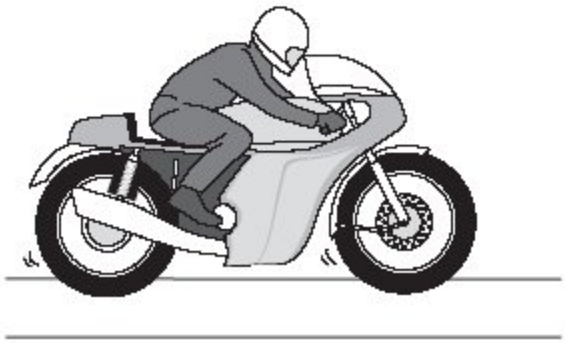
**1** The diagram shows a motorbike of mass 300 kg being ridden along a straight road.



The rider sees a traffic queue ahead. He applies the brakes and reduces the speed of the motorbike from 18 m/s to 3 m/s.

(a) Calculate the kinetic energy lost by the motorbike.

Show clearly how you work out your answer.

______________________________________________________________

______________________________________________________________

______________________________________________________________

______________________________________________________________

Kinetic energy lost = ______________________________ J

**(2)**

(b) (i) How much work is done on the motorbike by the braking force?

______________________________________________________________

**(1)**

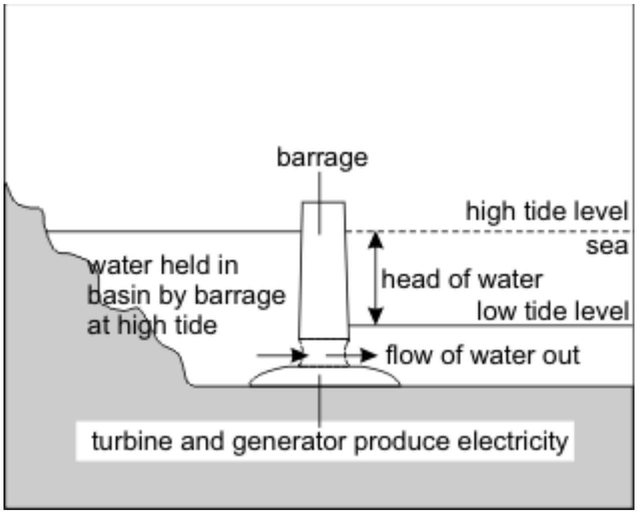
(ii) What happens to the kinetic energy lost by the motorbike?

______________________________________________________________

**(1)**

**(Total 4 marks)**

**2** The outline diagram below shows a tidal power generating system.




Gates in the barrage are open when the tide is coming in and the basin is filling to the high tide level. The gates are then closed as the tide begins to fall.

Once the tide outside the barrage has dropped the water can flow through large turbines in the barrage which drive generators to produce electrical energy.

In one second $1.2 \times 10^9$ kg of water flows through the turbines at a speed of 20 m/s.

(a) Calculate the total kinetic energy of the water which passes through the turbines each second.

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**(3)**

(b) As the height of water in the basin falls, the water speed through the turbines halves.

(i) What mass of water will now pass through the turbines each second?

___

(ii) By how much will the power available to the generators decrease?

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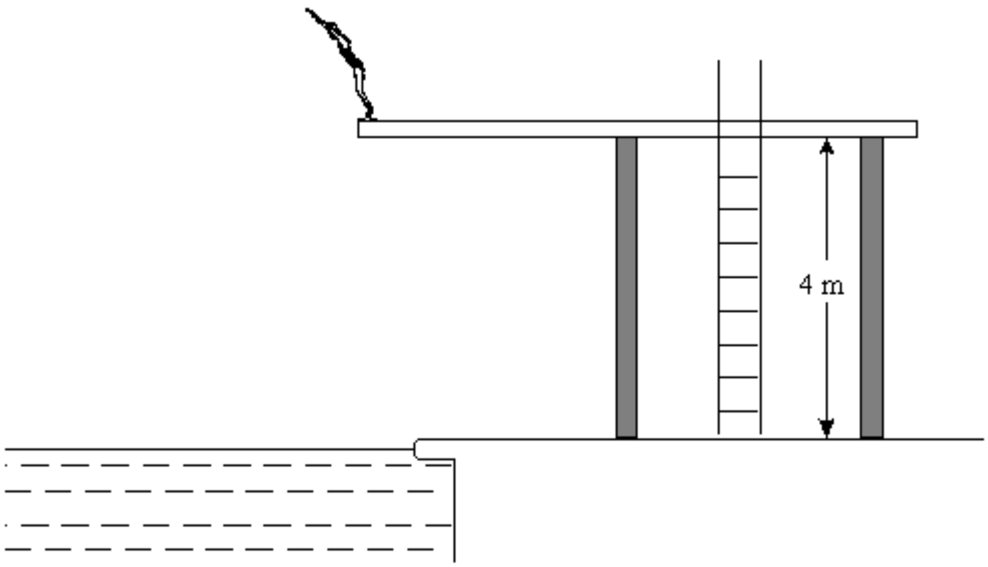
**(5)**

**(Total 8 marks)**

**3** The diagram shows a diver diving from the end of a diving board.




The height of the diving board above the poolside is 4 m. The mass of the diver is 50 kg. Gravitational field strength is 10 N/kg.

(a) Calculate the gain of gravitational potential energy as the diver climbs from the poolside to the diving board.

______________________________________________

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**(4)**

(b) The diver enters the water at a speed of 8 m/s.

Calculate the kinetic energy of the diver as she hits the water.

______________________________________________

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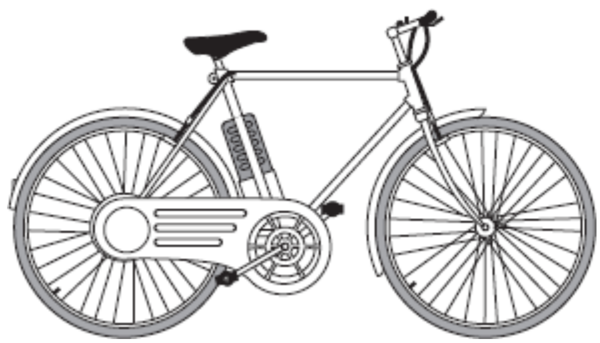
**(4)**

(c) As she hits the water her kinetic energy is different from the potential energy she gained as she climbed to the diving board. Explain why.

**(2)**

**(Total 10 marks)**

**4** The picture shows an electric bicycle. The bicycle is usually powered using a combination of the rider pedalling and an electric motor.



(a) A 36 volt battery powers the electric motor. The battery is made using individual 1.2 volt cells.

(i) Explain how a 36 volt battery can be produced using individual 1.2 volt cells.

To gain full marks, you must include a calculation in your answer.

**(2)**

(ii) The battery supplies a direct current (d.c.).

What is a *direct current (d.c.)*?

**(1)**

(iii) When fully charged, the battery can deliver a current of 5 A for 2 hours. The battery is then fully discharged.

Calculate the maximum charge that the battery stores.

Show clearly how you work out your answer and give the unit.

______________________________________________________________

______________________________________________________________

Charge stored = ______________________________

**(3)**

(b) When powered only by the electric motor, the bicycle can carry a 90 kg rider at a maximum speed of 6 m/s. Under these conditions, the maximum distance that the bicycle can cover before the battery needs recharging is 32 km.

The bicycle has a mass of 30 kg.

(i) Calculate the maximum kinetic energy of the bicycle **and** rider when the rider is not pedalling.

Show clearly how you work out your answer.

______________________________________________________________

______________________________________________________________

Kinetic energy = ______________________________ J

**(2)**

(ii) The bicycle can be fitted with panniers (bags) to carry a small amount of luggage.

What effect would fitting panniers and carrying luggage have on the distance the bicycle can cover before the battery needs recharging?

______________________________________________________________

Give a reason for your answer.

______________________________________________________________

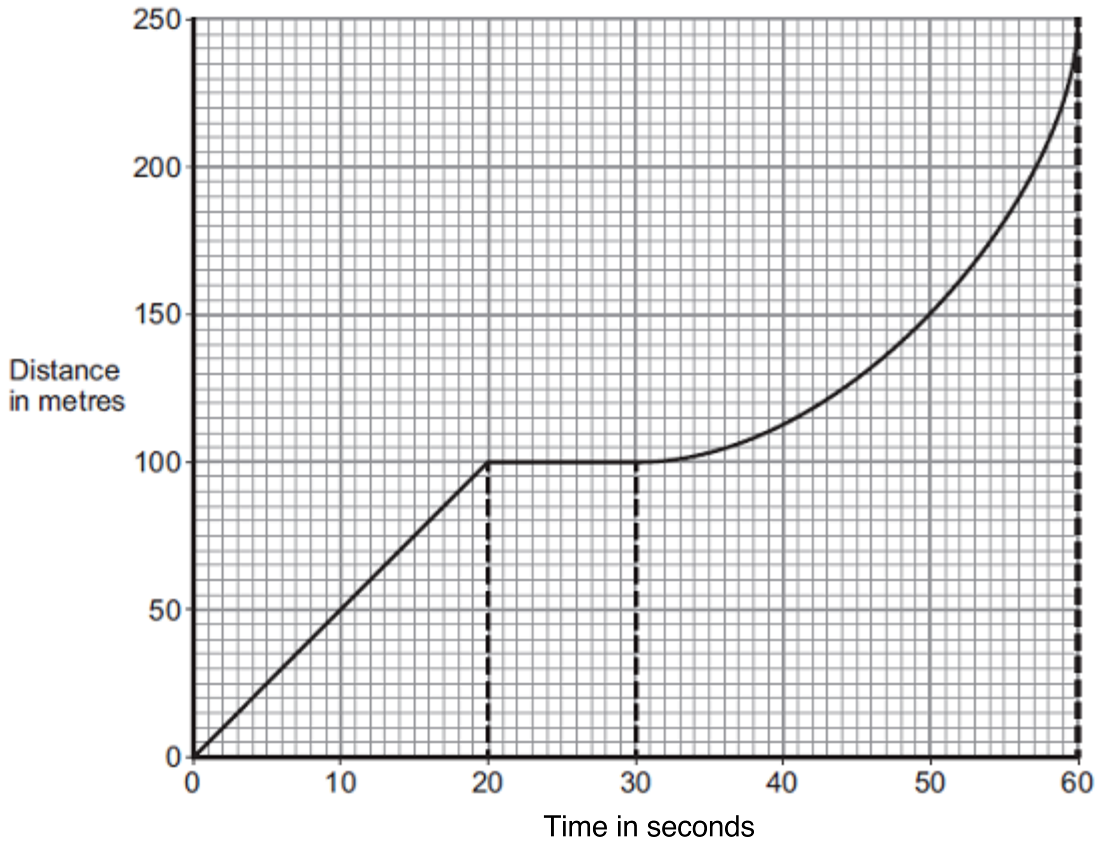
______________________________________________________________

**(2)**

**(Total 10 marks)**

**5** A bus is taking some children to school.

(a) The bus has to stop a few times. The figure below shows the distance–time graph for part of the journey.




(i) How far has the bus travelled in the first 20 seconds?

Distance travelled = ________________________ m

**(1)**

(ii) Describe the motion of the bus between 20 seconds and 30 seconds.

___________________________________________________________________

___________________________________________________________________

**(1)**

(iii) Describe the motion of the bus between 30 seconds and 60 seconds.

Tick (✓) **one** box.

| | **Tick (✓)** |
|---|---|
| Accelerating | |
| Reversing | |
| Travelling at constant speed | |

**(1)**

(iv) What is the speed of the bus at 45 seconds?

Show clearly on the figure above how you obtained your answer.

______________________________________________________________

______________________________________________________________

______________________________________________________________

Speed = ______________________ m / s

**(3)**

(b) Later in the journey, the bus is moving and has 500 000 J of kinetic energy.

The brakes are applied and the bus stops.

(i) How much work is needed to stop the bus?

______________________________________________________________

Work = ______________________ J

**(1)**

(ii) The bus stopped in a distance of 25 m.

Calculate the force that was needed to stop the bus.

______________________________________________________________

______________________________________________________________

Force = ______________________ N

**(2)**

(iii) What happens to the kinetic energy of the bus as it is braking?

______________________________________________________________

______________________________________________________________

______________________________________________________________

______________________________________________________________

**(2)**

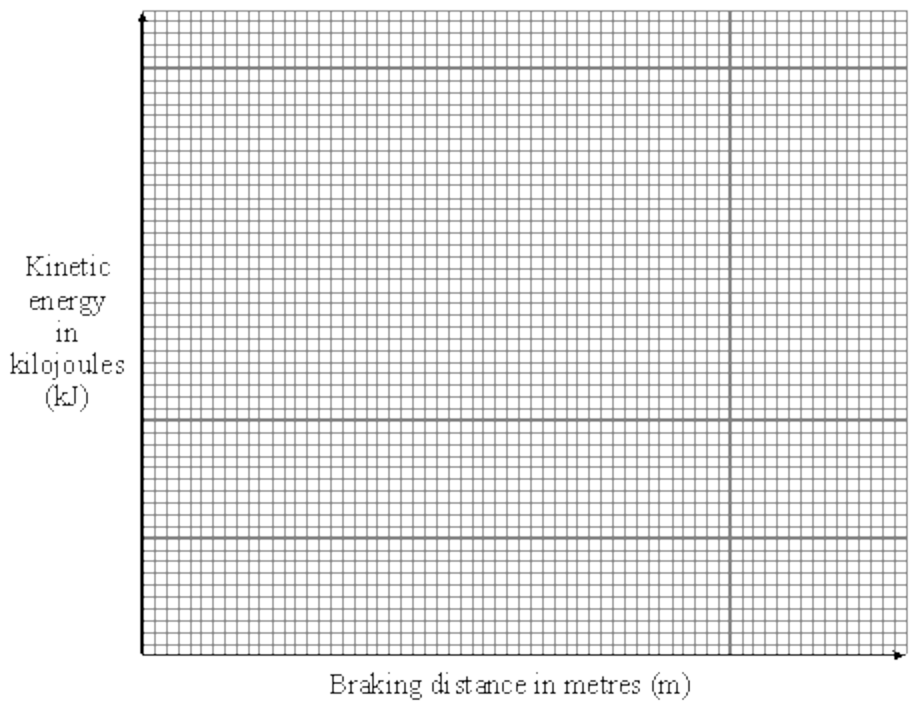
**(Total 11 marks)**

**6** The table shows the braking distances for a car at different speeds and kinetic energy. The braking distance is how far the car travels once the brakes have been applied.

| Braking distance in m | Speed of car in m/s | Kinetic energy of car in kJ |
|---|---|---|
| 5 | 10 | 40 |
| 12 | 15 | 90 |
| 20 | 20 | 160 |
| 33 | 25 | 250 |
| 45 | 30 | 360 |

(a) A student suggests, "*the braking distance is directly proportional to the kinetic energy*."

(i) Draw a line graph to test this suggestion.




**(3)**

(ii) Does the graph show that the student's suggestion was correct or incorrect? Give a reason for your answer.

______________________________________________________________________

______________________________________________________________________

**(1)**

(iii) Use your graph and the equation for kinetic energy to predict a braking distance for a speed of 35 metres per second (m/s). The mass of the car is 800 kilograms (kg). Show clearly how you obtain your answer.

______________________________________________________________

______________________________________________________________

Braking distance = ____________________ m

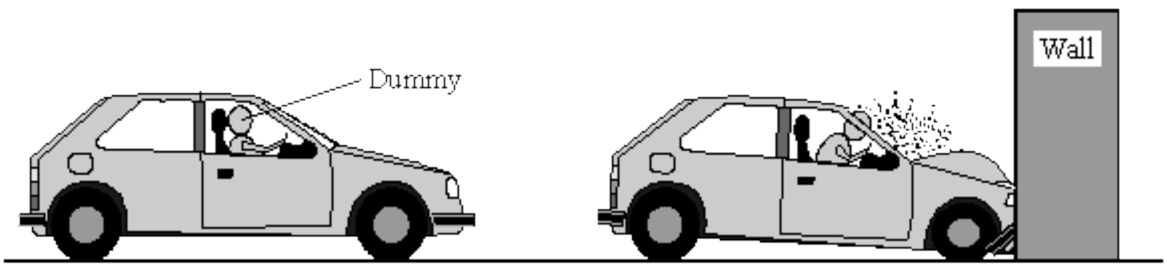
**(2)**

(iv) State **one** factor, apart from speed, which would increase the car's braking distance.

______________________________________________________________

**(1)**

(b) The diagram shows a car before and during a crash test. The car hits the wall at 14 metres per second (m/s) and takes 0.25 seconds (s) to stop.




(i) Write down the equation which links acceleration, change in velocity and time taken.

______________________________________________________________

**(1)**

(ii) Calculate the deceleration of the car.

______________________________________________________________

Deceleration = ____________________ $m/s^2$

**(1)**

(iii) In an accident the crumple zone at the front of a car collapses progressively. This increases the time it takes the car to stop. In a front end collision the injury to the car passengers should be reduced. Explain why. The answer has been started for you.

*By increasing the time it takes for the car to stop, the* ____________________

______________________________________________________________

______________________________________________________________

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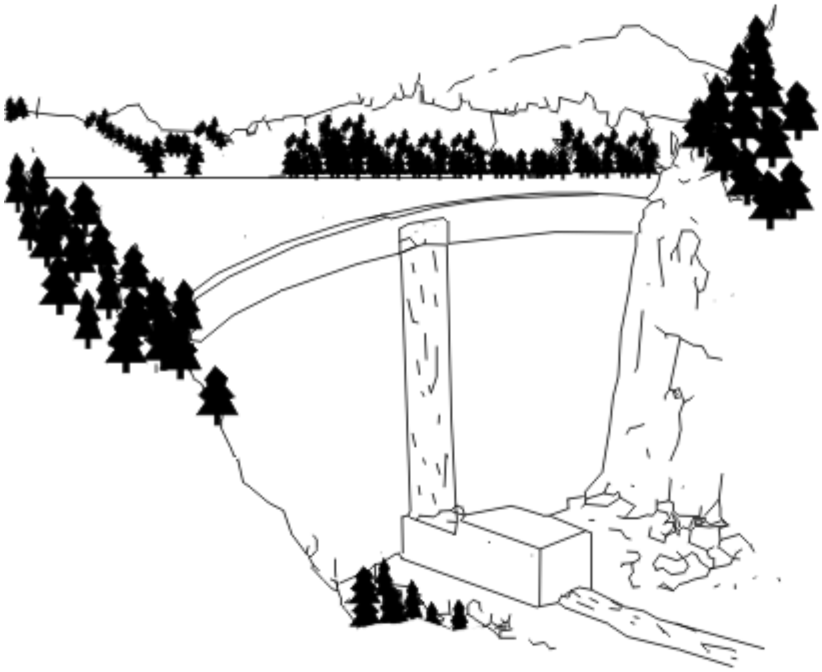
**(2)**

**(Total 11 marks)**

**7** The diagram below shows water falling from a dam. Each minute 12 000 kg of water falls vertically into the pool at the bottom.



The time taken for the water to fall is 2 s and the acceleration of the water is 10 m/s$^2$.

(a) Assume the speed of the water at the bottom of the dam is zero. Calculate the speed of the water just before it hits the pool at the bottom.

______________________________________________

______________________________________________

**(2)**

(b) Use your answer to part (a) to calculate the average speed of the falling water.

______________________________________________

**(1)**

(c) Calculate the height that the water falls.

______________________________________________

______________________________________________

**(2)**

(d) What weight of water falls into the pool each minute?

______________________________________________

______________________________________________

**(2)**

(e) How much work is done by gravity each minute as the water falls?

______________________________________________________________________

______________________________________________________________________

**(2)**

(f) A small electrical generator has been built at the foot of the waterfall. It uses the falling water to produce electrical power.

(i) How much energy is available from the falling water each minute?

______________________________________________________________________

(ii) How much power is available from the falling water?

______________________________________________________________________

______________________________________________________________________

(iii) If the generator is 20% efficient, calculate the electrical power output of the generator.

______________________________________________________________________

______________________________________________________________________

**(4)**

**(Total 13 marks)**

**8** Mira and Susan are rock climbing. They are using a nylon climbing rope. Mira has fastened herself to the rock face and to one end of the rope. The other end of the rope is fastened to Susan. This means that, if Susan falls, the rope will hold her. Susan weighs 540 N.

(a) (i) Use the words *distance*, *force* and *work* to write an equation which shows the relationship between them

___________________________________________________________________

**(1)**

(ii) What vertical distance up the rock face does Susan climb when she does 2000 J of work against gravity? Show your working and give your answer to the nearest 0.1 m.

___________________________________________________________________

___________________________________________________________________

Distance = ______________________ metres

**(2)**

(iii) How much gravitational energy will Susan gain when she does 2000 J of work against gravity?

___________________________________________________________________

**(1)**

(b) The climbers dislodge a 3 kg stone which falls down the rock face.

What is the speed of the stone when its kinetic energy is 600 J?

kinetic energy = $\frac{1}{2}$ mass × speed$^2$

Show clearly how you get to your answer and give the unit.

___________________________________________________________________

___________________________________________________________________

___________________________________________________________________

Speed = ______________________________

**(3)**

(c) The climbing rope is made of nylon. Nylon is very strong. Another advantage is that it stretches. This means that, if Susan falls, it transfers some of her kinetic energy to elastic (or strain) energy at the end of the fall.

Explain, in terms of *force* and *deceleration*, what would happen if Susan fell and the climbing rope did **not** transfer any of her kinetic energy to elastic energy.

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**(3)**

**(Total 10 marks)**

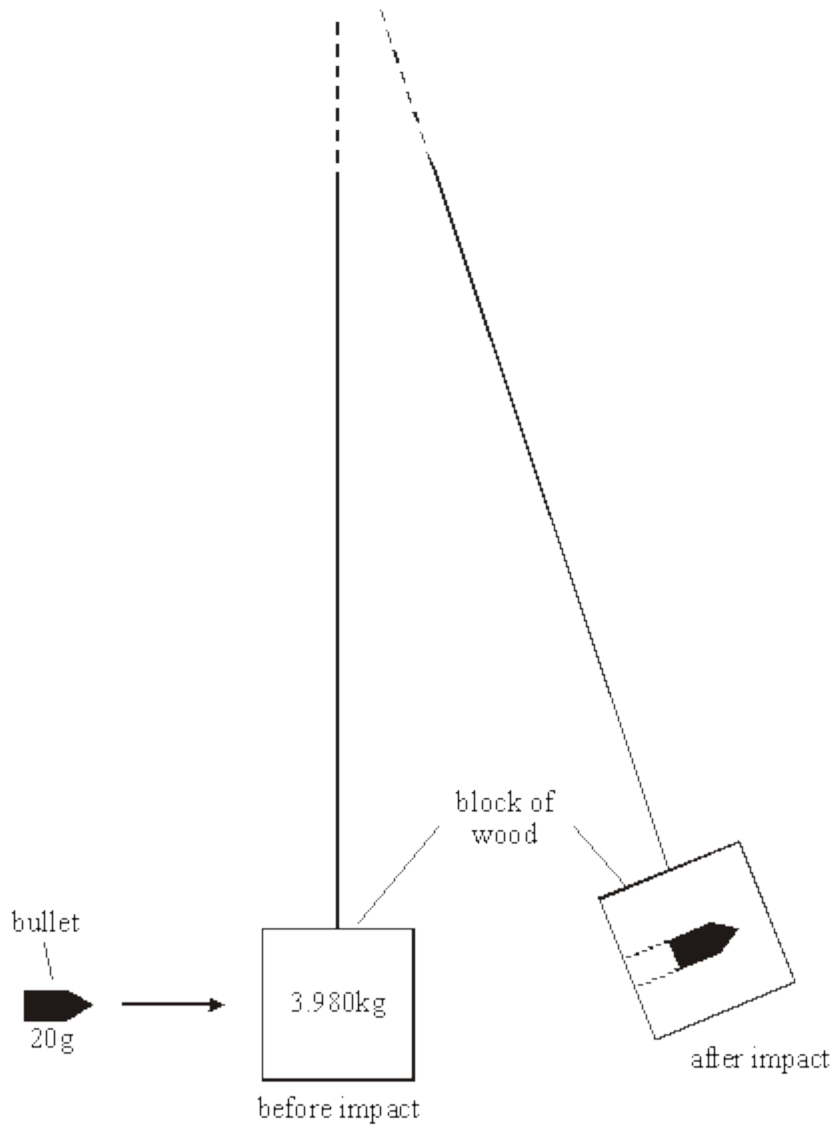
**9** (a) When an object is moving it is said to have momentum.
Define momentum.

___________________________________________________________________

___________________________________________________________________

**(1)**

(b) The diagram below shows one way of measuring the velocity of a bullet.




A bullet is fired into a block of wood suspended by a long thread.
The bullet stops in the wooden block.
The impact of the bullet makes the block swing.
The velocity of the wooden block can be calculated from the distance it swings.

In one such experiment the block of wood and bullet had a velocity of 2 m/s **immediately after** impact. The mass of the bullet was 20 g and the mass of the wooden block 3.980 kg.

(i) Calculate the combined mass of the block of wood and bullet.

______________________________________ Mass _____________________

**(1)**

(ii) Calculate the momentum of the block of wood and bullet **immediately after** impact.

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

______________________________________ Momentum ________________

**(3)**

(iii) State the momentum of the bullet **immediately before** impact.

______________________________________________________________________

**(1)**

(iv) Calculate the velocity of the bullet **before** impact.

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

______________________________________ Velocity _______________ m/s

**(3)**

(v) Calculate the kinetic energy of the block of wood and bullet **immediately after** impact.

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

_____________________________________ Kinetic energy _____________ J

**(3)**

(vi) The kinetic energy of the bullet before the impact was 1600 joules. This is much greater than the kinetic energy of the bullet and block just after the impact. What has happened to the rest of the energy?

______________________________________________________________________

______________________________________________________________________

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**(1)**

**(Total 13 marks)**

**10** (a) The stopping distance of a vehicle is made up of two parts, the thinking distance and the braking distance.

(i) What is meant by *thinking distance*?

___________________________________________________________________

___________________________________________________________________

**(1)**

(ii) State **two** factors that affect thinking distance.

1. _________________________________________________________________

___________________________________________________________________

2. _________________________________________________________________

___________________________________________________________________

**(2)**

(b) A car is travelling at a speed of 20 m/s when the driver applies the brakes. The car decelerates at a constant rate and stops.

(i) The mass of the car and driver is 1600 kg.

Calculate the kinetic energy of the car and driver before the brakes are applied.

___________________________________________________________________

___________________________________________________________________

___________________________________________________________________

Kinetic energy = ___________________________ J

**(2)**

(ii) How much work is done by the braking force to stop the car and driver?

Work done = ___________________________ J

**(1)**

(iii) The braking force used to stop the car and driver was 8000 N.

Calculate the braking distance of the car.

___________________________________________

___________________________________________

___________________________________________

___________________________________________

Braking distance = ______________________ m

**(2)**

(iv) The braking distance of a car depends on the speed of the car and the braking force applied.

State **one** other factor that affects braking distance.

___________________________________________

___________________________________________

**(1)**

(v) Applying the brakes of the car causes the temperature of the brakes to increase.

Explain why.

___________________________________________

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___________________________________________

**(2)**

(c) Hybrid cars have an electric engine and a petrol engine. This type of car is often fitted with a regenerative braking system. A regenerative braking system not only slows a car down but at the same time causes a generator to charge the car's battery.

State and explain the benefit of a hybrid car being fitted with a regenerative braking system.

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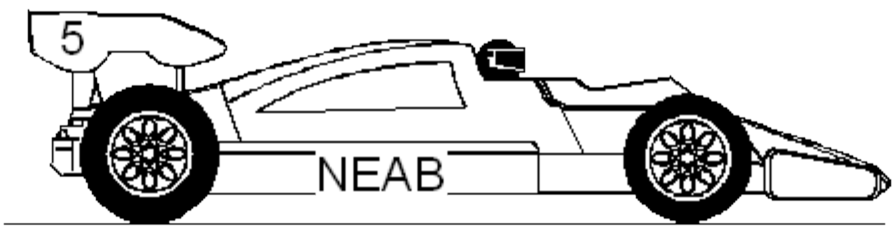
**(3)**

**(Total 14 marks)**

**11** A racing driver is driving his car along a **straight** and **level** road as shown in the diagram below.




(a) The driver pushes the accelerator pedal as far down as possible. The car does not accelerate above a certain maximum speed. Explain the reasons for this in terms of the forces acting on the car.

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**(4)**

(b) The racing car has a mass of 1250 kg. When the brake pedal is pushed down a constant braking force of 10 000 N is exerted on the car.

(i) Calculate the acceleration of the car.

___________________________________________________________________

___________________________________________________________________

___________________________________________________________________

___________________________________________________________________

___________________________________________________________________

(ii) Calculate the kinetic energy of the car when it is travelling at a speed of 48 m/s.

___________________________________________________________________

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___________________________________________________________________

(iii) When the brakes are applied with a constant force of 10 000 N the car travels a distance of 144 m before it stops. Calculate the work done in stopping the car.

___________________________________________________________________

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**(12)**

**(Total 16 marks)**