1)

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

....

.... **[1]**

(b) Fig. 3.1 shows a car travelling up a slope at a constant speed.

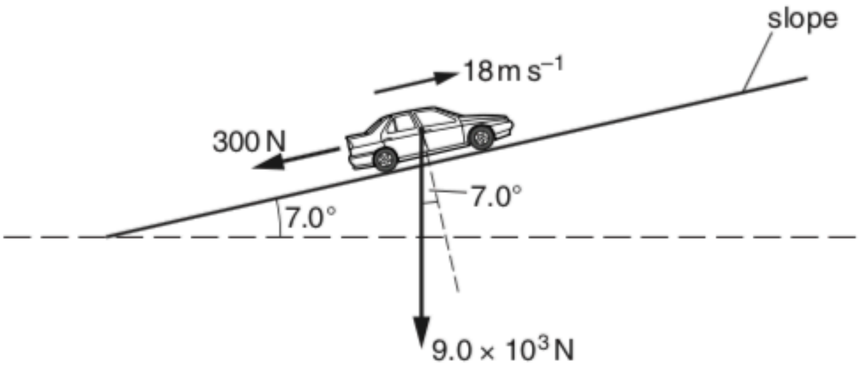

Fig. 3.1

The angle between the slope and the horizontal is 7.0°. The weight of the car is 9.0×10^3 N. The car travels up the slope at a constant speed of 18 m s^{-1}. A resistive force of 300 N acts on the car down the slope.

(i) What is the net force acting on the car? Explain your answer.

....

....

.... **[2]**

(ii) Calculate the component of the weight of the car acting down the slope.

component of weight = ... N **[2]**

(iii) Calculate the work done per second against the resistive force.

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

(iv) Calculate the power developed by the car as it travels up the slope.

power = ... W **[3]**

[Total: 9]

2)

(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.

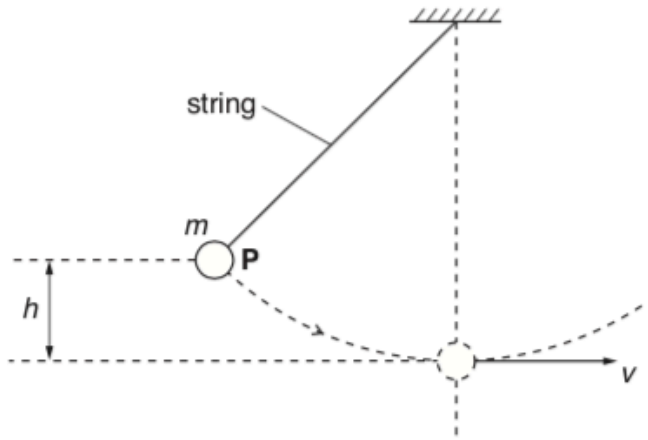

Fig. 5.1

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 1.2×10^{-2} m over a surface area of 2.0×10^{7} m^2 during a time of 900 s. The rain falls from an average height of 2.5×10^{3} m. The density of rainwater is 1.0×10^{3} kg m^{-3}. About 30% of the gravitational potential energy of the rain can be converted into electrical energy at the ground.

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

[2]

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

[3]

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

....

.... **[1]**

[Total: 11]

3)

(a) Write a word equation for *kinetic energy*.

kinetic energy =

[1]

(b) A bullet of mass 3.0×10^{-2} kg is fired at a sheet of plastic of thickness 0.015 m. The bullet enters the plastic with a speed of $200\,m\,s^{-1}$ and emerges from the other side with a speed of $50\,m\,s^{-1}$.

Calculate

(i) the loss of kinetic energy of the bullet as it passes through the plastic

loss of kinetic energy = ... J **[3]**

(ii) the average frictional force exerted by the plastic on the bullet.

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

[Total: 6]

4)

(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 $2.0 \times 10^4\,m\,s^{-1}$.

[2]

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

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

[Total: 10]

5)

5 Use your knowledge of physics to state if each statement is correct or incorrect. You then need to explain the reason for your answer. An example has been done for you:

In a vacuum, a 2.0 kg object will fall faster towards the ground than an object of mass 1.0 kg.

This statement is **incorrect**.
Explanation: **All objects falling towards the Earth in a vacuum have the same acceleration**.

(a) The mass of a particle (e.g. electron) remains constant as its speed approaches the speed of light.

This statement is ....

Explanation: ....

....

.... **[2]**

(b) A ball is thrown vertically upwards. Air resistance has negligible effect on its motion. During the flight, the total energy of the ball remains constant.

This statement is ....

Explanation: ....

....

.... **[2]**

(c) An object falling through air has a terminal velocity of $30\,m\,s^{-1}$. At terminal velocity, the weight of the object is equal to the acceleration of free fall.

This statement is ....

Explanation: ....

....

.... **[2]**

(d) The technique of 'triangle of vectors' is used by a global positioning system (GPS) to locate the position of cars.

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

This statement is ....

Explanation: ....

....

.... **[2]**

[Total: 8]

6)

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

....

.... **[1]**

(b) Fig. 6.1 shows a water slide.

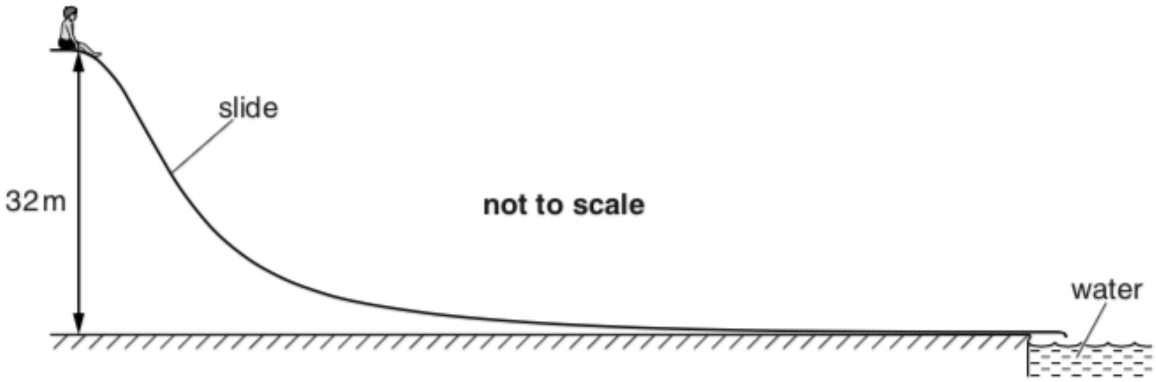

Fig. 6.1

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

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

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

(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]

7)

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

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

....

.... **[1]**

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

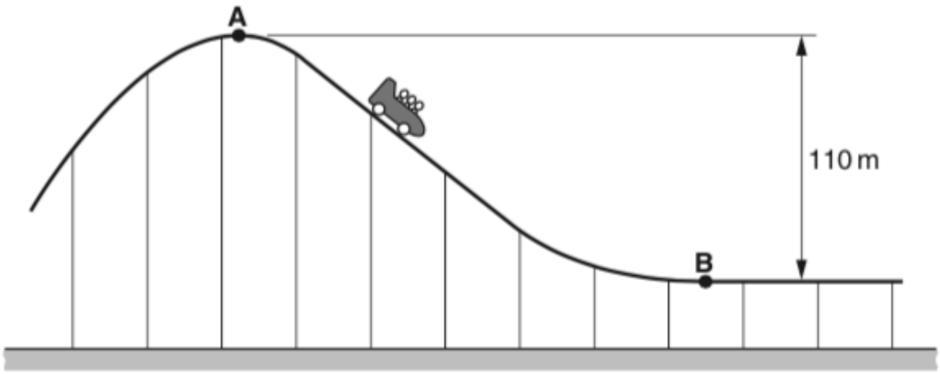

Fig. 4.1

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

8)

(a) The areas under the graphs below are physical quantities.

(i) Fig. 1.1 shows a force against extension graph for a rubber band.

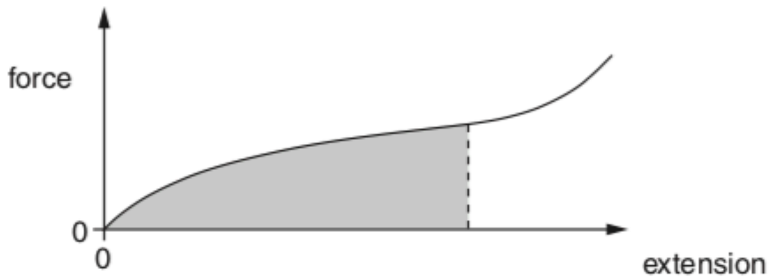

Fig. 1.1

State the quantity represented by the area under the force against extension graph.

.... **[1]**

(ii) Fig. 1.2 shows the velocity against time graph for an accelerating car.

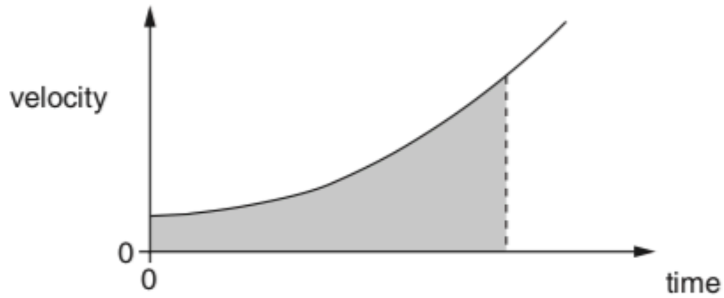

Fig. 1.2

State the quantity represented by the area under the velocity against time graph.

.... **[1]**

(b) State two quantities in physics that have the **same** unit of newton metre (N m).

quantity 1 .... **[1]**

quantity 2 .... **[1]**

[Total: 4]

9)

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

....

....

.... **[1]**

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

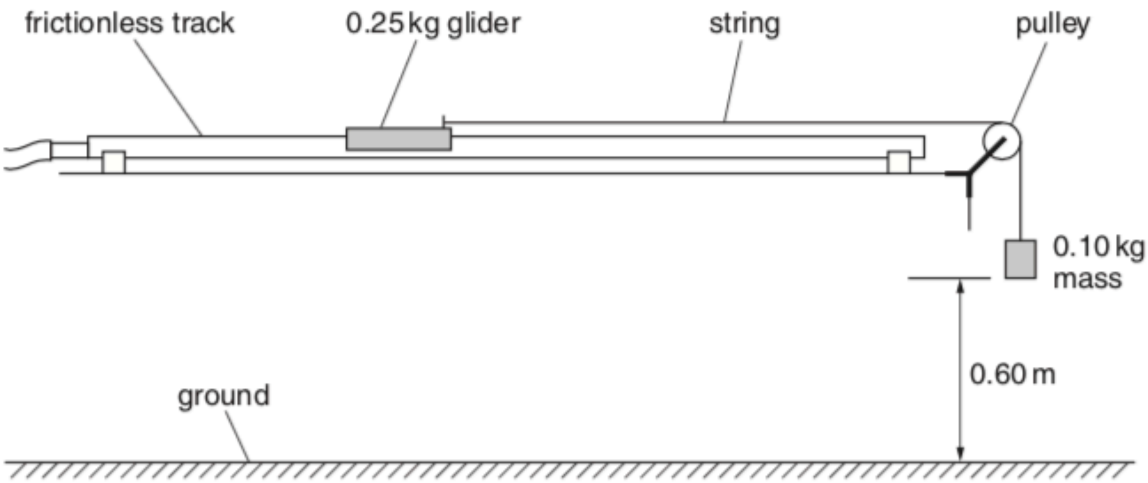

Fig. 6.1

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]

10)

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

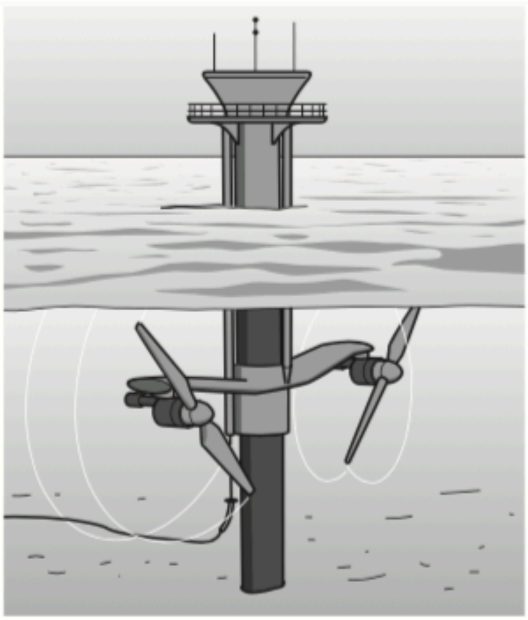

Fig. 7.1

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

11)

(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]

12)

In February 1999 NASA launched its Stardust spacecraft on a mission to collect dust particles from the comet Tempel 1. After a journey of 5.0×10^{12} m that took 6.9 years, Stardust returned to Earth with samples of the dust particles embedded in a special low-density gel. When a dust particle hits the gel, it buries itself in the gel creating a cone-shaped track as shown in Fig. 6.1. The length of the track is typically 200 times the diameter of the dust particle.

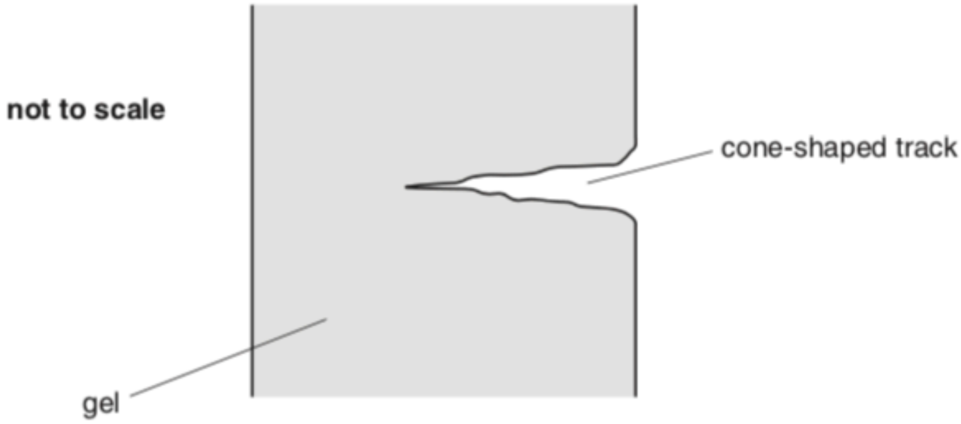

Fig. 6.1

(a) Calculate the average speed in m s^{-1} of Stardust during its voyage.

speed = ... ms^{-1} **[2]**

(b) Calculate the average stopping force produced by the gel for a dust particle of diameter 0.70 mm and mass 4.0×10^{-6} kg travelling at a velocity of 6.1×10^{3} m s^{-1} relative to Stardust.

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

[Total: 5]

13)

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

....

.... **[1]**

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

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

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

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

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

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

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

[Total: 4]

14)

(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 50 m. The van is now fully loaded with goods and travels at the same speed on the same road.

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

....

....

....

....

....

....

.... **[3]**

[Total: 7]

15)

(a) Define *velocity*.

....

.... **[1]**

(b) The mass of an ostrich is 130 kg. It can run at a maximum speed of 70 kilometres per hour.

(i) Calculate the maximum kinetic energy of the ostrich when it is running.

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

(ii) Scientists have recently found fossils of a prehistoric bird known as Mononykus. Fig. 1.1 shows what the Mononykus would have looked like.

Fig. 1.1

According to a student, the Mononykus looks similar to our modern day ostrich. The length, height and width of the Mononykus were all **half** that of an ostrich.
Estimate the mass of the Mononykus. Explain your reasoning.

....

....

....

.... **[2]**

[Total: 6]

16)

(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.

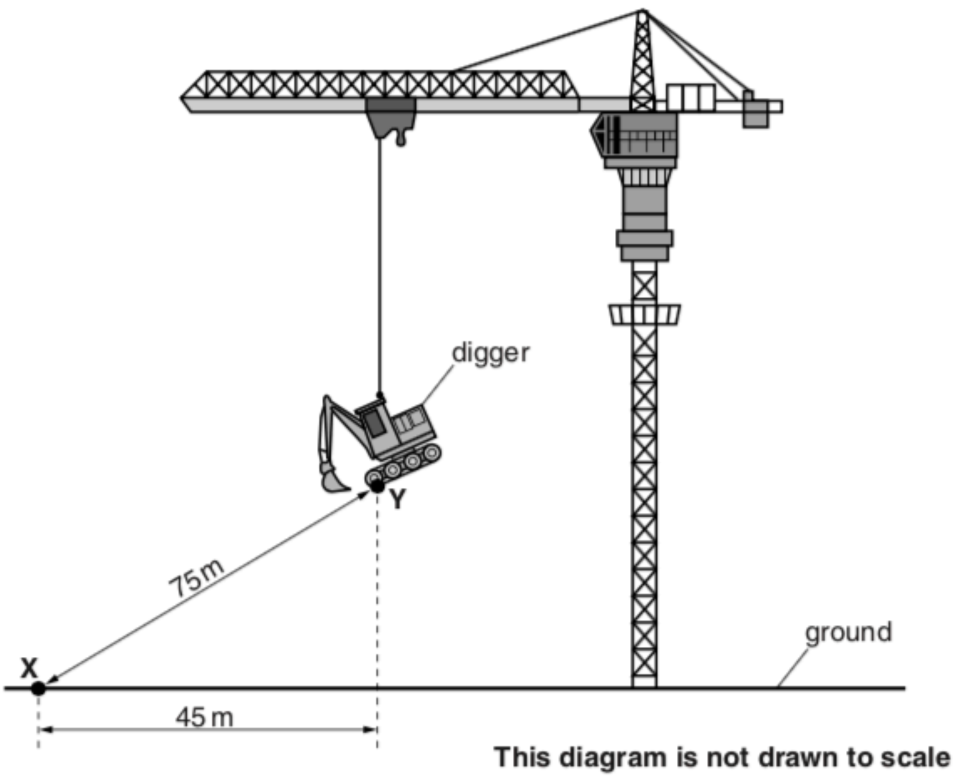

Fig. 6.1

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]

17)

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

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

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

....

....

....

....

....

....

....

....

....

.... **[4]**

18)

Fig. 3.1 shows a stunt rider on a powerful motorbike at **X** at the top of a ramp.

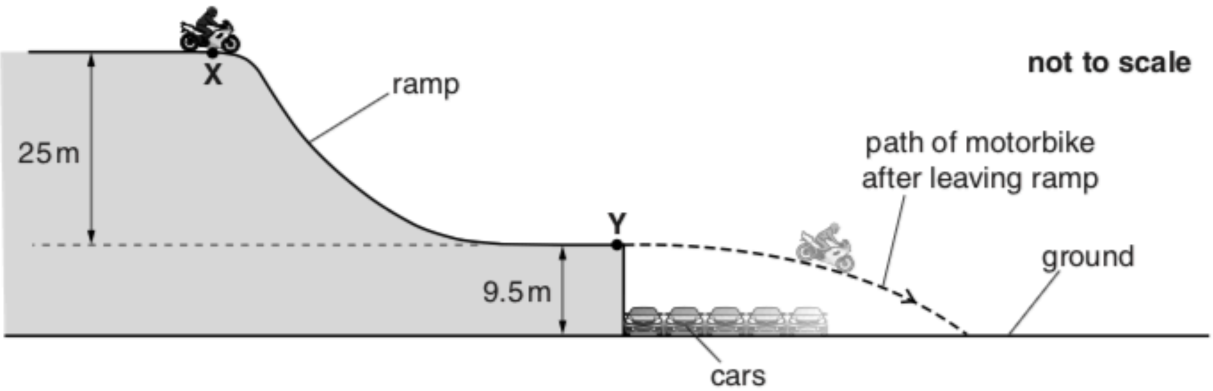

Fig. 3.1

The total mass of motorbike and rider is 190 kg. The height difference between the top and the bottom of the ramp is 25 m. The rider uses the engine to accelerate down the ramp. He leaves the end of the horizontal section of the ramp at **Y** with a speed of $30\,\mathrm{m\,s^{-1}}$.

(a) Calculate the loss of gravitational potential energy E_p of the rider and motorbike from **X** to **Y**.

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

(b) Calculate the kinetic energy E_k of the rider and motorbike at **Y**.

E_k = ... J **[1]**

(c) Explain why your answer to **(b)** is **greater** than your answer to **(a)**.

....

....

.... **[1]**