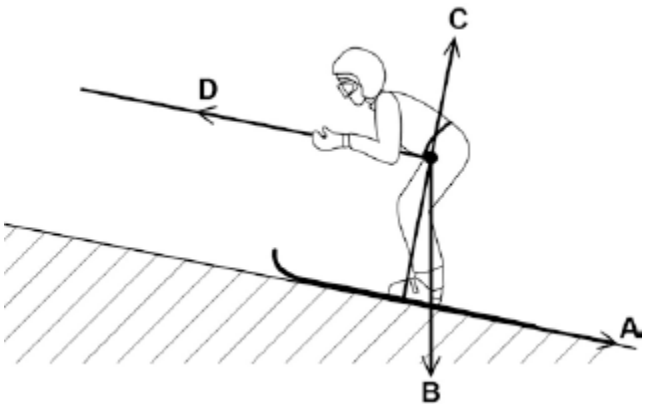
1 **Figure 1** shows a skier using a drag lift.

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

.....

.....

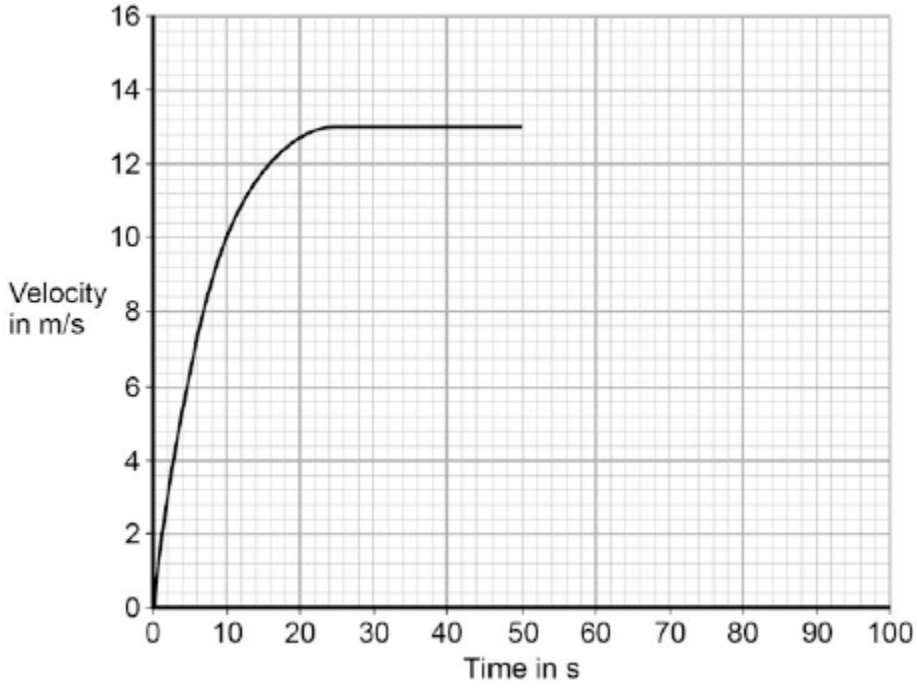
Work done = ... J

(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.

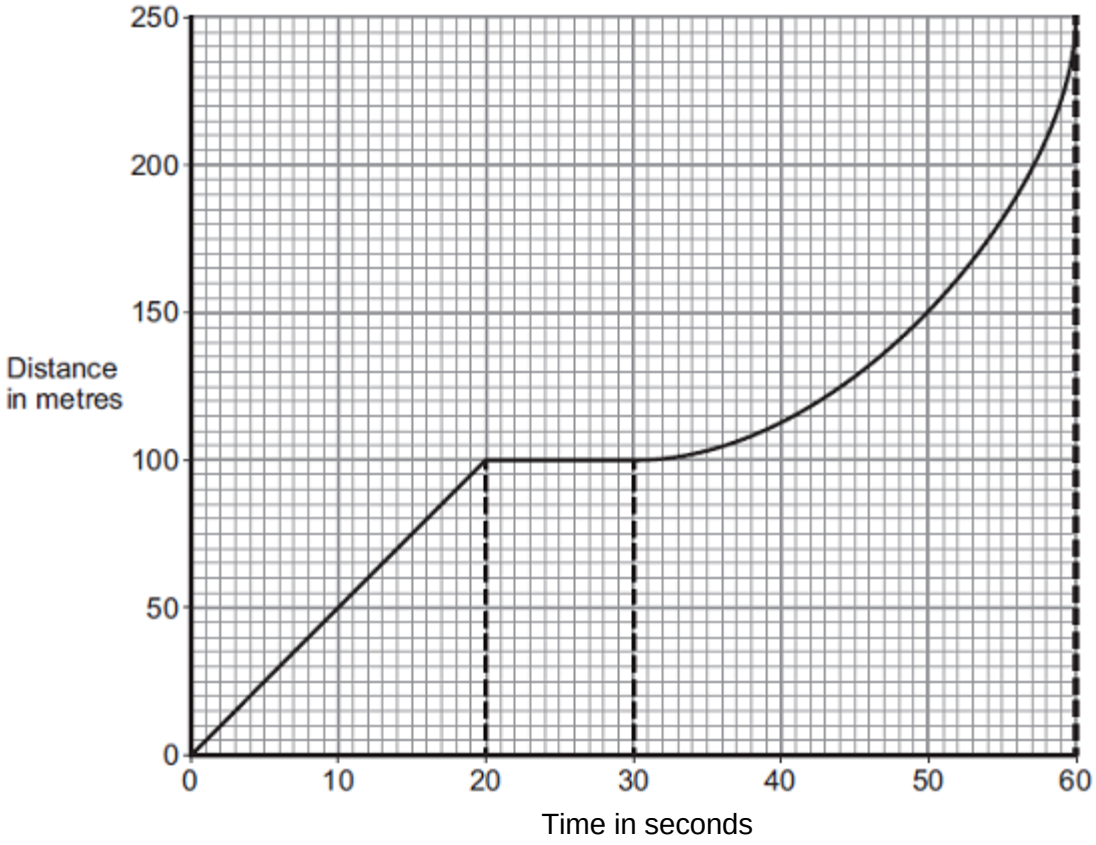
The skier decelerates at a constant rate coming to a stop in 15 seconds.

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)

2 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?

.....

.....

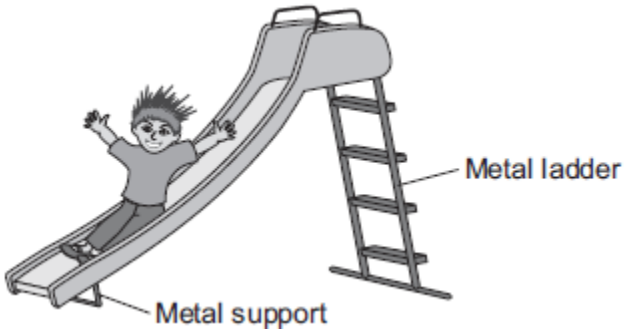
.....

.....

(2)

(Total 11 marks)

3 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?

.....

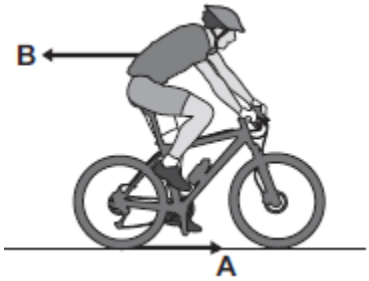
.....

(1)

(Total 7 marks)

4 (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**?

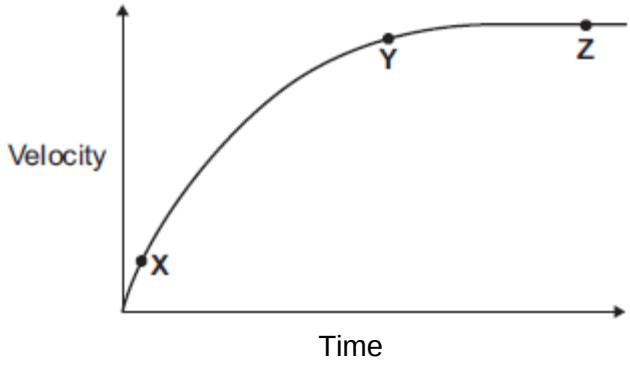
.....

(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**.

.....

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Extra space .....

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(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

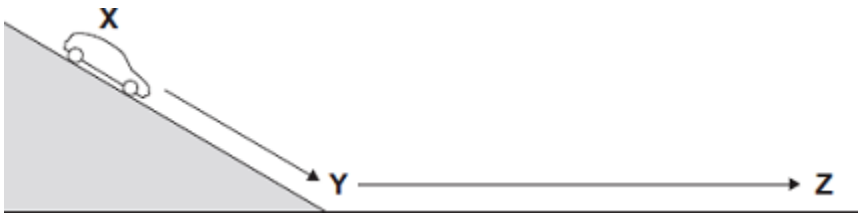
bicycle ..... .

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

(2)

(Total 13 marks)

5 (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**?

.....

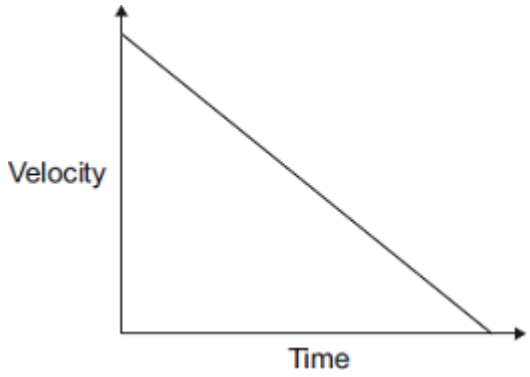
(1)

(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**?

.....

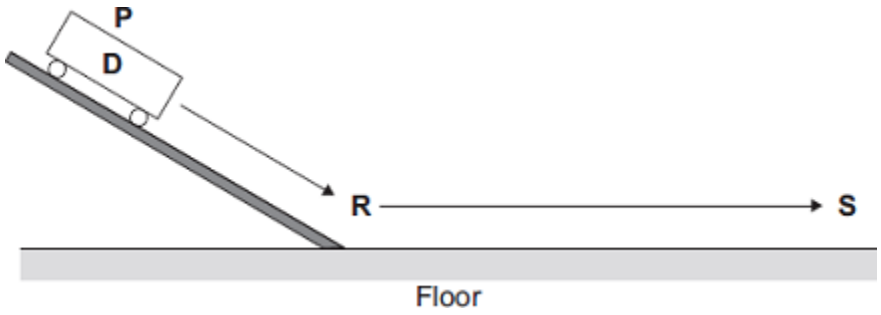
(1)

(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.

.....

.....

.....

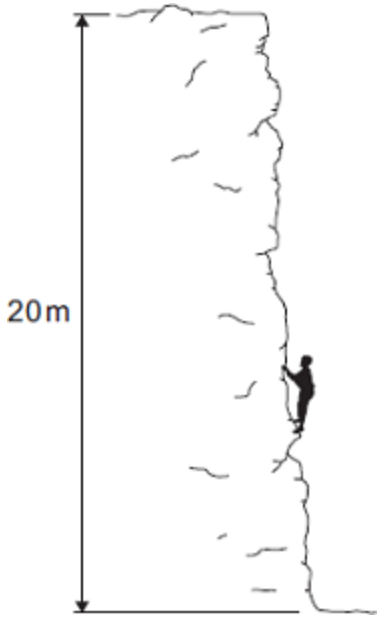
.....

.....

.....

(3)
(Total 12 marks)

6 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)

7 (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.

.....

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.....

.....

.....

.....

(3)
(Total 14 marks)

8 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.

.....

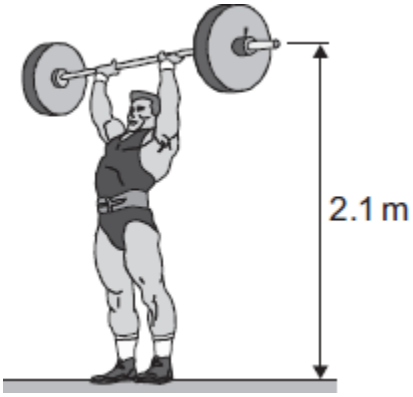
.....

.....

Work done =.....

(3)
(Total 8 marks)

9 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.

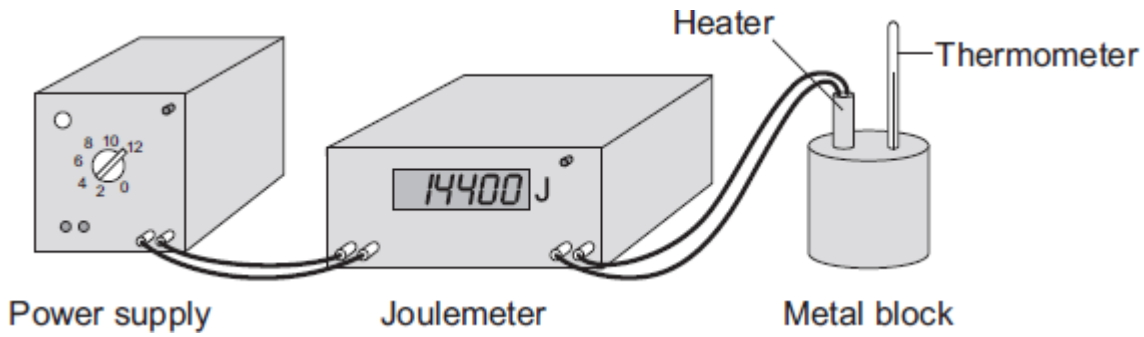
.....

.....

(2)

(Total 7 marks)

10 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

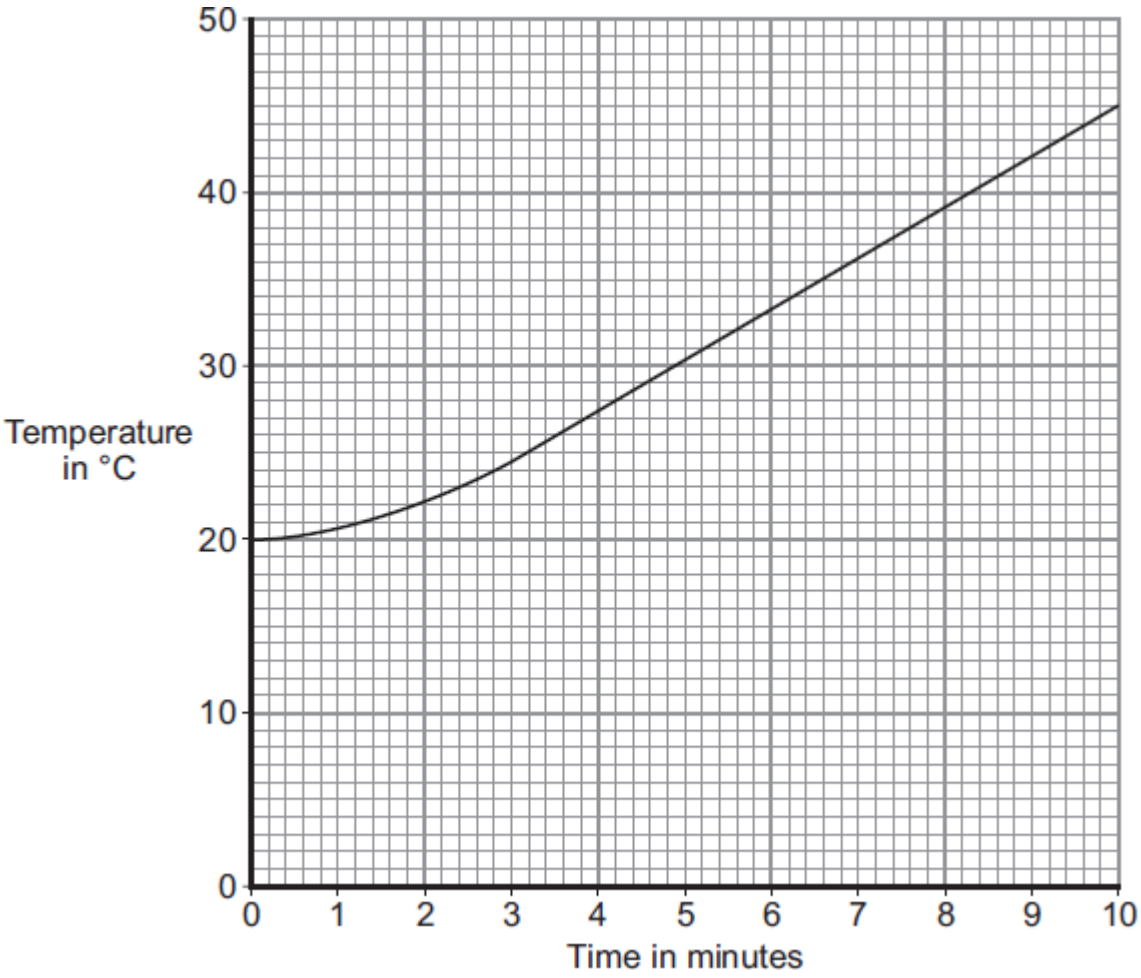
(2)

(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.

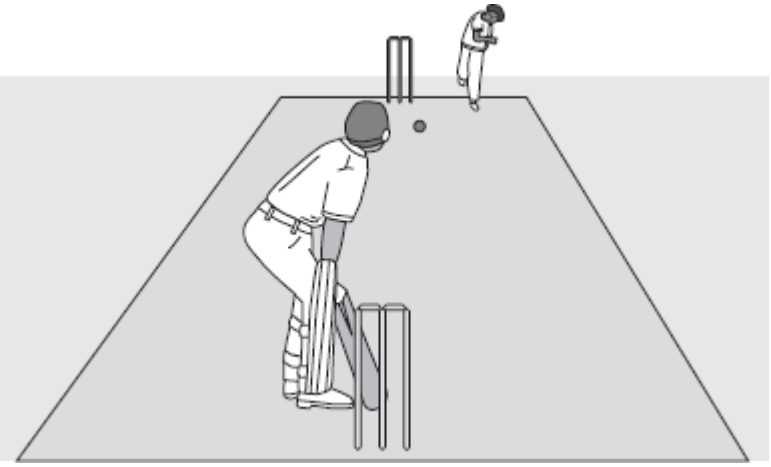
The student does not read the thermometer accurately. ☐

The block transfers energy to the surroundings. ☐

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

(1)
(Total 5 marks)

11 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.

.....

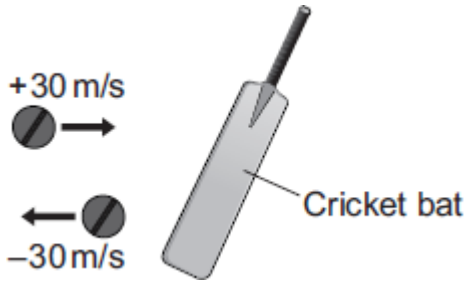
.....

.....

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.

momentum = mass × 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.

.....

.....

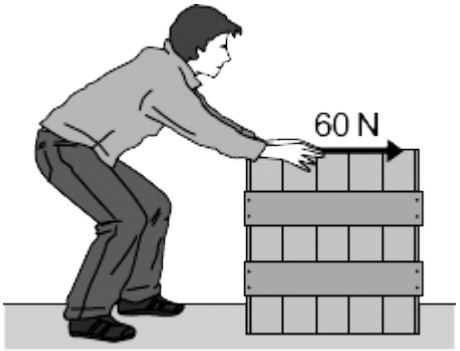
.....

.....

.....

(2)
(Total 7 marks)

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



My Revision Notes AQA GCSE Physics for A* – C,
Steve Witney, © Philip Allan UK

(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**

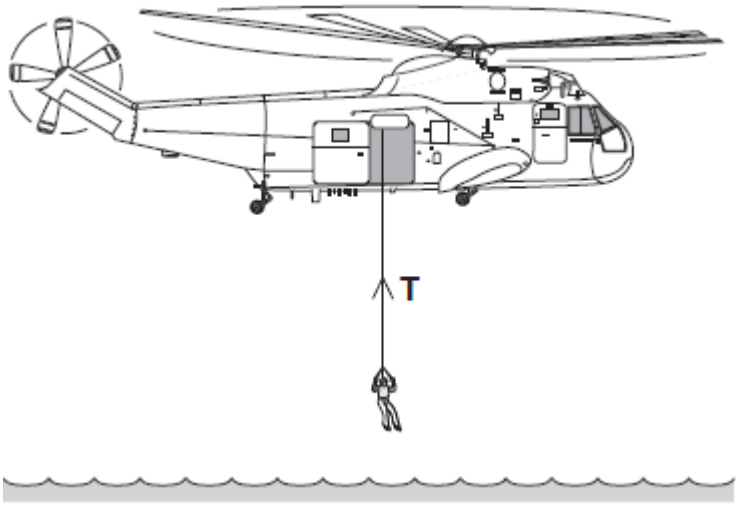
.....

.....

Work done = ...

(3)
(Total 6 marks)

13 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)**

.....

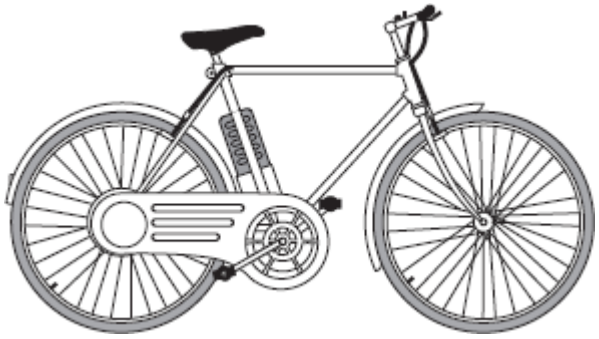
.....

Power = ...

(3)

(Total 7 marks)

14 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.

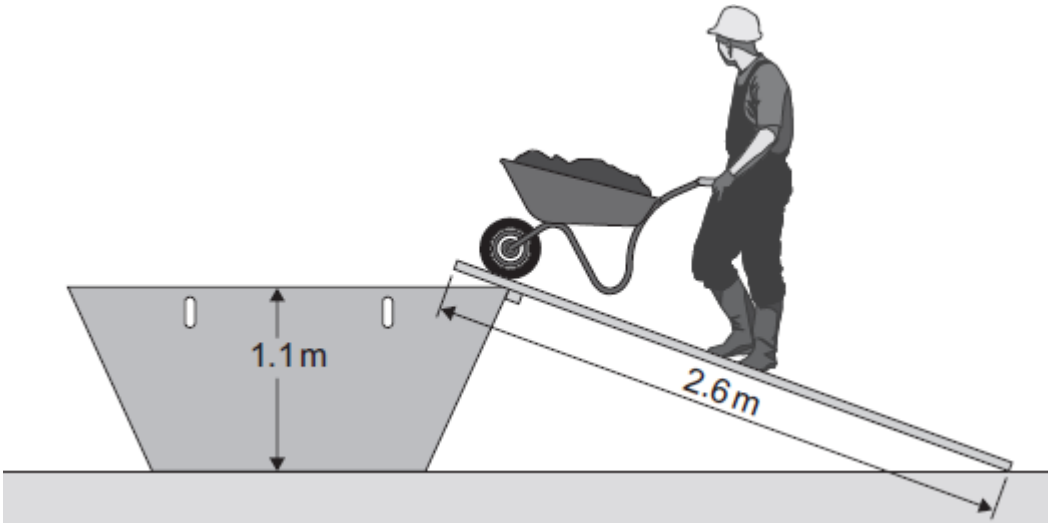
.....

.....

(2)

(Total 10 marks)

15 (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.

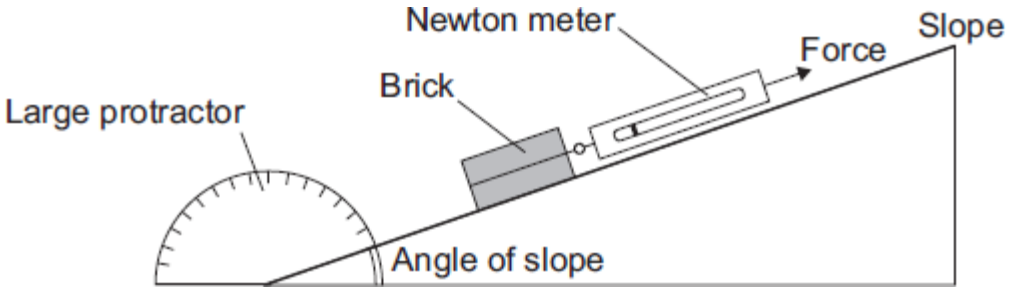
.....

.....

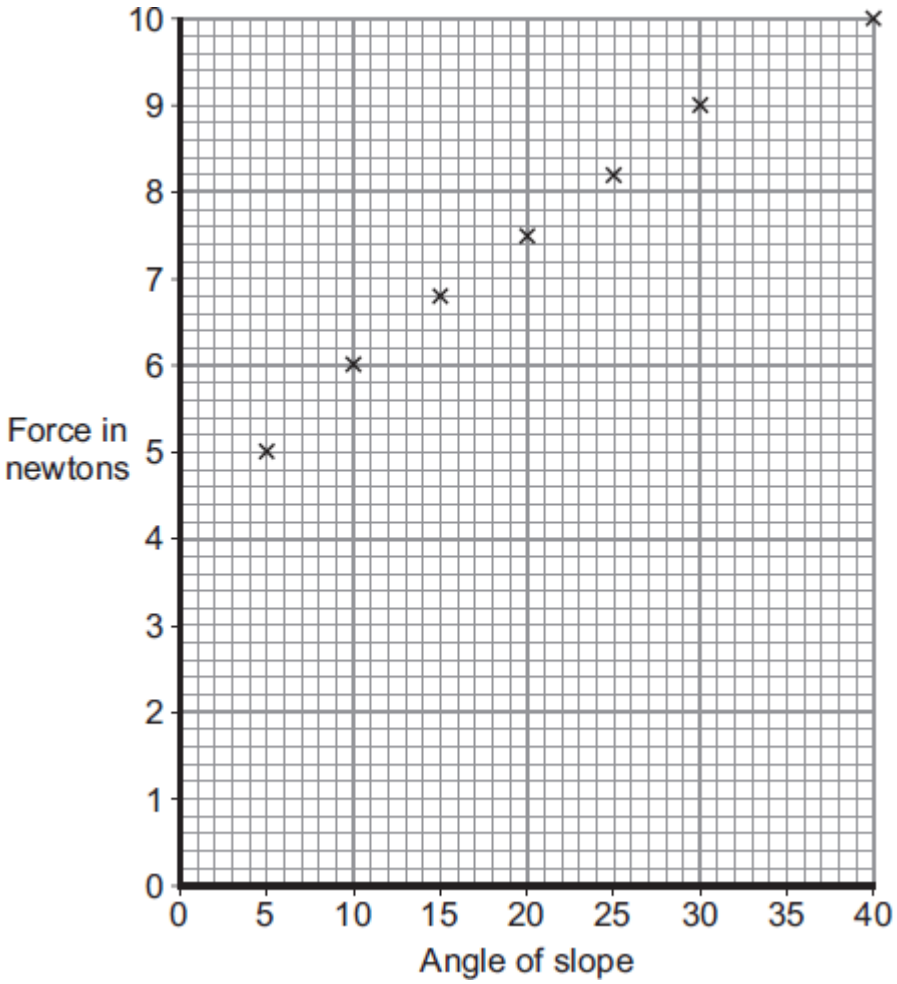
Work done = ... J

(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.

.....

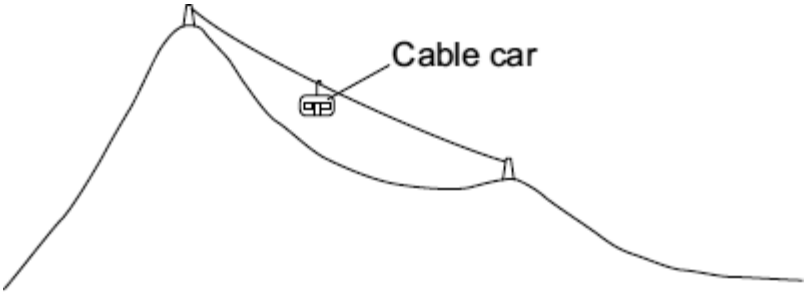
.....

.....

.....

(2)
(Total 6 marks)

16 (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)

17 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

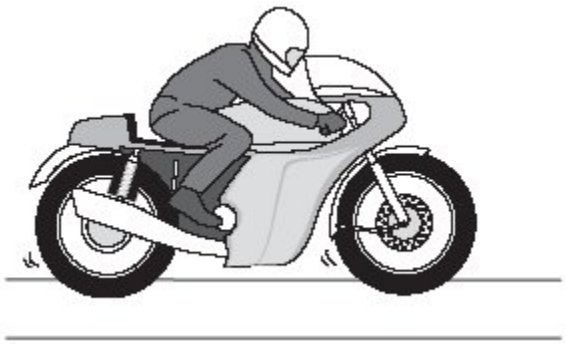
heat
light
sound

.

(1)

(Total 6 marks)

18 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)

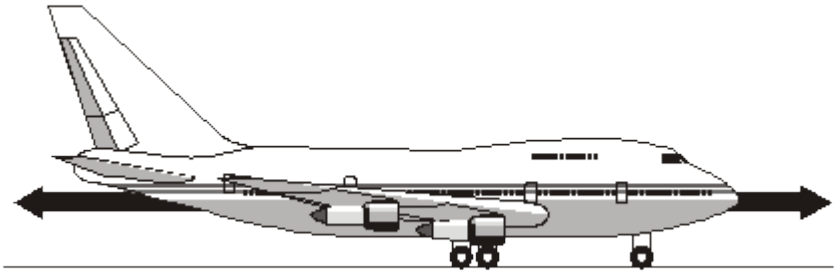
(ii) What happens to the kinetic energy lost by the motorbike?

.....

(1)

(Total 4 marks)

19 (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.

.....

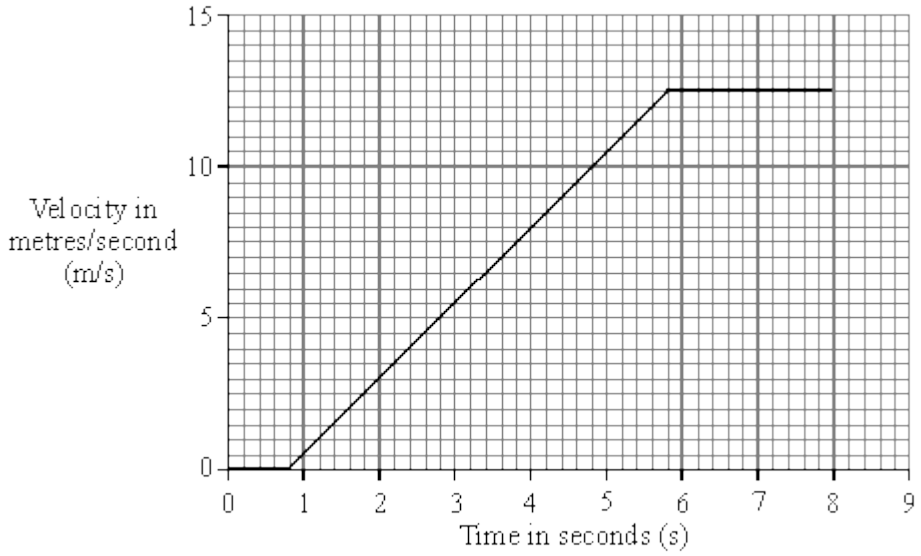
.....

.....

.....

(2)
(Total 7 marks)

20 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.

.....

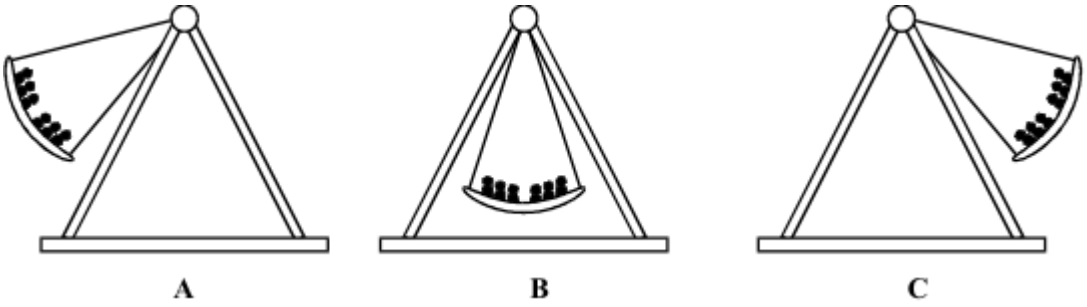
.....

Force = ... newtons

(2)

(Total 11 marks)

21 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.

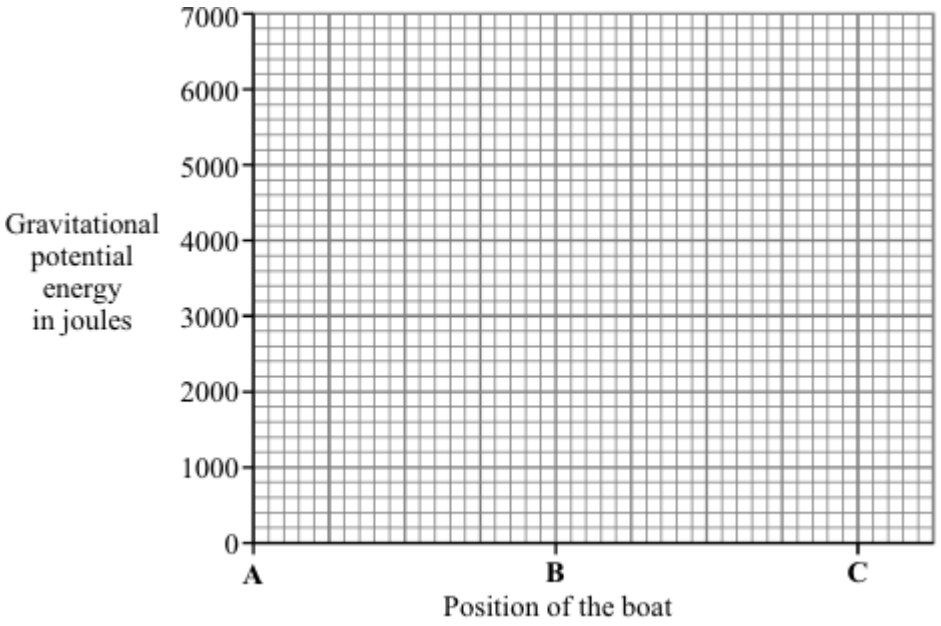
.....

.....

Speed = ... m/s

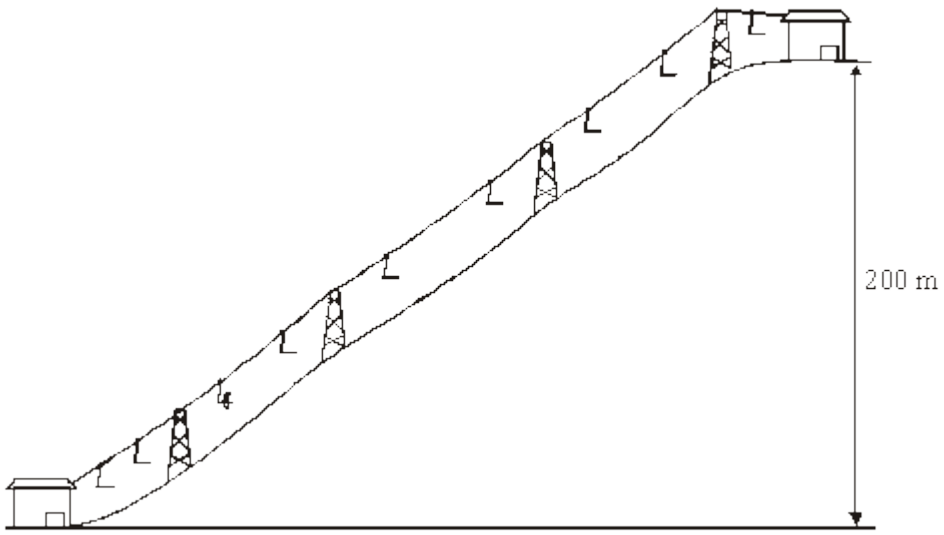
(2)

(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)

22 (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.

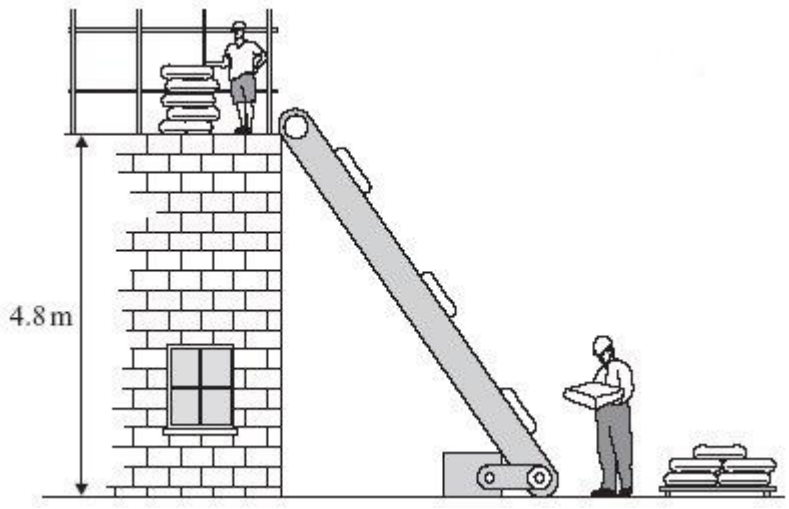
When the ski lift is working ..... energy supplied to the motor

is usefully transferred as gravitational ..... energy.

(1)

(Total 8 marks)

23 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)

24 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)

25 (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

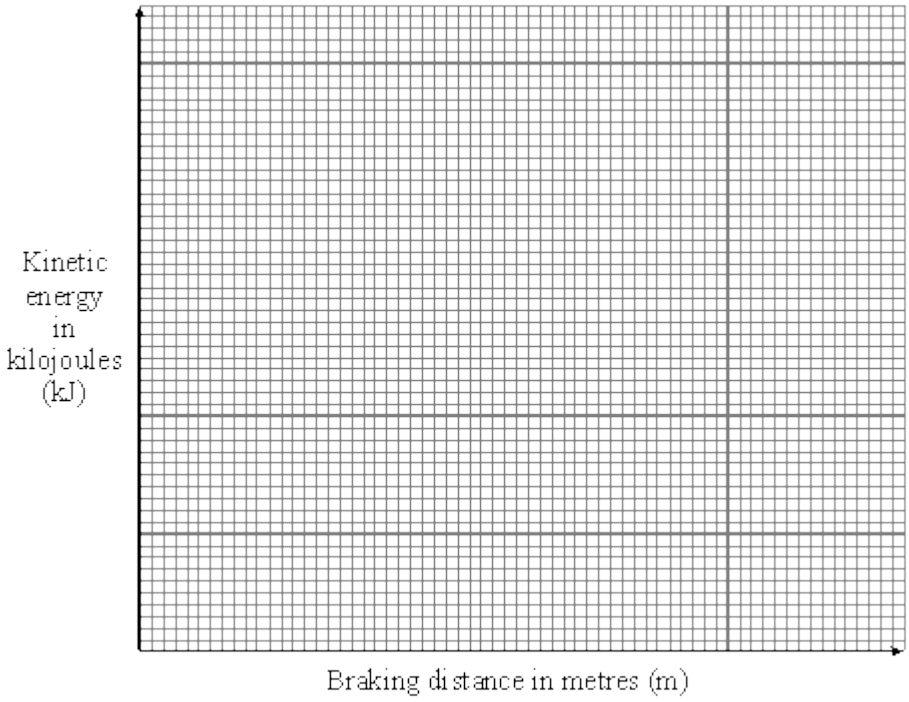
(2)
(Total 5 marks)

26 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

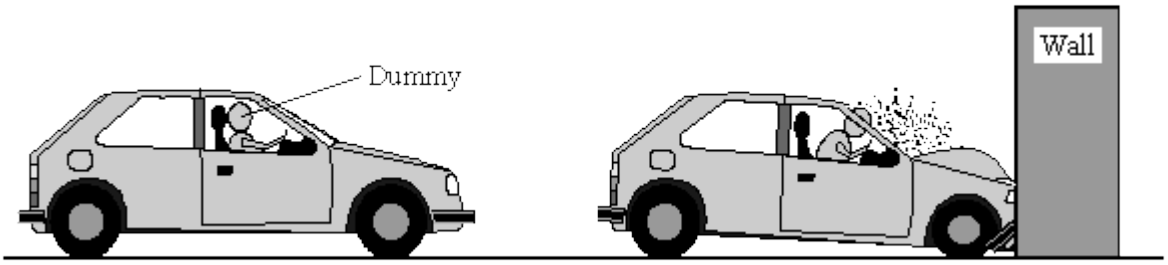
(2)

(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 .....

.....

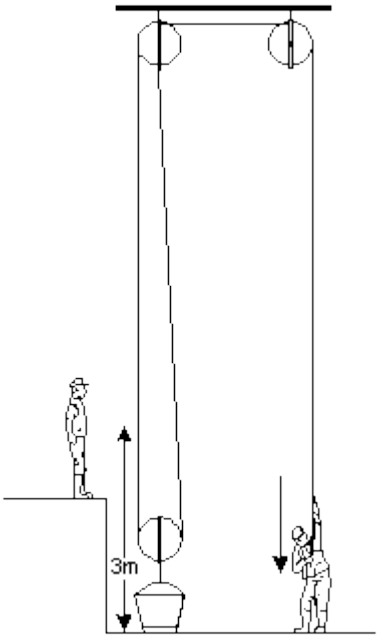
.....

.....

(2)

(Total 11 marks)

27 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.

.....

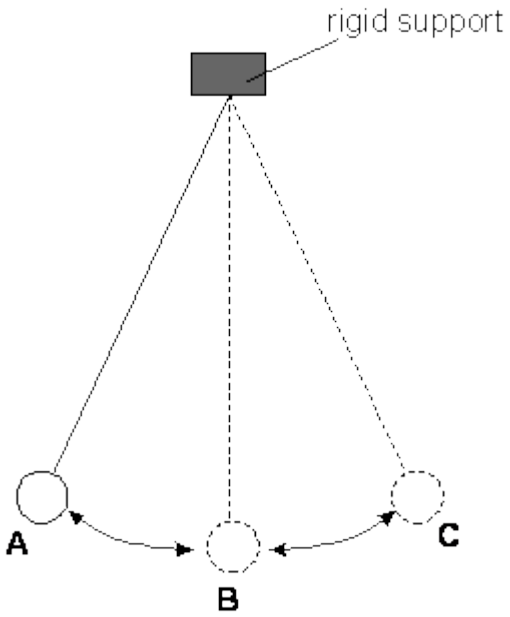
.....

Answer ..... J

(2)

(Total 4 marks)

28 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)

29 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.

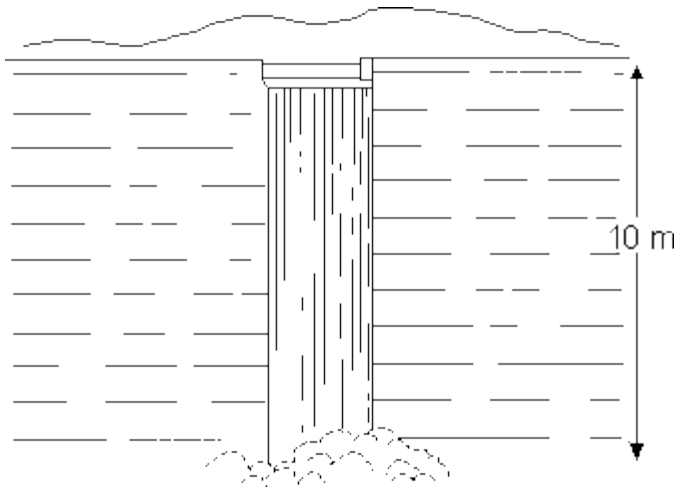
.....

.....

.....

(3)
(Total 7 marks)

30 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.

.....

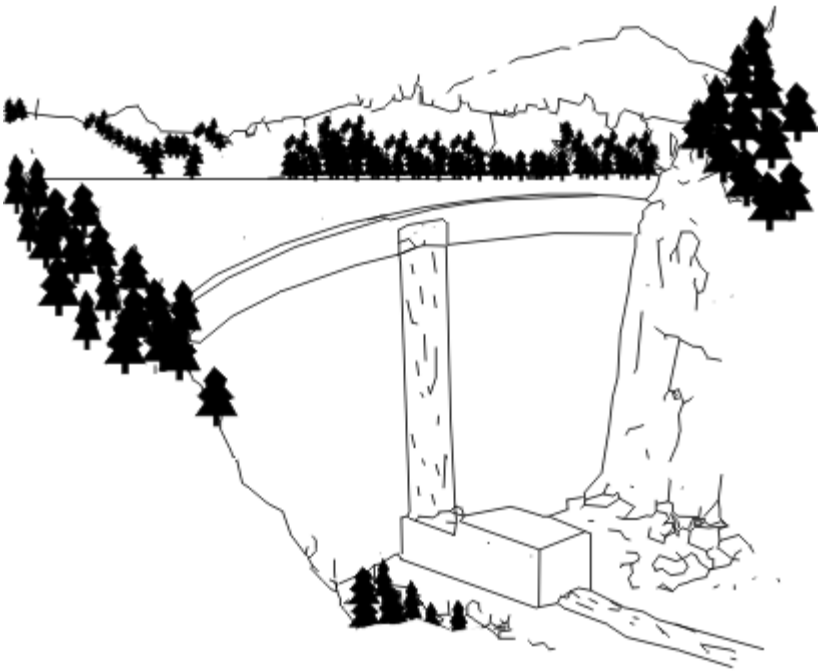
.....

.....

Answer ..... m/s

(3)
(Total 6 marks)

31 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?

.....

.....

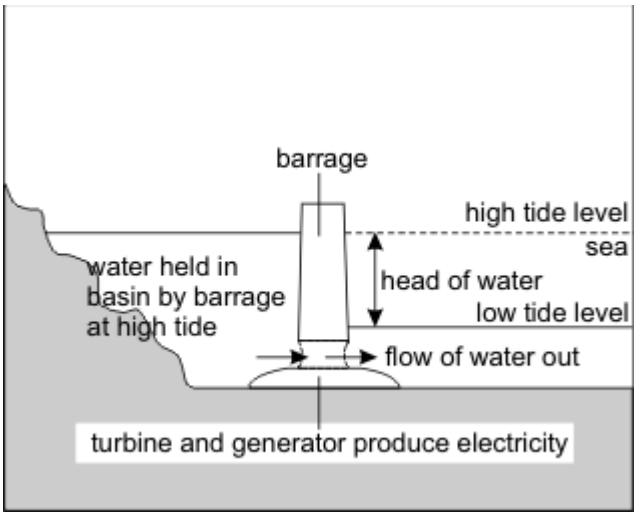
(iii) If the generator is 20% efficient, calculate the electrical power output of the generator.

.....

.....

(4)
(Total 13 marks)

32 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?

.....

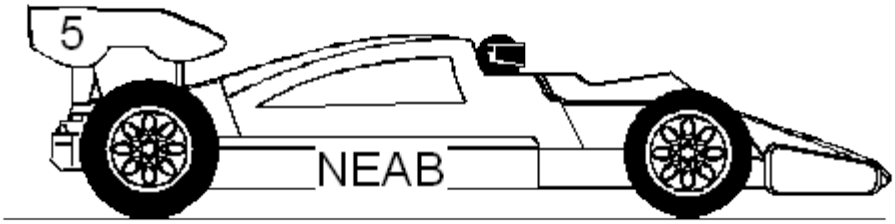
.....

.....

.....

(5)
(Total 8 marks)

33 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.

.....

.....

.....

.....

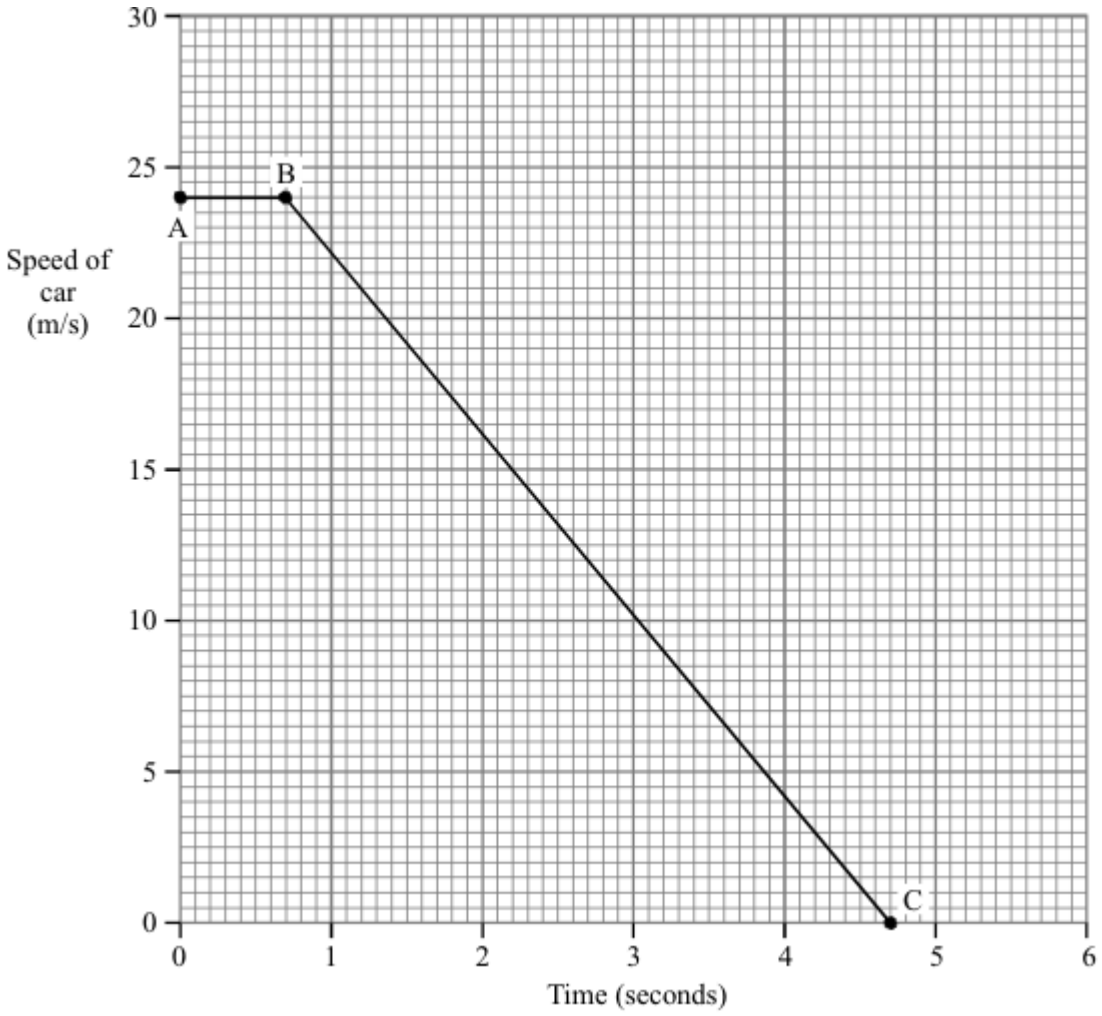
.....

.....

(12)
(Total 16 marks)

34 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.

.....

.....

.....

.....

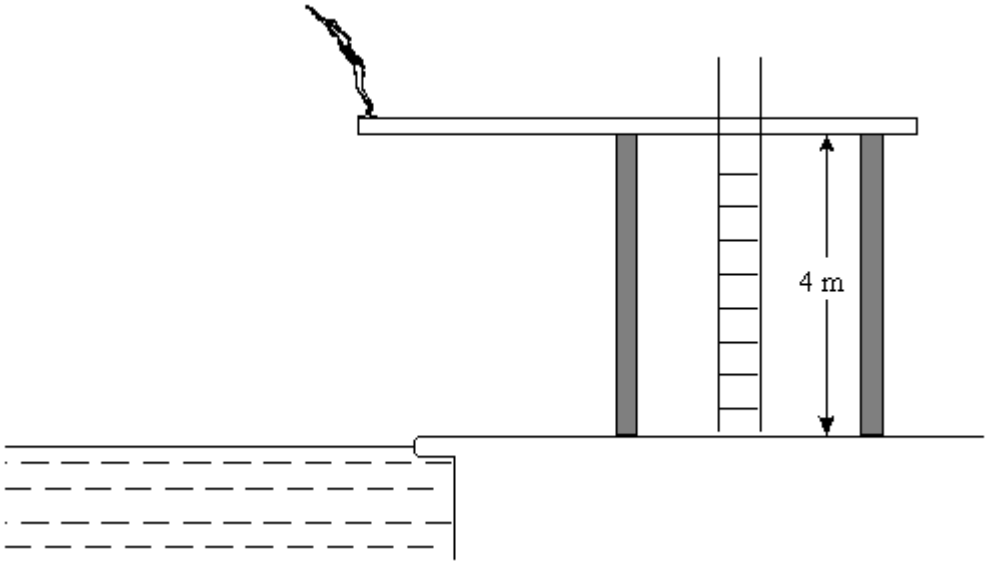
.....

Braking force ..... N

(3)

(Total 15 marks)

35 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.

.....

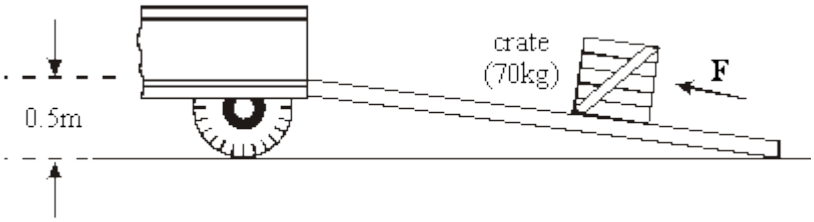
.....

.....

.....

(2)
(Total 10 marks)

36 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)

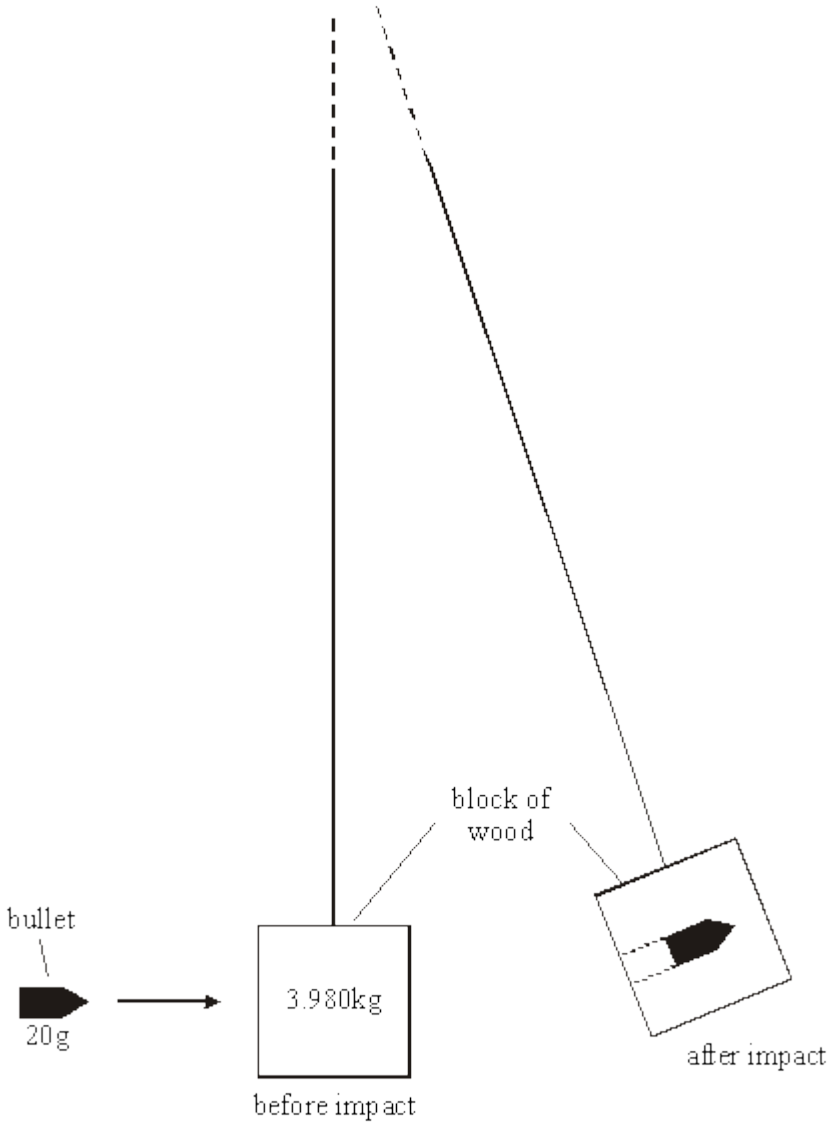
37 (a) When an object is moving it is said to have momentum.
Define momentum.

.....

.....

(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)

38 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**

.....

.....

.....

.....

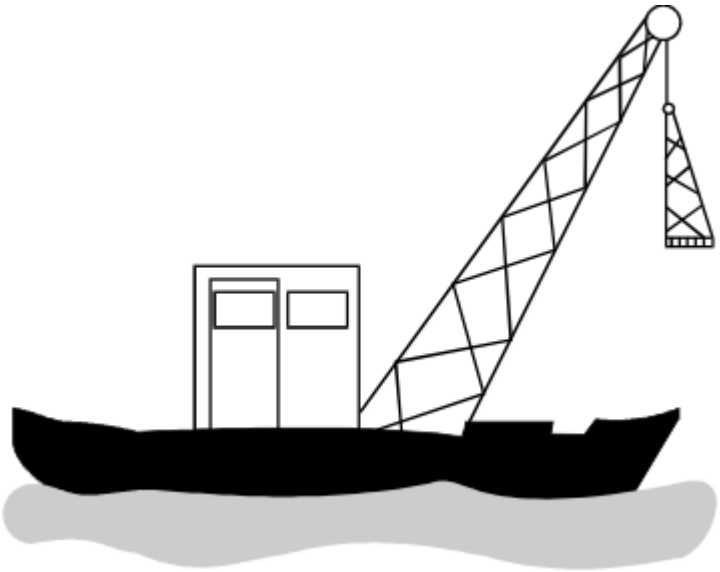
.....

Speed ..... m/s

(3)

(Total 7 marks)

39 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.

.....

.....

.....

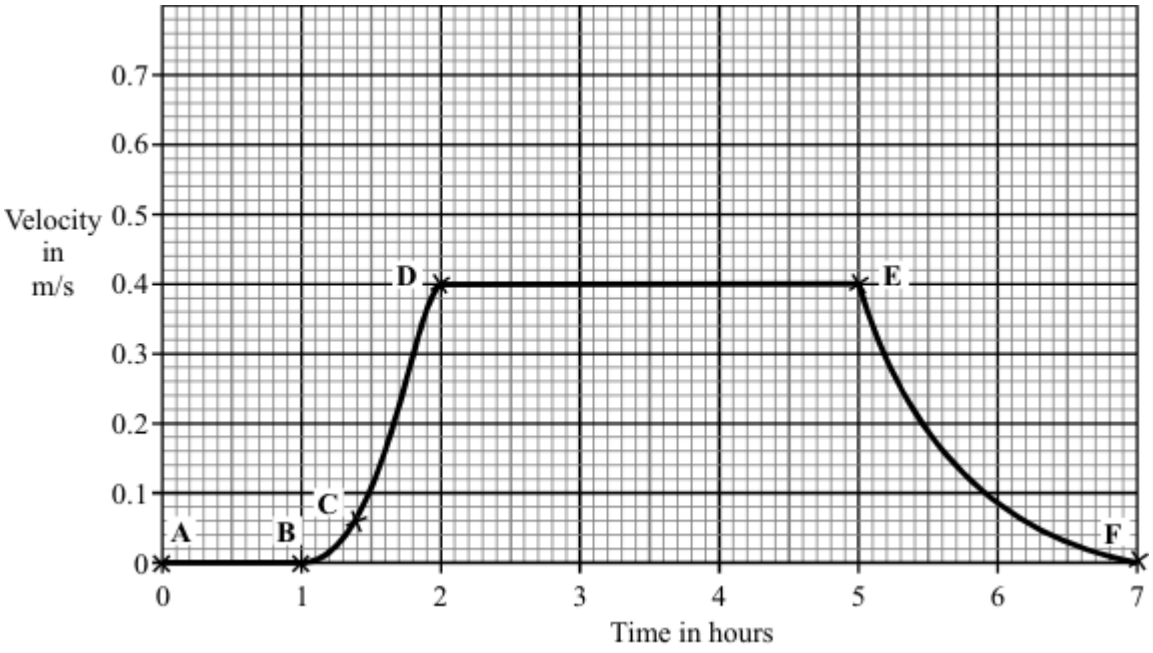
.....

.....

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.

.....

.....

.....

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.....

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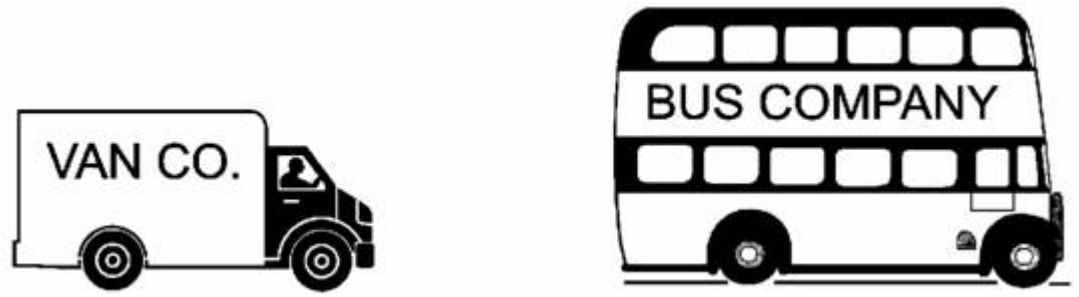
.....

.....

(5)
(Total 10 marks)

40 **'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.

.....

.....

.....

.....

.....

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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.

.....

.....

.....

(1)

(Total 8 marks)

41 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)

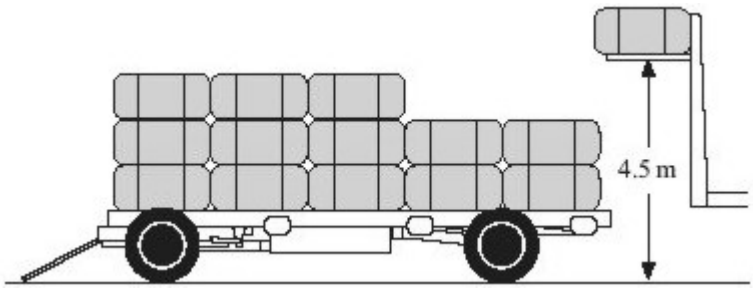
The first one has been done for you.

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

(Total 2 marks)

42 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)

43 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.

.....

.....

.....

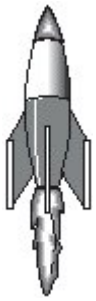
.....

.....

Force = ... N

(Total 3 marks)

44 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.

.....

.....

.....

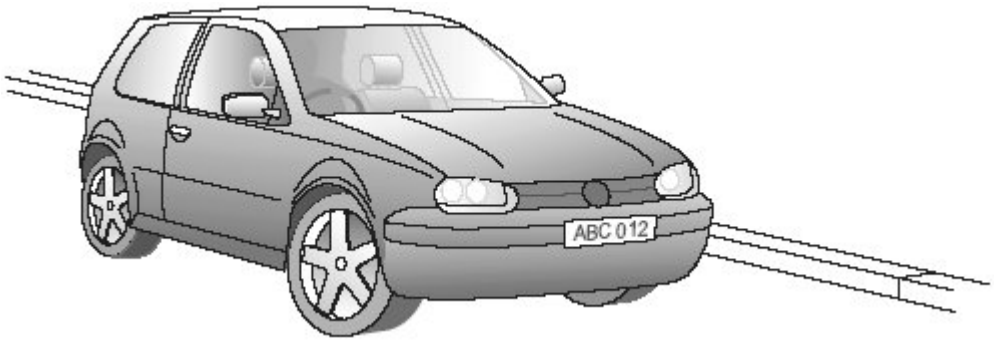
.....

.....

Kinetic energy = ... kJ

(Total 3 marks)

45 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.

.....

.....

.....

.....

.....

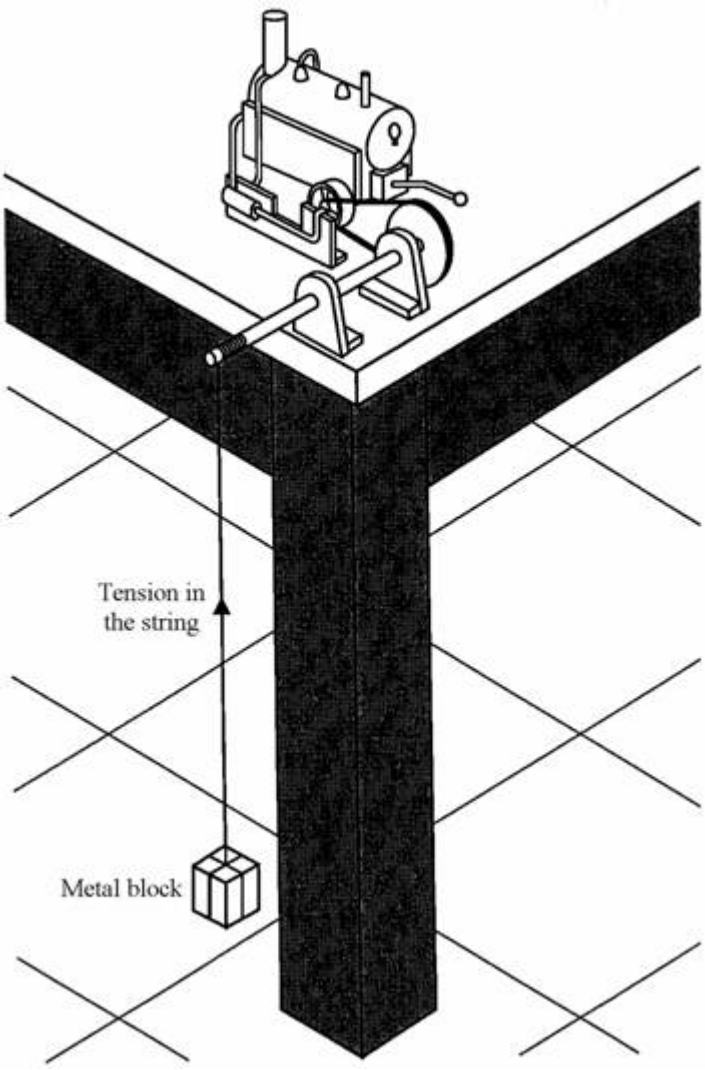
.....

.....

Mass of the car = ...

(Total 5 marks)

46 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)

47 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.

.....

.....

.....

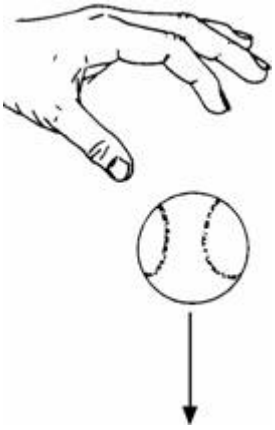
.....

.....

.....

(3)
(Total 10 marks)

48 Complete the following sentences.



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

This happens because the ..... pulls the ball

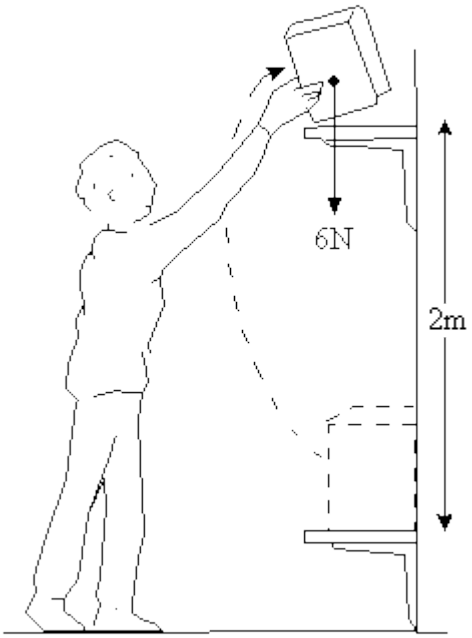
towards it with a force called ..... .

Forces are measured in units called ..... .

(Total 3 marks)

49 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 9.8m/s².

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.

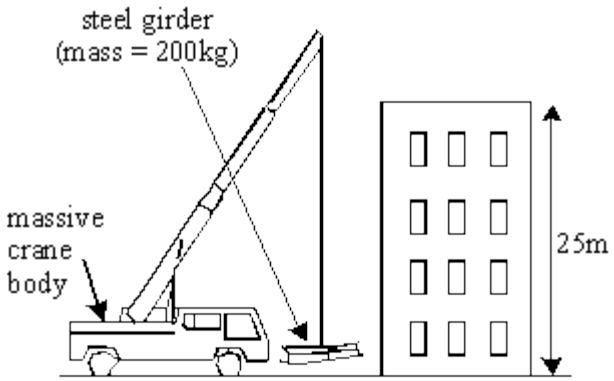
.....

.....

.....

(3)
(Total 9 marks)

50 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)

51 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.)

.....

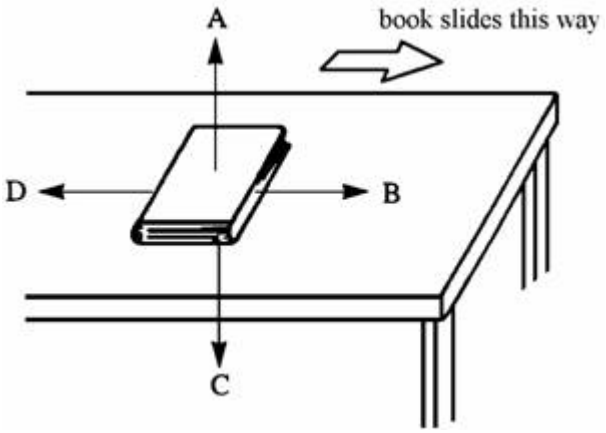
.....

.....

.....

(4)
(Total 10 marks)

52 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? .....

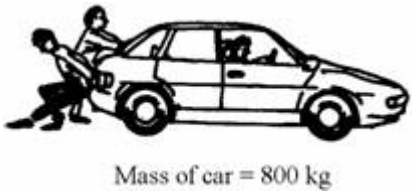
(1)

(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)

53 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.)

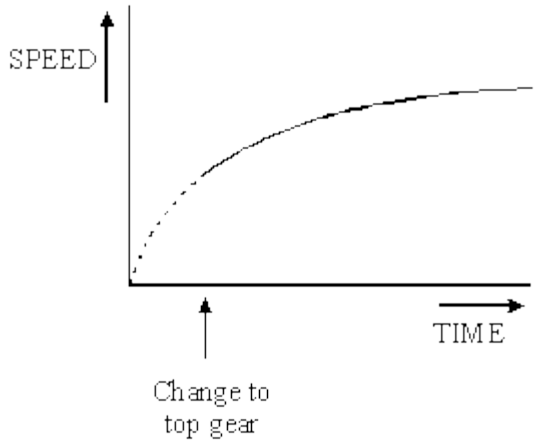
.....

.....

(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)

54 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)

55 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)

56 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)

1

(a) D

1

(b) C

1

(c) W = 300 × 45

1

W = 13 500

1

*allow 13 500 with no working shown for **2** marks*

(d) straight line drawn from 13 m / s to 0 m / s

1

finishing on x-axis at 65 s

1

[6]

2

(a) (i) 100 (m)

1

(ii) stationary

1

(iii) accelerating

1

(iv) tangent drawn at *t* = 45 s

1

attempt to determine slope

1

speed in the range 3.2 – 4.2 (m / s)

dependent on 1st marking point

1

(b) (i) 500 000 (J)

ignore negative sign

1

(ii) 20 000 (N)

ignore negative sign

*allow **1** mark for correct substitution, ie*

500 000 = F × 25

***or** their part (b)(i) = F × 25*

provided no subsequent step

2

(iii) *(kinetic) energy* transferred by heating

1

to the brakes

ignore references to sound energy

*if no other marks scored allow k.e. decreases for **1** mark*

1

[11]

3 (a) 450

*allow **1** mark for correct substitution,*

ie 18 × 10 × 2.5 provided no subsequent step shown

2

(b) (i) friction between child ('s clothing) and slide

accept friction between two insulators

accept child rubs against the slide

accept when two insulators rub (together)

1

causes electron / charge transfer (between child and slide)

accept specific reference, eg electrons move onto / off the child / slide

reference to positive electrons / protons / positive charge / atoms transfer negates this mark

answers in terms of the slide being initially charged score zero

1

(ii) all the charges (on the hair) are the same (polarity)

accept (all) the charge/hair is negative / positive

accept it is positive/negative

1

charges / hairs are repelling

both parts should be marked together

1

(iii) charge would pass through the metal (to earth)

accept metal is a conductor

accept metal is not an insulator

accept there is no charge / electron transfer

accept the slide is earthed

accept metals contain free electrons

1

[7]

4 (a) (i) friction

1

(ii) air resistance

accept drag

friction is insufficient

1

(iii) Marks awarded for this answer will be determined by the Quality of Written Communication (QWC) as well as the standard of the scientific response. Examiners should also refer to the information on page 5, and apply a 'best-fit' approach to the marking.

0 marks
No relevant content.

Level 1 (1–2 marks)
There is an attempt to explain in terms of forces A and B why the velocity of the cyclist changes between any two points
or
a description of how the velocity changes between any two points.

Level 2 (3–4 marks)
There is an explanation in terms of forces A and B of how the velocity changes between X and Y and between Y and Z
or
a complete description of how the velocity changes from X to Z.
or
an explanation and description of velocity change for either X to Y or Y to Z

Level 3 (5–6 marks)
There is a clear explanation in terms of forces A and B of how the velocity changes between X and Z
and
a description of the change in velocity between X and Z.

examples of the points made in the response

extra information

X to Y

- at X force A is greater than force B
- cyclist accelerates
- and velocity increases
- as cyclist moves toward Y, force B (air resistance) increases (with increasing velocity)
- resultant force decreases
- cyclist continues to accelerate but at a smaller value
- so velocity continues to increase but at a lower rate

Y to Z

- from Y to Z force B (air resistance) increases
- acceleration decreases
- force B becomes equal to force A
- resultant force is now zero
- acceleration becomes zero

- velocity increases until…
- cyclist travels at constant / terminal velocity

accept speed for velocity throughout

6

(b) (i) 3360

*allow **1** mark for correct substitution,*

ie 140 × 24 provided no subsequent step

*accept 3400 for **2** marks if correct substitution is shown*

2

joule / J

*do **not** accept j*

*do **not** accept Nm*

1

(ii) decreases

accept an alternative word / description for decrease

do not accept slows down

1

temperature

accept thermal energy

accept heat

1

[13]

5 (a) (i) gravitational potential (energy)

1

(ii) kinetic (energy)

1

(b) (i) slope or gradient

1

(ii) area (under graph)

*do **not** accept region*

1

(iii) starts at same y−intercept

1

steeper slope than original and cuts time axis before original

the entire line must be below the given line

allow curve

1

(c) (i) 31

and

31

*correct answers to 2 significant figures gains **3** marks even if no working shown*

*both values to more than 2 significant figures gains **2** marks:*
30.952……
30.769….

65 / 2.1 and / or
*80 / 2.6 gains **1** mark*

*if incorrect answers given but if both are to 2 significant figures allow **1** mark*

3

(ii) student 1 incorrect because 80 ≠ 65

1

student 2 correct because average velocities similar

*ecf from **(c)(i)***

1

student 3 incorrect because times are different

1

[12]

6

(a) potential

1

(b) (i) 13 200

*allow **1** mark for correct substitution, ie 660 × 20 provided no subsequent step shown*

2

(ii) 16.5

allow 1 mark for correct

or

$\frac{\text{their (b)(i)}}{800}$ correctly calculated

substitution, ie $\frac{13\,200}{800}$ ***or*** $\frac{\text{their (b)(i)}}{800}$

provided no subsequent step shown

2

[5]

7

(a) (i) distance vehicle travels during driver's reaction time

accept distance vehicle travels while driver reacts

1

(ii) any **two** from:

- tiredness
- (drinking) alcohol
- (taking) drugs
- speed
- age

accept as an alternative factor distractions, eg using a mobile phone

2

(b) (i) 320 000

*allow **1** mark for correct substitution, ie* $\frac{1}{2} \times 1600 \times 20^2$ *provided no subsequent step shown*

2

(ii) 320000 **or** their (b)(i)

1

(iii) 40

or

$\frac{\text{their (b)(ii)}}{8000}$ correctly calculated

*allow **1** mark for statement work done = KE lost*

or

*allow **1** mark for correct substitution, ie*
*8000 × distance = 320 000 **or** their (b)(ii)*

2

(iv) any **one** from:

- icy / wet roads

  accept weather conditions
- (worn) tyres
- road surface
- mass (of car and passengers)

  accept number of passengers
- (efficiency / condition of the) brakes

1

(v) (work done by) friction
(between brakes and wheel)

*do **not** accept friction between road and tyres / wheels*

1

(causes) decrease in KE and increase in thermal energy

accept heat for thermal energy accept
KE transferred to thermal energy

1

(c) the battery needs recharging less often

accept car for battery

1

or
increases the range of the car

*accept less demand for other fuels **or** lower emissions **or** lower fuel costs*
environmentally friendly is insufficient

as the efficiency of the car is increased

accept it is energy efficient

1

the decrease in (kinetic) energy / work done charges the battery (up)

accept because not all work done / (kinetic) energy is wasted

1

[14]

8 (a) gravitational / gravity / weight

*do **not** accept gravitational potential*

1

(b) accelerating

accept speed / velocity increases

1

the distance between the drops increases

1

but the time between the drops is the same

accept the time between drops is (always) 5 seconds
accept the drops fall at the same rate

1

(c) (i) any **one** from:

- speed / velocity
- (condition of) brakes / road surface / tyres
- weather (conditions)

accept specific examples, eg wet / icy roads

accept mass / weight of car friction is insufficient

reference to any factor affecting thinking distance negates this answer

1

(ii) 75 000

*allow **1** mark for correct substitution, ie 3000 × 25 provided no subsequent step shown*

***or** allow **1** mark for an answer 75*
***or** allow **2** marks for*
75 k(+ incorrect unit), eg 75 kN

2

joules / J

*do **not** accept j*

*an answer 75 kJ gains **3** marks*

for full marks the unit and numerical answer must be consistent

1

[8]

9 (a) 1800 (N)

*allow **1** mark for correct substitution ie 180 × 10 provided no further steps shown*

2

(b) 3780
or
their (a) × 2.1 correctly calculated

*allow **1** mark for correct substitution*

*ie 1800 **or** their (a) × 2.1 provided no further steps shown*

2

joule

accept J

accept any clear indication of correct answer

1

(c) 0

reason does not score if 0 not chosen

1

work is only done when a force makes an object move

accept distance moved is zero

accept no energy transfer (to the bar)

accept the bar is not moving/is stationary

'it' refers to the bar/weights

1

[7]

10 (a) (i) 24

*allow **1** mark for converting time to 600 seconds*

***or** showing method ie 14400/10*

or $\frac{14400}{10 \times 60}$

provided no further steps shown

2

(ii) 24

ignore any unit

or

their (a)(i)

1

(b) (i) 20 45

***both** required – either order*

1

(ii) the block transfers energy to the surroundings

1

[5]

11 (a) 98

*allow **1** mark for correct substitution*

ie ½ × 0.16 × 35 × 35 provided no subsequent step shown

an answer of 98 000 scores 0

2

(b) (i) 9.6

*allow **1** mark for (change in velocity =) 60*

ignore negative sign

2

(ii) 9600

ignore negative sign

or

their (b)(i) ÷ 0.001 correctly calculated, unless (b) (i) equals 0

1

(c) increases the time

1

to reduce/change momentum (to zero)

only scores if 1st mark scored

decreases rate of change of momentum scores both marks provided there are no contradictions

accept decreased acceleration/deceleration

equations on their own are insufficient

1

[7]

12 (a) (i) horizontal arrow pointing to the left

judge by eye

drawn anywhere on the diagram

1

(ii) 60 (N)

1

(at steady speed) resultant force must be zero

accept forces must balance/are equal

accept no acceleration

*do **not** accept constant speed*

1

(b) 1680

*allow **1** mark for correct substitution, ie 60 x 28 provided no subsequent step shown*

2

joule

accept J
do not accept j

1

[6]

13 (a) (i) 720

*allow **1** mark for correct substitution,*

ie 72 × 10 provided no subsequent step shown

2

(ii) 720
or
their (a)(i)

1

(b) (i) gravitational potential

allow gravitational

allow potential

1

(ii) 432

*allow **1** mark for correct substitution, ie* $\frac{21600}{50}$ *provided no subsequent step shown*

2

watt / W

1

[7]

14 (a) (i) (connect) 30 (cells)

1

in series

1

(ii) current always flows in the same direction

or

current only flows one way

1

(iii) 36 000

*allow **1** mark for correctly converting 2 hours to 7200 seconds*

*answers 10 or 600 score **1** mark*

2

coulombs / C

*do **not** accept c*

1

(b) (i) 2160

*allow **1** mark for correct substitution, ie ½ × 120 × 6^2*

*answers of 1620 or 540 score **1** mark*

2

(ii) reduce it

1

any **one** from:

- draws a larger current (from battery)
- motor draws greater power (from battery)

  accept energy per second for power

  accept more energy needed to move the bicycle
- greater resistance force (to motion) / air resistance / drag / friction

  accept less streamlined

  more mass to carry is insufficient

1

[10]

15 (a) 572

*allow **1** mark for correct substitution,*

ie 220 × 2.6

*allow **1** mark for*

220 × 260 = 57 200

or

220 × 2600 = 572 000

but to score this mark the entire calculation must be shown

2

(b) (i) smooth curve drawn

accept a line that is extrapolated back to 0 degrees, but not through the origin

accept a straight line of best fit (point at 40 degrees can be treated as anomalous and line may stop at 30 degrees)

*do **not** accept straight lines drawn 'dot to dot' or directly from first to last point or a line going through the origin*

1

(ii) increases

accept a positive correlation

*do **not** accept proportional*

1

(iii) long plank

no mark for this, the marks are for the explanation

makes the angle small(er) (than a short plank)

accept increases the distance

accept small(er) slope

1

a small(er) force is needed
or
short plank

no mark for this, the marks are for the explanation

a large(r) force is used over a short(er) distance (1)

less work done (1)

accept less energy transfer

1

[6]

16 (a) (i) 75 000

*accept correct substitution for **1** mark*
ie 7500 × 10

2

newtons / N

*do **not** accept n*
*full credit for using g = 9.8 **or** 9.81*

1

(ii) 60 000 000

accept for both marks
their (a)(i) × 800 correctly calculated
*accept correct substitution for **1** mark*
ie their (a)(i) × 800

2

(b) (i) arrow drawn parallel (to) **and** down (the) slope

accept arrow drawn anywhere on the diagram

1

(ii) increases

1

GPE transformed to KE
or
speed increasing

accept is accelerating
however 'speed increasing' only scores if correctly linked to increasing kinetic energy

1

(c) so more likely to wear one
or
they know wearing a helmet is likely to / will reduce (risk) head injury
or
so can make an (informed) choice (about wearing one)

1

[9]

17 (a) (i) 50 (N)

ignore any units

1

(ii) resultant force

1

(iii) 4000

*accept their (a)(i) × 80 correctly calculated for **2** marks*
*allow **1** mark for correct substitution i.e. 50 × 80 or their (a)(i) × 80*
ignore any units

2

(b) (i) joule

1

(ii) heat

1

[6]

18 (a) 47250

*answers of 1350/ 33750/ 48600 gain **1** mark*
*allow **1** mark for correct substitution using both 18 and 3*

2

(b) (i) 47250 or their (a)

accept statement 'same as the KE (lost)'
ignore any units

1

(ii) transformed into heat/ thermal energy

sound on its own is insufficient
accept transferred/ lost/ for transformed
*do **not** accept any other form of energy included as a list*

1

[4]

19 (a) (i) a single force that has the same effect as all the forces combined

accept all the forces added / the sum of the forces / overall force

1

(ii) constant speed (in a straight line)

*do **not** accept stationary*

or constant velocity

1

(b) 3

*allow **1** mark for correct substitution into transformed equation*
*accept answer 0.003 gains **1** mark*
*answer = 0.75 gains **1** mark*

2

m/s^2

1

(c) as speed increases air resistance increases

accept drag / friction for air resistance

1

reducing the resultant force

1

[7]

20 (a) concentration / tiredness / drugs / alcohol

accept any reasonable factor that could affect a driver's reactions
*do **not** accept speed or any physical condition unrelated to the driver*

1

(b) 31.25

*credit for **1** mark correct attempt to calculate the area under the slope **or** for using the equation*
distance = <u>average</u> velocity (speed) × time

*credit for **1** mark use of correct velocity change (12.5) <u>and</u> correct time (5) **or** answer of 62.5*

3

(c) 2.5

*credit for **1** mark triangle drawn on slope **or** correct equation **or** two correct pairs of coordinates*

credit for 1 mark use of correct velocity change (12.5) and correct time (5)
accept time = between 4.8 and 5.2 if used in (b)

do not accept an attempt using one pair of coordinates taken from the slope

3

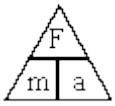
metres / second / second **or** metres / second / squared **or** m/s^2 **or** ms^{-2}

1

(d) (i) force = mass × acceleration

accept correct transformation

accept F = m × a

accept 

provided subsequent use of Δ is correct

*do **not** accept an equation in units*

1

(ii) 2250

credit their (c) × 900 for 2 marks

*credit **1** mark for correct substitution*

2

[11]

21

(a) (i) kinetic energy = $\frac{1}{2}$ × mass × $speed^2$

accept ke = $\frac{1}{2}$ mv^2

*do **not** accept KE = $\frac{1}{2}$ ms^2*

1

(ii) 13

allow 1 mark for correct substitution or transformation

2

(b)

*if B is at the top of the curve - **no** marks*

PE at A maximum
PE at B minimum
PE at C just less than **or** = to A

*do **not** accept wavy lines **or** very non-symmetrical*
accept straight lines or curves

1

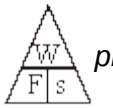
difference between A and B is 5000 to 5200

1

[5]

22 (a) (i) work (done) = force (applied) × distance (moved)

accept W = F × s or W = F × d

accept 

provided subsequent method is correct

1

(ii) 240 000

*allow **1** mark for correct substitution **or** correct use of 1200 (N)*

2

joules

accept J
*do **not** accept j / Nm*

1

(b) 800 (watts)

accept 0.8 kW
*accept their (a)(ii) ÷ 300 correctly evaluated for **2** marks*
*allow **1** mark for correct substitution*
*(a)(ii) ÷ 5 correctly evaluated for **1** mark*

2

(c) (i) any **one** from:

- needs to raise the chair / lift
- lifting more than one chair

  allow lifting more than 2 people
  implication of a heavier weight
- energy transfer to the surroundings

  correctly qualified

  accept loss for transfer

  *do **not** accept motor inefficient*

  *do **not** accept motor gets hot*

  *do **not** accept friction unless the location is specified as external to the motor*

1

(ii) electrical

accept electric

potential

***both** answers required for the mark*

1

[8]

23 (a) (i) gpe = weight × height

accept Ep = mgh
accept pe= mgh

1

(ii) 1200

accept values using 9.8 (1)
*allow **1** mark for correct substitution*

2

(b) (i) 120

accept $\frac{\text{their (a)(ii)} \times 6}{60}$

1

(ii) 300

allow b(i) ÷ 0.4 for both marks
*allow **1** mark for correct transformation*

2

[6]

24

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

accept velocity for speed

accept KE = $\frac{1}{2} mv^2$

1

(ii) 32 000

accept 32 kJ

1

[2]

25

(a) (i) gravitational potential

accept gravitational
accept potential

1

(ii) 2250 (N)

1

forces must be balanced
or
forces are equal and opposite

*do **not** accept because it is not moving*
*do **not** accept 'equilibrium' by itself*
*do **not** accept 'it is not balanced'*
*do **not** accept 'forces are equal'*
*do **not** accept 'forces are the same'*

1

(b) 1500

***1** mark for correct substitution*

2

[5]

26 (a) (i) linear scales used

do not credit if less than half paper used

1

points plotted correctly

all of paper used

1

(straight) line of best fit drawn

allow a tolerance of ± half square

1

(ii) correct **and** straight line through origin

***all** needed*

e.c.f. if their (a)(i) is straight but not through the origin - incorrect because line does not go through origin

credit a calculation that shows proportionality

1

(iii) 62 ± 0.5 (m)

*credit **1** mark for KE = 490000 **or** 490kJ*

*credit **1** mark for correct use of graph clearly shown*

2

(iv) any **one** from: wet **or** icy **or** worn **or** smooth road

accept slippery slope

brakes worn

accept faulty brakes

car heavily loaded
worn tyres
downhill slope

do not accept anything to do with thinking distance e.g. driver tired or drunk

1

(b) (i) acceleration = $\frac{\text{change in velocity}}{\text{time taken}}$

accept correct transformation

accept $\frac{v-u}{t}=a$

accept m/s^2 = $\frac{m/s}{s}$

*do **not** accept acceleration* = $\frac{velocity}{time}$

1

(ii) 56

accept –56

1

(iii) deceleration is reduced

accept deceleration is slower

accept acceleration

1

force on car and or passengers is reduced

accept an answer in terms of change in momentum for full credit

1

[11]

27 (a) potential; bucket/pulley

for 1 mark each

2

(b) 300

gains 2 marks

else working

gains 1 mark

2

[4]

28

(a) (i) B unless unqualified

for 1 mark

1

(ii) B unless unqualified

for 1 mark

1

(iii) energy lost, doing work against air resistance/friction

for 1 mark

1

(b) intensity of gravity less (not zero)

for 1 mark

energies/restoring forces less

for 1 mark

2

[5]

29

(a) 3

gains 1 mark

m/s^2

gains 1 mark

else working *gains 1 mark*

2

(b) 2850 ecf

gains 1 mark

N

gains 1 mark

else working

gains 1 mark

2

(c) friction/air resistance increases with speed;
till frictional = max forward force;
then force/acceleration is zero

for 1 mark each

alternative limitation for safety

gains 1 mark only

3

[7]

30 (a) 100

gains 2 marks

else working

gains 1 mark

2

(b) 100 ecf

for 1 mark

1

(c) rounds to 14 (accept 14.142 or 14.14) ecf

gains 3 marks

else working to $v^2 = 200$

gains 2 marks

else initial working v = 200

gains 1 mark

3

[6]

31 (a) 20 m/s

gets 2 marks

Else working

gets 1 mark

2

(b) 10 m/s

1

(c) 20 m

gets 2 marks

Else working

gets 1 mark

2

(d) 12 000 N

gets 2 marks

Else working

gets 1 mark

2

(e) 2 400 000 J

gets 2 marks

Else working

gets 1 mark

2

(f) (i) Ans to (e)

1

(ii) Ans to (e)/60
Else working

2

(iii) Ans to (ii)/5

1

[13]

32 (a) $k = 1/2mv^2$
$k = 1/2.1.2.109.202$
$k = 2.4.1011$

for one mark each

3

(b) (i) 0.6.109

(ii) mass halved
speed halved
(speed)2 quartered
ke and/or power cut to one eight
for 1 mark each

5

[8]

33 (a) there is a (maximum) forward force
drag/friction/resistance (**opposes** motion) (**not** pressure)
increases with speed
till forward and backward forces equal
so no net force/acceleration
any 4 for 1 mark each

4

(b) (i) F = ma
10 000 = 1250a
a = 8
m/s^2
for 1 mark each

4

(ii) ke = 1/2 mv^2
ke = 1/2 1250.48^2
ke = 1 440 000
J
for 1 mark each

4

(iii) W = Fd
W = 10 000.144
W = 1 440 000
J
for 1 mark each

4

[16]

34 (a) AB
for 1 mark

1

(b) (i) 0.7

for 1 mark each

1

(ii) 16.8

gains 2 marks

2

but correct working
(d = v.t, d = 24 × 0.7, or in terms of area under graph)

gains 1 mark

1

(c) a = (v-u)/t
= 24/4
= 6
m/s^2

(see marking of calculations)

(can work in terms of graph gradient)

4

(d) d = v.t
= 24/2 × 4
= 48

(see marking of calculations)

(can work in terms of area under graph)

3

(e) F = ma
= 800 × 6
= 4800

(see marking of calculations)

3

[15]

35 (a) p = mgh
= 50 × 10 × 4 = 2000
J/Nm
(see marking of calculations)

4

(b) $k = ½ mv^2$
$= ½ × 50 × 8^2$
= 1600
J/Nm
(see marking of calculations)

4

(c) work is done against air resistance
fall of her C of G differs from rise in climbing stairs
part of gained pe used to rotate body
diver gains PE on take-off

any 2 for 1 mark each

2

[10]

36 (i) 700 or 686

gets 2

Else mg or 70 × 10 or 70 × 9.8 (1)

gets 1

2

(ii) 350J

gets 4

Else 350

gets 3

Else 700 × 0.5

gets 2

Else W = F.d.

gets 1

Any answer with unit J may score 1, 2 or 3 (see general instructions)

4

[6]

37 (a) product of mass and velocity

1

(b) (i) 4kg or 4000g

1

(ii) M = 8kgm/s or Ns

for 3 marks

else M = 8

for 2 marks

else M – mv or 4 × 2

for 1 mark

3

(iii) 8 kgm/s (watch e.c.f.)

1

(iv) v = 400

for 3 marks

else v = 8/0.02

for 2 marks

else M – mv, v – M/m or 8 = 0.02v

for 1 mark

3

(v) ke = 8

for 3 marks

else ke = 1/2 (4×2^2)

for 2 marks

else ke = 1/2 (mv^2)

for 1 mark

3

(vi) transferred to heat and sound
or does work against wood/pushing wood aside/deforming bullet

1

[13]

38 (a) W = 65 × 10
(*allow* a maximum of 3 marks if candidate uses g = 9.8N / Kg (as ecf))

gains 1 mark

but
W = 650 (N)
(*allow* use of p.e.= m × g × h)

gains 2 marks

but

PE change = 650 × 1.25 **or** 65 × 10 × 1.25

gains 3 marks

but

PE change = 812.5 (J) (*allow* 813J or 812J)

gains 4 marks

4

(b) k.e. = p.e.

gains 1 mark

but

(speed)² = 812.5 × 2 / 65 **or** 812.5 = ½ × 65 × (speed)² ecf

gains 2 marks

but

speed = 5 (m/s) (*allow* 4.99 → 5.002)

(if answer = 25mls check working: 812.5 = ½ m × v gains 1 mark for KE = PE)

(but if 812.5 = ½m × v² = ½ × 65 × v² or $v^2 = \frac{2 \times 812.5}{65}$ gains 2 marks)

25, with no working shown gains 0 marks

gains 3 marks

3

[7]

39 (a) mass

1

(b) work (done) = force (applied) × distance (moved in the direction of the force)

*do **not** accept correctly substituted figures for this equation mark*
*accept W = Fs **or** W = Fd **or** W = Fh (well done) = force × height)*
mark formula independently

1

1 000 000 × 15

allow 1 000 000 × $\frac{15}{1000}$

1

= 15 000 000

= 15 000

1

J / joules

KJ / kilojoules

1

allow 1 000 000 × 1500

= 15 00 000 000 for 1 mark only – no unit mark

allow 3 marks for correct answer if no working / correct working is shown

(c) **Quality of written communication**

The answer to this question requires ideas in good English, in a sensible order with correct use of scientific terms. Quality of written communication should be considered in crediting points in the mark scheme

Max.4 if ideas not well expressed

A – **B** not moving

*accept stationary **or** at rest*

1

B - C acceleration **or C** – **D** acceleration

accept increases speed / velocity accept gets faster

1

comparison made that the acceleration **B – C** is less than **C** – **D**

*accept comparison made that the acceleration **C-D** is greater than **B-C***

1

D – E constant velocity

*accept steady speed **or** at 0.4 m/s*

1

E – **F** deceleration

accept decreases speed / velocity accept gets slower

1

[10]

40 (a) the greater the mass / weight

1

then the greater the kinetic energy

accept the greater the momentum
accept greater mass / weight therefore greater force = 2

1

(b) (i)

Note: this calculation requires candidates to show clearly how they work out their answer

k.e. $\frac{1}{2}$ mv^2

accept evidence of equation

1

86 400 (J) at 12 m/s

accept ½ × 1200 × 12^2 ***or*** *86.4 KJ*

1

194 400 (J) at 18 m/s

accept ½ × 1200 × 18^2 ***or*** *194.4KJ*

1

increase in k.e. = 108 000
NB 10800 = 0 marks

N.B. if no working at all then max 3 for a correct numerical answer

1

joules **or J**

accept 108 kilojoules ***or*** *kJ*

1

(ii) explanation that ke $\propto$ v^2

1

[8]

41 newton **or** N

metre **or** m

joules **or** J

all three correct 2 marks
two or one correct 1 mark

[2]

42 8550

correct answer with no working = 3
if incorrect, allow 1 mark for work = force / weight × distance, 2 marks for = 1900 × 4.5

N.B. correct answer from the incorrectly recalled relationship mass × distance = 2 marks

[3]

43 12 100

correct answer with no working = 3
if answer incorrect, allow 1 mark for force = mass × acceleration
1210 × 10 = 2 force / weight = mass × gravity is neutral

N.B. no marks for correct answers with incorrectly recalled relationship

[3]

44 900 000

correct with no working = 3 if answer incorrect, allow:

1 mark for K.E. $= \frac{1}{2} \times mass \times speed^2$

2 marks for $\frac{1}{2} \times 5000 \times 600^2$

N.B. correct answer with the incorrectly recalled relationship

$\frac{1}{2} \times weight \times speed^2 = 2$ *marks*

[3]

45 1050

4

kg

if answer incorrect then kinetic energy $= \frac{1}{2} mv^2$ *or*
accept indication by correct substitution for 1 mark
accept 900 for 1 mark

accept $m = \frac{2KE}{v^2}$ *or indication by correct substitution for 1 mark*

1

[5]

46 (a) **either**
gravity

1

due to mass of the Earth

or
(the) interaction / attraction between the (1)

mass of the block
and the mass of the Earth (1)

1

(b) (i) 4.5 N

unit required accept equal to weight (lifted)
do not credit ..mass..

1

(ii) the forces are balanced

accept because the block is not accelerating

accept because the block is moving at a steady speed (in a straight line) accept because the block's velocity is constant

1

(c) (i) **either**

4.05 J

3

or

work (done)
= force (applied)
× distance (moved in the direction of the force)

***or** work =4.5 ×0.9*
note '= 4.5 × 0.9' is not an equation

1

= 4.05

1

joules **or** J **or** newton metres

405 J will be a common answer
it gets (1) (for the unit) if correct equation is not shown but (2) otherwise

*4.5 ÷ 0.9, **or** variations on this theme, get (1) (for the unit) at most*

1

(ii) 4.05 J

***or** same as the answer to (c) (i) provided that the same unit for energy is shown in both cases*

1

(d) 4.16

accept 4, 4.2, 4.17, 4.16

1

[10]

47 (a) (i) work = force × distance

or *any correctly transposed version e.g.*

$$force = \frac{work}{distance}$$

or *in correct units throughout e.g.*

$J = N \times m$

or *in acceptable abbreviations e.g.*

$W = f \times d$

do not credit $W = Nm$ ***or*** *any other*

ambiguous ***or*** *unclear response*

do not credit

unless subsequent calculation shows understanding

1

(ii) **EITHER**

3.7 (m)

2

OR

(distance =) $\frac{2000}{540}$

1

(iii) 2000 J

unit required

1

(b) **EITHER**

20

3

OR

speed ^{2} = 600 ÷ 1.5

or $speed^2 = 600 \times \frac{2}{3}$

or $speed^2 = 400$

or $speed^2 = KE \div \frac{1}{2} mass$

1

metres per second

or *m/s*

1

(c) any **three** from

deceleration (would be) (very) great

or rate of change of speed / velocity would be (very) great

(because) F = ma

or (because) force is proportional to deceleration / (negative) acceleration

(so the) force (on Susan / the rope) would be (very) great

do not credit she would be hurt

do not credit just the rope could snap

the rope may exceed its elastic limit

3

[10]

48 (centre of the) Earth [not ground]
gravity
newtons (allow N)

each for 1 mark

[3]

49 (a) WD = force × distance **or** 6 × 2

gains 1 mark

but 12 *gains 2 marks*
units J/joules [credit Nn]

for 1 mark

3

(b) 0.6 (i.e. using the **recalled** 10N/kg)

gains 1 mark

but evidence of force = mass × acceleration
or of correct substitution e.g. 6/9.8

gains 2 marks

but 0.61 (2...)

gains 3 marks

3

(c) *any reference to*
initial acceleration due to gravity
(force due to) friction/air resistance
each for 1 mark

ideas that
this increases as speed increases
forces eventually balance
each for 1 further mark

9

[9]

50

(a) **evidence of* acceleration = $\frac{\text{change in speed}}{\text{time}}$ or $\frac{0.6}{3}$
gains 1 mark

but 0.2
gains 2 marks

units m/s^2
for 1 mark

3

(b) (i) 2000 **or** 1960
for 1 mark

1

(ii) *evidence of* power = $\frac{\text{work done}}{\text{time taken}}$ **or** weight × speed (*credit figures)*/ $\frac{25}{0.6}$

(iii) $\frac{25}{0.6}$
gains 1 mark

but 1200/1176 **or** *figure consistent with (b)(i)*
gains 2 marks

2

(c) *evidence of* force = mass × acceleration **or** 200 × 0.3

gains 1 mark

but 60

gains 2 marks

but 60 + weight of girder (2060/2020*) *(or figure consistent with (b)(i))*

gains 3 marks

3

[9]

51 (a) *any evidence of:* momentum = mass × velocity (words, symbols or numbers) appropriate re-arrangement mass as 0.05kg

each gains 1 mark

but 800

gains 4 marks

4

(b) (i) *any reference to* friction with air/air resistance

gains 1 mark

but *idea that* friction with air/air resistance is high (at high speed)

gains 2 marks

2

(ii) *any evidence of:* k.e. $\propto v^2$ **or** k.e. = ½ mv^2

$\frac{\text{final k.e.}}{\text{initial k.e.}}$

either initial or final k.e. correctly calculated (i.e. 16000; 10240)

each gains 1 mark

but $(0.8)^2$

gains 3 marks

but 64%(credit 0.64)

gains 4 marks (also credit e.c.f)

4

[10]

52

(a) D

for 1 mark

1

(b) wear it away **or** make it warmer

for 1 mark do not accept 'stops it'

1

[2]

53

(a) *evidence of* $\frac{\text{change in speed}}{\text{time taken}}$ or $\frac{3}{12}$

gains 1 mark

but 0.25 **or** ¼

gains 2 marks

2

(b) *evidence of* $\frac{\text{work done}}{\text{time taken}}$ or $\frac{2400}{12}$

gains 1 mark

but 200

gains 2 marks

2

(c) *idea that*

second car has a bigger mass
(allow bigger weight/heavier)

gains 1 mark

but
second car has 1.5 times bigger mass
or
second car has mass of 1200 kg

gains 2 marks

2

(d) friction/resistance increases with speed

gains 1 marks

but

friction with/resistance of <u>air</u> increases with speed

gains 2 marks

- increase in speed because driving force greater than friction
- steady speed when friction = driving force

or

increases in speed until friction = driving force

each for 1 further mark to maximum of 3

3

[9]

54 (a) work done = force × distance **or** 250 × 5 **NB** *if formula given must be correct*

gains 1 mark

but

1250

gains 2 marks

[In this and similar examples, a correct answer only gets full marks.

From an incorrect formula, do not allow marks for 'error carried forward'

2

(b)
- (mainly) (transferred as) it is kinetic / movement <u>energy</u> (not 'mechanical')
- (some) lost / wasted / transferred as heat / sound

[Answers must refer to 'energy'. Do not allow 'it drives the bike']

or

used to overcome friction / air resistance

each for 1 mark

2

[4]

55 (a) [NB e.c.f not allowed from incorrect formula]
work done = force × distance or 250 × 5

gains 1 mark

but
1250

gains 2 marks

2

(b) • (mainly) transferred as kinetic / movement energy
[not makes bike move]

• (some) lost / wasted / transferred as heat / sound
or
used to overcome friction / air resistance

each · for 1 mark

2

[4]

56 (a) force distance (*either way round*)
energy

for 1 mark each

3

(b) joules

for 1 mark

1

[4]