Q1. 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.

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(2)

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

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

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(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.

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.....

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?

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Give a reason for your answer.

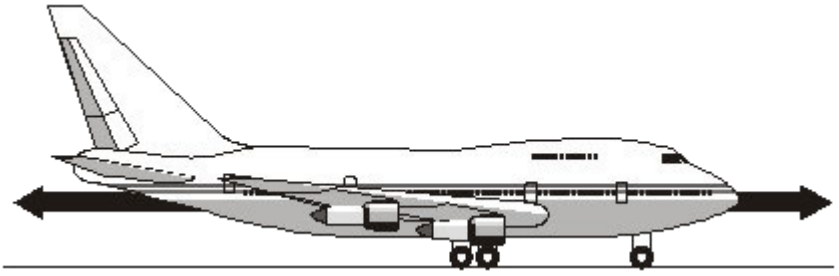
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(2)

(Total 10 marks)

Q2. (a) The diagram shows an aircraft and the horizontal forces acting on it as it moves along a runway. The *resultant force* on the aircraft is zero.



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

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.....

(1)

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

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(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.

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Acceleration = ...

(3)

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

Explain why.

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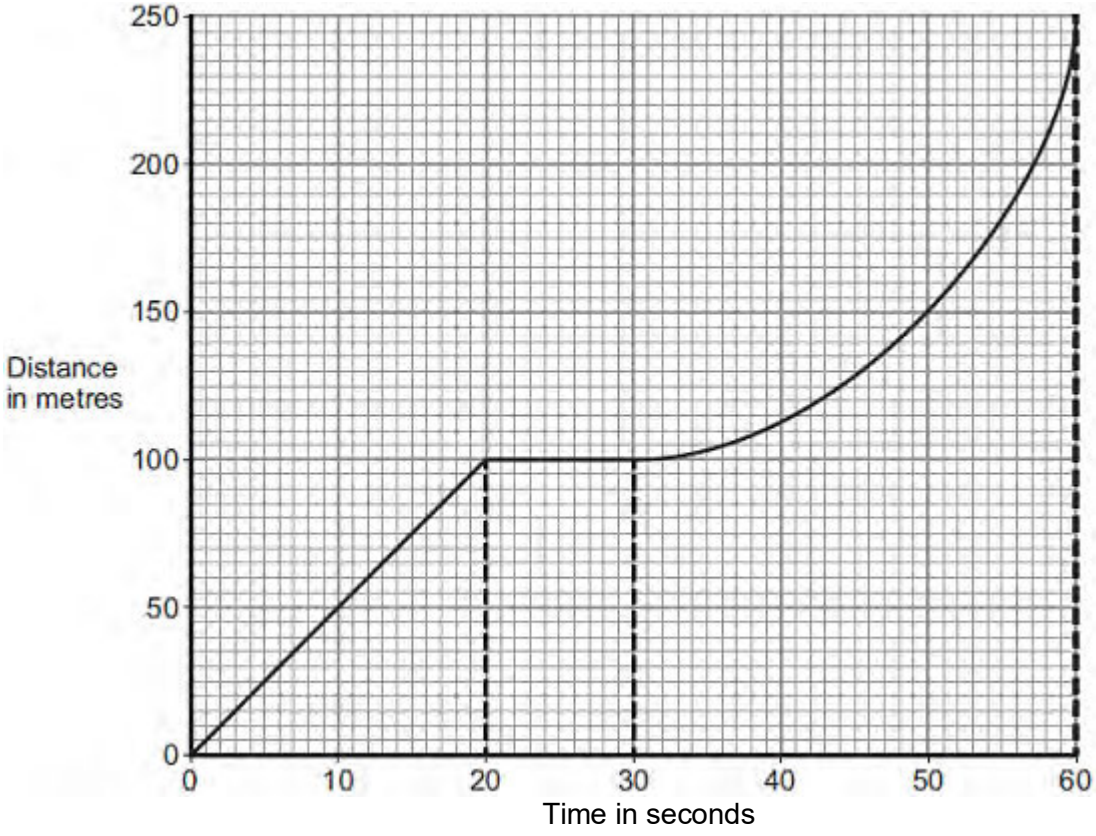
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(2)
(Total 7 marks)

Q3.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.

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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.

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Force = ... N

(2)

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

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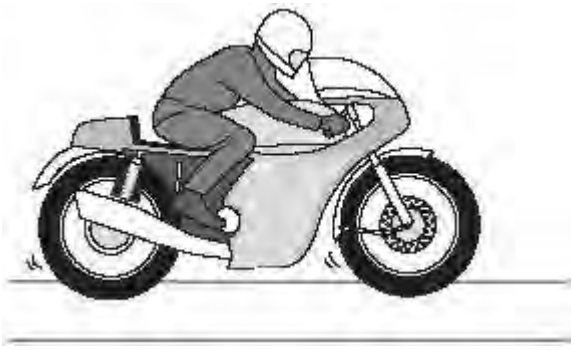
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(2)
(Total 11 marks)

Q4. 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.

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Kinetic energy lost = ... J

(2)

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

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(1)

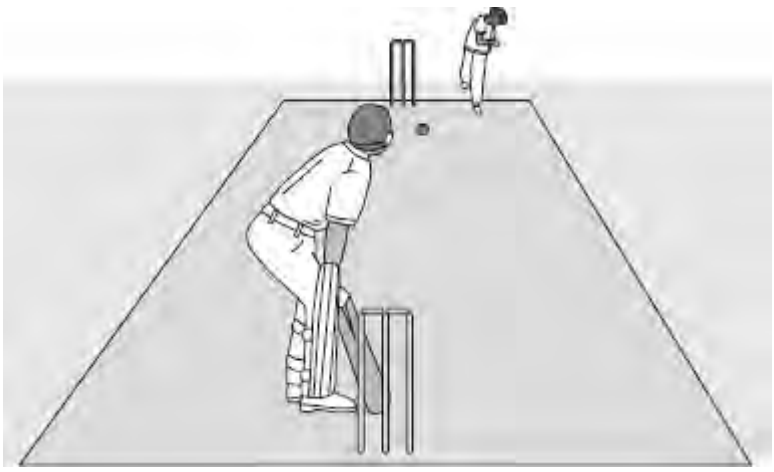
(ii) What happens to the kinetic energy lost by the motorbike?

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(1)

(Total 4 marks)

Q5. 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.

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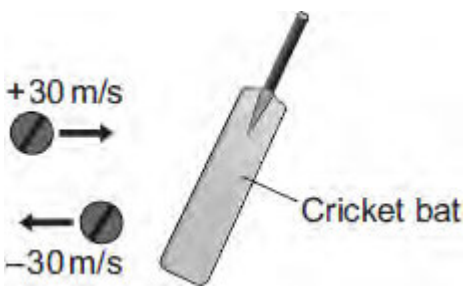
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Kinetic energy = ... J

(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.

.....

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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.

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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.

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(2)

(Total 7 marks)

Q6.(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*?

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(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.

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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.

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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.

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(1)

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

Explain why.

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(2)

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

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

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(3)
(Total 14 marks)