1 **(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.

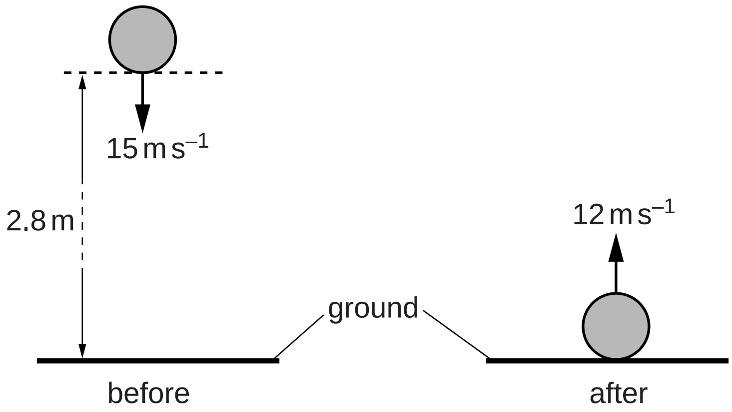


Fig. 4.1

(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]**

(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]**

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

....

....

.... **[1]**

(b) A crate is pushed along a rough horizontal surface at a constant speed. State what happens to the work done on the crate.

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

....

....

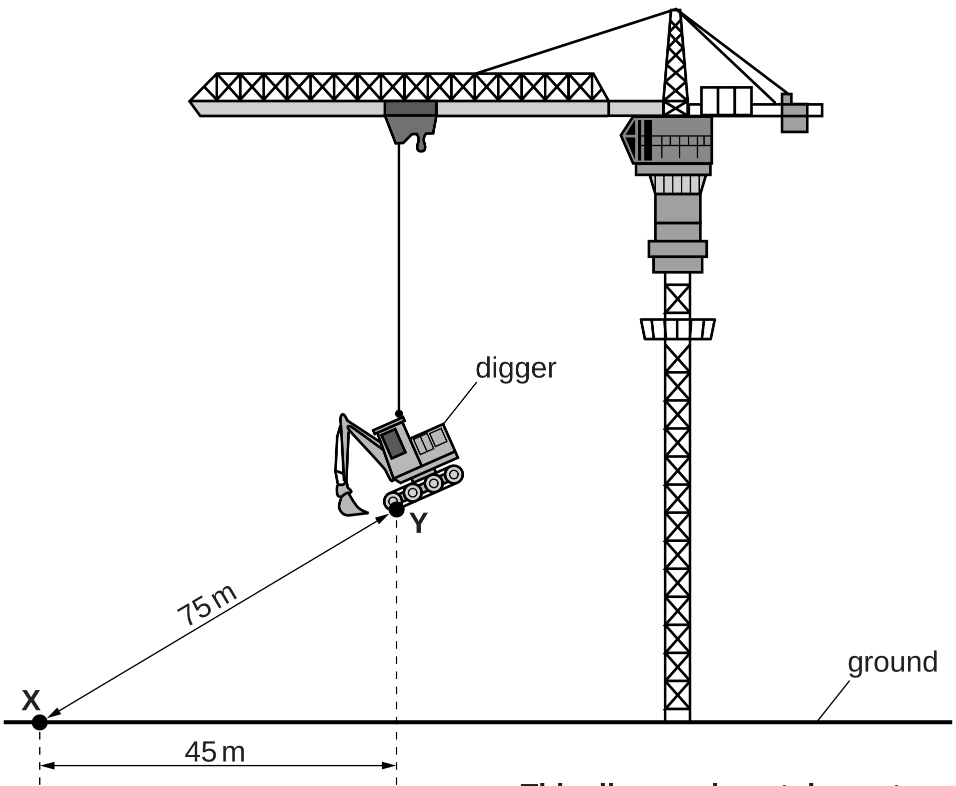
.... **[1]**

(c) Define the *watt*.

....

.... **[1]**

(d) Fig. 6.1 shows an electric crane lifting a mechanical digger.



This diagram is not drawn to scale

Fig. 6.1

The mass of the digger is 5200 kg. The crane takes 1.5 minutes to lift the digger from **X** to **Y**.

(i) Calculate the rate of work done to lift the digger from **X** to **Y**.

rate of work done = ... $J\,s^{-1}$ **[3]**

(ii) The total input power to the motors of the crane is 170 kW. Calculate the efficiency of the lifting operation.

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

[Total: 7]

3 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.

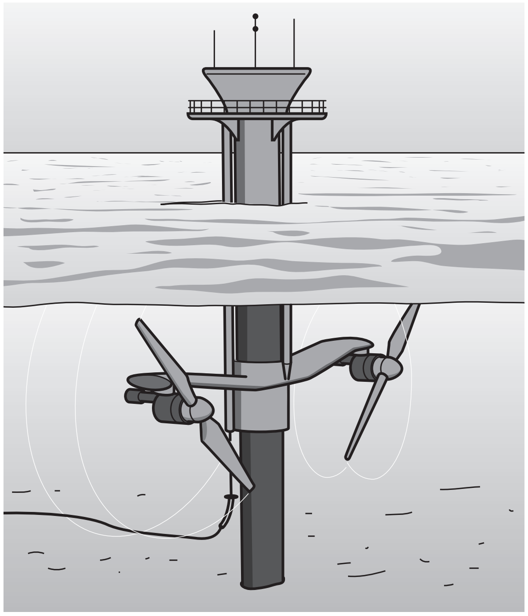


Fig. 7.1

When operating, 9.7×10^5 kg of seawater travelling at a speed of $3.0\,m\,s^{-1}$ 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]

(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]

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

....

....

.... **[1]**

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

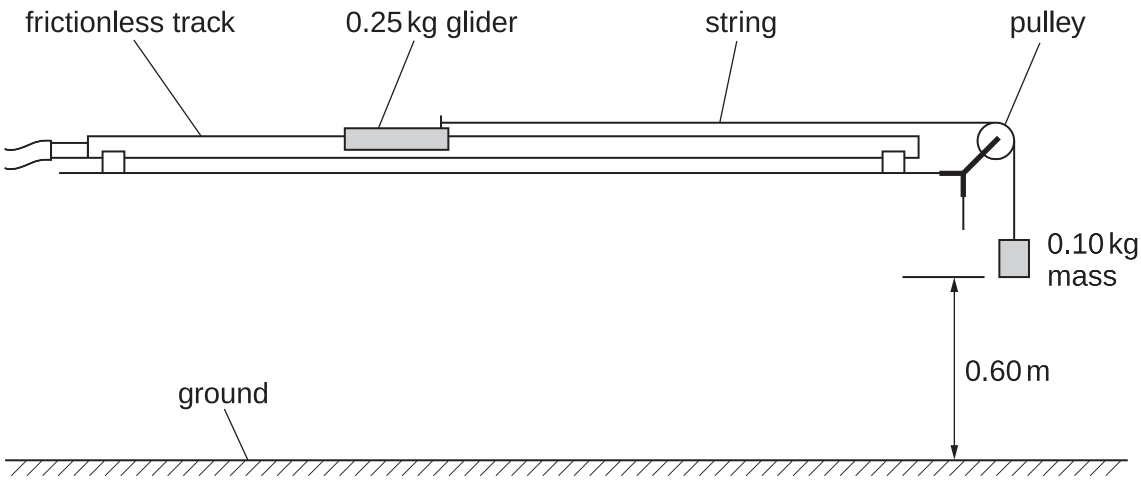


Fig. 6.1

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]**

(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]

5 **(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.

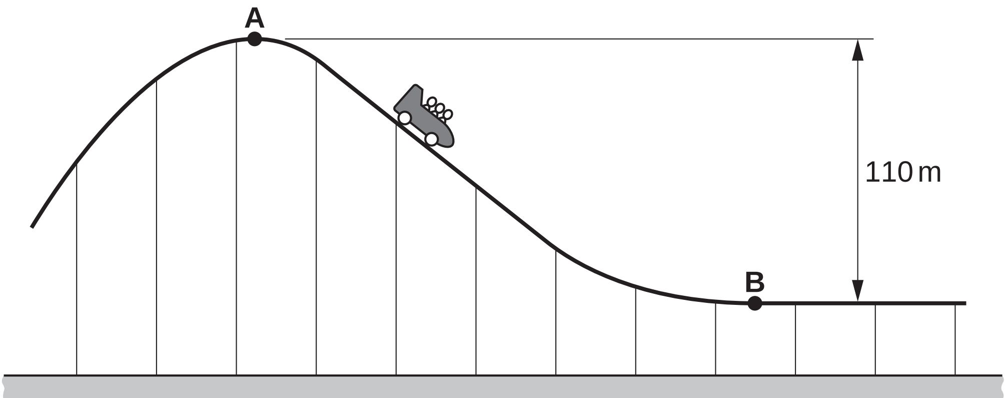


Fig. 4.1

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 110 m. The length of the track between **A** and **B** is 510 m. 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]

6 **(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]