

**Q1.** When a gun is fired, a very large force acts on the bullet for a very short time.

The change in momentum of the bullet is given by the following relationship:

$$\text{force (N)} \times \text{time(s)} = \text{change in momentum (kg m/s)}$$

(a) An average force of 4000 newton acts for 0.01 seconds on a bullet of mass 50g.

Calculate the speed of the bullet. (*Show your working.*)

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Answer ..... m/s

**(4)**

(b) The bullet is fired horizontally. In the short time it takes for the bullet to reach its target, its horizontal speed has fallen to 80% of its initial speed.

(i) Explain why the speed of the bullet decreases so quickly.

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**(2)**

(ii) Calculate the percentage of its original kinetic energy the bullet still has when it reaches its target.

*(Show your working.)*

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**(4)**

**(Total 10 marks)**

**Q2.** 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?

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(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?

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

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

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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.

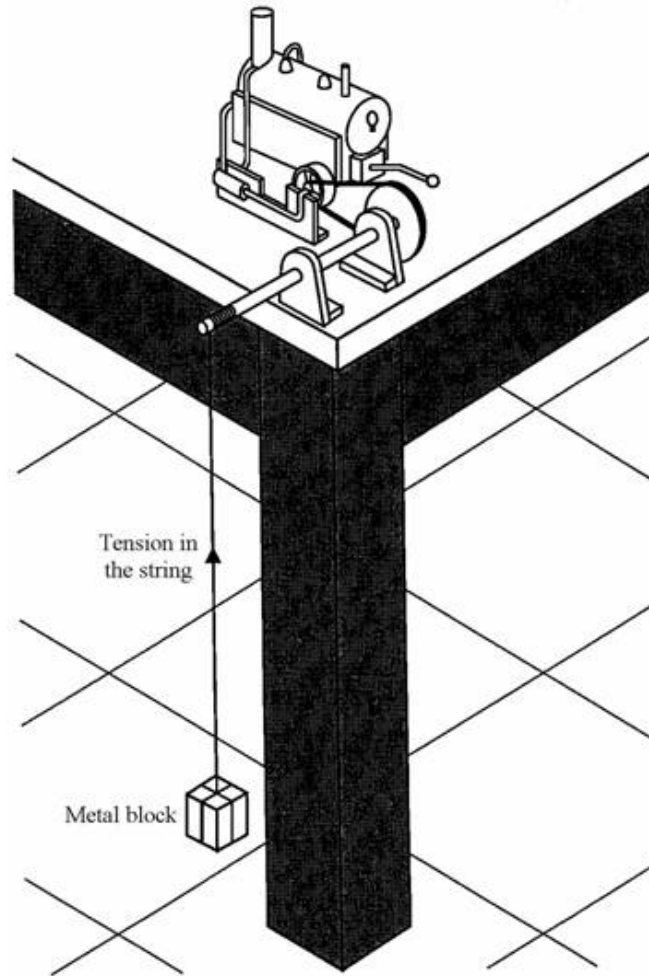
Explain, in terms of *force* and *deceleration*, what would happen if Susan fell and the climbing rope did **not** transfer any of her kinetic energy to elastic energy.

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(3)

(Total 10 marks)

**Q3.** The drawing shows an investigation using a model steam engine to lift a load.



In part of the investigation, a metal block with a weight of 4.5 N was lifted from the floor to a height of 90 cm.

(a) Explain what causes the weight of the metal block.

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(2)

(b) (i) What is the tension in the string when the block is lifted at a steady speed?

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(1)

(ii) Explain your answer to part (b) (i).

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(1)

- (c) (i) Calculate the work done in lifting this load. Write the equation you are going to use, show clearly how you get to your answer and give the unit.

Equation .....

.....

Work = .....

(3)

- (ii) How much useful energy is transferred to do the work in part (c) (i)?

.....

(1)

- (d) In another part of the investigation, 250J of work is done in one minute. Use the equation:

$$\text{power} = \frac{\text{work done}}{\text{time taken}}$$

to work out the useful power output. Give the unit.

.....

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Power = .....

(2)

(Total 10 marks)

**Q4.** A car which is moving has kinetic energy.



The faster a car goes, the more kinetic energy it has. The kinetic energy of this car was 472 500 J when travelling at 30 m/s.

Calculate the total mass of the car.

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

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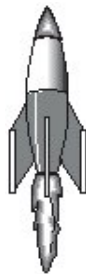
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Mass of the car = .....

**(Total 5 marks)**

**Q5.** A rocket has a mass of 5000 kg and is travelling at a speed of 600 m/s.



Calculate the rocket's kinetic energy in kilojoules. Show your working.

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Kinetic energy = ..... kJ

**(Total 3 marks)**

**Q6.** A rollercoaster car stops above a vertical drop. Suddenly it falls under gravity.



The drop is 60 metres high and at the bottom of the drop the car travels at 125 km/h. The acceleration experienced by the people in the car is  $10 \text{ m/s}^2$ . The mass of the car and its passengers is 1210 kg.

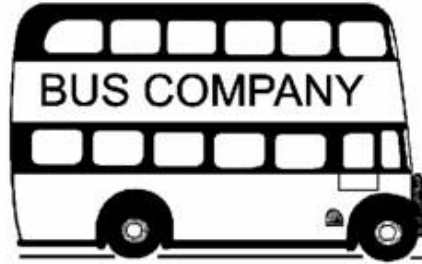
Calculate the force exerted on the car and its passengers. Show your working.

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Force = ..... N

**(Total 3 marks)**

**Q7.** 'SPEED KILLS' - was the heading of an advertising campaign. The scientific reason for this is that energy is transferred from the vehicle to the person it knocks down.



(a) The bus and the van are travelling at the same speed. The bus is more likely to cause more harm to a person who is knocked down than the van would. Explain why.

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(2)

(b) A car and its passengers have a mass of 1200 kg. It is travelling at 12 m/s.

(i) Calculate the increase in kinetic energy when the car increases its speed to 18 m/s.  
Show clearly how you work out your answer and give the unit.

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Increase in kinetic energy = .....

(5)



(ii) Explain why the increase in kinetic energy is much greater than the increase in speed.

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(1)  
 (Total 8 marks)

**Q8.** The diagram shows a high jumper.



In order to jump over the bar, the high jumper must raise his mass by 1.25 m. The high jumper has a mass of 65 kg. The gravitational field strength is 10 N/kg.

(a) The high jumper just clears the bar.

Use the following equations to calculate the gain in his gravitational potential energy.

<b>weight</b> (newton, N)	=	<b>mass</b> (kilogram, kg)	×	<b>gravitational field strength</b> (newton/kilogram, N/kg)
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<b>change in gravitational potential energy</b> (joule, J)	=	<b>weight</b> (Newton, N)	×	<b>change in vertical height</b> (metre, m)
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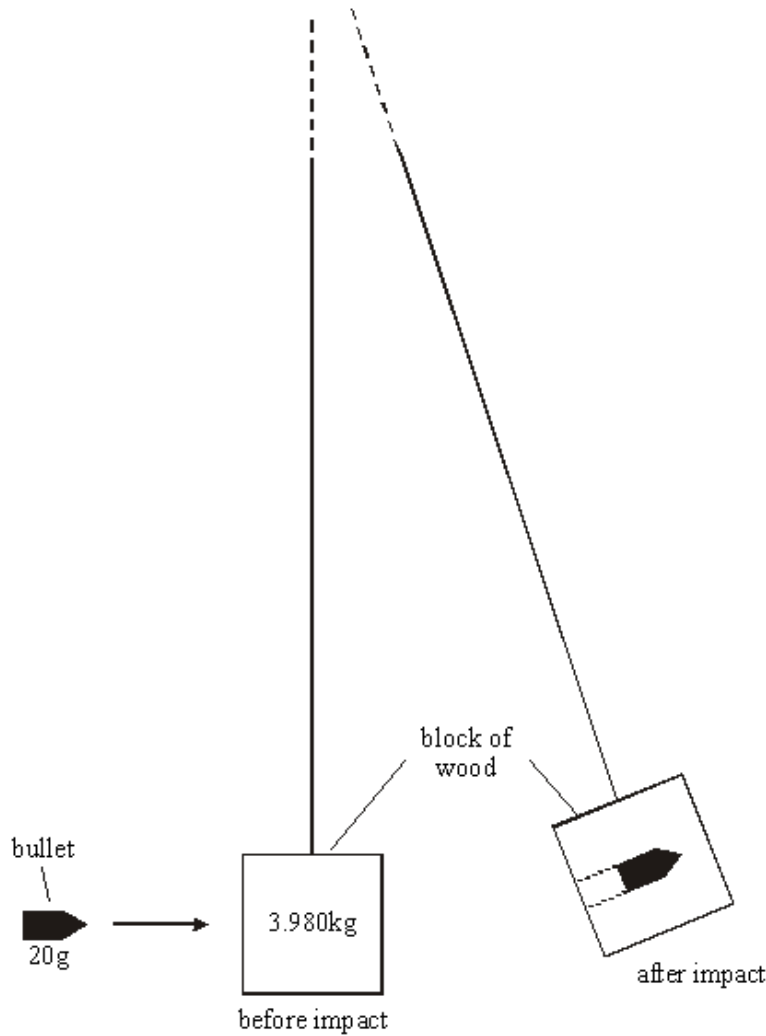
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Gain in gravitational potential energy ..... J

(4



(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.

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.....  
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..... Momentum .....

(3)

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

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(1)

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

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..... Velocity ..... m/s

(3)

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

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..... Kinetic energy ..... J

(3)

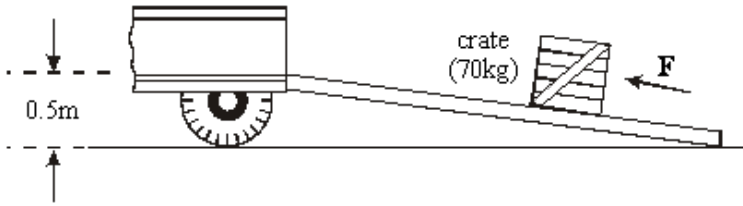
(vi) The kinetic energy of the bullet before the impact was 1600 joules. This is much greater than the kinetic energy of the bullet and block just after the impact. What has happened to the rest of the energy?

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(1)

(Total 13 marks)

**Q10.** The diagram below shows a plank being used as a simple machine. The crate is slid up the plank into the back of the lorry.



(i) The mass of the crate is 70kg. Calculate the weight of the crate.

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 ..... Weight ..... N

(2)

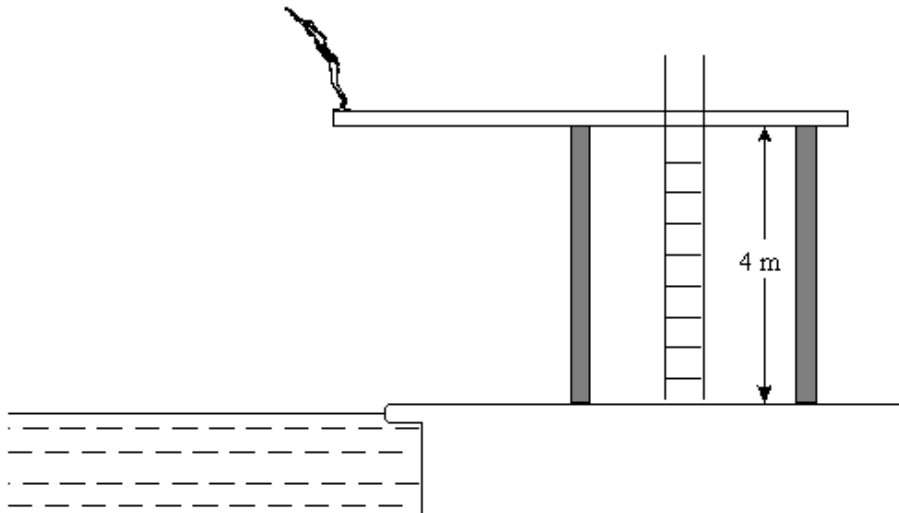
(ii) Calculate the work done when the crate is lifted a vertical distance of 0.5m.

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 ..... Work done .....

(4)

(Total 6 marks)

**Q11.** 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.

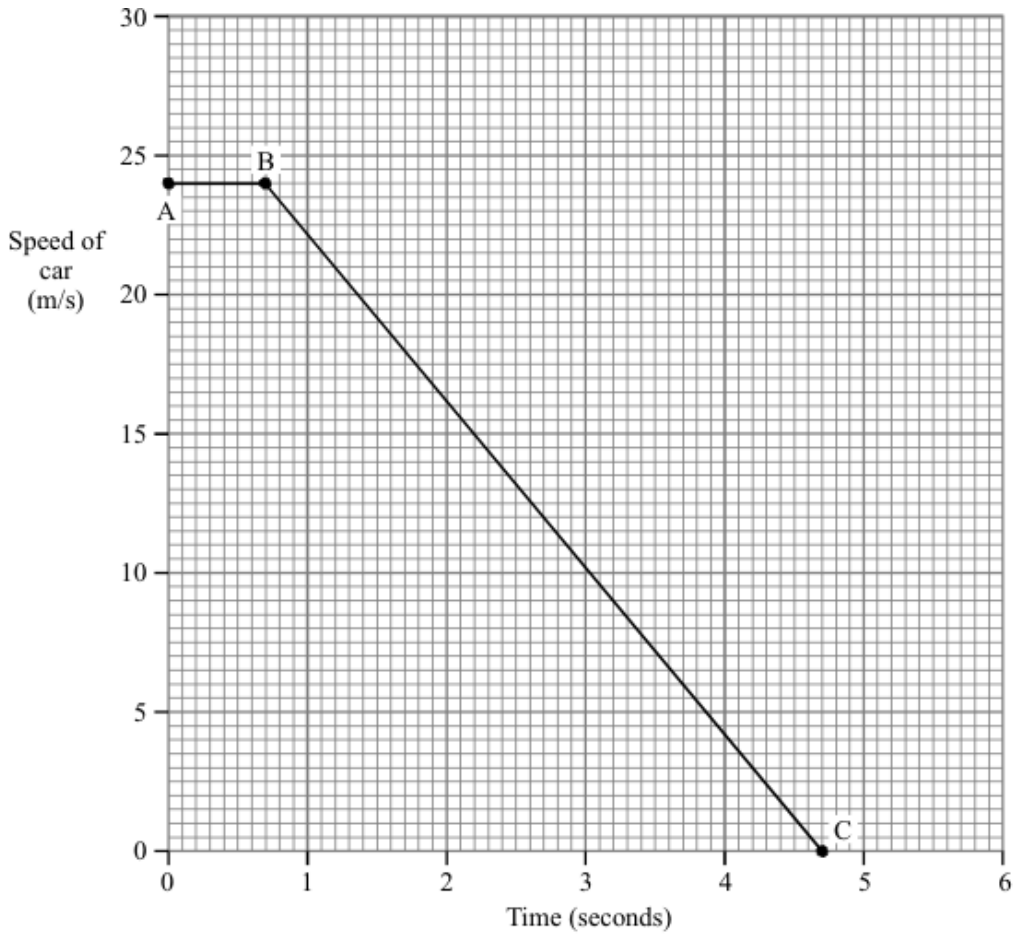
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(2)

(Total 10 marks)

**Q12.** A car driver sees a dog on the road ahead and has to make an emergency stop.

The graph shows how the speed of the car changes with time after the driver first sees the dog.



(a) Which part of the graph represents the “reaction time” or “thinking time” of the driver?

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(1)

(b) (i) What is the thinking time of the driver? Time ..... seconds

(1)

(ii) Calculate the distance travelled by the car in this thinking time.

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Distance ..... m

(3)

(c) Calculate the acceleration of the car after the brakes are applied.

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Acceleration .....

(4)

(d) Calculate the distance travelled by the car during braking.

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Distance ..... m

(3)

(e) The mass of the car is 800 kg. Calculate the braking force.

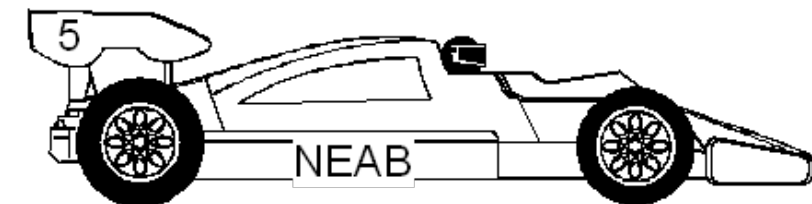
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Braking force ..... N

(3)

(Total 15 marks)

**Q13.** 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.

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

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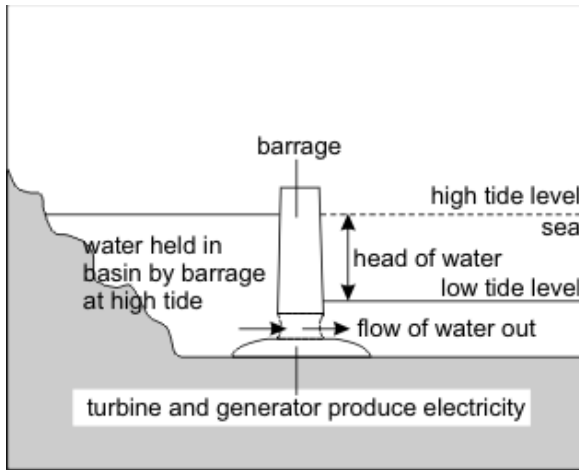
- (iii) When the brakes are applied with a constant force of 10 000 N the car travels a distance of 144 m before it stops. Calculate the work done in stopping the car.

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(12)

(Total 16 marks)

**Q14.** 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?

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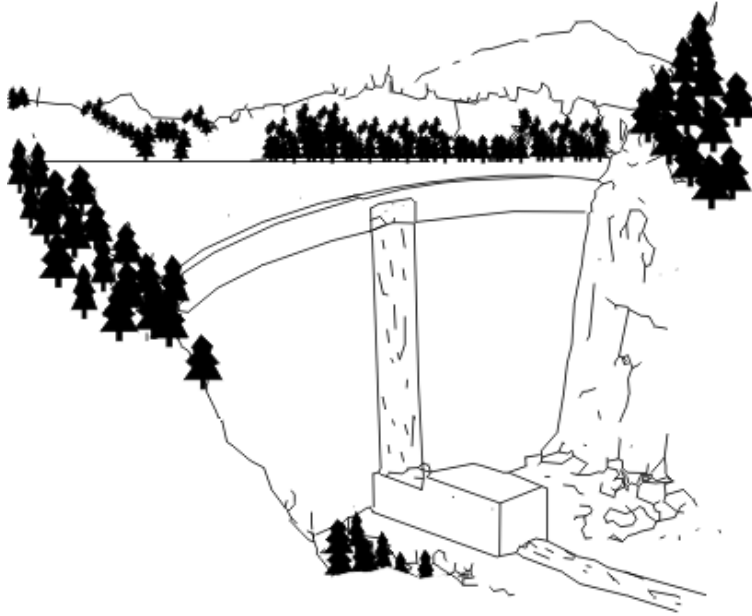
- (ii) By how much will the power available to the generators decrease?

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(5)

(Total 8 marks)

**Q15.** 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  $10 \text{ m/s}^2$ .

- (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.

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(2)

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

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(1)

- (c) Calculate the height that the water falls.

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(2)

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

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 .....

(2)

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

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(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?

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

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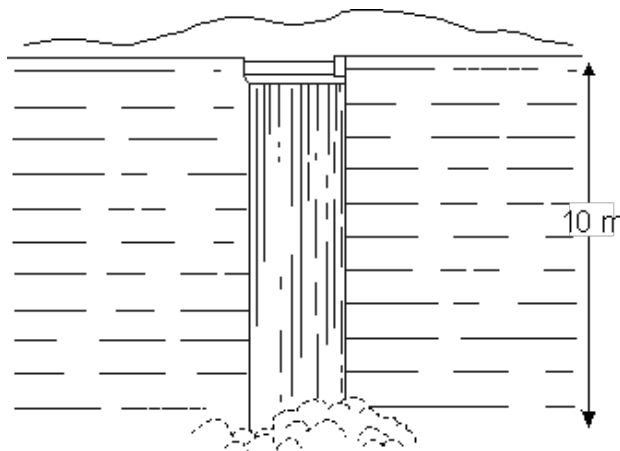
(iii) If the generator is 20% efficient, calculate the electrical power output of the generator.

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(4)  
(Total 13 marks)

**Q16.** The diagram below shows water falling over a dam at the end of a reservoir. The water falls a vertical distance of 10 m.



(a) Calculate the potential energy of 1 kg of water at the top of the waterfall.

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.....

Answer ..... J

(2)

(b) What will be the kinetic energy of 1 kg of the water just before it lands in the pool?

.....

Answer ..... J

(1)

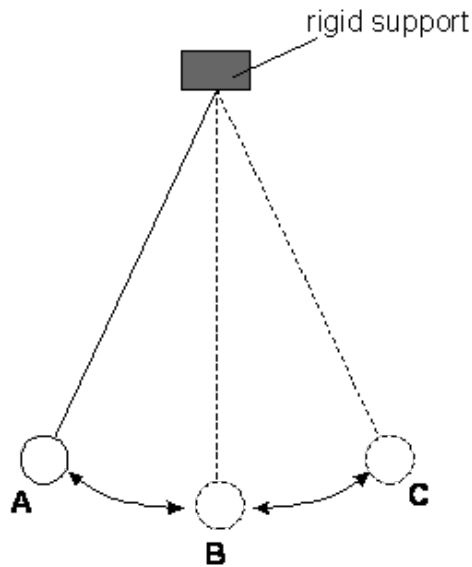
- (c) Use your answer to (b) to calculate the speed of the water as it lands at the bottom of the waterfall.

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Answer ..... m/s

(3)  
 (Total 6 marks)

- Q17.** The diagram below shows an experiment where a pendulum swings backwards and forwards.  
 A pendulum is a small heavy weight suspended by a light string.



- (a) (i) In which position, A, B or C, does the pendulum have least potential energy?  
 Explain your answer.

.....

(1)

- (ii) In which position, A, B or C, does the pendulum have greatest kinetic energy?  
 Explain your answer.

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(1)

- (iii) After a few minutes the size of the swings becomes smaller.  
 Explain why this happens.

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(1)

- (b) If the experiment were repeated on the Moon the pendulum would swing more slowly. Suggest a reason for this.

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(2)  
 (Total 5 marks)

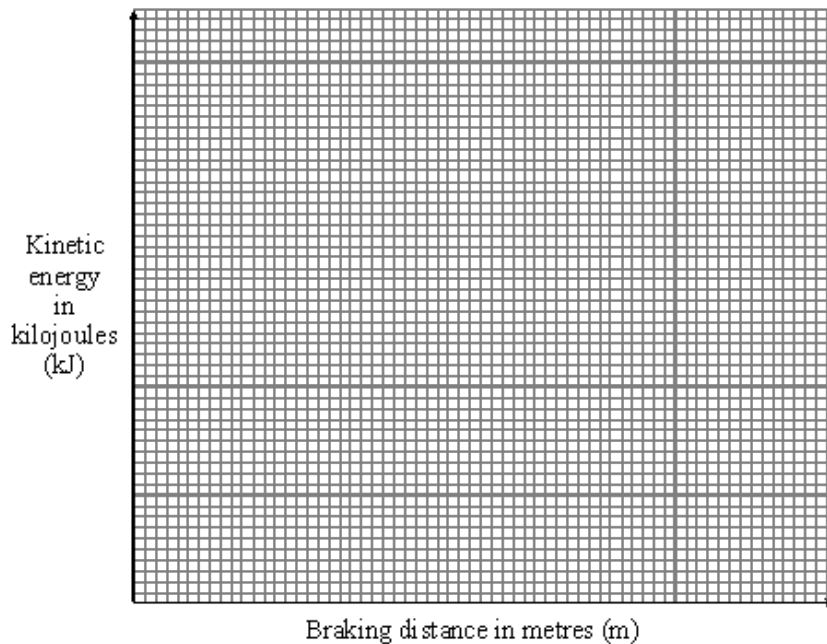
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The table shows the braking distances for a car at different speeds and kinetic energy. The braking distance is how far the car travels once the brakes have been applied.

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.

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 .....

(1)

- (iii) Use your graph and the following equation 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.

$$\text{kinetic energy} = \frac{1}{2} mv^2$$

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Braking distance = ..... m

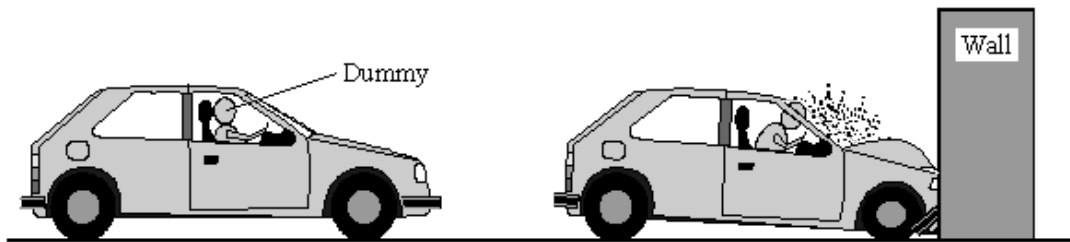
(2)

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

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(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<sup>2</sup>

(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)

**Q19.** The molten rock flowing from an erupting volcano can reach a speed of 8 m/s.

- (i) Write down the equation that links kinetic energy, mass and speed.

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(1)

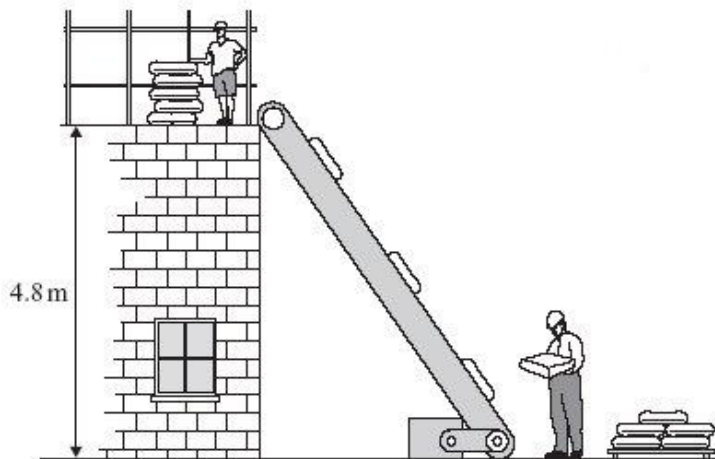
- (ii) Calculate the kinetic energy of 1 tonne of molten rock flowing at 8 m/s.  
 (1 tonne = 1000 kg)

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 .....

Kinetic energy = ..... joules

(1)  
 (Total 2 marks)

**Q20.** A machine is used to lift materials on a building site.





- (a) (i) Write down the equation that links change in gravitational potential energy, change in vertical height and weight.

.....

(1)

- (ii) A 25 kg bag of cement is lifted from the ground to the top of the building. Calculate the gain in the gravitational potential energy of the bag of cement.

(On Earth a 1 kg mass has a weight of 10 N.)

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Change in gravitational potential energy = ..... joules

(2)

- (b) The conveyor belt delivers six bags of cement each minute to the top of the building.

- (i) Calculate the useful energy transferred by the machine each second.

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Useful energy transfer each second = ..... J

(1)

- (ii) The machine is 40% efficient.  
Use the following equation to calculate the total energy supplied to the machine each second. Show how you work out your answer.

$$\text{Efficiency} = \frac{\text{useful energy transferred by device}}{\text{total energy supplied to device}}$$

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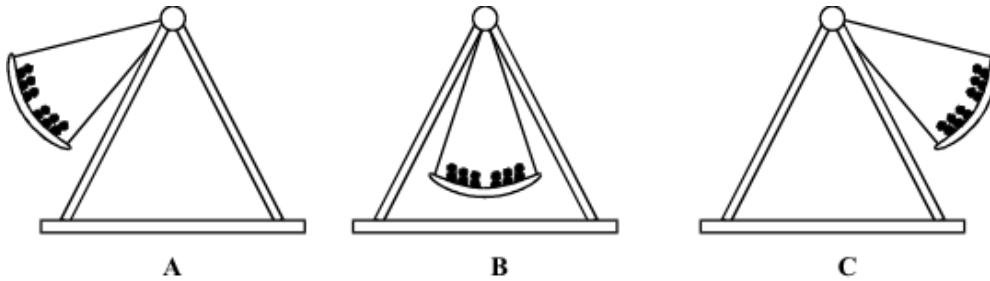
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Total energy supplied each second = ..... J

(2)

(Total 6 marks)

**Q21.** The Boat is a theme park ride. The Boat swings backwards and forwards. The diagrams show the Boat at the top and bottom of its swing.



(a) As the Boat swings from its position in **A** to its position in **B**, a child on the ride gains 5070 joules of kinetic energy. The child has a mass of 60 kg and is sitting at the centre.

(i) Write down the equation which links kinetic energy, mass and speed.

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(1)

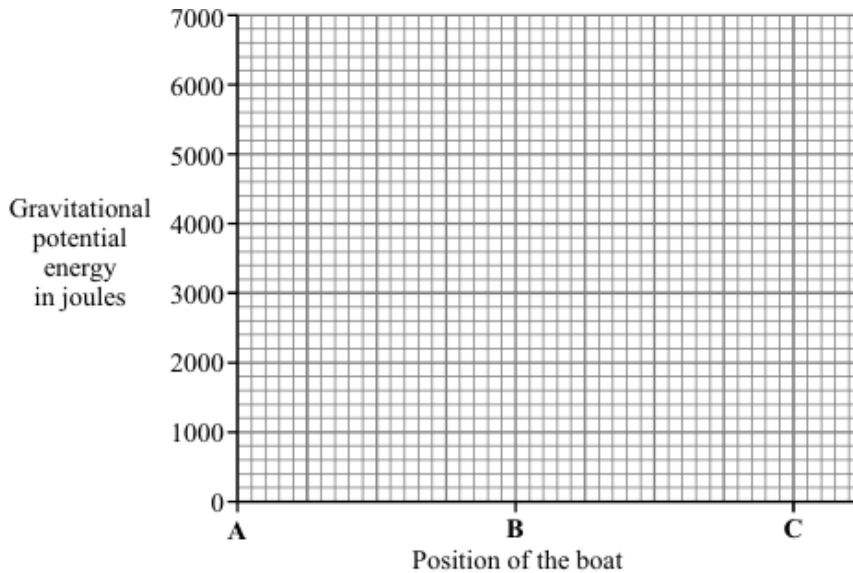
(ii) Calculate the speed of the child as the Boat passes through **B**. Show clearly how you work out your final answer.

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Speed = ..... m/s

(2)

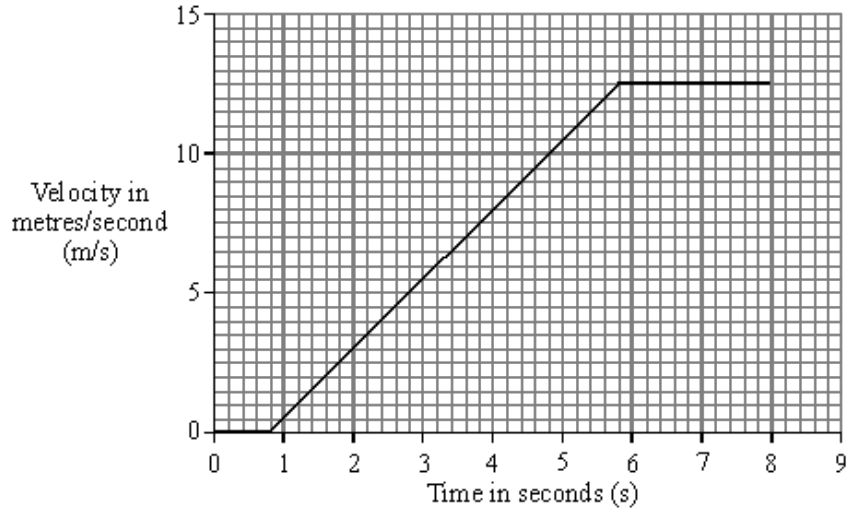
(b) Sketch a graph to show how the gravitational potential energy of the child changes as the Boat swings from **A** to **B** to **C**. The axes have been drawn for you.



(2)

(Total 5 marks)

**Q22.** A car travelling along a straight road has to stop and wait at red traffic lights. The graph shows how the velocity of the car changes after the traffic lights turn green.



(a) Between the traffic lights changing to green and the car starting to move there is a time delay. This is called the reaction time. Write down **one** factor that could affect the driver's reaction time.

..... (1)

(b) Calculate the distance the car travels while accelerating. Show clearly how you work out your answer.

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 .....

Distance = .....metres (3)

(c) Calculate the acceleration of the car. Show clearly how you work out your final answer and give the units.

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 .....

Acceleration = ..... (4)

(d) The mass of the car is 900 kg.

(i) Write down the equation that links acceleration, force and mass.

..... (1)

- (ii) Calculate the force used to accelerate the car. Show clearly how you work out your final answer.

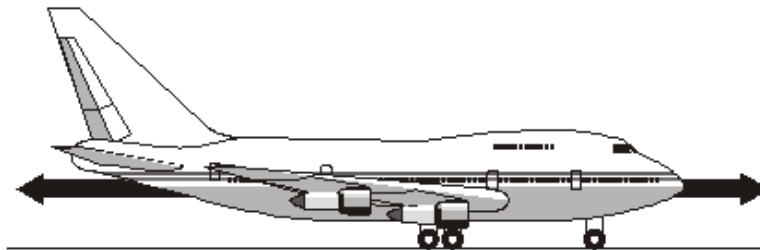
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Force = ..... newtons

(2)  
 (Total 11 marks)

**Q23.**

- (a) The diagram shows an aircraft and the horizontal forces acting on it as it moves along a runway. The *resultant force* on the aircraft is zero.



- (i) What is meant by the term *resultant force*?

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 .....

(1)

- (ii) Describe the movement of the aircraft when the resultant force is zero.

.....  
 .....

(1)

- (b) The aircraft has a take-off mass of 320 000 kg. Each of the 4 engines can produce a maximum force of 240 kN.

Use the equation in the box to calculate the maximum acceleration of the aircraft.

$\text{resultant force} = \text{mass} \times \text{acceleration}$
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Show clearly how you work out your answer and give the unit.

.....  
 .....

Acceleration = .....

(3)

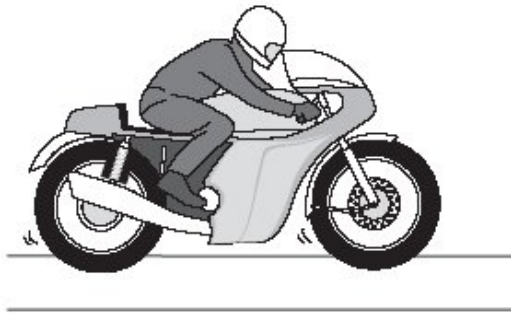
- (c) As the aircraft moves along the runway to take off, its acceleration decreases even though the force from the engines is constant.

Explain why.

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(2)  
(Total 7 marks)

- Q24.** 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) Use the equation in the box to calculate the kinetic energy lost by the motorbike.

$\text{kinetic energy} = \frac{1}{2} \times \text{mass} \times \text{speed}^2$
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Show clearly how you work out your answer.

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Kinetic energy lost = ..... J

(2)

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

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(1)

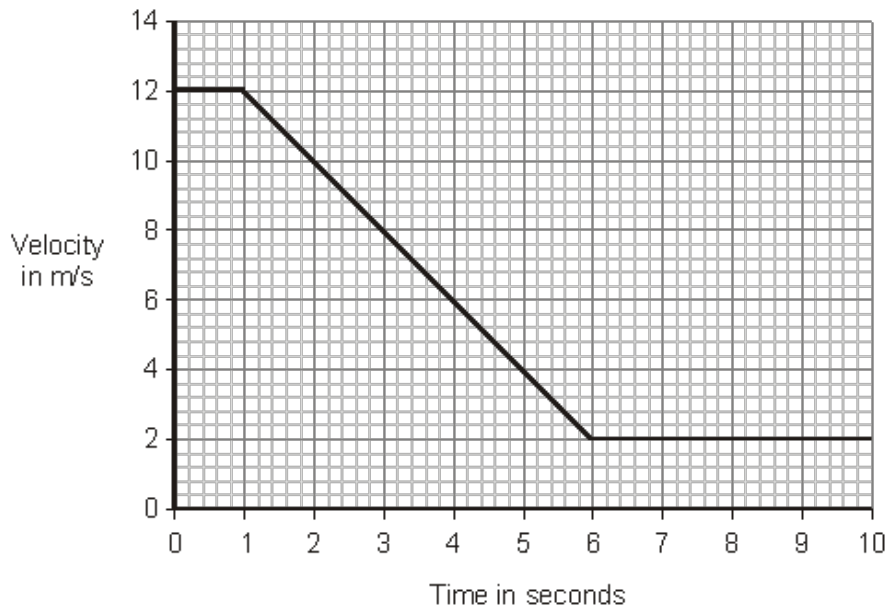
(ii) What happens to the kinetic energy lost by the motorbike?

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(1)

(Total 4 marks)

**Q25.** A car is driven along a straight, snow covered, road. The graph shows how the velocity of the car changes from the moment the driver sees a very slow moving queue of traffic ahead.



(a) Use the graph to calculate the distance the car travels while it is slowing down.

Show clearly how you work out your answer.

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Distance = ..... m

(3)

(b) The car has a mass of 1200 kg.

Calculate the kinetic of the car when it travels at a speed of 12 m/s.

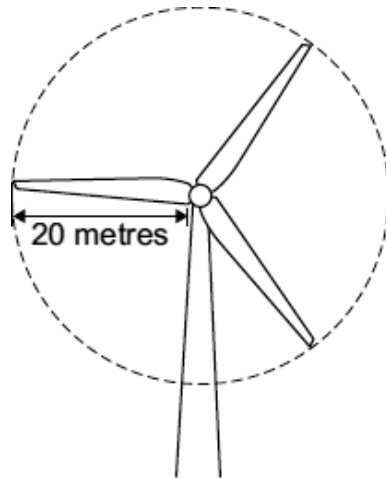
Write down the equation you use, and then show clearly how you work out your answer.

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Kinetic energy = ..... J

(2)  
(Total 5 marks)

**Q26.** The diagram shows a wind turbine.



(a) The blades of the turbine are 20 metres long. On average, 15 000 kg of air, moving at a speed of 12 m/s, hit the blades every second.

Use the equation in the box to calculate the kinetic energy of the air hitting the blades every second.

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

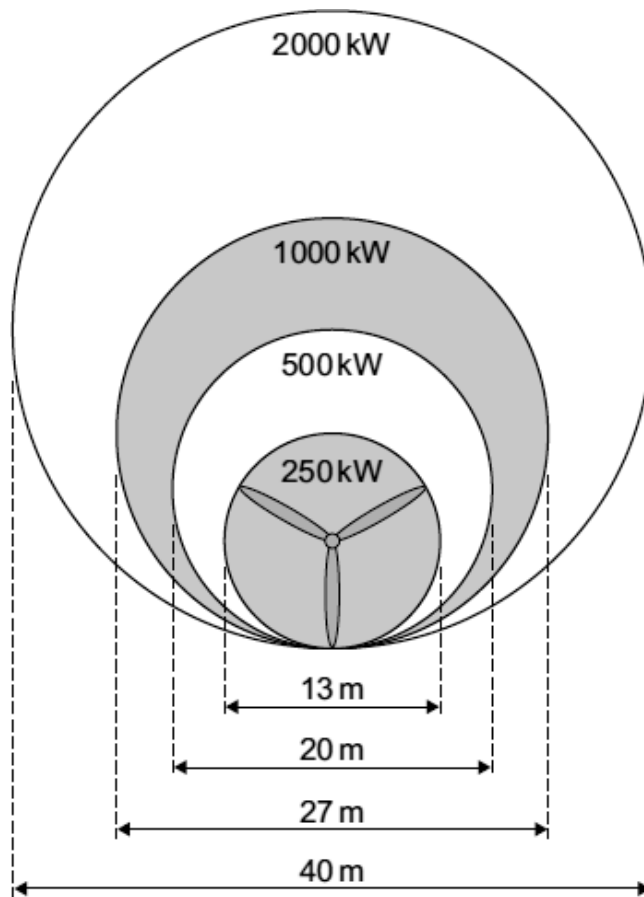
Show clearly how you work out your answer.

.....  
.....

Kinetic energy = ..... J

(2)

- (b) Part of the kinetic energy of the wind is transformed into electrical energy. The diagram shows that, for the same wind speed, the power output of a turbine, in kilowatts, depends on the length of the turbine blades.



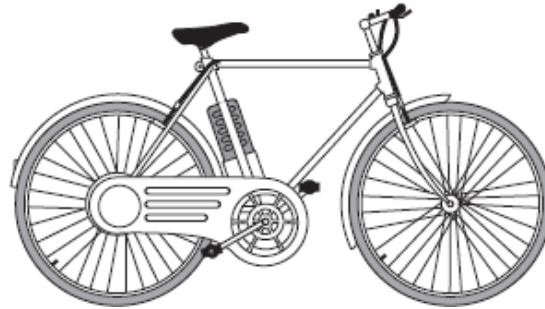
Give a reason why doubling the diameter of the blades more than doubles the power output of a turbine.

.....  
.....

(1)  
(Total 3 marks)



**Q27.** 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.

Use the equation in the box to calculate the maximum charge that the battery stores.

charge = current × time
-------------------------

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) Use the equation in the box to calculate the maximum kinetic energy of the bicycle **and** rider when the rider is not pedalling.

$\text{kinetic energy} = \frac{1}{2} \times \text{mass} \times \text{speed}^2$
--

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?

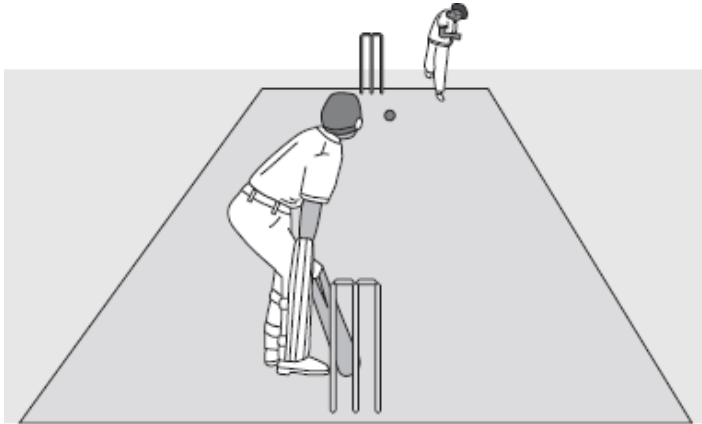
.....

Give a reason for your answer.

.....  
.....

(2)  
(Total 10 marks)

**Q28.** The picture shows players in a cricket match.



- (a) A fast bowler bowls the ball at 35 m/s. The ball has a mass of 0.16 kg.

Use the equation in the box to calculate the kinetic energy of the cricket ball as it leaves the bowler's hand.

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

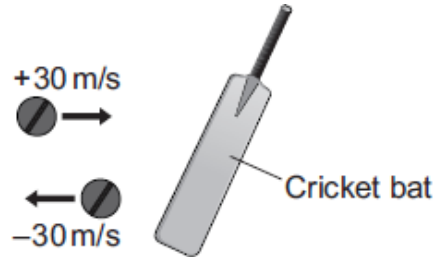
Show clearly how you work out your answer.

.....  
.....  
.....

Kinetic energy = ..... J

(2)

- (b) When the ball reaches the batsman it is travelling at 30 m/s. The batsman strikes the ball which moves off at 30 m/s in the opposite direction.



- (i) Use the equation in the box to calculate the change in momentum of the ball.

$\text{momentum} = \text{mass} \times \text{velocity}$
--

Show clearly how you work out your answer.

.....  
 .....

Change in momentum = ..... kg m/s

(2)

- (ii) The ball is in contact with the bat for 0.001 s.

Use the equation in the box to calculate the force exerted by the bat on the ball.

$\text{force} = \frac{\text{change in momentum}}{\text{time taken for the change}}$
---

Show clearly how you work out your answer.

.....  
 .....

Force = ..... N

(1)

- (c) A fielder, as he catches a cricket ball, pulls his hands backwards.

Explain why this action reduces the force on his hands.

.....  
.....  
.....  
.....  
.....

(2)  
(Total 7 marks)

- Q29.** (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.

Use the correct equation from the Physics Equations Sheet.

.....  
.....  
.....

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.

Use the correct equation from the Physics Equations Sheet.

.....  
.....  
.....  
.....

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.

.....  
.....  
.....  
.....

(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)

