1. Motion, forces and energy

1.7 Energy, work and power

Paper 3 and 4

Question Paper

Paper 3

Questions are applicable for both core and extended candidates

1 **(b)** **(i)** Another person pushes a shopping trolley with a force of 40 N. The shopping trolley moves at a constant speed along a horizontal path.

Calculate the work done by the 40 N force to move the shopping trolley a distance of 50 m.

work done = ... J [3]

(ii) The work done on the shopping trolley as it starts moving is transferred into other energy stores.
State **two** such energy stores.

1 ....

2 ....
[2]

2 **(a)** Fig. 4.1 shows the energy transfers in a lamp.

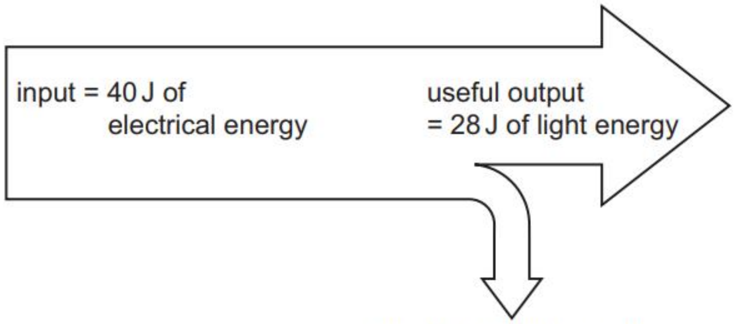


Fig. 4.1 (not to scale)

(i) State the value of the wasted output energy.

wasted output energy = ... J [1]

(ii) The energy that is wasted is transferred to an energy store. State the energy store that is increased by the wasted energy.

.... [1]

(b) A 15 W lamp is switched on for 5.0 minutes.

Calculate the electrical work done in the lamp circuit during this time.

electrical energy supplied = ... J [4]

(c) The lamp uses electrical energy that is generated by a wind turbine.
Fig. 4.2 shows a wind turbine.

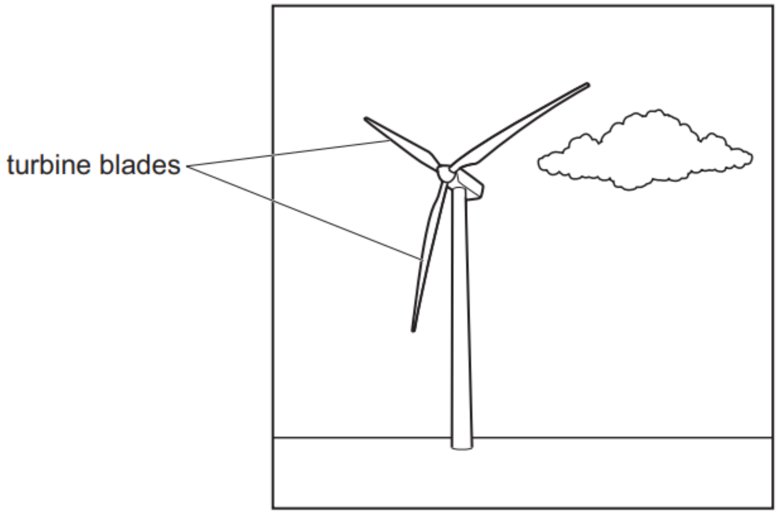


Fig. 4.2

Describe **three** energy transfers that take place when energy from the Sun causes electrical energy to be generated by the wind turbine.

....

....

.... [3]

[Total: 9]

3 **(b)** The car is lifted vertically 0.78 m onto the recovery vehicle, as shown in Fig. 3.3.

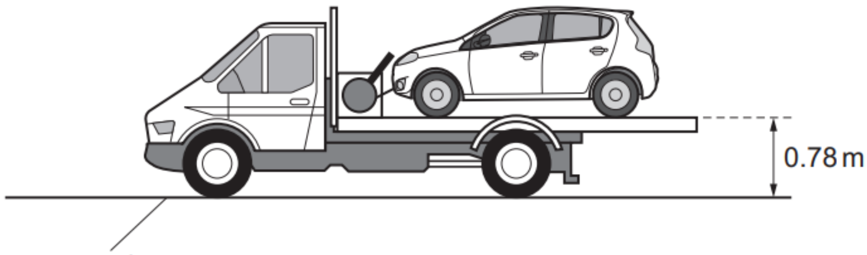


Fig. 3.3

The weight of the car is 14 000 N.
Calculate the minimum work done on the car in lifting it onto the recovery vehicle from the ground.
Include the unit.

work done = ... unit .... [4]

[Total: 8]

4 **(a)** Energy stored in the water behind hydroelectric dams is an example of a renewable energy source.

(i) State what is meant by a renewable energy source.

.... [1]

(ii) State the name of **one other** renewable energy source.

.... [1]

(b) Electrical power is generated from the energy store in nuclear fuels.
Fig. 4.1 shows an energy flow diagram for transferring energy from the nuclear store.

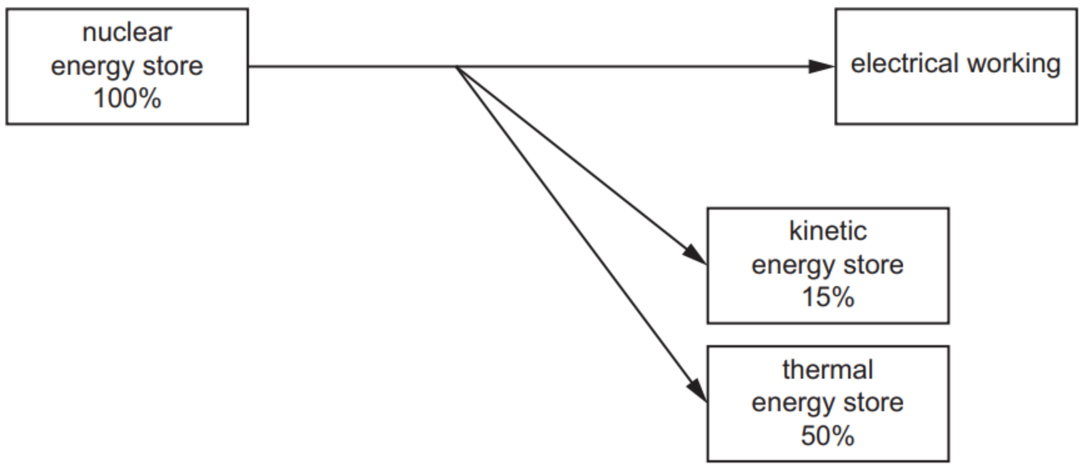


Fig. 4.1

Using the information in Fig. 4.1, calculate:

(i) the percentage of energy wasted to thermal and kinetic energy stores

energy wasted = ... % [1]

(ii) the percentage of energy transferred as electrical working.

electrical working = ... % [1]

(c) Electrical power is also generated from the water behind hydroelectric dams.

State **two disadvantages** of generating electricity from the water behind hydroelectric dams compared with using the energy store in nuclear fuels. Ignore costs of construction and maintenance.

1 ....

2 ....
[2]

[Total: 6]

5 The government of a country decides to reduce the amount of fossil fuel burned for generating electrical power.

(a) State **two** reasons, apart from cost, for reducing the amount of fossil fuel burned.

1 ....

....

2 ....

....
[2]

(b) **(i)** Describe how a hydroelectric power station generates electrical power.

....

....

....

....

.... [3]

(ii) Hydroelectric power stations are expensive to build.

State **two** other disadvantages of using a hydroelectric power station to generate electrical power.

1 ....

....

2 ....

....
[2]

(c) The government plans to build some wind turbines. The government plans to store some of the electrical energy generated by the wind turbines.

Suggest **one** method of storing the electrical energy generated by a wind turbine.

....

.... [1]

[Total: 8]

6 Fig. 4.1 shows a flow diagram for the energy transferred in a television.

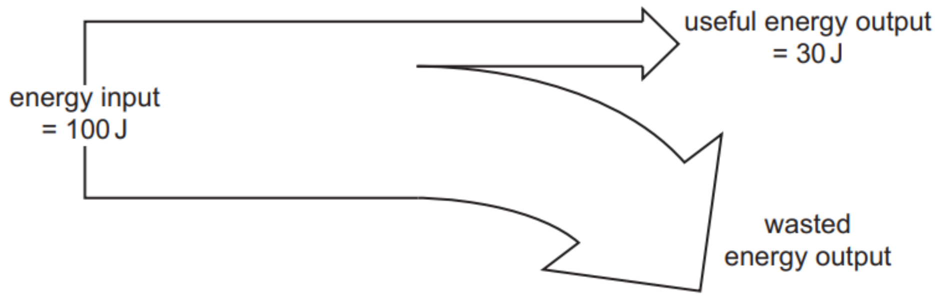


Fig. 4.1

(a) **(i)** State **two** ways in which **useful** energy is transferred from the television.

1 ....

2 .... [2]

(ii) Determine the value of the wasted energy output from the television.

wasted energy = ... J [1]

(b) Fig. 4.2 represents a hydroelectric power station.

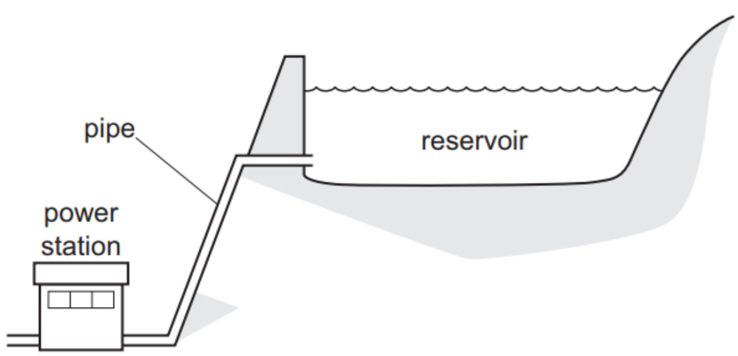


Fig. 4.2

(i) Describe how a hydroelectric power station generates electrical power.

....

....

....

....

.... [3]

(ii) Apart from cost, state **one** advantage and **one** disadvantage of generating electrical power using a hydroelectric power station compared to a coal-fired power station.

advantage ....

....

disadvantage ....

....
[2]

[Total: 8]

7 Fig. 6.1 shows four wind turbines.

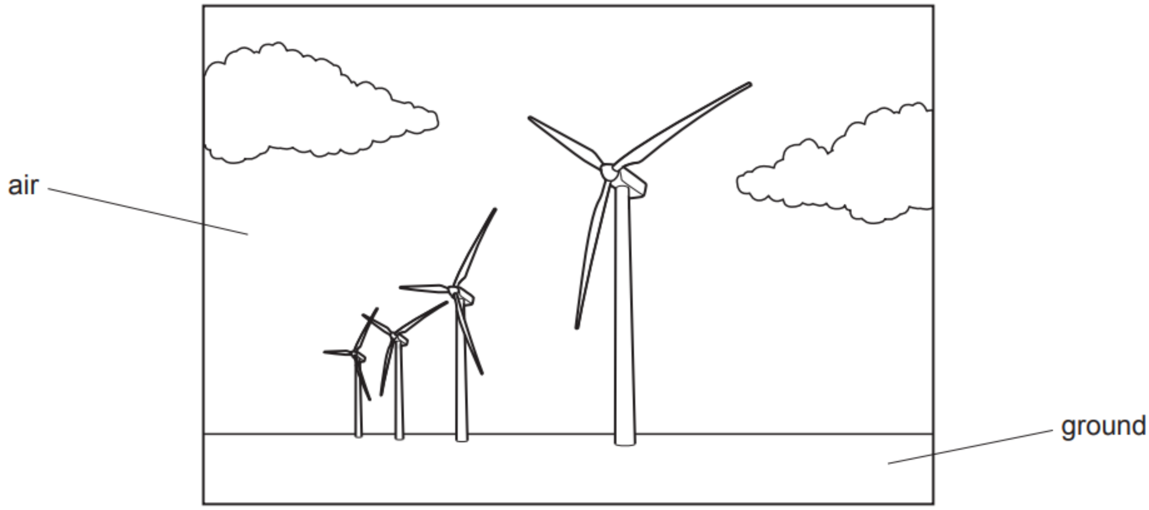


Fig. 6.1

(a) Describe how a wind turbine generates electrical power.

....

....

.... [3]

(b) The electrical power output of a wind turbine is 624 kW. The output current is 520 A.

Calculate the output voltage of the wind turbine.

output voltage = ... V [4]

(c) For transmission, the output voltage is increased to 132 kV.

State **two** advantages of transmitting electrical power at high voltage.

1 ....

2 ....

[2]

[Total: 9]

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

.... [1]

(b) Fig. 2.1 shows the energy flow diagram for a car powered by a petrol engine.

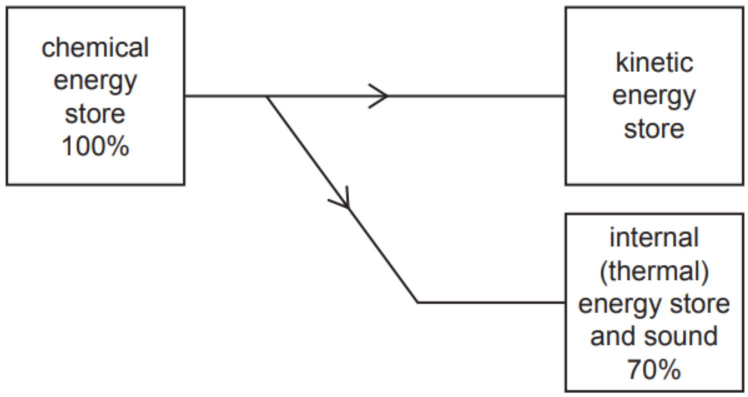


Fig. 2.1

(i) Using the information in Fig. 2.1, calculate the percentage of energy transferred from the chemical store to the kinetic store.

percentage = ... % [2]

(ii) Fig. 2.2 shows the energy flow diagram for an electric car. The electric car is driven by an electric motor which is powered by a battery.

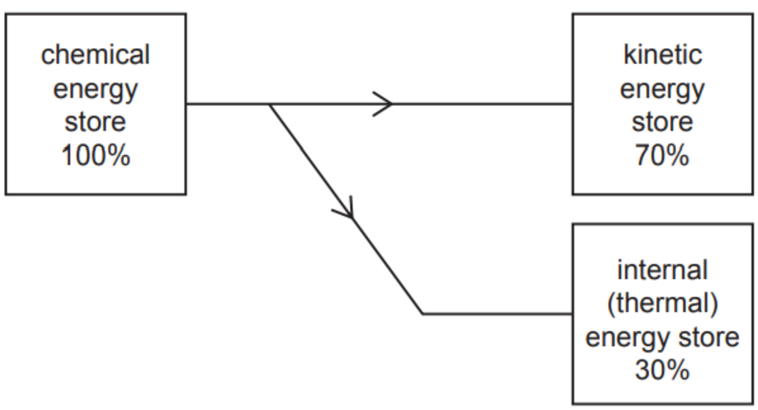


Fig. 2.2

Using the information in Fig. 2.1 and Fig. 2.2, state which car is more efficient. Give a reason for your answer.

car ....

reason ....

....
[1]

[Total: 4]

9 A student holds a pile of books. The mass of the books is 3.2 kg.

(a) Calculate the weight of the books.

weight = ... N [2]

(b) The student carries the books from the bottom to the top of the stairs shown in Fig. 4.1.

The vertical height of the stairs is 4.5 m.

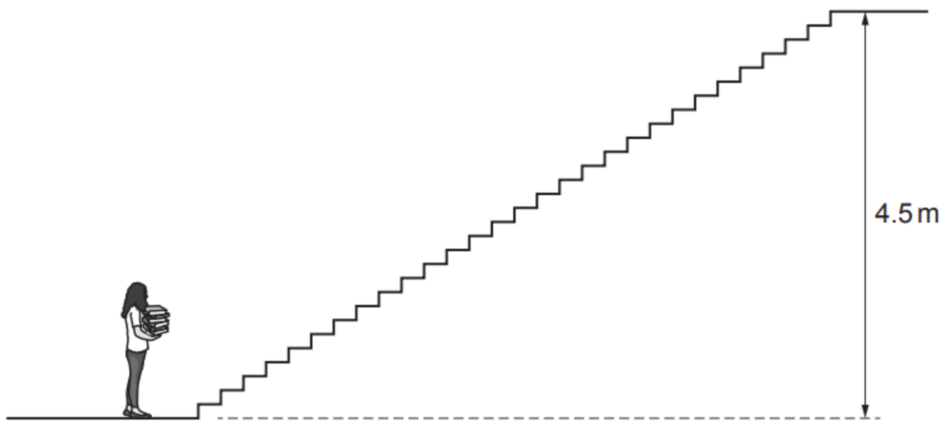


Fig. 4.1

(i) Show that the work done on the books when they are carried to the top of the stairs is approximately 140 J.

[3]

(ii) Determine the gravitational potential energy gained by the books.

Give a reason for your answer.

gravitational potential energy = ... J

reason ....

[2]

[Total: 7]

10 Fig. 5.1 shows a tidal turbine.

A tidal turbine generates electricity from the energy stored in tides.

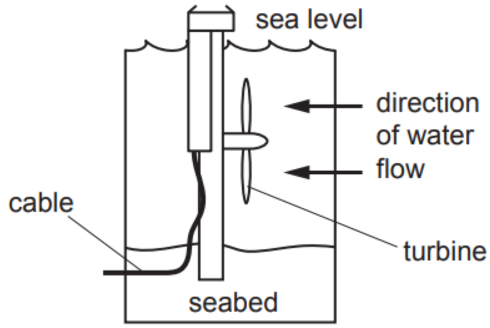


Fig. 5.1

(a) State **two advantages** of using the energy stored in tides for generating electricity compared with using a coal-fired power station. Ignore building and other costs.

1 ....

2 ....
[2]

(b) State **two disadvantages** of using the energy stored in tides for generating electricity compared with using a coal-fired power station. Ignore building and other costs.

1 ....

2 ....
[2]

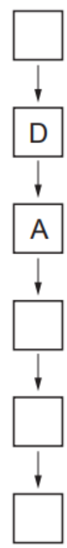
[Total: 4]

11 Electricity is distributed from wind turbines to homes and industry.

(a) Statements A–F describe the main stages in the transfer of energy from the Sun to electrical energy in a wind turbine generator.
The statements A–F are **not** in the correct order.

A Air moves from regions of high pressure to regions of low pressure.
B The turbine blades turn a generator.
C Energy from the Sun heats the atmosphere unevenly.
D Uneven heating of the atmosphere produces regions of different atmospheric pressure.
E The generator produces electrical energy.
F Moving air turns the turbine blades.

Complete the flow chart to describe how a wind turbine uses energy from the Sun to generate electrical energy. Insert the missing letters in the empty boxes.



[3]

(b) State **two** disadvantages, apart from cost, of using wind turbines to produce electrical energy for homes and industry.

1 ....

2 ....
[2]

[Total: 5]

12 A student uses an electric motor to lift a load. Fig. 4.1 shows the arrangement.

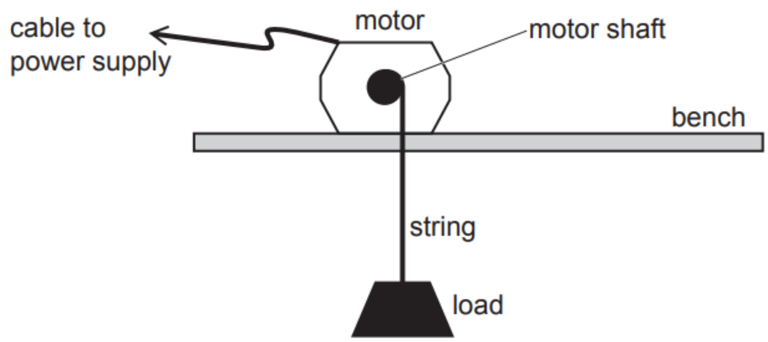


Fig. 4.1 (not to scale)

(a) **(i)** The motor exerts a force of 25 N on the load. It lifts the load a vertical distance of 2.0 m.

Calculate the work done by the motor on the load.

work done on the load = ... J [3]

(ii) State the useful energy output of the electric motor when it lifts the load 2.0 m.

useful energy output = ... J [1]

(iii) The useful energy output of the motor is less than the energy input to the motor.

Explain why the useful energy output is less than the energy input.

....

.... [2]

(b) The student uses the motor to lift a different load. The motor does 80 J of work when it lifts this load. It takes 5.0 s to lift the load.

Calculate the power output of the electric motor.

power output = ... W [3]

[Total: 9]

13 A student has a battery-powered torch. Fig. 3.1 shows the torch.

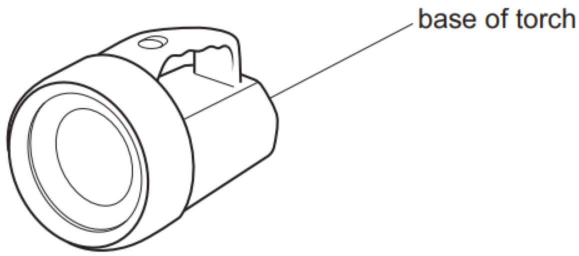


Fig. 3.1

(a) Fig. 3.2 shows the energy transfers when the torch is switched on. The diagram is incomplete.

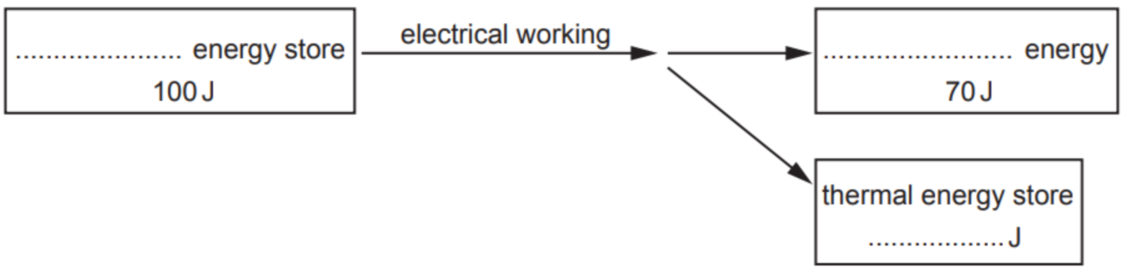


Fig. 3.2

Show the energy transfers in the torch by completing the labels on Fig. 3.2. [3]

(b) The weight of the torch is 8.5 N. The student lifts the torch a vertical distance of 0.80 m to place it on a shelf.

Calculate the work done on the torch by the student.

work done = ... J [3]

14 Fig. 4.1 shows an electric motor and pulley wheel being used to raise a load M. The electric motor uses a belt to turn the pulley wheel.

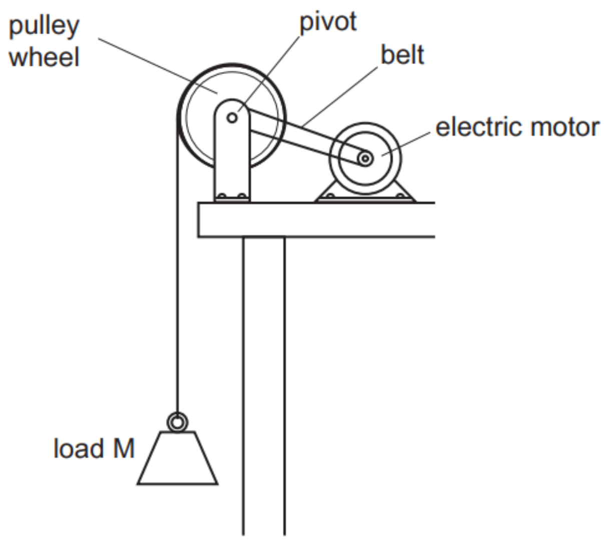


Fig. 4.1

(a) When the electric motor lifts the load, it transfers energy. Fig. 4.2 shows the energy transfers.

Write on Fig. 4.2 to complete the label in each box. The first label is done for you.

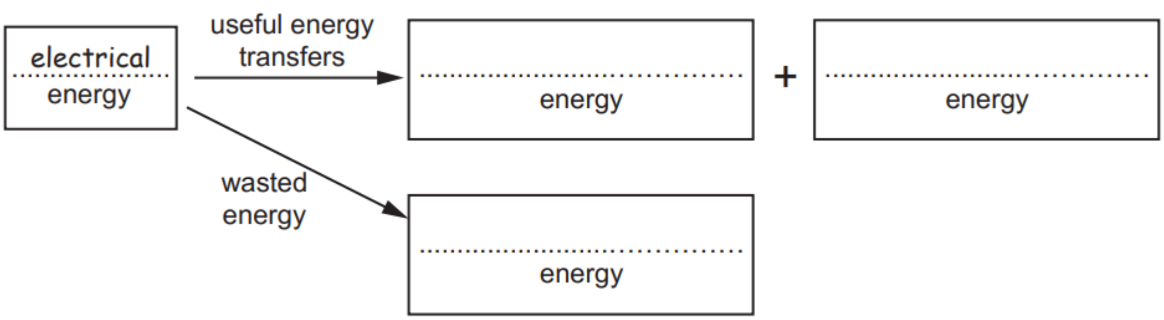


Fig. 4.2

[3]

15 **(a)** Describe how a wind turbine generates electricity from energy in the wind.

....

....

.... [3]

(b) Apart from cost, state **two advantages** of generating electricity using wind turbines compared with using a power station that burns coal.

1. ....

2. ....

[2]

(c) Apart from cost, state **two disadvantages** of generating electricity using wind turbines compared with using a power station that burns coal.

1. ....

2. ....

[2]

[Total: 7]

16 Fig. 4.1 shows parts of a coal-fired power station.

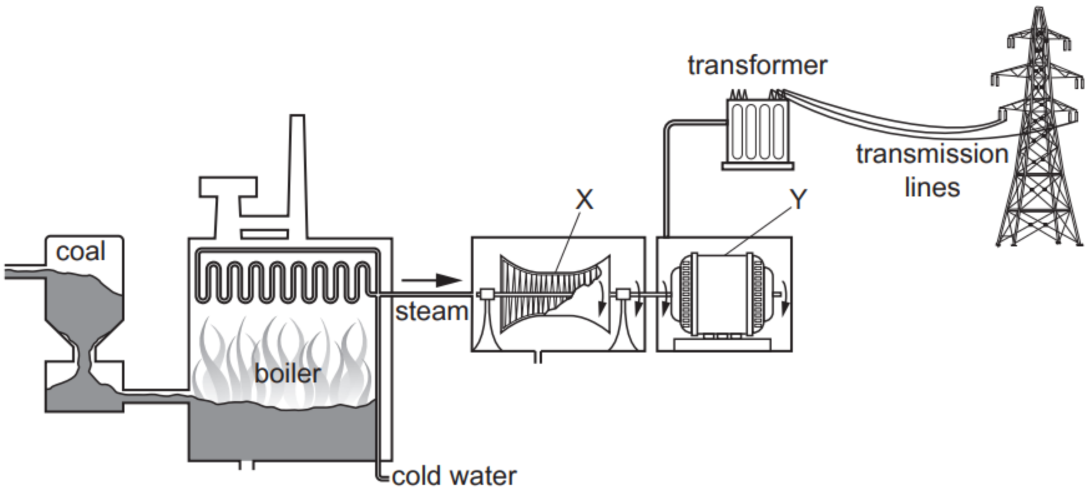


Fig. 4.1

(a) **(i)** State the names of the parts of the power station labelled X and Y.

X ....

Y ....
[2]

(ii) Describe **two** useful energy transfers in this power station.

1. ....

2. ....
[2]

(b) The power station contains a transformer. The primary voltage V_p for the transformer is 25 000 V.
The number of turns on the primary coil N_p is 600.
The number of turns on the secondary coil N_s is 4800.

Calculate the secondary voltage V_s for the transformer.

V_s = ... V [3]

(c) Give **two** reasons for transmitting electrical energy at very high voltages.

1. ....

....

2. ....

....
[2]

[Total: 9]

17 Fig. 8.1 shows a simplified diagram of a geothermal power station.

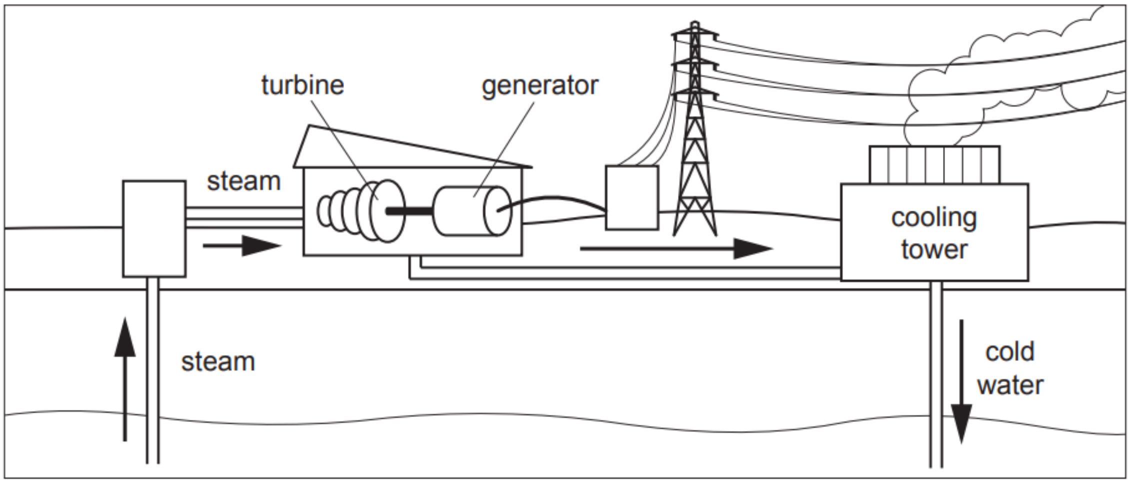


Fig. 8.1

(a) **(i)** State the energy source for a geothermal power station. .... [1]

(ii) Complete the sentence about useful energy transfer in the power station.

The generator converts .... energy into .... energy. [2]

(b) **(i)** State **two** advantages of a geothermal power station compared to a coal-fired power station.

1 ....

2 .... [2]

(ii) State **one** disadvantage of using geothermal energy rather than coal in a power station.

.... [1]

[Total: 6]

18 A country needs to build new power stations to provide electricity for homes and industry.

One type of power station is a coal-fired power station.

(a) Describe how the energy stored in the coal is used in a coal-fired power station to generate electrical energy.

....

....

....

....

....

.... [4]

(b) Some people in the country argue against building a new coal-fired power station.

They say that the power station is expensive and not very efficient.

Explain the meaning of *not very efficient*.

....

.... [1]

(c) Apart from cost and efficiency, give **two** other reasons for **not** building a coal-fired power station.

1. ....

2. ....

[2]

[Total: 7]

19 Here are some statements about energy and energy resources.

Some statements are correct. Put a tick (✓) in the box alongside each of these.

- ☐ Building hydroelectric power stations has an impact on the environment.
- ☐ Burning fossil fuels produces atmospheric pollution.
- ☐ Wind turbines are turned using gravitational potential energy.
- ☐ Coal and crude oil are sources of renewable energy.
- ☐ Geothermal energy is obtained from hot rocks below the ground.

[3]

[Total: 3]

20 **(a)** Energy sources used to generate electricity are shown in the box.

gas	oil	tides	waves	wind

Which energy sources are non-renewable?

Draw a ring around **each** energy source that is non-renewable. [1]

(b) The diagram shows a geothermal power station.

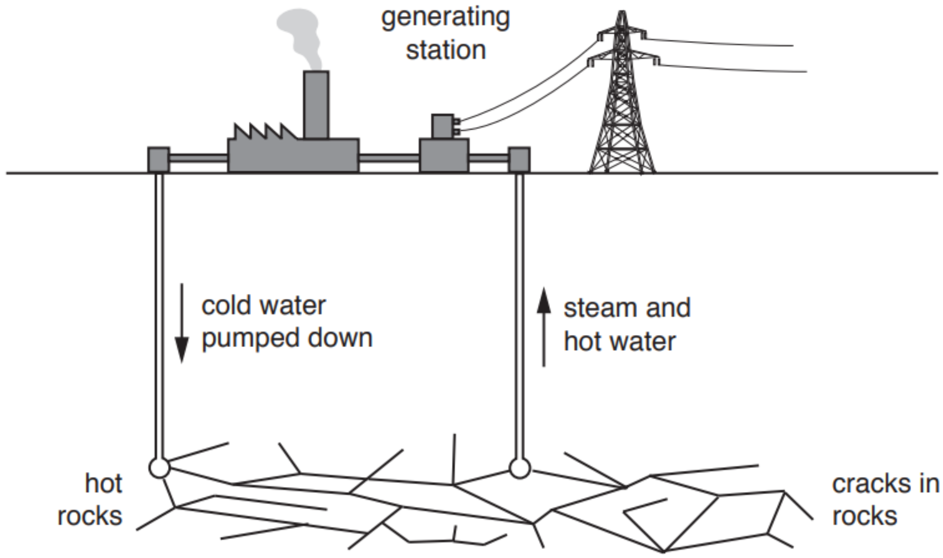


Fig. 5.1

Describe how the geothermal power station generates electricity.

....

....

....

....

.... [4]

[Total: 5]

21 Coal is a non-renewable source of energy.

(a) **(i)** Explain what is meant by the term *non-renewable*.

....

.... [1]

(ii) There are other non-renewable sources of energy.

Place a tick in the box by each non-renewable source of energy.

☐ nuclear

☐ oil

☐ solar

☐ wave

☐ wind

[1]

(b) State **two** advantages and **two** disadvantages of using natural gas as an energy source.

advantages

1. ....

....

2. ....

....

disadvantages

1. ....

....

2. ....

....

[4]

[Total: 6]

22 A tidal barrage (dam) produces electricity using tides. Fig. 5.1 shows a diagram of a tidal barrage (simplified).

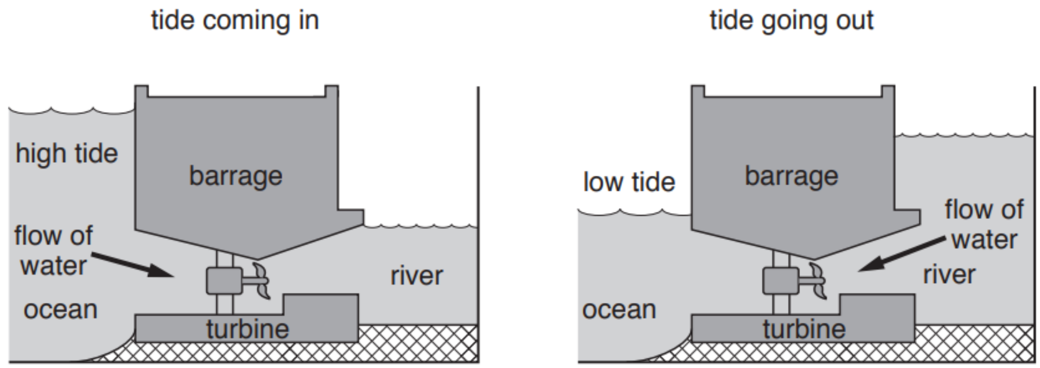


Fig. 5.1

(a) The water behind the barrage (dam) is a store of energy. State the name of this stored energy.

.... [1]

(b) Explain how the tidal barrage (dam) produces electricity.

....

....

....

.... [3]

[Total: 4]

Paper 4

Questions are applicable for both core and extended candidates unless indicated in the question

23 **(a)** State **two** energy resources for which radiation from the Sun is the main source of energy. **(extended only)**

1 ....

2 .... [2]

(b) A wind turbine is used to generate electricity.
The useful output from the turbine in 1.0 s is 6000 J. The kinetic energy of the wind hitting the turbine in 1.0 s is 11 000 J. The velocity of the wind hitting the turbine is 6.3 m/s.

(i) Show that the mass of air hitting the turbine each second is approximately 550 kg. **(extended only)**

[2]

(ii) Calculate the efficiency of the turbines. You may assume that all the kinetic energy stored in the wind is transferred to the turbine. **(extended only)**

efficiency = ...% [2]

(c) Tidal energy and wind energy are both renewable energy resources.
Suggest **one** reason why tidal energy is a more useful energy resource than wind energy.

Ignore the costs of construction and maintenance.

....

.... [1]

[Total: 7]

24 Fig. 2.1 shows two identical trolleys, P and Q, held at rest on a frictionless horizontal surface. A load is fixed to trolley P.

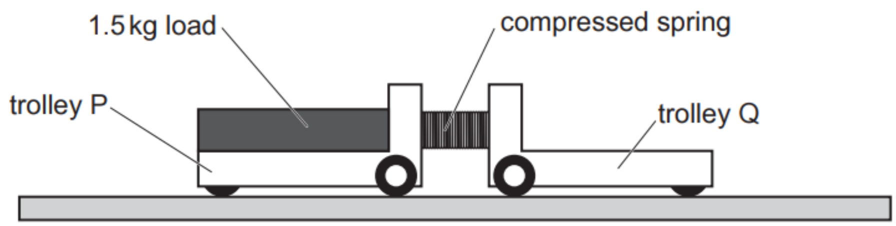


Fig. 2.1

There is a compressed spring between trolley P and trolley Q.

The trolleys are released. As the spring expands, it pushes the trolleys apart.

Trolley Q moves to the right at a constant speed of 0.36 m/s.

The mass of each trolley is 1.2 kg. The mass of the load on trolley P is 1.5 kg.

The spring has negligible mass.

(i) the speed at which trolley P moves to the left **(extended only)**

speed of P = ... [3]

(ii) the kinetic energy of trolley Q when it moves at 0.36 m/s. **(extended only)**

kinetic energy of Q = ... [3]

(b) State the energy transfer that takes place as the spring expands.

....

....

.... [2]

[Total: 8]

25 A student drops a heavy ball from a vertical height of 1.8 m above the ground. The ball then falls to the ground. It does **not** bounce after hitting the ground.

(a) Describe the transfers of energy of the ball between stores from when the ball begins to fall to when it reaches the ground.

....

....

....

....

.... [3]

(b) Calculate the maximum speed of the ball. Ignore air resistance.

Show your working. **(extended only)**

maximum speed = ... [3]

[Total: 6]

26 A girl holds a rubber ball out of a window of a tall building. The mass of the ball is 0.20 kg. The ball is at rest 10 m above a concrete path.

(a) Calculate the gravitational potential energy of the ball relative to the concrete path. **(extended only)**

gravitational potential energy = ... [2]

(b) The girl releases the ball and it falls towards the path. The ball strikes the path and bounces vertically upwards.

Fig. 1.1 shows the ball falling towards the path.

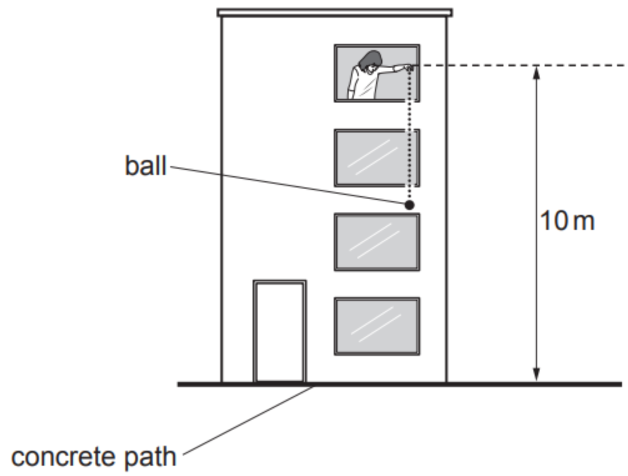


Fig. 1.1

The speed of the ball immediately **before** it strikes the path is 14 m/s.

The speed of the ball immediately **after** it strikes the path is 12 m/s.

(i) Calculate the kinetic energy of the ball immediately **after** it strikes the concrete path. **(extended only)**

kinetic energy = ... [2]

27 Many methods of generating electrical power involve the use of water.

(a) Describe **one** method of generating electrical power from energy stored in water.

....

....

....

....

.... [3]

(b) For the method you chose in **(a)**, state **one** advantage and **one** disadvantage of generating electricity this way.

advantage ....

....

disadvantage ....

....

[2]

(c) State **two** methods of generating electrical power for which the main source of energy is **not** the Sun. **(extended only)**

1 ....

2 ....

[2]

[Total: 7]

28 **(a)** Fig. 1.1 shows a helicopter which is stationary at a height of 1500 m above the ground.

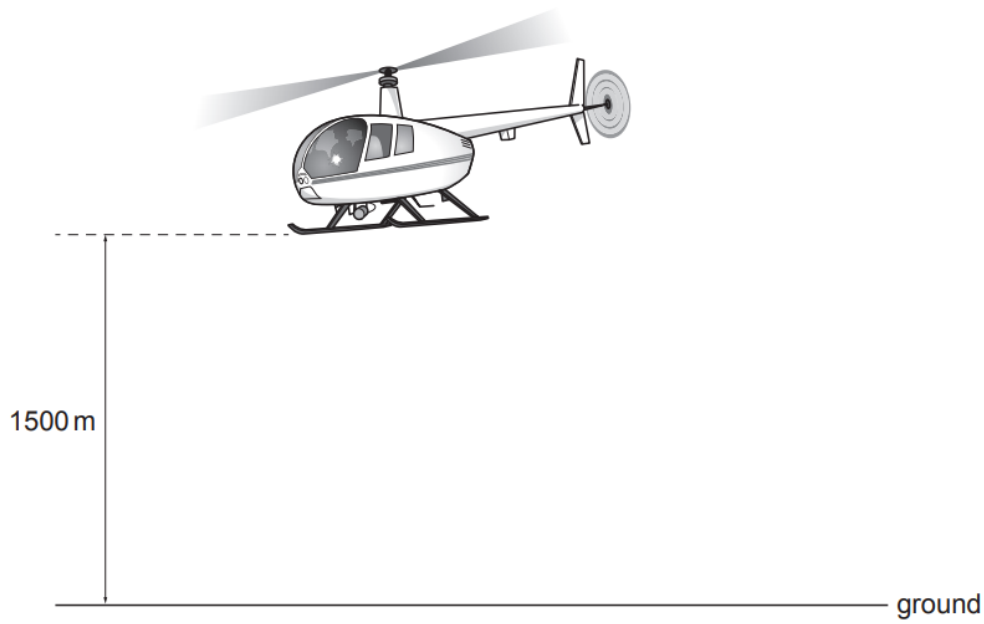


Fig. 1.1 (not to scale)

(i) State the **two** conditions necessary for the helicopter to remain in equilibrium.

condition 1 ....

....

condition 2 ....

....
[2]

(ii) The mass of the helicopter is 3200 kg.

Calculate the change in the gravitational potential energy of the helicopter as it rises from the ground to 1500 m. **(extended only)**

change in gravitational potential energy = ... [2]

29 A student catches a cricket ball. The speed of the ball immediately before it is caught is 18 m/s. The mass of the cricket ball is 160 g.

(a) Calculate the kinetic energy stored in the cricket ball immediately before it is caught.
(extended only)

kinetic energy = ... [3]

30 Two blocks, A and B, are joined by a thin thread that passes over a frictionless pulley. Block A is at rest on a rough horizontal surface and block B is held at rest, just below the pulley.

Fig. 1.1 shows the thread hanging loose.

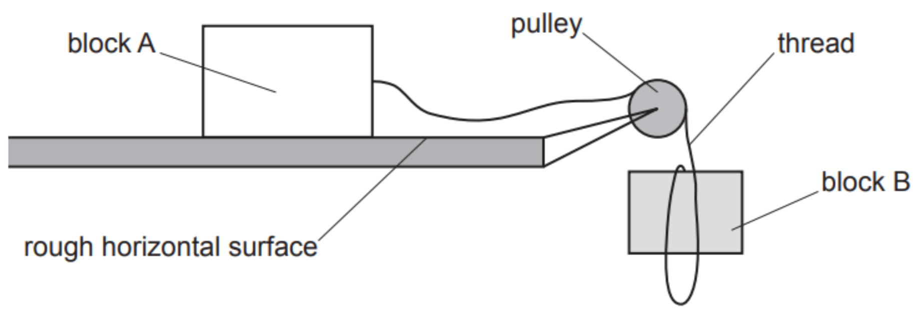


Fig. 1.1 (not to scale)

Block B is released and it falls vertically. The thread remains loose until block B has fallen a distance of 0.45 m.

The mass of block B is 0.50 kg.

(a) Calculate the change in the gravitational potential energy (g.p.e.) of block B as it falls through 0.45 m. **(extended only)**

change in g.p.e. .... [2]

31 Fig. 1.1 shows sea water flowing down a channel into a tank without splashing. The water is flowing at a rate of 800 kg/min. The length and width of the tank are 3.10 m and 1.20 m. The density of the sea water is 1020 kg/m^3.

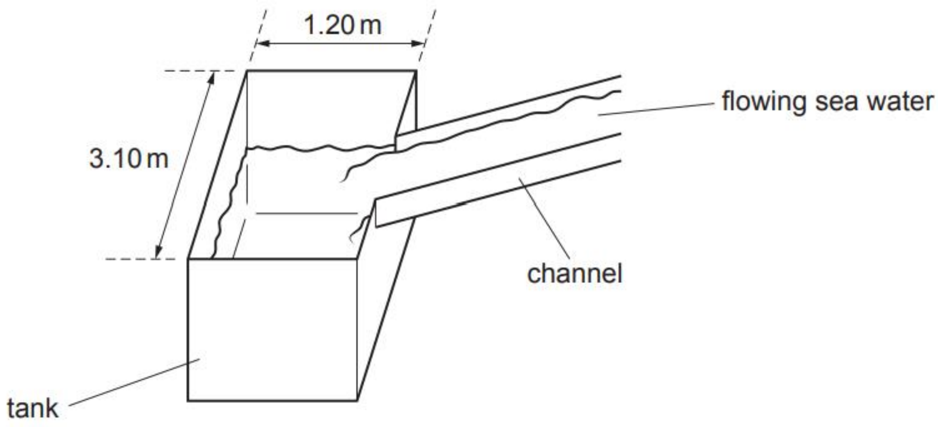


Fig. 1.1 (not to scale)

(a) Initially, the tank is empty.

Calculate the depth of water in the tank after 1.00 minute. Give your answer to three significant figures.

depth = ... [3]

(b) The height of the water decreases by 0.420 m as it flows down the channel.

Calculate the decrease in gravitational potential energy of the water each second. **(extended only)**

decrease in gravitational potential energy = ... [3]

32 **(a)** Tidal power derives most of its energy from the Moon and part of its energy from the Sun.

(i) State **one** other source of power which derives its energy from the Sun. **(extended only)**

.... [1]

(ii) State **one** source of power which does **not** derive its energy from the Sun. **(extended only)**

.... [1]

(b) Fig. 3.1 shows a small water turbine driven by a tidal flow of water to generate electrical power.

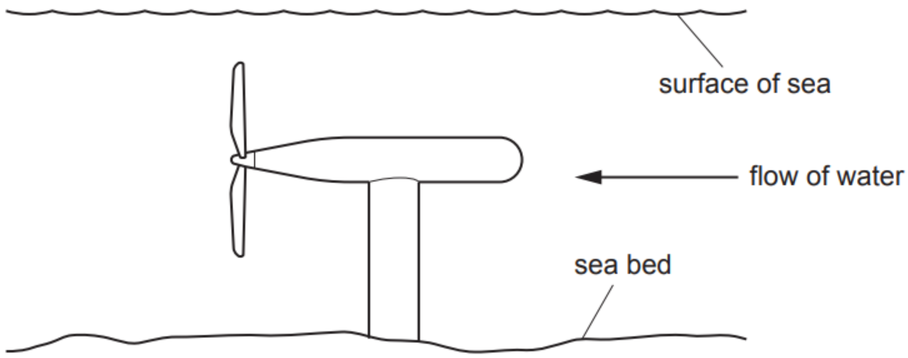


Fig. 3.1

(i) Explain whether this method of generation of electrical power is renewable.

....

....

.... [2]

(ii) The mass of water passing through the turbine each second is 6.0×10^3 kg. The speed of the water is 2.0 m/s. 40% of the kinetic energy of the water is converted to electrical energy.

Calculate the electrical power generated. **(extended only)**

power = ... [4]

[Total: 8]

33 Fig. 1.1 shows an electrically powered bicycle.

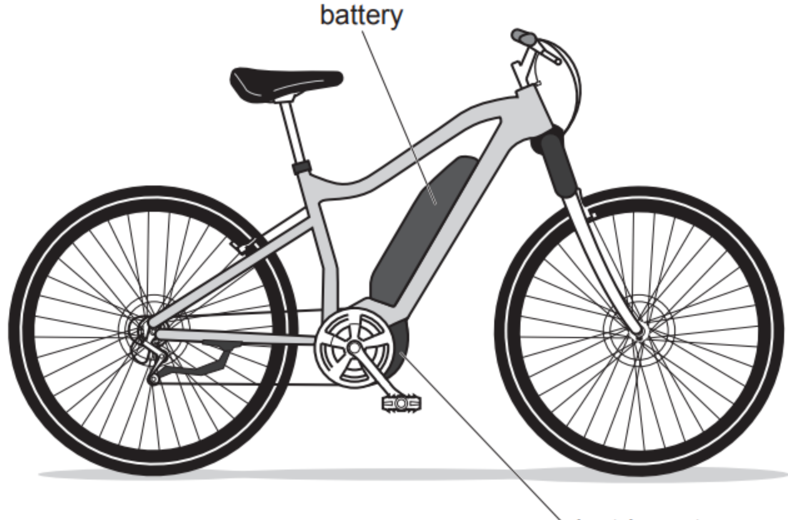


Fig. 1.1

When fully charged, the battery can deliver a power of 600 W for 60 min.

(a) **(i)** Calculate the energy, in joules, stored in the battery when fully charged.

energy = ... J [3]

(ii) State the form of energy stored by the battery.

.... [1]

(b) The bicycle has a motor with an electrical input power of 250 W.

Calculate the time for which the battery can power the bicycle.

time = ... [2]

(c) Consider this bicycle compared to a small motorcycle.

State **two** environmental benefits of the electrically powered bicycle.

1. ....

2. ....
[2]

[Total: 8]

34 A train of mass 1.8×10^5 kg is at rest in a station. At time $t = 0$, the train begins to accelerate along a straight, horizontal track and reaches a speed of 20 m/s at $t = 15$ s. The train continues at a speed of 20 m/s for 10 s.

At $t = 25$ s, the driver applies the brakes and the resistive force on the train causes it to decelerate uniformly to rest in a further 24 s.

Fig. 4.1 is an incomplete distance–time graph for this journey.

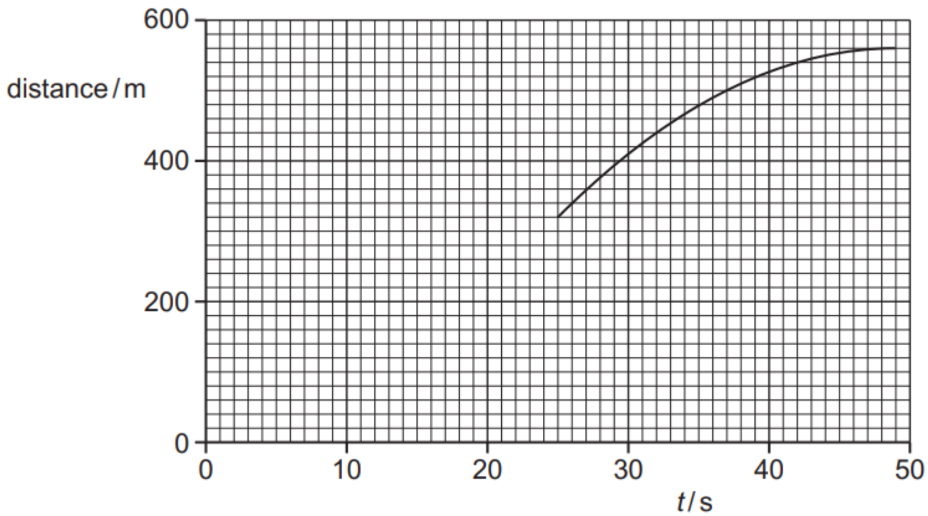


Fig. 4.1

(a) Complete Fig. 4.1 by drawing:

(i) a line to represent the motion of the train between $t = 15$ s and $t = 25$ s [1]

(ii) a curve to represent the motion of the train between $t = 0$ and $t = 15$ s. [1]

(b) Calculate the kinetic energy of the train between $t = 15$ s and $t = 25$ s.
(extended only)

kinetic energy = ... [3]

(c) While the train decelerates to rest, it does work against the resistive force and its kinetic energy decreases.

(i) Define *work done*.

....

.... [2]

(ii) Using Fig. 4.1, determine the distance moved by the train while it decelerates.

distance moved = ... [1]

(iii) Calculate the resultant force acting on the train while it decelerates.
(extended only)

resultant force = ... [2]

[Total: 10]

35 **(a)** A power station uses wind energy to generate electricity.

State and explain whether this method of generating electricity is renewable.

statement ....

explanation ....

....

.... [2]

(b) State **two** energy resources that do **not** have the Sun as their source. **(extended only)**

1 ....

2 .... [2]

(c) For each energy resource, state the form of energy stored in:

fossil fuels ....

water behind hydroelectric dams. .... [2]

[Total: 6]

36 A vertical tube contains a liquid. A metal ball is held at rest by a thread just below the surface of the liquid, as shown in Fig. 2.1.

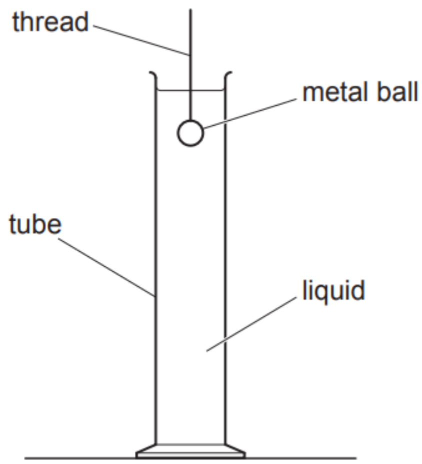


Fig. 2.1 (not to scale)

The diameter of the tube is much greater than the diameter of the ball. The ball is released and it accelerates downwards uniformly for a short period of time.

(c) The metal ball has a mass of 2.1 g. It falls a distance of 0.80 m between being released and reaching the bottom of the tube.

(i) Calculate the gravitational potential energy transferred from the ball as it falls. **(extended only)**

gravitational potential energy transferred = ... [2]

(ii) When the ball reaches the bottom of the tube, it has a speed of 1.2 m/s. Calculate the kinetic energy of the ball at the bottom of the tube. **(extended only)**

kinetic energy = ... [3]

(iii) Explain why the value calculated in **(c)(i)** is different from that calculated in **(c)(ii)**.

....

.... [1]

37 The kinetic energy of air passing through a wind turbine every minute is 720 000 J. The electrical output of the turbine is 9.0 A at a potential difference (p.d.) of 240 V.

Calculate the efficiency (%) of the wind turbine. **(extended only)**

efficiency = ... % [5]

38 Fig. 2.1 shows a fork-lift truck lifting a box.

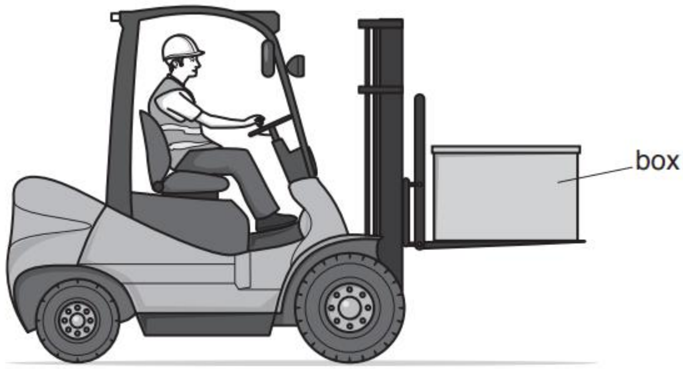


Fig. 2.1

The electric motor that drives the lifting mechanism is powered by batteries.

(a) State the form of the energy stored in the batteries.

....[1]

(b) The lifting mechanism raises a box of mass 32 kg through a vertical distance of 2.5 m in 5.4 s.

(i) Calculate the gravitational potential energy gained by the box. **(extended only)**

gravitational potential energy = ...[2]

(ii) The efficiency of the lifting mechanism is 0.65 (65%). **(extended only)**

Calculate the input power to the lifting mechanism.

input power = ...[3]

(c) The batteries are recharged from a mains voltage supply that is generated in an oil-fired power station.

By comparison with a wind farm, state one advantage and one disadvantage of running a power station using oil.

advantage ....

....

disadvantage ....

....[2]

[Total: 8]

39 Fig. 3.1 shows an aircraft on the deck of an aircraft carrier.

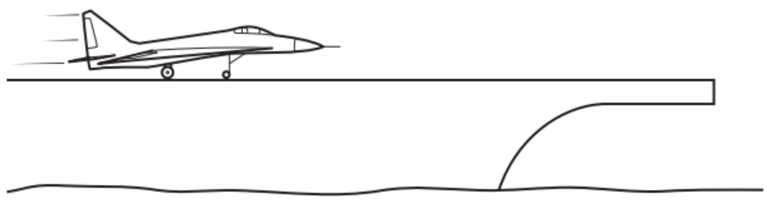


Fig. 3.1

The aircraft accelerates from rest along the deck. At take-off, the aircraft has a speed of 75 m/s. The mass of the aircraft is 9500 kg.

(a) Calculate the kinetic energy of the aircraft at take-off. **(extended only)**

kinetic energy = ... [3]