient. When operating at full power, it has a useful output of 2.0 kW.

How much electrical energy is transferred at full power in one minute?

A 0.80 kJ **B** 5.0 kJ **C** 48 kJ **D** 300 kJ

Space for working

5 A metal block X of mass m, specific heat capacity c and temperature 80°C is placed in good thermal contact with a second metal block Y of mass $2m$, specific heat capacity $2c$ and temperature 30°C.

Assume no energy losses to the surroundings.

What will be the final temperature of both blocks?

A 30 °C **B** 40 °C **C** 55 °C **D** 70 °C

6 A refrigeration system requires heat to be extracted from a cool-box at a rate of 2.5 kW. This is achieved by having a special fluid, called the refrigerant, vaporise into a gas. The energy required for this vaporisation is extracted from the cool-box.

The specific latent heat of vaporisation of the refrigerant is 150 kJ kg^{-1}.

What is the mass of refrigerant that needs to be vaporised in one minute?

A 17 g **B** 1.0 kg **C** 17 kg **D** 1000 kg

7 In a body-armour test, a bullet of mass 1.9 g is fired with a velocity of 530 m s^{-1} into a fixed block of Kevlar. The bullet comes to rest within the Kevlar block, causing the temperature of the block to rise by 0.38 °C.

The block has a mass of 0.50 kg.

What is the specific heat capacity of the Kevlar?

A 1.4 kJ kg^{-1} K^{-1}

B 1.4 MJ kg^{-1} K^{-1}

C 2.7 kJ kg^{-1} K^{-1}

D 2.7 J kg^{-1} K^{-1}

Space for working

8 A car of mass 1000 kg is moving at 25 m s^{-1}. The brakes are applied, causing the car to stop.

The car has four brakes, each consisting of a 3.0 kg metal disc that rubs against a wheel. The specific heat capacity of the metal from which the discs are made is 400 J kg^{-1} K^{-1}.

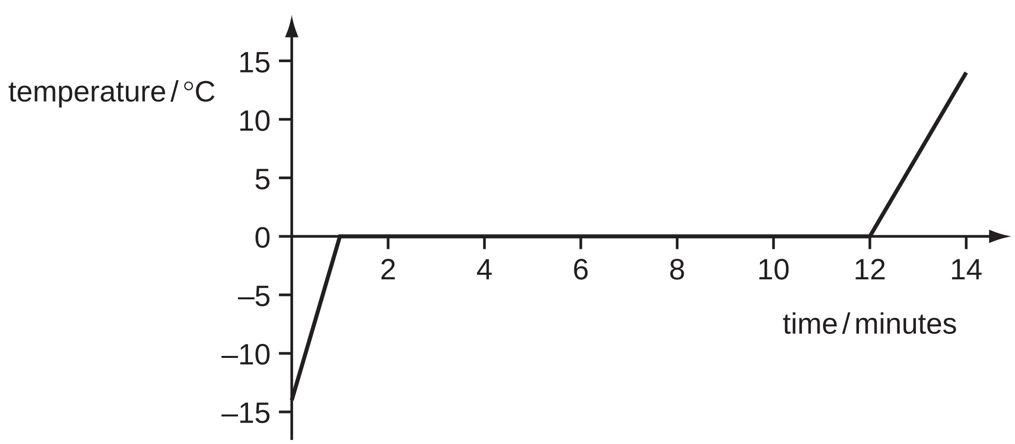
What is the maximum rise in the temperature of the brakes?

A 2.6 °C **B** 5.2 °C **C** 65 °C **D** 260 °C

Space for working

9 A block of ice is heated at a constant rate by a 0.25 kW heater.

The graph below shows how the temperature of the ice (and subsequently water) changes with time.



Assume that all the energy supplied is used to heat the ice.

What is the original mass of the block of ice? The specific latent heat of fusion of water is 3.3×10^5 J kg^{-1}.

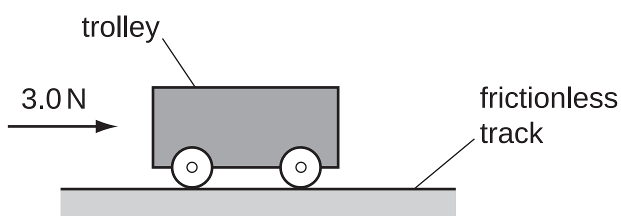
A 0.5 g **B** 8.3 g **C** 0.5 kg **D** 8.3 kg

10 In order to calculate the energy needed to vaporise a certain quantity of a liquid, it is necessary to know the values of which two quantities?

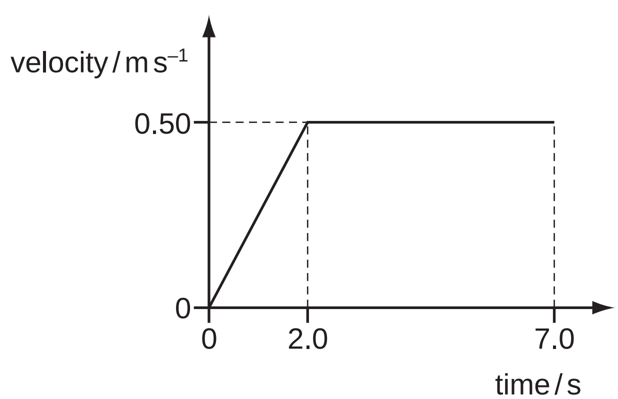
	quantity 1	quantity 2
A	boiling point	specific heat capacity of liquid
B	boiling point	specific latent heat of liquid
C	mass	specific heat capacity of liquid
D	mass	specific latent heat of liquid

Space for working

11 A trolley is pushed with a force of 3.0 N for 2.0 s along a frictionless track.



The graph shows the velocity of the trolley against time.



How much work is done by the force on the trolley?

A 1.5 J **B** 3.0 J **C** 6.0 J **D** 9.0 J

12 Sky City in Tokyo is 1.00 km tall. The lifts take 2.0 minutes to reach the top.

A lift of mass 450 kg carries two passengers who have a combined mass of 140 kg.

What is the average power supplied to the ascending lift?

A 4.9 kW **B** 37 kW **C** 48 kW **D** 2900 kW

Space for working

13 In June 2009, it was reported that a 14-year old German boy had been hit by a pea-sized meteorite.

The meteorite was spherical, with diameter 15 mm and its density was 7300 kg m^{-3}.

The meteorite was travelling at 350 km h^{-1} when it hit the boy.

What was the approximate kinetic energy of the meteorite when it hit the boy? (The volume of a sphere of radius r is given by the formula $V = \frac{4}{3}\pi r^3$.)

A 0.63 J **B** 61 J **C** 490 J **D** 24 000 J

14 A storage heater is made up of several bricks each of mass 1.25 kg. They are warmed by an electric heater to 75 °C in the night-time.

During the day, the bricks cool to 18°C, giving out 4.2×10^7 J of their stored energy to the room.

The specific heat capacity of brick is 840 J kg^{-1} K^{-1}. Approximately how many bricks are needed?

A 530 **B** 700 **C** 880 **D** 2200

15 A vacuum flask of water contains 150 g of water at 10 °C.

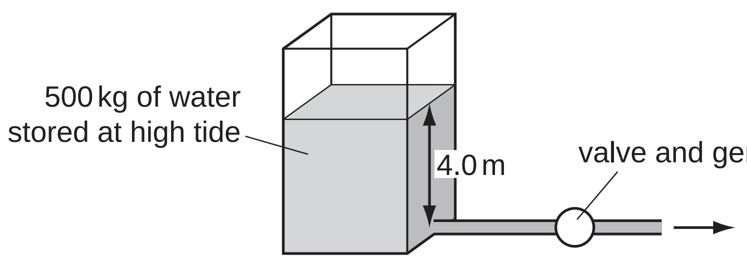
What mass of ice at 0 °C must be added to the flask to reduce the temperature of the water to 0 °C?

Assume the heat transfer from the flask is negligible.
Specific heat capacity of water = $4200\ \mathrm{J\,kg^{-1}\,K^{-1}}$.
Latent heat of fusion of water = $3.4 \times 10^5\ \mathrm{J\,kg^{-1}}$.

A 1.9 g **B** 19 g **C** 1.9 kg **D** 19 kg

Space for working

16 A simple idea for generating electricity from the tides allows water stored in a container at high tide to flow away through a generator at low tide.



At high tide 500 kg of water is stored to a height of 4.0 m. When the valve is opened the container empties in 5.0 s and the generator operates with an efficiency of 40%.

What is the average electrical power generated during the period of water flow?

A 780 W **B** 1600 W **C** 2000 W **D** 3900 W

17 A dam is to be built across the Congo River in Africa. The water will fall through 150 m providing energy to operate a power station.

The rate at which the water falls is 26 400 $m^3 s^{-1}$.

What is the power delivered to the power station? Take the density of water as 1000 $kg\,m^{-3}$.

A 0.0390 MW **B** 259 MW **C** 3960 MW **D** 39 000 MW

18 Water is pumped through a car engine in order to keep it at a constant temperature. The pump stops working, and the engine transfers energy to the water in the engine block at a rate of 100 kW. The volume of water in the engine block is $6.0 \times 10^{-3}\,m^3$.

At what rate does the temperature of the water rise? Water has a specific heat capacity of 4200 $J\,kg^{-1}\,K^{-1}$ and a density of 1000 $kg\,m^{-3}$.

A 0.0040 $K\,s^{-1}$ **B** 0.25 $K\,s^{-1}$ **C** 4.0 $K\,s^{-1}$ **D** 24 $K\,s^{-1}$

19 Before the invention of the modern refrigerator, ice was manufactured industrially and delivered to households.

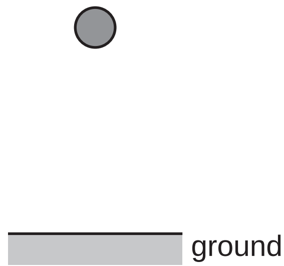
One method used ammonia. 75 % of the energy required for the ammonia to evaporate came from liquid water at 0 °C, turning the water into ice.

If 8.0×10^4 kg of ice was produced in six hours, at what rate did the ammonia need to be evaporated?
The specific latent heat of fusion of water is 330 $kJ\,kg^{-1}$.
The specific latent heat of vaporisation of ammonia is 1370 $kJ\,kg^{-1}$.

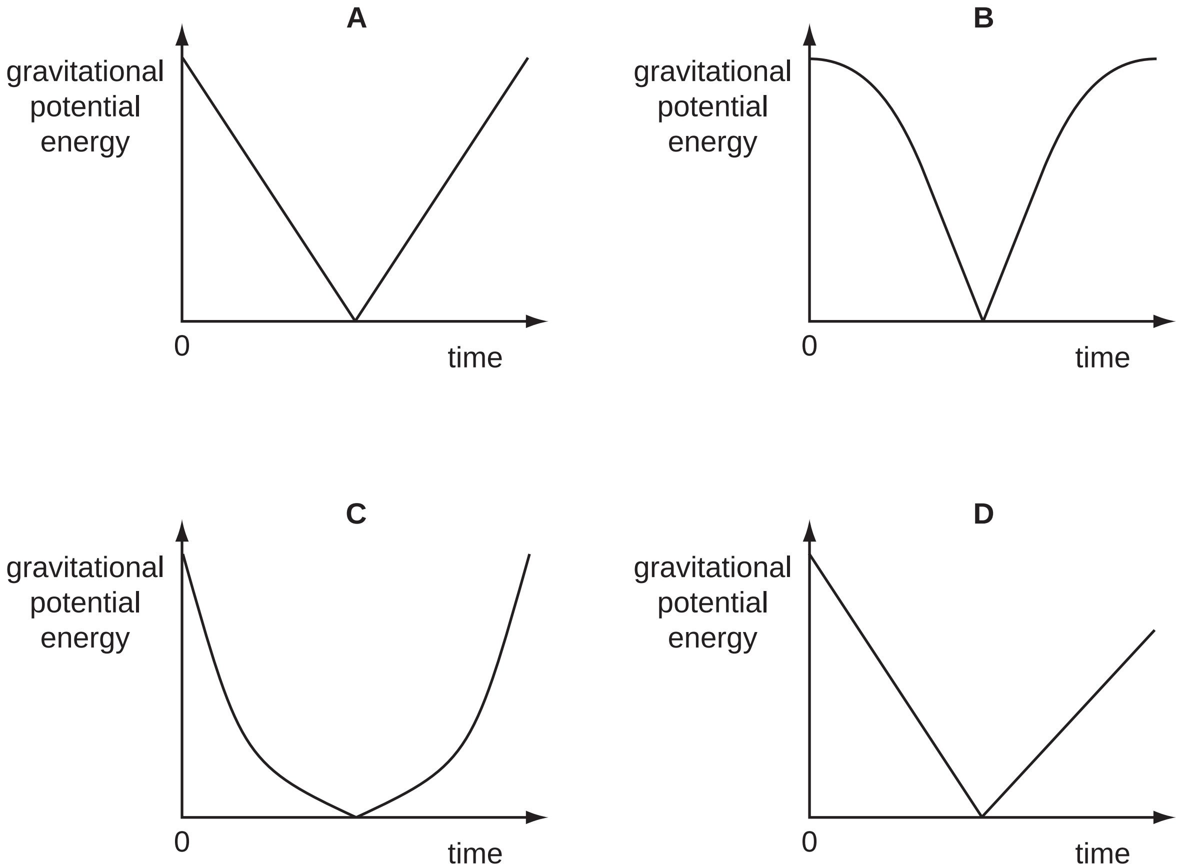
A 0.67 $kg\,s^{-1}$ **B** 1.20 $kg\,s^{-1}$ **C** 12.00 $kg\,s^{-1}$ **D** 20.00 $kg\,s^{-1}$

Space for working

20 A ball is released from rest. It falls vertically, hits the ground and bounces back up. Energy losses are negligible.



Which graph shows how the gravitational potential energy of the ball changes during the bounce?



Space for working

21 In the Rhinns of Islay lighthouse in Scotland, there are 131 steps to the light at the top. The average height of each step is 23 cm. It takes the lighthouse keeper exactly two minutes to run up all the steps.

The mass of the keeper is 74 kg.

What is the keeper's average power?

A 18.6 W **B** 182 W **C** 1.86 kW **D** 18.2 kW

Space for working

22 The Kingda Ka, the tallest and fastest rollercoaster in the world, was opened in 2005 in New Jersey, USA.

A car carrying passengers starts from rest at a height of 139.5 m. It then descends to a height of 12.5 m.

What is the velocity of the car at the lowest point? (Ignore energy losses due to friction).

A $16\,m\,s^{-1}$ **B** $35\,m\,s^{-1}$ **C** $50\,m\,s^{-1}$ **D** $52\,m\,s^{-1}$

23 A motor of power 10 W is used to lift a load of 20 N.

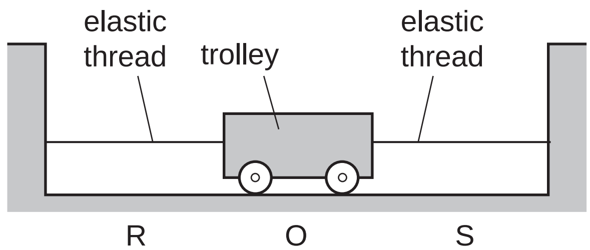
The efficiency of the motor is 25 %.

How long does it take to lift the load through a vertical distance of 0.50 m?

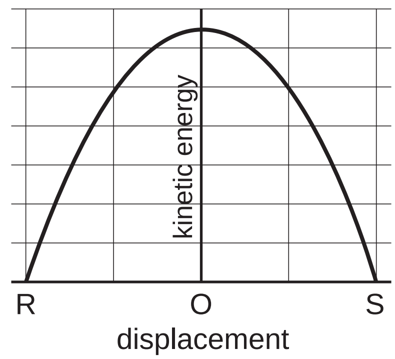
A 0.040 s **B** 0.25 s **C** 4.0 s **D** 39 s

Space for working

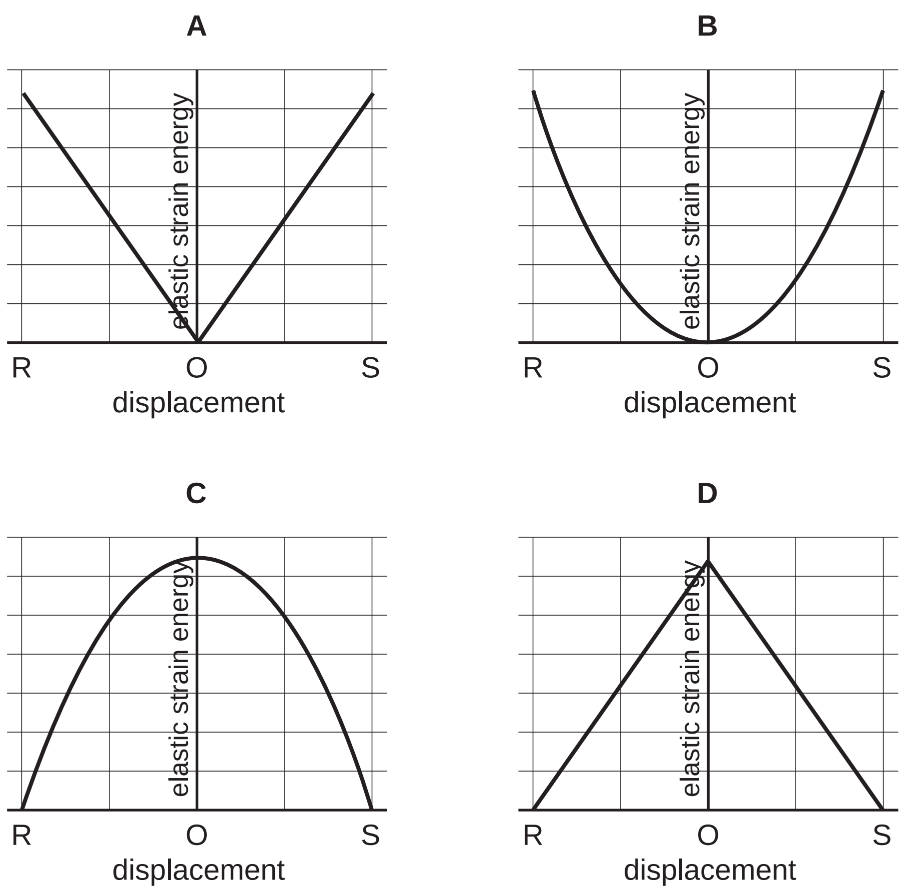
24 A trolley is attached to two similar stretched elastic threads. It is pulled to the left, to position R, and released from rest.



The graph shows how the kinetic energy of the trolley varies with displacement as it moves from R to S.

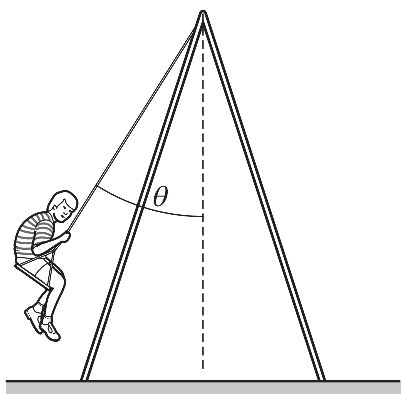


How does the elastic strain energy in the system vary with the displacement of the trolley?



25 A child of mass 50 kg is on a swing which is suspended by 4.0 m ropes from a rigid support.

The horizontal speed of the swing as it passes through the lowest point is 3.0 m s^{-1}.



What is the angle θ that the ropes make with the vertical when the swing is at its highest point?

A 28° **B** 40° **C** 42° **D** 62°

26 An 80 kg man and his 40 kg son take an elevator to the top floor of a building which is 64 m above ground level.

Which row describes the change in gravitational potential for both of them in going from ground level to the top floor?

	change in gravitational potential for 80 kg man / J kg^{-1}	change in gravitational potential for 40 kg son / J kg^{-1}
A	decrease of 6.3×10^2	decrease of 6.3×10^2
B	decrease of 5.0×10^4	decrease of 2.5×10^4
C	increase of 6.3×10^2	increase of 6.3×10^2
D	increase of 5.0×10^4	increase of 2.5×10^4

Space for working

27 A rectangular tank, with vertical sides, contains water to a depth of 30 cm. On a cold day, the water is initially 0 °C. The top 3.0 cm of it freezes into ice at 0 °C.

Assume that half of the latent heat given out by the ice goes to heating the remainder of the water.

What is now the temperature of the water below the ice?

(The specific latent heat of fusion of water is $330\,kJ\,kg^{-1}$ and the specific heat capacity of water is $4.2\,kJ\,kg^{-1}\,K^{-1}$.)

A 3.9 °C **B** 4.4 °C **C** 7.9 °C **D** 8.7 °C

28 A ball is thrown with kinetic energy *K* from ground level at an angle of 45° to the horizontal.

Which statement is **not** correct?

A The kinetic energy of the ball is $\frac{K}{2}$ at the maximum height.

B The kinetic energy of the ball is $\frac{K}{2}$ when the ball reaches a height equal to half the maximum height.

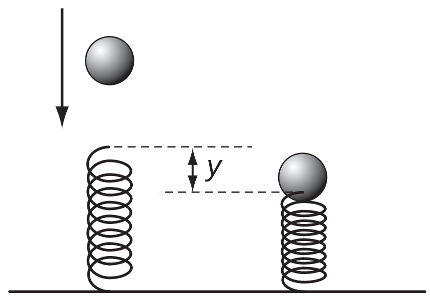
C The potential energy of the ball is $\frac{K}{2}$ at the maximum height.

D The potential energy of the ball is $\frac{K}{4}$ when the ball reaches a height equal to half the maximum height.

Space for working

29 A ball of mass m falls freely from rest. When it has reached a speed v, it strikes a vertical spring.

The spring is compressed by a distance y before the ball begins to move upwards.



Assume that all the energy the ball loses becomes elastic potential energy in the spring.

What is the average force exerted by the spring during its compression?

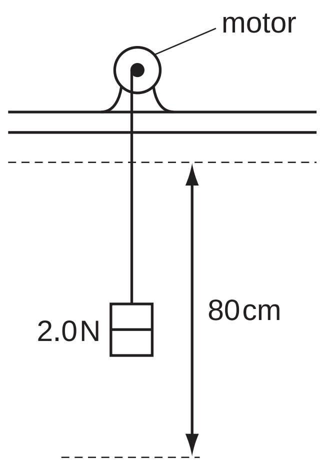
A $\frac{mv^2}{2y}$

B $\frac{m}{2y}(v^2 - 2gy)$

C $\frac{mv^2}{y}$

D $\frac{m}{2y}(v^2 + 2gy)$

30 A small electric motor is used to raise a weight of 2.0 N at constant speed through a vertical height of 80 cm in 4.0 s.



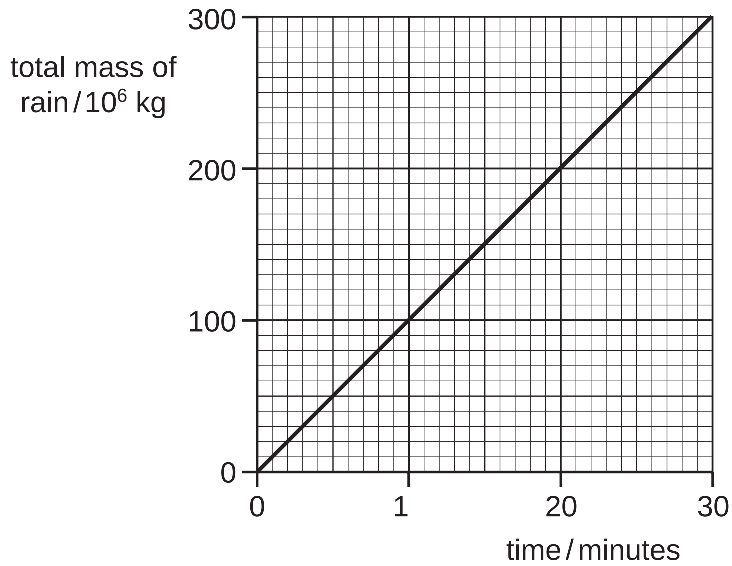
The efficiency of the motor is 20 %.

What is the electrical power supplied to the motor?

A 0.080 W **B** 0.80 W **C** 2.0 W **D** 200 W

Space for working

31 Rain from a thunderstorm reaches the ground at a speed of $12\,\text{m}\,\text{s}^{-1}$. The graph shows how the total mass of deposited rain increases with time.



What is the average power delivered by the rain as it hits the ground?

A $1.0 \times 10^6\,\text{W}$ **B** $1.2 \times 10^7\,\text{W}$ **C** $2.4 \times 10^7\,\text{W}$ **D** $7.2 \times 10^8\,\text{W}$

32 A rocket is travelling away from Earth at a speed of $11\,\text{km}\,\text{s}^{-1}$ in a direction at 60° to the Earth's surface at a point where the gravitational field strength is $9.3\,\text{N}\,\text{kg}^{-1}$.

If the mass of the rocket at this moment is 4.0×10^6 kg, at what rate is the rocket gaining gravitational potential energy?

A $4.2 \times 10^8\,\text{W}$

B $3.6 \times 10^{10}\,\text{W}$

C $2.1 \times 10^{11}\,\text{W}$

D $3.5 \times 10^{11}\,\text{W}$

Space for working

33 An object falling at terminal velocity through air is converting

A gravitational potential energy to kinetic energy.

B gravitational potential energy to thermal energy.

C kinetic energy to gravitational potential energy.

D kinetic energy to thermal energy.