WORK DONE AND ENERGY TRANSFER

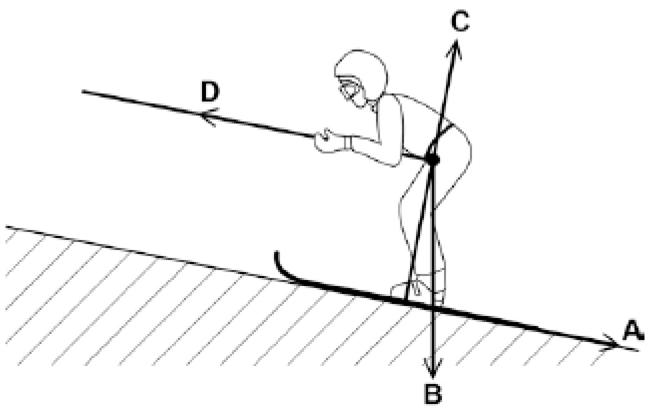
Q1.

Figure 1 shows a skier using a drag lift.

The drag lift pulls the skier from the bottom to the top of a ski slope.

The arrows, **A**, **B**, **C** and **D** represent the forces acting on the skier and her skis.

Figure 1



(a) Which arrow represents the force pulling the skier up the slope?

Tick **one** box.

A ☐

B ☐

C ☐

D ☐

(1)

(b) Which arrow represents the normal contact force?

Tick **one** box.

A ☐

B ☐

C ☐

D ☐

(1)

(c) The drag lift pulls the skier with a constant resultant force of 300N for a distance of 45 m.

Use the following equation to calculate the work done to pull the skier up the slope.

work done = force × distance

____

____

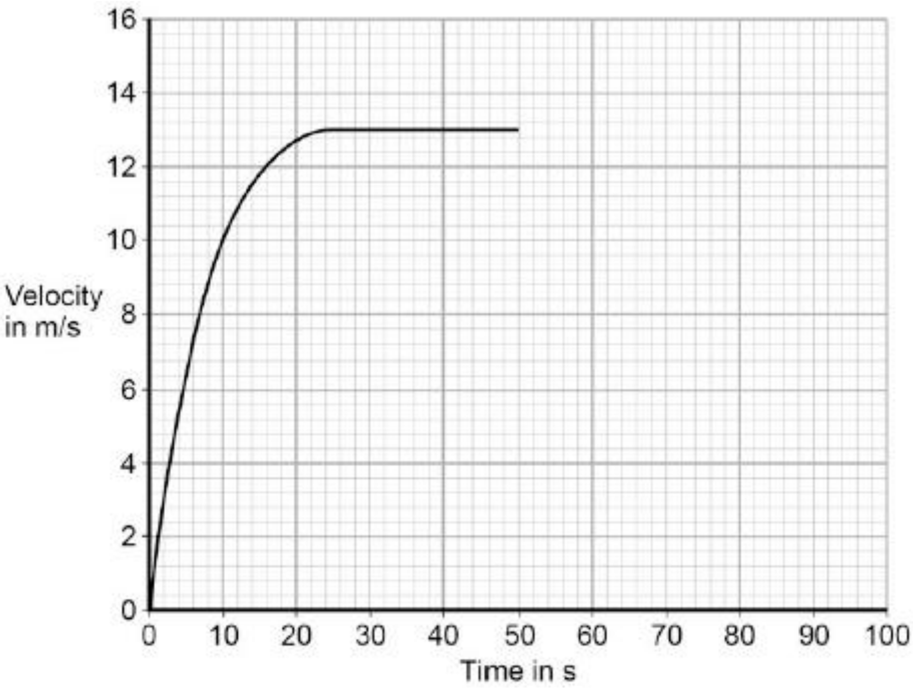
Work done = ___________________________ J

(2)

(d) At the top of the slope the skier leaves the drag lift and skis back to the bottom of the slope.

Figure 2 shows how the velocity of the skier changes with time as the skier moves down the slope.

Figure 2



After 50 seconds the skier starts to slow down.

The skier decelerates at a constant rate coming to a stop in 15 seconds.

Draw a line on **Figure 2** to show the change in velocity of the skier as she slows down and comes to a stop.

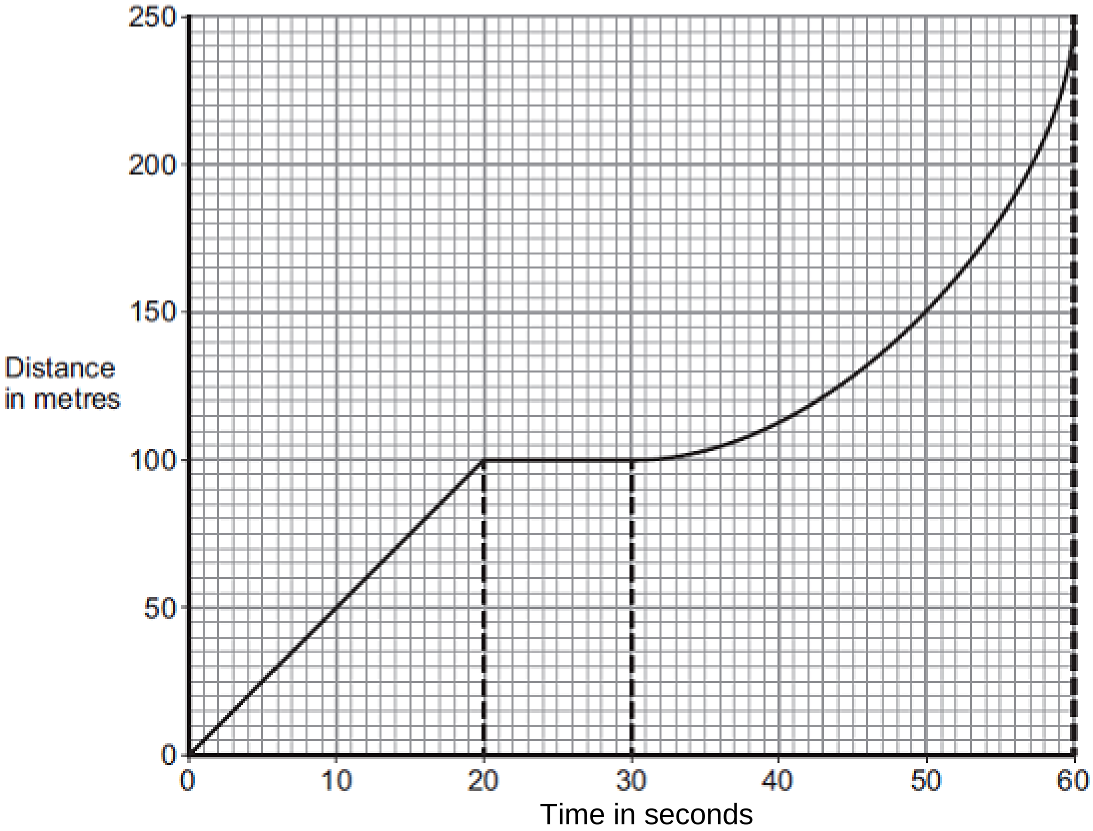
(2)

(Total 6 marks)

Q2.

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)

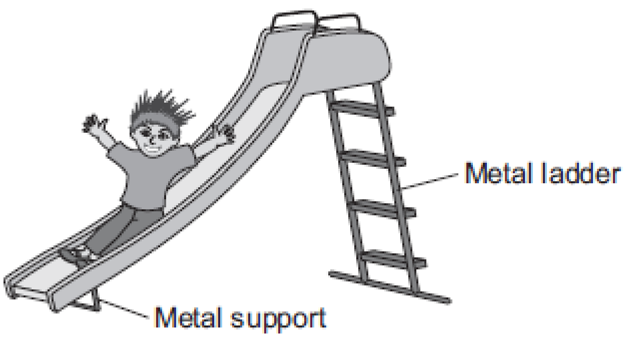
(iii) What happens to the kinetic energy of the bus as it is braking?

(2)

(Total 11 marks)

Q3.

The figure below shows a slide in a children's playground.



(a) A child of mass 18 kilograms goes down the slide.

The vertical distance from the top to the bottom of the slide is 2.5 metres.

Calculate the decrease in gravitational potential energy of the child sliding from the top to the bottom of the slide.

Gravitational field strength = 10 N / kg

____

____

____

Decrease in gravitational potential energy = ________________ J

(2)

(b) The slide is made of plastic.

(i) The child becomes electrically charged when he goes down the slide.

Explain why.

____

____

____

____

(2)

(ii) Going down the slide causes the child's hair to stand on end.

What conclusion about the electrical charge on the child's hair can be made from this observation?

____

____

Give a reason for your answer.

____

____

(2)

(iii) Why would the child **not** become electrically charged if the slide was made from metal?

____

____

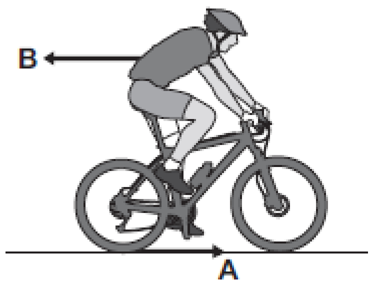
(1)

(Total 7 marks)

Q4.

(a) **Figure 1** shows the horizontal forces acting on a moving bicycle and cyclist.

Figure 1



(i) What causes force **A**?

Draw a ring around the correct answer.

friction **gravity** **weight**

(1)

(ii) What causes force **B**?

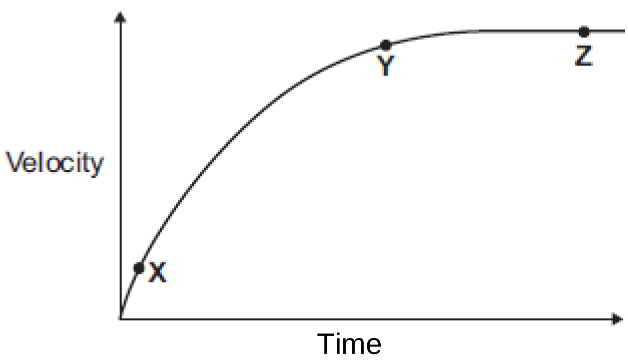
____

(1)

(iii) **In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate.**

Figure 2 shows how the velocity of the cyclist changes during the first part of a journey along a straight and level road. During this part of the journey the force applied by the cyclist to the bicycle pedals is constant.

Figure 2



Describe how **and** explain, in terms of the forces **A** and **B**, why the velocity of the cyclist changes:

- between the points **X** and **Y**
- and between the points **Y** and **Z**, marked on the graph in **Figure 2**.

____

____

____

____

____

____

____

____

____

____

____

____

Extra space ____

____

____

____

____

____

____

____

____

____

____

____

(6)

(b) (i) The cyclist used the brakes to slow down and stop the bicycle.

A constant braking force of 140 N stopped the bicycle in a distance of 24 m.

Calculate the work done by the braking force to stop the bicycle. Give the unit.

____

____

____

Work done = ______________________________

(3)

(ii) Complete the following sentences.

When the brakes are used, the bicycle slows down. The kinetic energy of the

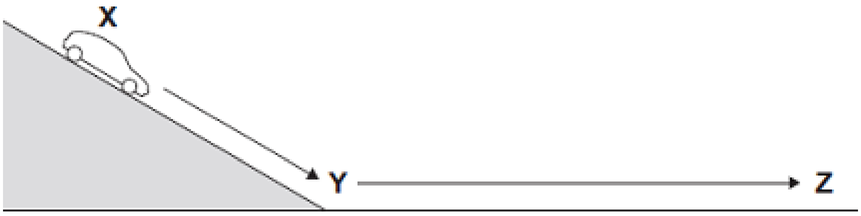
bicycle ______________________________ .

At the same time, the ______________________________ of the brakes increases.

(2)
(Total 13 marks)

Q5.

(a) The diagram shows a car at position **X**.



The handbrake is released and the car rolls down the slope to **Y**.
The car continues to roll along a horizontal surface before stopping at **Z**.
The brakes have **not** been used during this time.

(i) What type of energy does the car have at **X**?

____

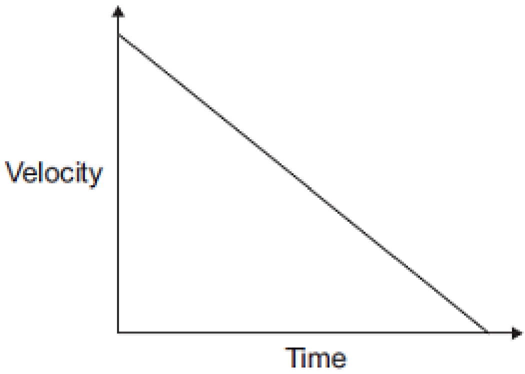
(1)

(ii) What type of energy does the car have at **Y**?

____

(1)

(b) The graph shows how the velocity of the car changes with time between **Y** and **Z**.



(i) Which feature of the graph represents the negative acceleration between **Y** and **Z**?

____

(1)

(ii) Which feature of the graph represents the distance travelled between **Y** and **Z**?

____

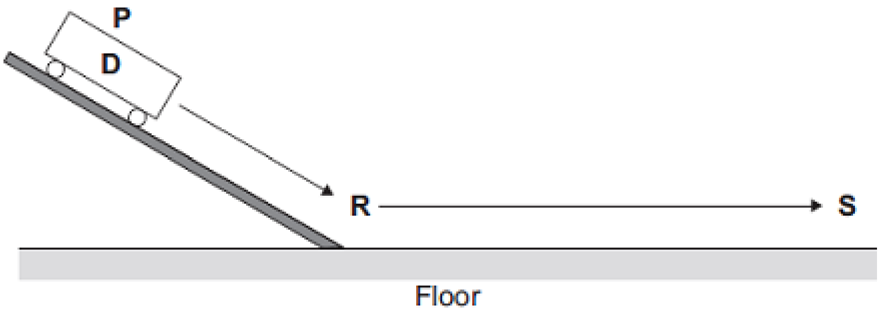
(1)

(iii) The car starts again at position **X** and rolls down the slope as before. This time the brakes are applied lightly at **Y** until the car stops.

Draw on the graph another straight line to show the motion of the car between **Y** and **Z**.

(2)

(c) Three students carry out an investigation. The students put trolley **D** at position **P** on a slope. They release the trolley. The trolley rolls down the slope and along the floor as shown in the diagram.



The students measure the distance from **R** at the bottom of the slope to **S** where the trolley stops. They also measure the time taken for the trolley to travel the distance **RS**.
They repeat the investigation with another trolley, **E**.

Their results are shown in the table.

Trolley	Distance RS in centimetres	Time taken in seconds	Average velocity in centimetres per second
D	65	2.1	
E	80	2.6	

(i) Calculate the average velocity, in centimetres per second, between **R** and **S** for trolleys **D** and **E**. Write your answers in the table.

___

___

___

(3)

(ii) Before the investigation, each student made a prediction.

- Student **1** predicted that the two trolleys would travel the same distance.
- Student **2** predicted that the average velocity of the two trolleys would be the same.
- Student **3** predicted that the negative acceleration of the two trolleys would be the same.

Is each prediction correct?

Justify your answers.

____

____

____

____

____

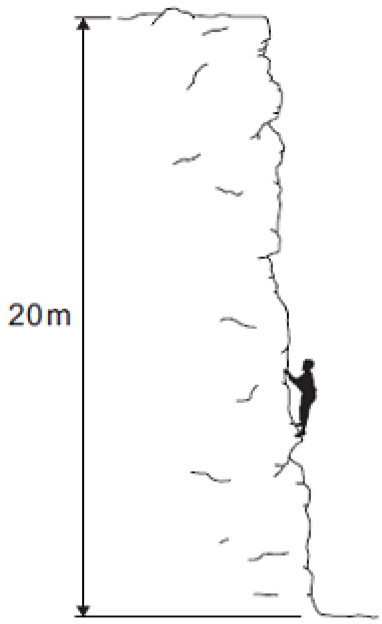
____

(3)

(Total 12 marks)

Q6.

The diagram shows a climber part way up a cliff.



(a) Complete the sentence.

When the climber moves up the cliff, the climber

gains gravitational ______________________ energy.

(1)

(b) The climber weighs 660 N.

(i) Calculate the work the climber must do against gravity, to climb to the top of the cliff.

____

____

Work done = _________________________ J

(2)

(ii) It takes the climber 800 seconds to climb to the top of the cliff.

During this time the energy transferred to the climber equals the work done by the climber.

Calculate the power of the climber during the climb.

____

____

Power = ___________________________ W

(2)

(Total 5 marks)

Q7.

(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.

____

____

____

____

(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.

____

____

____

____

____

____

(3)

(Total 14 marks)

Q8.

A car has an oil leak. Every 5 seconds an oil drop falls from the bottom of the car onto the road.

(a) What force causes the oil drop to fall towards the road?

___

(1)

(b) The diagram shows the spacing of the oil drops left on the road during part of a journey

Describe the motion of the car as it moves from **A** to **B**.

___

Explain the reason for your answer.

___

___

___

___

(3)

(c) When the brakes are applied, a braking force slows down and stops the car.

(i) The size of the braking force affects the braking distance of the car.

State **one** other factor that affects the braking distance of the car.

___

(1)

(ii) A braking force of 3 kN is used to slow down and stop the car in a distance of 25 m.

Calculate the work done by the brakes to stop the car and give the unit.

___

___

___

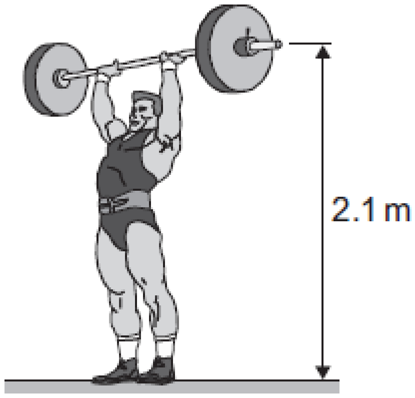
Work done = ___

(3)

(Total 8 marks)

Q9.

A powerlifter lifts a 180 kg bar from the floor to above his head.



(a) Use the equation in the box to calculate the weight of the bar.

weight = mass × gravitational field strength

gravitational field strength = 10 N/kg

Show clearly how you work out your answer.

___

___

Weight = ____________ N

(2)

(b) The powerlifter uses a constant force to lift the bar a distance of 2.1 m.

Use the equation in the box to calculate the work done by the powerlifter.

work done = force applied × distance moved in direction of force

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

Choose the unit from the list below.

joule **newton** **watt**

___

___

Work done = ____________

(3)

(c) At the end of the lift, the powerlifter holds the bar stationary, above his head, for two seconds.

How much work does the powerlifter do on the bar during these two seconds?

Draw a ring around your answer.

0 **90** **360** **900**

Give a reason for your answer.

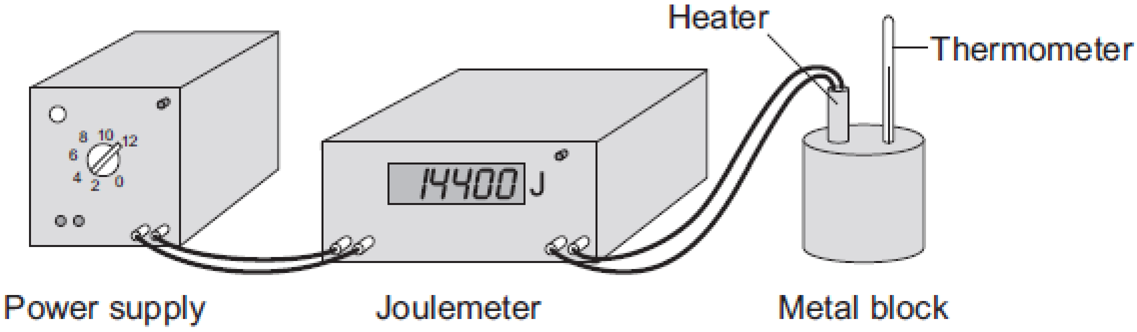
___

___

(2)
(Total 7 marks)

Q10.

A student used an electric heater to heat a metal block. The student measured the energy input to the heater with a joulemeter.



Before starting the experiment, the student reset the joulemeter to zero. The student switched the power supply on for exactly 10 minutes. During this time, the reading on the joulemeter increased to 14 400.

(a) (i) Calculate the energy transferred each second from the power supply to the heater.

Show clearly how you work out your answer.

___

___

Energy transferred each second = ____________________ J/s

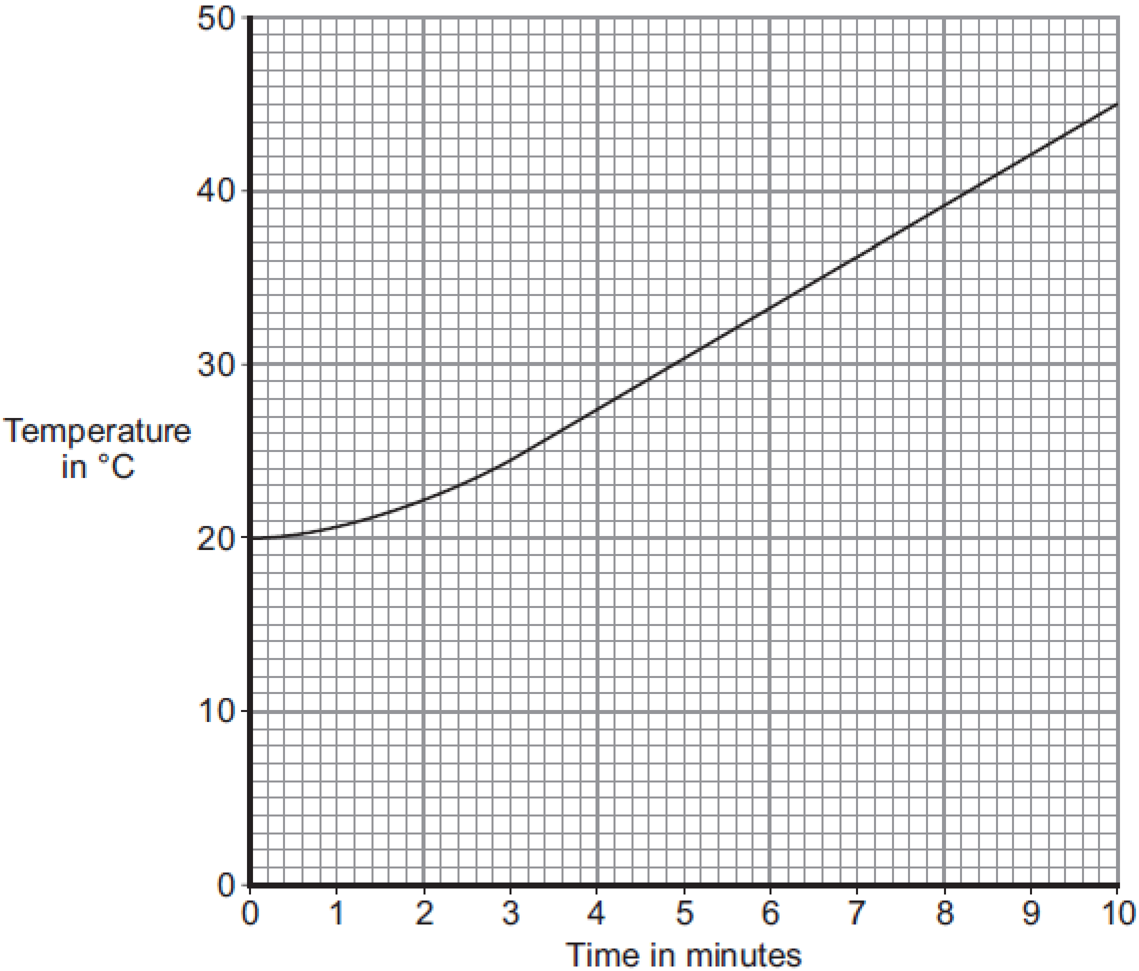
(2)

(ii) What is the power of the heater?

___

(1)

(b) The student measured the temperature of the metal block every minute. The data obtained by the student is displayed in the graph.



(i) What range of temperatures did the student measure?

From ______________________ °C to ______________________ °C

(1)

(ii) Before starting the experiment, the student had calculated that the temperature of the block would go up by 36 °C.

The student's data shows a smaller increase.

Which **one** of the following statements gives the most likely reason for this?

Put a tick (✓) in the box next to your answer.

The student does not read the thermometer accurately. ☐

The block transfers energy to the surroundings. ☐

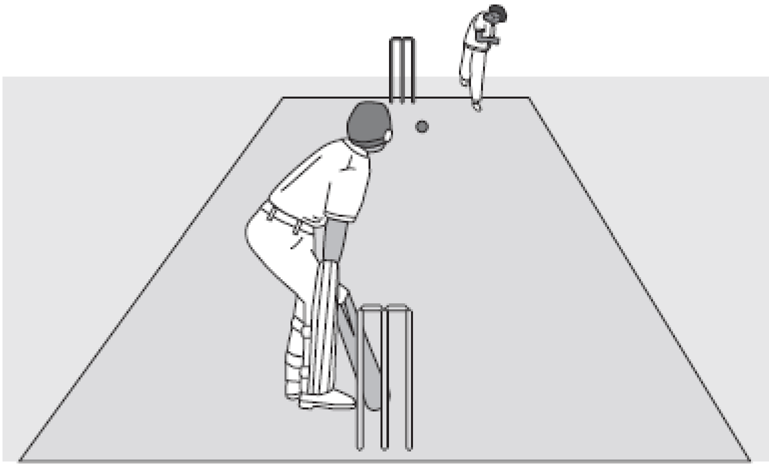
The power supply is not connected correctly to the joulemeter. ☐

(1)

(Total 5 marks)

Q11.

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.

___

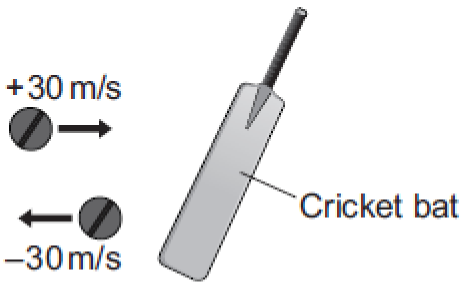
___

___

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.

____

____

____

____

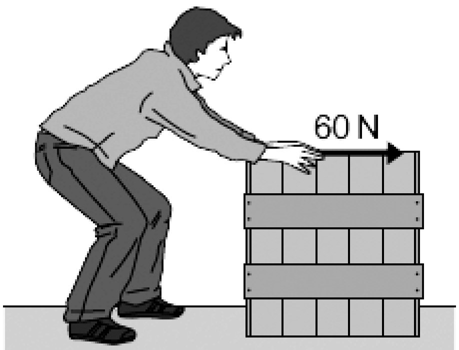
____

(2)

(Total 7 marks)

Q12.

The diagram shows a worker using a constant force of 60 N to push a crate across the floor.



(a) The crate moves at a constant speed in a straight line

(i) Draw an arrow on the diagram to show the direction of the friction force acting on the moving crate.

(1)

(ii) State the size of the friction force acting on the moving crate.

____________________ N

Give the reason for your answer.

____

____

(2)

(b) Calculate the work done by the worker to push the crate 28 metres.

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

Choose the unit from the list below.

joule **newton** **watt**

____

____

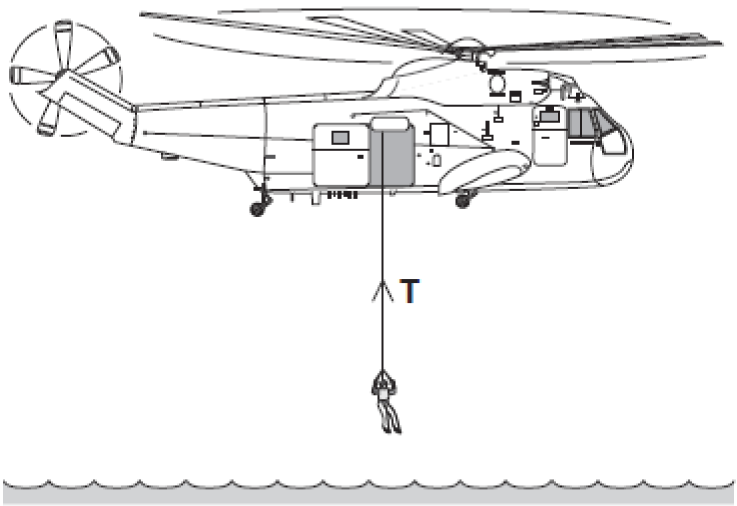
Work done = ____________________

(3)

(Total 6 marks)

Q13.

The diagram shows a helicopter being used to rescue a person from the sea.



(a) (i) The mass of the rescued person is 72 kg.

Use the equation in the box to calculate the weight of the rescued person.

weight = mass × gravitational field strength

gravitational field strength = 10 N/kg

Show clearly how you work out your answer.

____

____

Weight = ___________________________ N

(2)

(ii) An electric motor is used to lift the person up to the helicopter.
The motor lifts the person at a constant speed.

State the size of the force, **T**, in the cable.

Force **T** = ___________________________ N

(1)

(b) To lift the person up to the helicopter, the electric motor transformed 21 600 joules of energy usefully.

(i) Use a form of energy from the box to complete the following sentence.

gravitational potential	heat	sound

The electric motor transforms electrical energy to kinetic energy. The kinetic energy

is then transformed into useful _____________________________ energy.

(1)

(ii) It takes 50 seconds for the electric motor to lift the person up to the helicopter.

Use the equation in the box to calculate the power of the electric motor.

$$\text{power} = \frac{\text{energy transformed}}{\text{time}}$$

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

Choose the unit from the list below.

coulomb (C) **hertz (Hz)** **watt (W)**

____

____

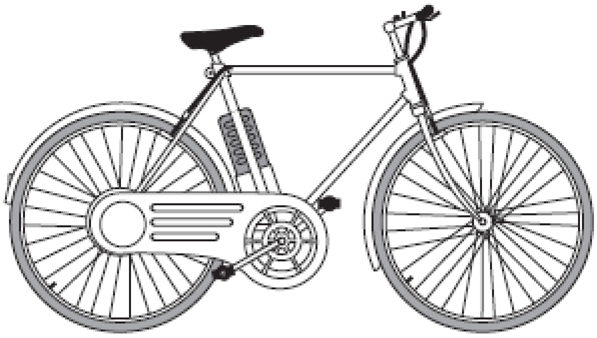
Power = ___________________________

(3)

(Total 7 marks)

Q14.

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.

____

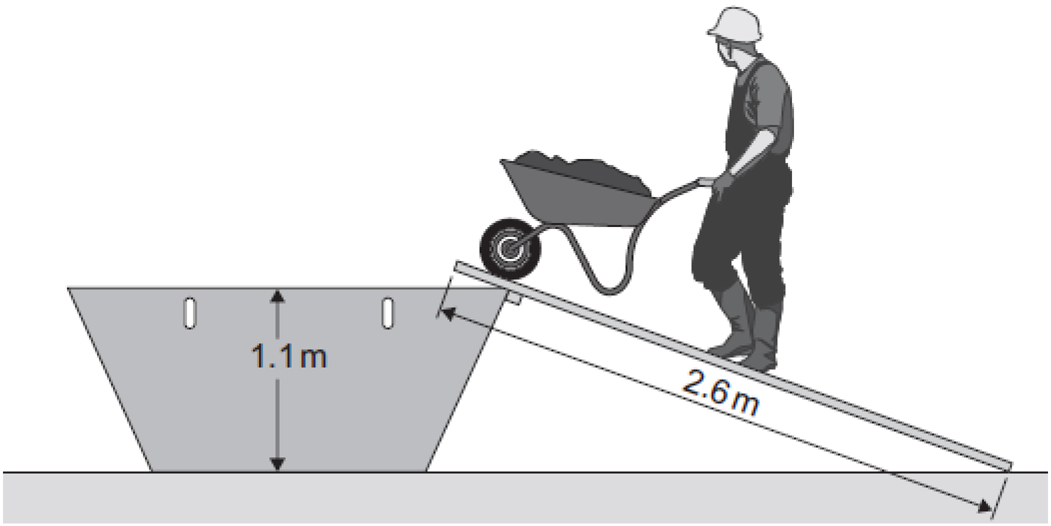
____

(2)

(Total 10 marks)

Q15.

(a) The diagram shows a builder using a plank to help load rubble into a skip.



The builder uses a force of 220 N to push the wheelbarrow up the plank.

Use information from the diagram to calculate the work done to push the wheelbarrow up the plank to the skip.

Show clearly how you work out your answer.

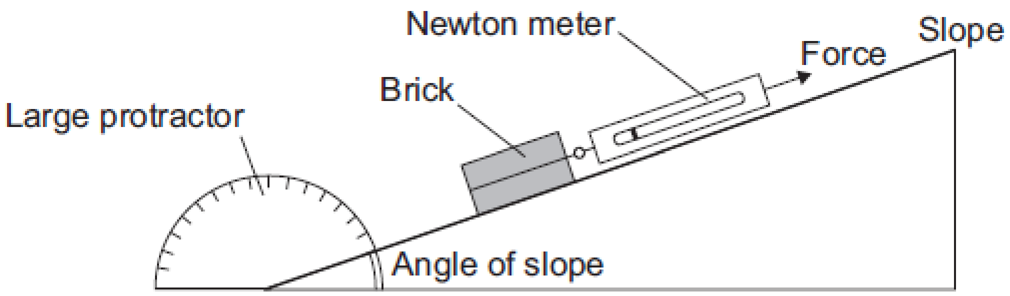
____

____

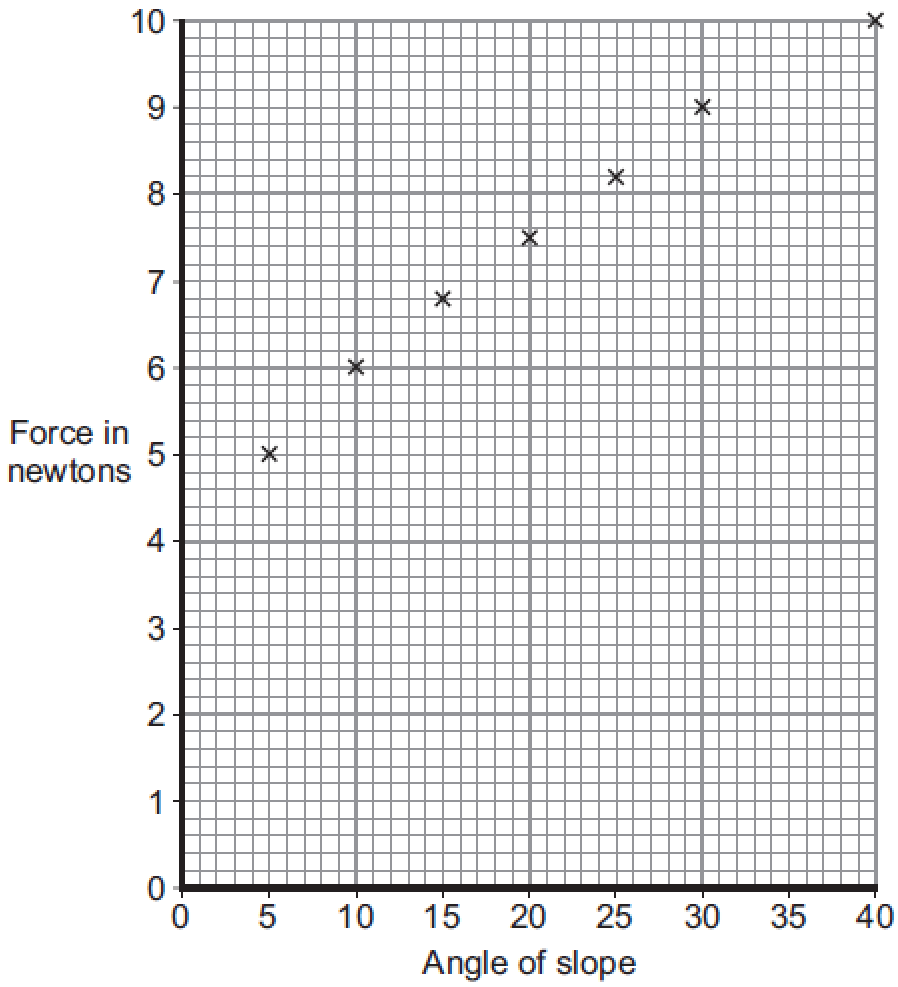
Work done = ________________________________ J

(2)

(b) A student investigated how the force needed to pull a brick up a slope, at a steady speed, depends on the angle of the slope.
The apparatus used by the student is shown in the diagram.



The student used the results from the investigation to plot the points for a graph of force used against the angle of the slope.



(i) Draw a line of best fit for these points.

(1)

(ii) How does the force used to pull the brick up the slope change as the angle of the slope increases?

___

___

(1)

(iii) Consider the results from this experiment.
Should the student recommend that the builder use a long plank or a short plank to help load the skip?

Draw a ring around your answer.

long plank **short plank**

Explain the reason for your answer.

____

____

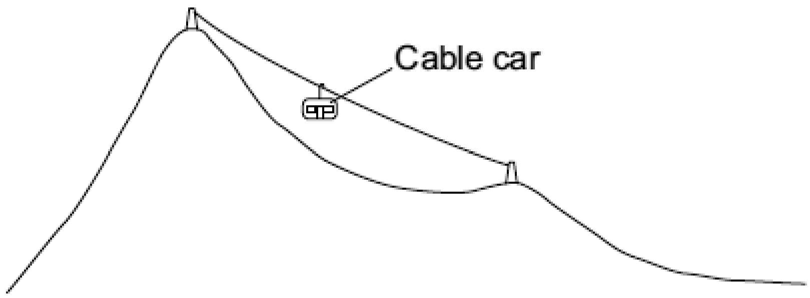
____

____

(2)
(Total 6 marks)

Q16.

(a) The diagram shows a cable car used to take skiers to the top of a mountain.



(i) The total mass of the cable car and skiers is 7500 kg.

Calculate the weight of the cable car and skiers.

gravitational field strength = 10 N/kg

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

____

____

Weight = ____

(3)

(ii) The cable car moves at a constant speed. It lifts skiers through a vertical height of 800 metres in 7 minutes.

Calculate the work done to lift the cable car and skiers.

Show clearly how you work out your answer.

____

____

Work done = ________________________ J

(2)

(b) The diagram shows a skier who is accelerating down a steep ski slope.

(i) Draw an arrow on the diagram to show the direction of the resultant force acting on the skier.

(1)

(ii) How and why does the kinetic energy of the skier change?

____

____

____

____

(2)

(c) Last year, 18 000 skiers suffered a head injury. It is thought that nearly 8000 of these injuries could have been avoided if the skier had been wearing a helmet. However, at present, there are no laws to make skiers wear helmets.

Suggest why skiers should be made aware of the benefits of wearing a helmet.

____

____

(1)

(Total 9 marks)

Q17.

The diagram shows an adult and a child pushing a loaded shopping trolley.

(a) (i) What is the *total force* on the trolley due to the adult and child?

____

(1)

(ii) Which **one** of the terms in the box means the same as *total force*?

Draw a ring around your answer.

answer force	**mean force**	**resultant force**

(1)

(iii) The trolley is pushed at a constant speed for 80 metres.

Calculate the work done to push the trolley 80 metres.

Show clearly how you work out your answer.

____

____

Work done = ______________________________

(2)

(b) Complete the following sentences by drawing a ring around the correct word in each of the boxes.

(i) The unit of work done is the [joule / newton / watt].

(1)

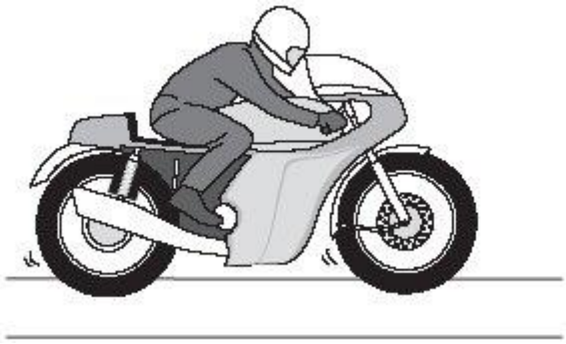
(ii) Most of the work done to push the trolley is transformed into [heat / light / sound].

(1)

(Total 6 marks)

Q18.

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?

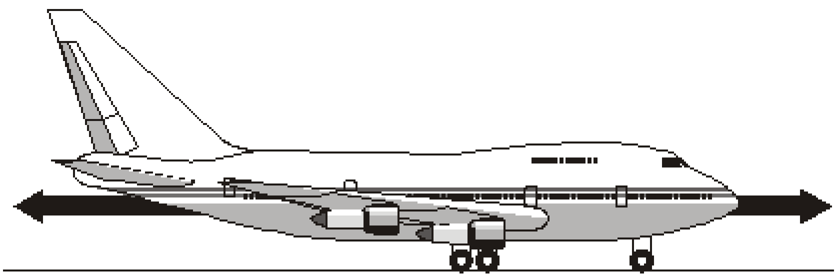
____

(1)

(Total 4 marks)

Q19.

(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*?

____

____

(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.

Calculate the maximum acceleration of the aircraft.

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.

____

____

____

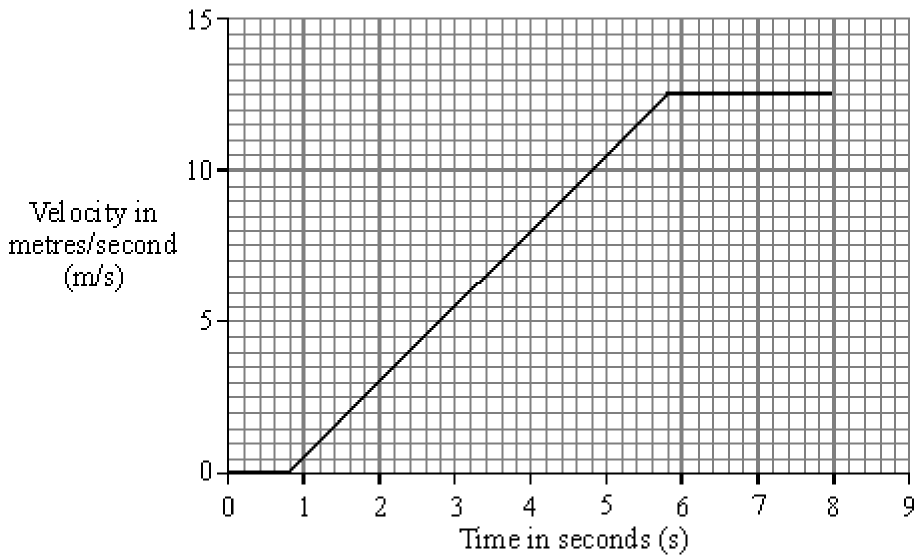
____

(2)

(Total 7 marks)

Q20.

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.

____

____

Distance = ______________________ metres

(3)

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

____

____

____

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.

____

____

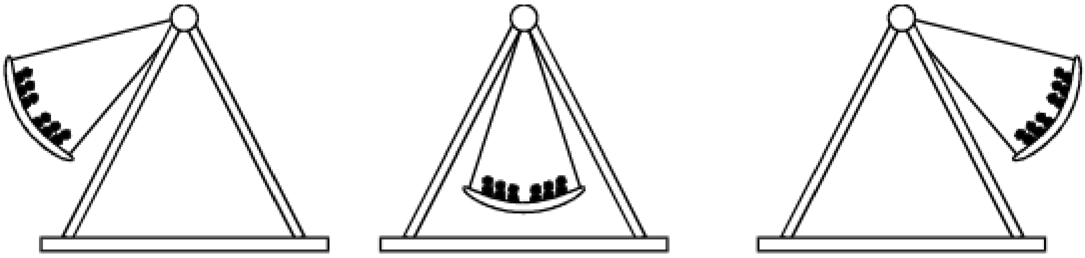
Force = ___________________________ newtons

(2)

(Total 11 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.

____

____

(1)

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

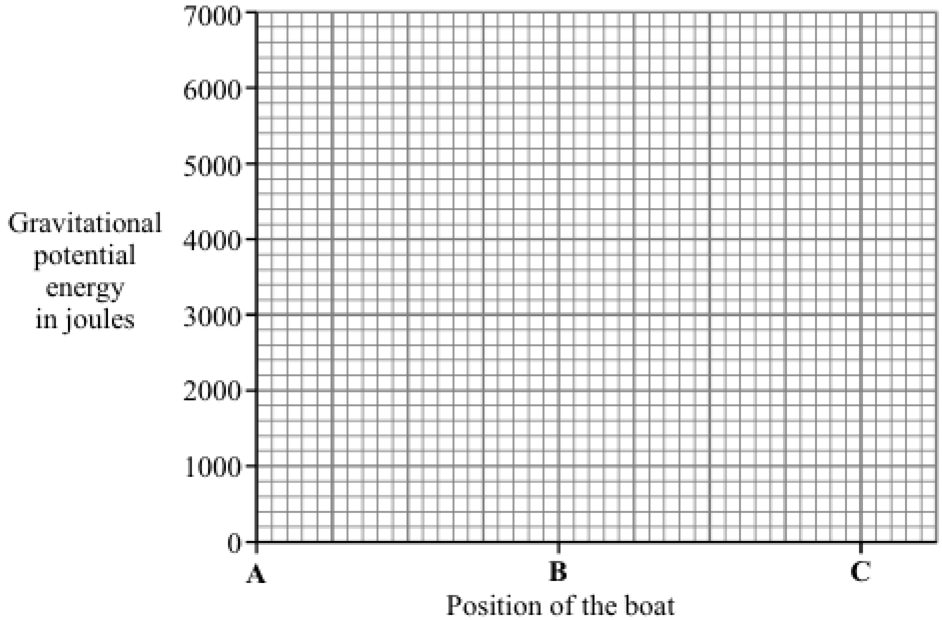
____

____

Speed = ________________________ m/s

(2)

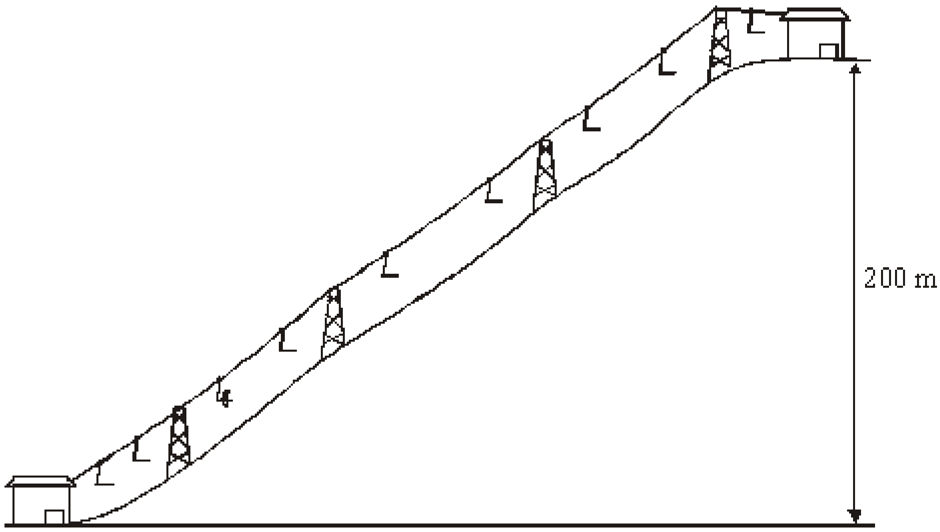
(b) Sketch a graph to show how the gravitational potential energy of the child changes as the Boat swings from **A** to **B** to **C**. The axes have been drawn for you.



(2)
(Total 5 marks)

Q22.

(a) A chair lift carries two skiers, Greg and Jill, to the top of a ski slope. Greg weighs 700 N and Jill weighs 500 N.



(i) Write down the equation that links distance moved, force applied and work done.

____

(1)

(ii) Calculate the work done to lift Greg and Jill through a vertical height of 200 m. Show clearly how you work out your answer and give the unit.

____

____

____

work done = ___________________________________

(3)

(b) The chair takes 5 minutes to move from the bottom to the top of the ski slope.

Calculate the power required to lift Greg and Jill to the top of the ski slope. Show clearly how you work out your answer.

____

____

power = _________________________________ watts

(2)

(c) The chair lift is driven by an electric motor.

(i) Why would the power output of the electric motor need to be larger than your answer to part (b)?

____

____

(1)

(ii) Complete the following sentence.

When the ski lift is working _________________ energy supplied to the motor

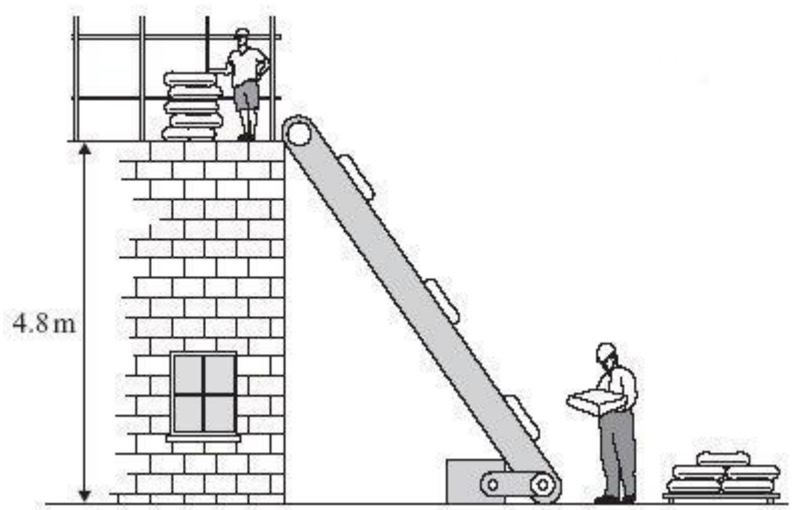
is usefully transferred as gravitational ____________________ energy.

(1)

(Total 8 marks)

Q23.

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.)

____

____

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.

____

____

____

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.

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

____

____

Total energy supplied each second = _________________________ J

(2)

(Total 6 marks)

Q24.

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.

____

(1)

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

____

____

Kinetic energy = _______________________ joules

(1)

(Total 2 marks)

Q25.

(a) The weightlifter in the picture has lifted a weight of 2250 newtons above his head. The weight is held still.

(i) In the box are the names of three forms of energy.

gravitational potential	kinetic	sound

Which **one** of these forms of energy does the weight have?

____

(1)

(ii) What force is used by the weightlifter to hold the weight still?

Size of force = ______________________________ N

Give a reason for your answer ______________________________________

____

____

(2)

(b) To lift the weight, the weightlifter does 4500 joules of work in 3.0 seconds.

Calculate the power developed by the weightlifter. Show clearly how you work out your answer.

____

____

Power = ____________________________ watts

(2)

(Total 5 marks)

Q26.

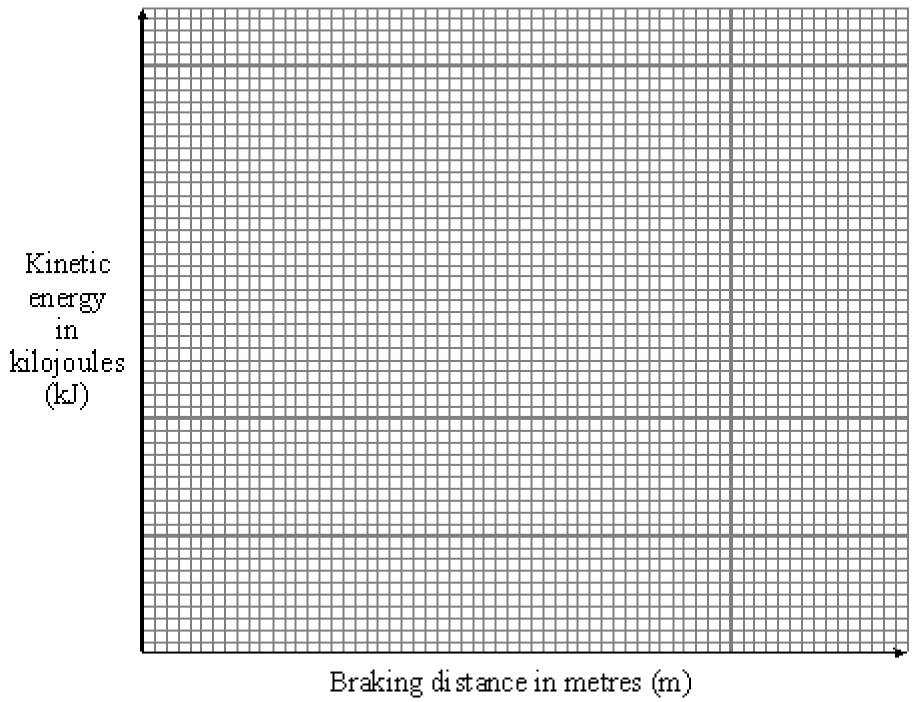
The table shows the braking distances for a car at different speeds and kinetic energy.
The braking distance is how far the car travels once the brakes have been applied.

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

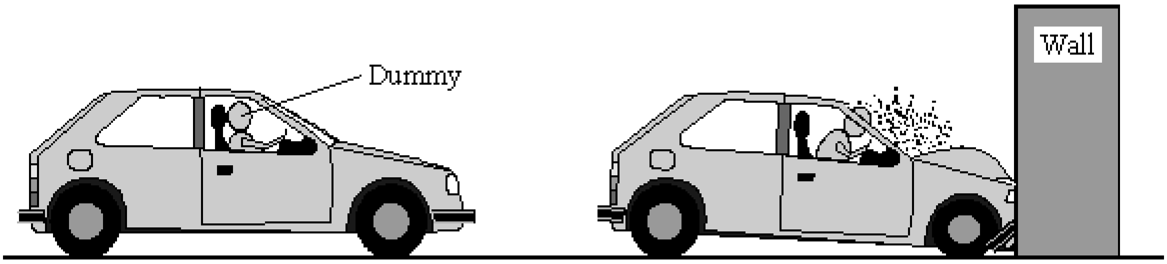
(2)

(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 ____________________

____

____

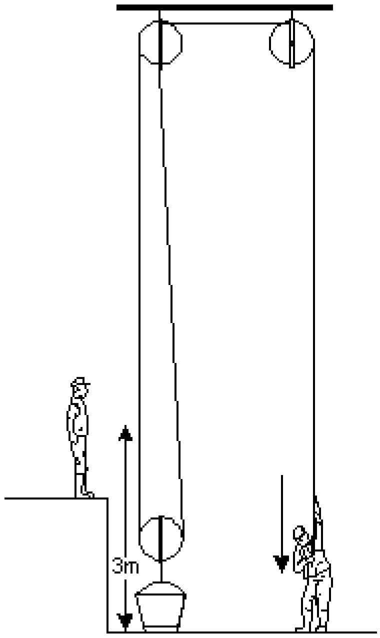
____

(2)

(Total 11 marks)

Q27.

The diagram below shows one way of lifting a bucket of bricks.



(a) When the free end of the rope is pulled down, the load is lifted.

Complete the following sentence.

The work done in pulling the rope down is used to increase the ________________

energy of the ____________________ and bricks.

(2)

(b) The weight of the bricks is 100 N and they are lifted 3 m.

Calculate the work done on the bricks.

____

____

Answer ________________________ J

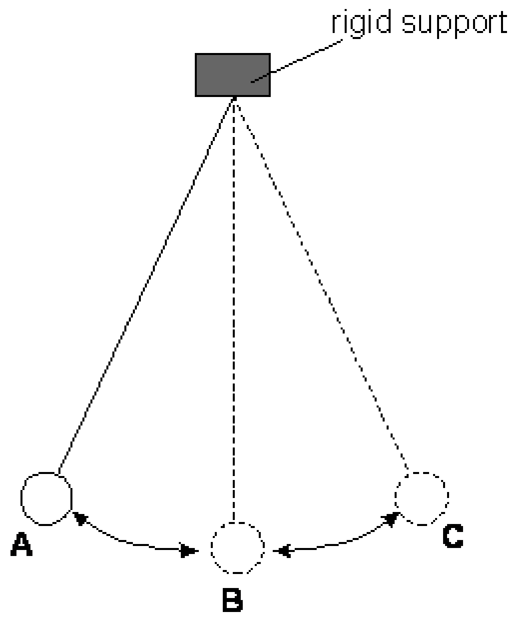
(2)

(Total 4 marks)

Q28.

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.

____

(1)

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

____

____

(1)

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

____

____

(2)
(Total 5 marks)

Q29.

The manufacturer of a family car gave the following information.

Mass of car 950 kg

The car will accelerate from 0 to 33 m/s in 11 seconds.

(a) Calculate the acceleration of the car during the 11 seconds.

____

____

____

(2)

(b) Calculate the force needed to produce this acceleration.

____

____

____

(2)

(c) The manufacturer of the car claims a top speed of 110 miles per hour. Explain why there must be a top speed for any car.

____

____

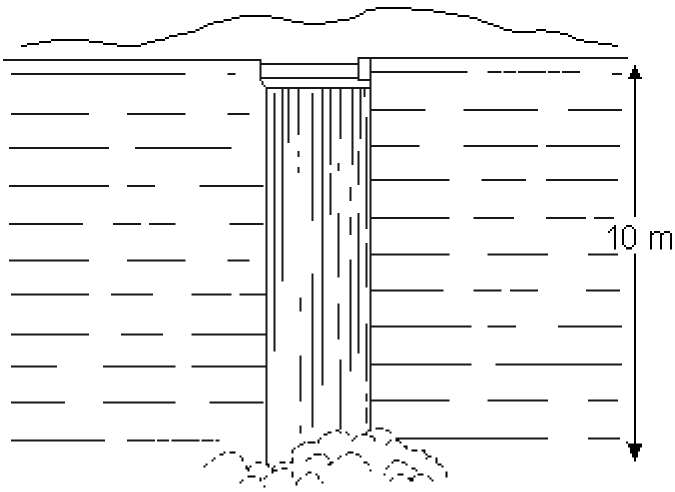
____

(3)

(Total 7 marks)

Q30.

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.

____

____

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.

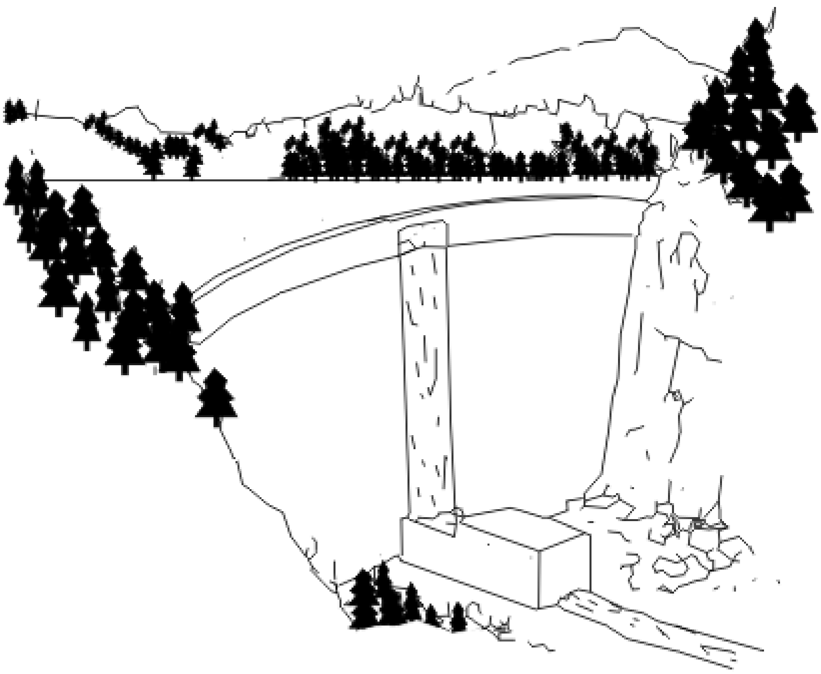
Answer _____________ m/s

(3)

(Total 6 marks)

Q31.

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.

____

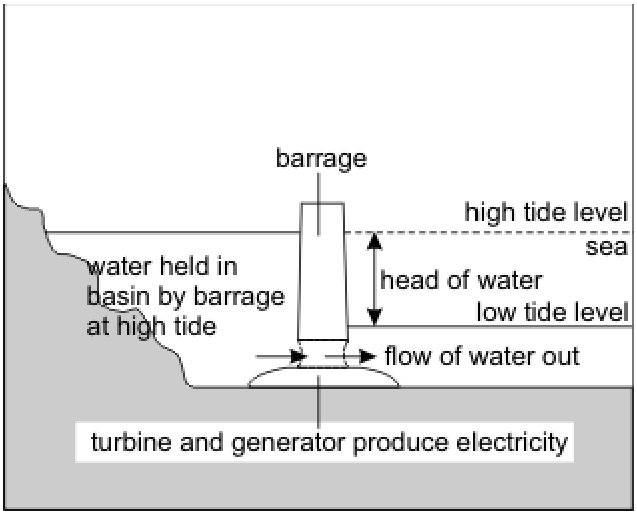
____

(4)

(Total 13 marks)

Q32.

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 1.2×10^9 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.

___

___

___

(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?

___

___

___

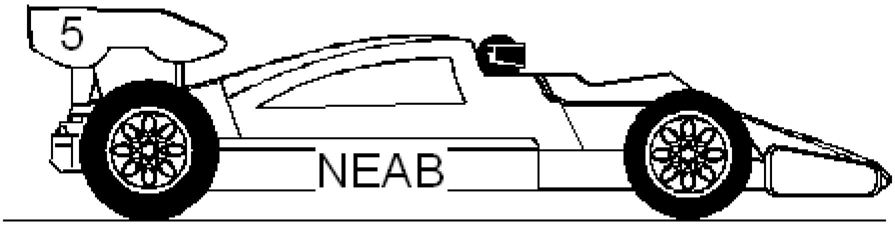
___

(5)

(Total 8 marks)

Q33.

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.

____

____

____

____

____

____

(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.

____

____

____

____

(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.

____

____

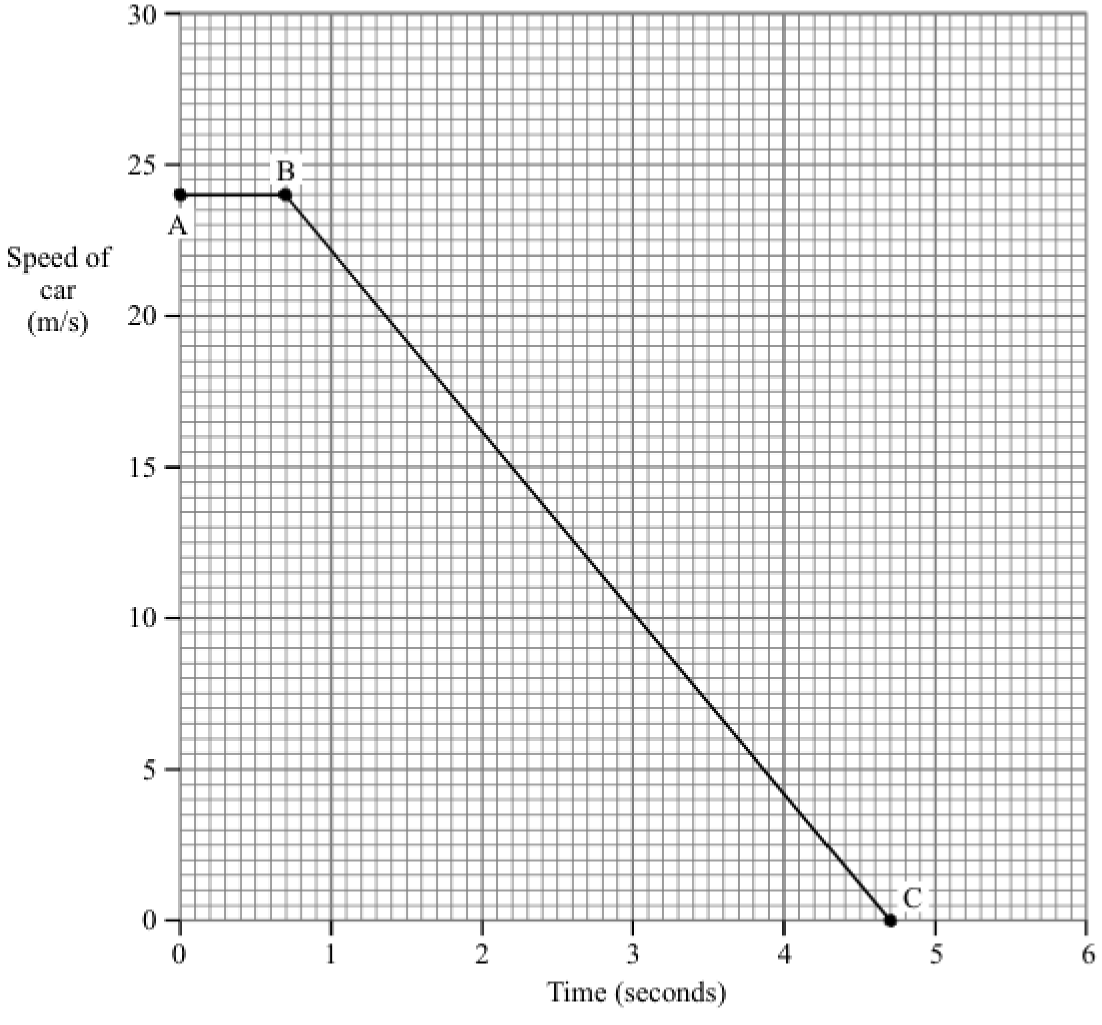
____

(12)
(Total 16 marks)

Q34.

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?

____

(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.

Distance ____________________ m

(3)

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

Acceleration ________________________

(4)

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

Distance __________________________ m

(3)

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

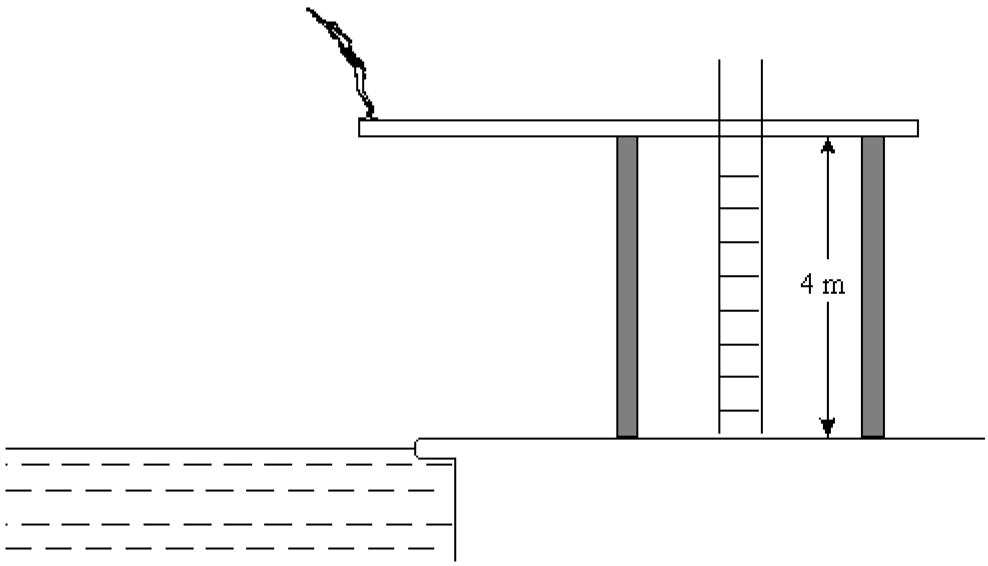
Braking force _____________________ N

(3)

(Total 15 marks)

Q35.

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.

____

____

____

(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.

____

____

____

(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.

____

____

____

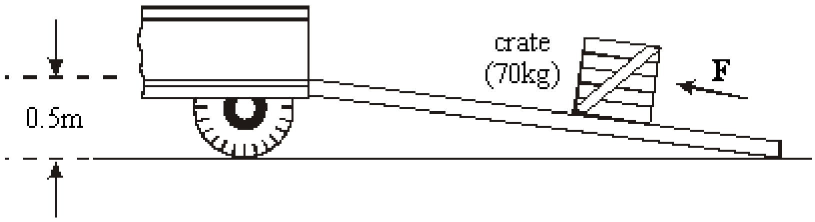
____

(2)

(Total 10 marks)

Q36.

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.

____

_______________________________________ Weight ________________________ N

(2)

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

____

____

____

____ Work done ______________________

(4)

(Total 6 marks)

Q37.

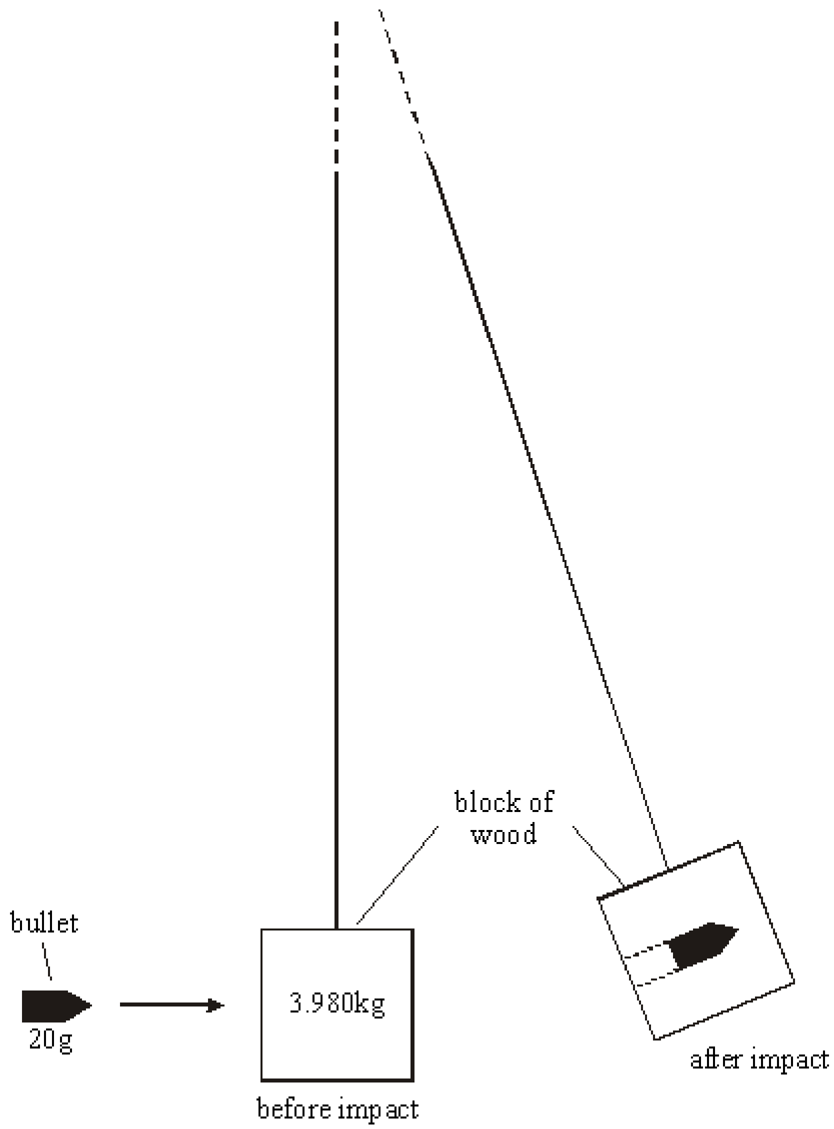
(a) When an object is moving it is said to have momentum.
Define momentum.

____

____

(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?

____

____

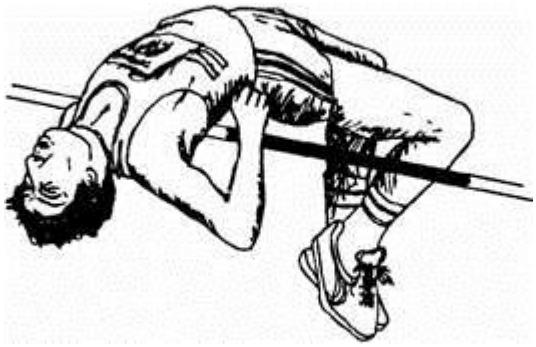
____

____

(1)
(Total 13 marks)

Q38.

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.

Calculate the gain in his gravitational potential energy.

___

___

___

___

___

___

Gain in gravitational potential energy ___________ J

(4)

(b) Calculate the minimum speed the high jumper must reach for take-off in order to jump over the bar.

(joule, J) **(kilogram, kg)** **[(metre/second)^2, (m/s)^2**

___

___

___

___

___

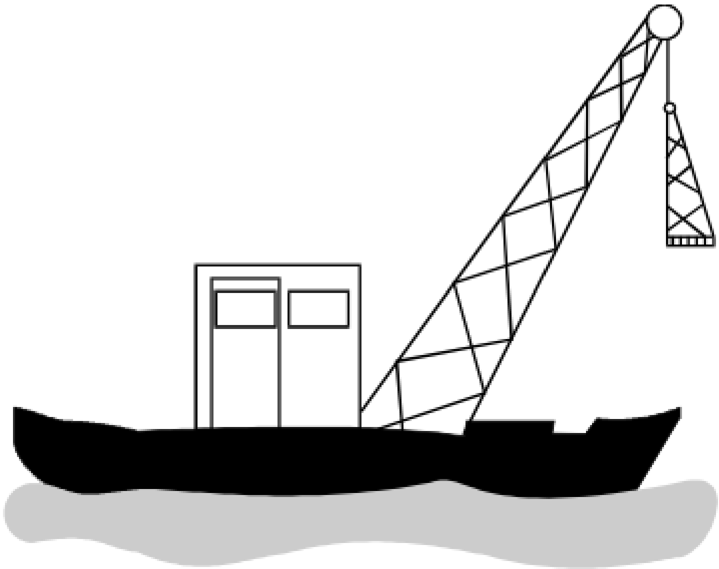
Speed ___________ m/s

(3)

(Total 7 marks)

Q39.

A crane on a barge lifts a girder and then carries it along the river.



The girder has a weight of 1 000 000 N and is lifted to a height of 1500 cm.

(a) Complete the sentence.

The weight of the girder is caused by the Earth's gravitational field strength acting

on its ______________________________ .

(1)

(b) Calculate the work done in lifting the girder.

Write the equation you are going to use.

____

(1)

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

____

____

____

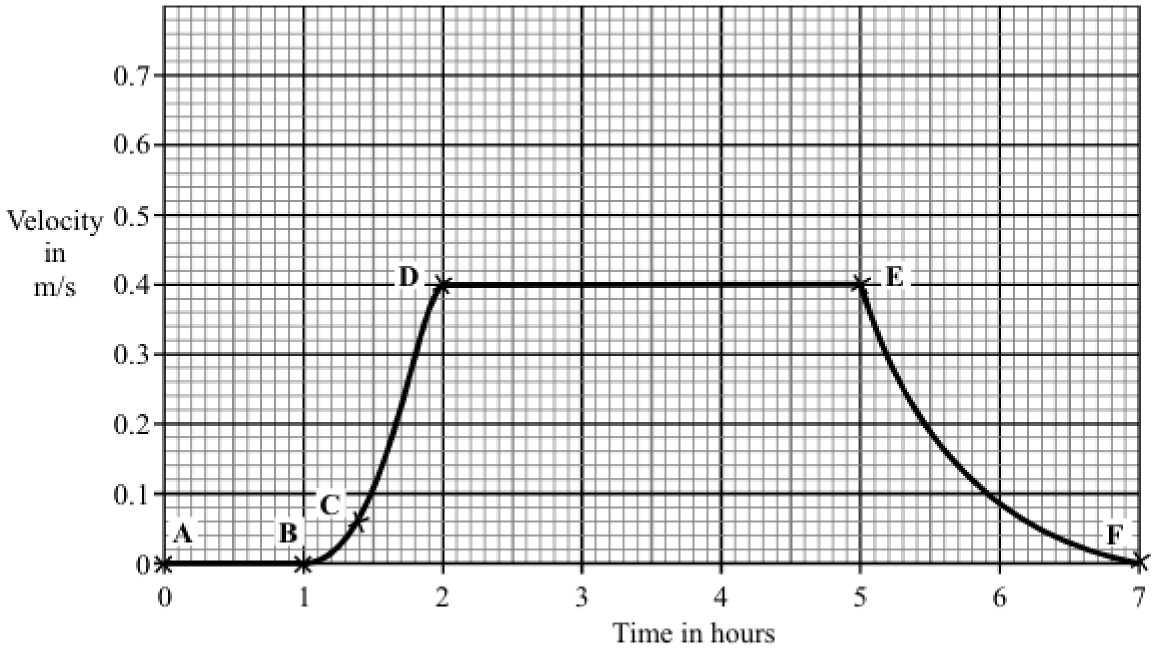
____

____

Work done = ______________________________

(3)

(c) The velocity–time graph represents the motion of the barge after the girder had been lifted.



To gain full marks in this question you should write your ideas in good English. Put them in a sensible order and use the correct scientific words.

Describe the motion of the barge over this period of seven hours. You must refer to the points **A**, **B**, **C**, **D**, **E** and **F** in your description.

____

____

____

____

____

____

____

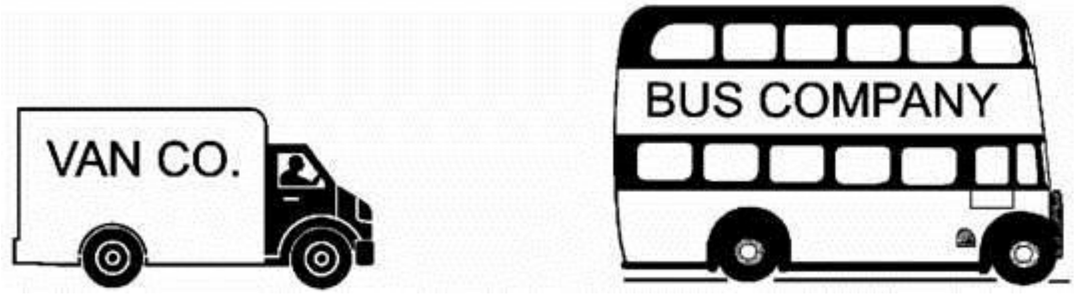
____

(5)

(Total 10 marks)

Q40.

'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.

____

____

____

(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.

____

____

____

____

____

____

____

____

Increase in kinetic energy = ____________________

(5)

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

____

____

____

(1)

(Total 8 marks)

Q41.

When you transfer *energy* to a shopping trolley, the amount of *work done* depends on the *force* used and the *distance moved*.

Complete the table by using the correct units from the box.

joule (J)	metre (m)	newton (N)

The first one has been done for you.

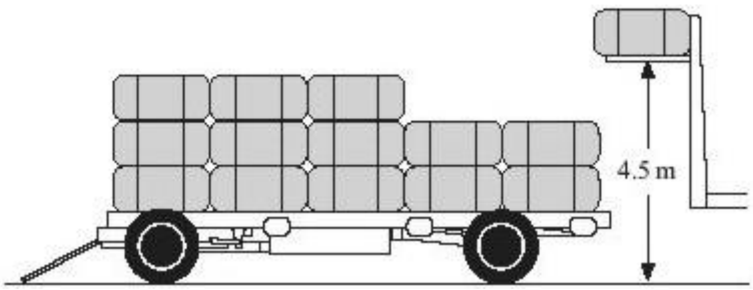
Quantity	Unit
energy (transferred)	joule
force	
distance (moved)	
work done	

(Total 2 marks)

Q42.

A forklift truck was used to stack boxes on to a trailer.

It lifted a box weighing 1900 N through 4.5 m.



Calculate the work done on the box. Show your working.

___

___

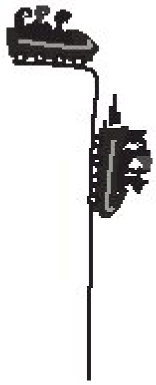
___

___

Work done = _______________ J
(Total 3 marks)

Q43.

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 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.

____

____

____

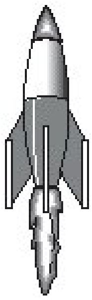
____

____

Force = ______________ N
(Total 3 marks)

Q44.

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.

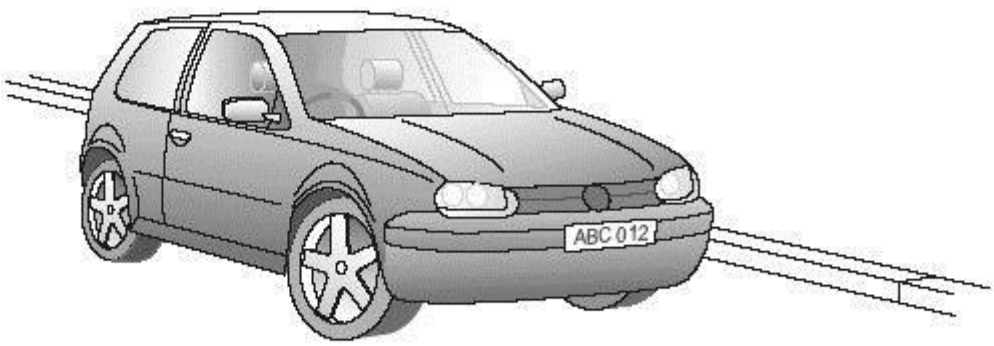
____

Kinetic energy = _______________ kJ

(Total 3 marks)

Q45.

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.

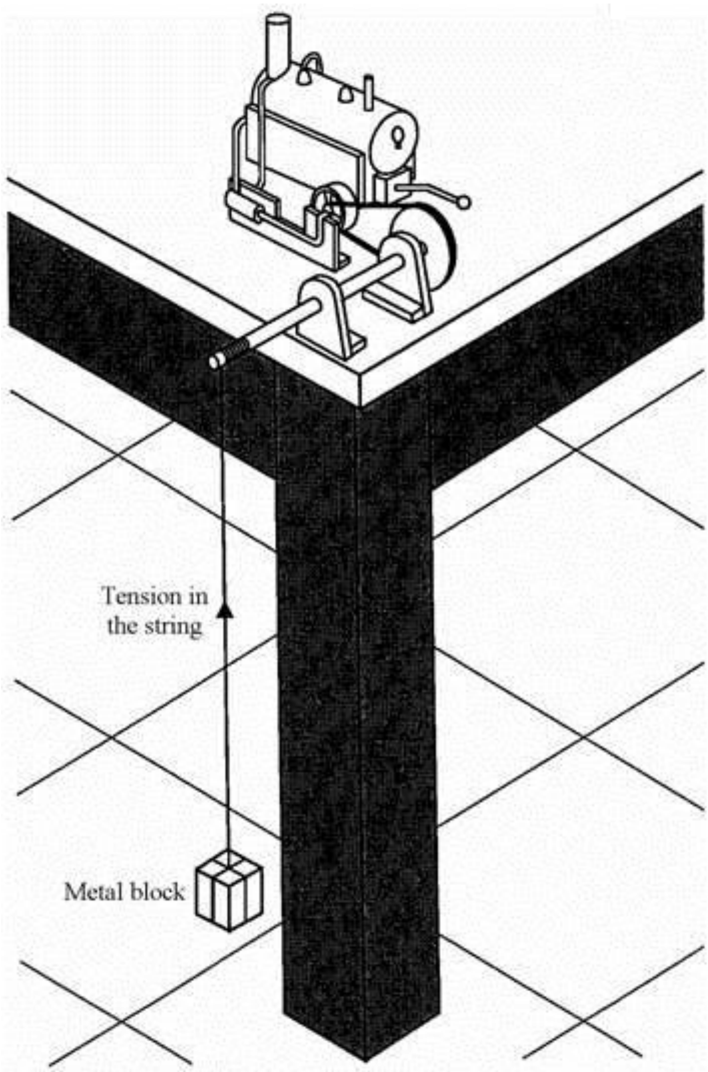
Show clearly how you work out your answer and give the unit.

Mass of the car = ______________________________

(Total 5 marks)

Q46.

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.

___

___

___

(2)

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

___

(1)

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

___

___

(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.

____

____

Power = ________________

(2)

(Total 10 marks)

Q47.

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.

____

____

____

____

____

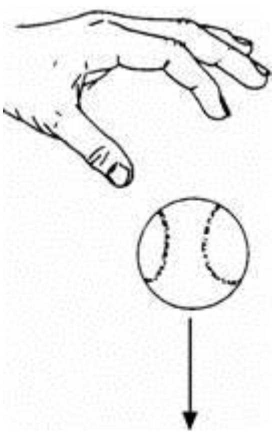
____

(3)

(Total 10 marks)

Q48.

Complete the following sentences.



When you drop a ball, it falls to the ground.

This happens because the _________________ pulls the ball towards it with a force called ______________________________ .

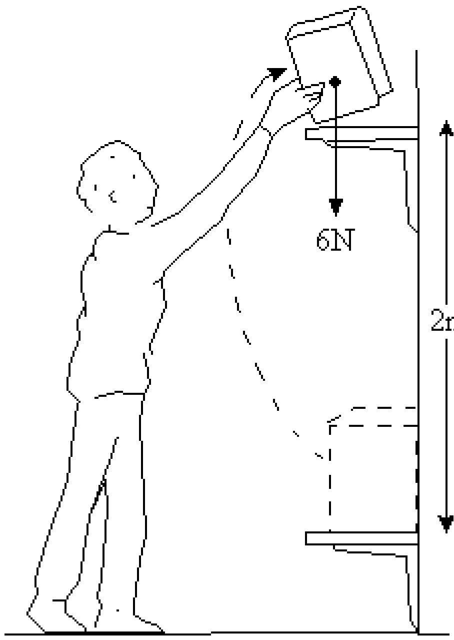
Forces are measured in units called ________________________ .

(Total 3 marks)

Q49.

A book weighs 6 newtons.

A librarian picks up the book from one shelf and puts it on a shelf 2 metres higher.



(a) Calculate the work done on the book. [Show your working].

____

____

____

(3)

(b) The next person to take the book from the shelf accidentally drops it.

The book accelerates at $9.8 m/s^2$.

Use this information to calculate the mass of the book. [Show your working].

____

____

____

Answer ___________________ kg.

(3)

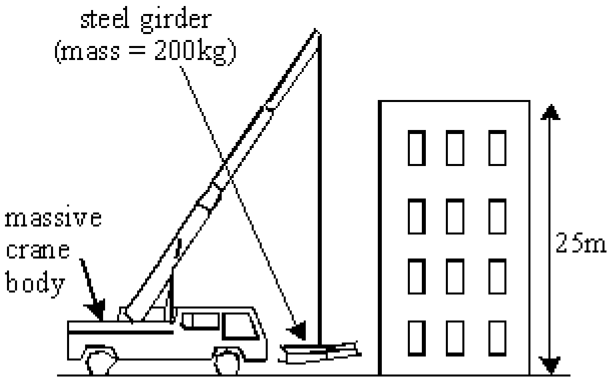
(c) If the book was dropped from an aeroplane high in the sky, it would accelerate to begin with. Eventually it would fall at a steady speed.

Explain, in as much detail as you can, why this happens.

(3)
(Total 9 marks)

Q50.

A crane is used to lift a steel girder to the top of a high building.



When it is lifted by the crane:

- the girder accelerates from rest to a speed of 0.6 m/s in the first 3 seconds;
- it then rises at a steady speed.

(a) Calculate the **acceleration** of the girder.

(Show your working.)

(3)

(b) (i) What is the **weight** of the steel girder?

Answer ______________________ N

(1)

(ii) Calculate the **power** of the crane motor as it lifts the girder at a steady speed of 0.6 m/s.

(*Show your working. You can ignore the weight of the cable and hook which is small compared to the weight of the girder.*)

Answer ____________________ W

(2)

(c) A new motor is fitted to the crane. This motor accelerates the girder at 0.3 m/s^2.

Calculate the **force** which the crane applies to the girder to produce this acceleration.

(Show your working.)

Answer ____________________ N

(3)

(Total 9 marks)

Q51.

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:

force (N) × time(s) = 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*.)

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.

(2)

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

(Show your working.)

____

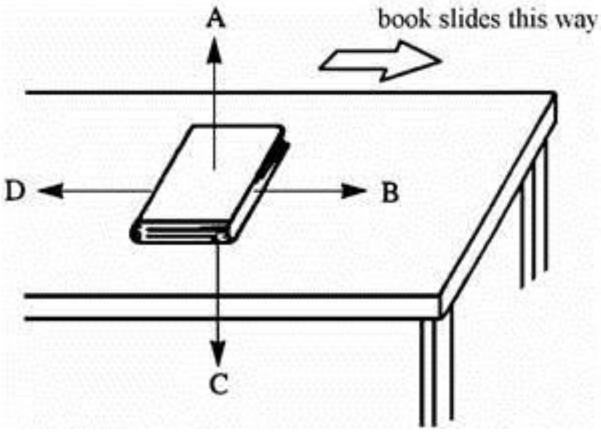
____

____

(4)
(Total 10 marks)

Q52.

When you slide a book across a table, there is a force of friction between the book and the table.



(a) Which arrow shows the force of friction that acts on the book? ________________

(1)

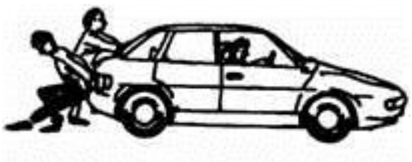
(b) The force of friction will slow the book down.
Write down **one** other effect that the force of friction will have on the book.

____

(1)
(Total 2 marks)

Q53.

A man's car will not start, so two friends help him by pushing it.


Mass of car = 800 kg

By pushing as hard as they can for 12 seconds they make the car reach a speed of 3 metres per second.

(a) Calculate the acceleration they give to the car.

____

____

____________________________ Answer __________ m/s^2

(2)

(b) Whilst pushing the car the two friends together do a total of 2400 joules of work. Calculate their total power.

____

____

____ Answer __________ watts

(2)

(c) Another motorist has the same problem. The two friends push his car along the same stretch of road with the same force as before.

It takes them 18 seconds to get the second car up to a speed of 3 metres per second.

What does this tell you about the mass of the second car?
(You can ignore forces of friction.)

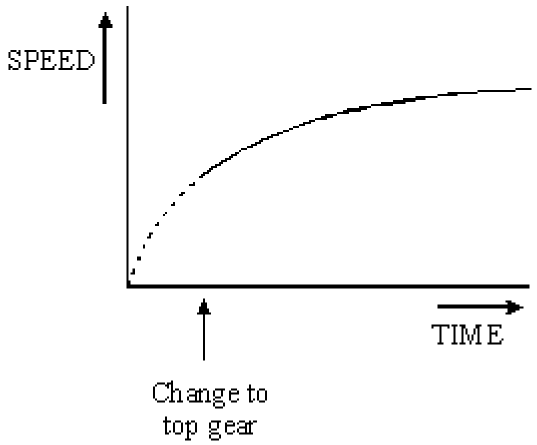
____

____

(2)

(d) On a flat stretch of a motorway a lorry driver changes into top gear. He then makes the lorry go as fast as he can.

The graph shows what happens to the speed of the lorry.



Explain why the speed of the lorry increases at first but then levels out.

____

____

(3)
(Total 9 marks)

Q54.

A cyclist accelerates from a set of traffic lights.

The driving force of the back tyre on the ground is 250 N.

(a) How much work is done by this force when the cyclist travels 5 metres?
(Show your working.)

Answer ________________ joules (J)

(2)

(b) What happens to the energy transferred by this force?

(2)

(Total 4 marks)

Q55.

A cyclist accelerates from a set of traffic lights.

The driving force of the back tyre on the ground is 250 N.

(a) How much work is done by this force when the cyclist travels 5 metres? (Show your working.)

Answer ______________ joules (J)

(2)

(b) What happens to the energy transferred by this force?

(2)

(Total 4 marks)

Q56.

To get a bobsleigh moving quickly, the crew push it hard for a few metres and then jump in.

(a) Choose from the following words to complete the sentences below.

distance **energy** **force** **speed** **time**

You can calculate the work done by the bobsleigh crew like this:

work done = ______________ × _________________

The work done by the crew is transferred to the bobsleigh as kinetic ___________

(3)

(b) Which of the following units is used for the amount of work done?
Underline the correct one.

joules **newtons** **metres** **metres per second**

(1)
(Total 4 marks)