**Q1.** The stopping distance of a car is the sum of the thinking distance and the braking distance.

The table below shows how the thinking distance and braking distance vary with speed.

| Speed in m / s | Thinking distance in m | Braking distance in m |
|---|---|---|
| 10 | 6 | 6.0 |
| 15 | 9 | 13.5 |
| 20 | 12 | 24.0 |
| 25 | 15 | 37.5 |
| 30 | 18 | 54.0 |

(a) What is meant by the braking distance of a vehicle?

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**(1)**

(b) The data in the table above refers to a car in good mechanical condition driven by an alert driver.

Explain why the stopping distance of the car increases if the driver is very tired.

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**(2)**

(c) A student looks at the data in the table above and writes the following:

thinking distance $\propto$ speed

thinking distance ∝ speed

Explain whether the student is correct.

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**(2)**

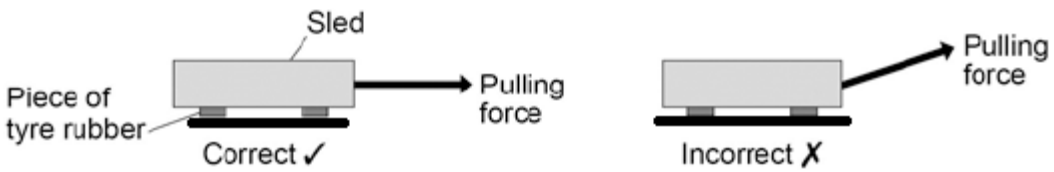
(d) Applying the brakes with too much force can cause a car to skid.

The distance a car skids before stopping depends on the friction between the road surface and the car tyres and also the speed of the car.

Friction can be investigated by pulling a device called a 'sled' across a surface at constant speed.

The figure below shows a sled being pulled correctly and incorrectly across a surface.

The constant of friction for the surface is calculated from the value of the force pulling the sled and the weight of the sled.




Why is it important that the sled is pulled at a constant speed?

Tick **one** box.

If the sled accelerates it will be difficult to control. ☐

If the sled accelerates the value for the constant of friction will be wrong. ☐

If the sled accelerates the normal contact force will change. ☐

**(1)**

(e) If the sled is pulled at an angle to the surface the value calculated for the constant of

friction would not be appropriate.

Explain why.

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**(2)**

(f) By measuring the length of the skid marks, an accident investigator determines that the distance a car travelled between the brakes being applied and stopping was 22 m.

The investigator used a sled to determine the friction. The investigator then calculated that the car decelerated at 7.2 m / $s^2$.

Calculate the speed of the car just before the brakes were applied.

Give your answer to two significant figures.

Use the correct equation from the Physics Equation Sheet.

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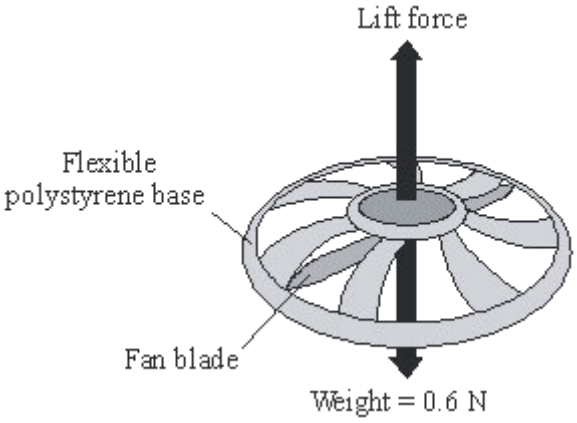
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Speed = ..... m / s

**(3)**

**(Total 11 marks)**

**Q2.** The diagram shows a small, radio-controlled, flying toy. A fan inside the toy pushes air downwards creating the lift force on the toy.




When the toy is hovering in mid-air, the fan is pushing 1.5 kg of air downwards every 10 seconds. Before the toy is switched on, the air is stationary.

(a) Use the equation in the box to calculate the velocity of the air when the toy is hovering.

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

Show clearly how you work out your answer.

.....

.....

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Velocity = ..... m/s

**(3)**

(b) Explain why the toy accelerates upwards when the fan rotates faster.

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**(2)**

(c) The toy is not easy to control so it often falls to the ground.

Explain how the flexible polystyrene base helps to protect the toy from being damaged when it crashes into the ground.

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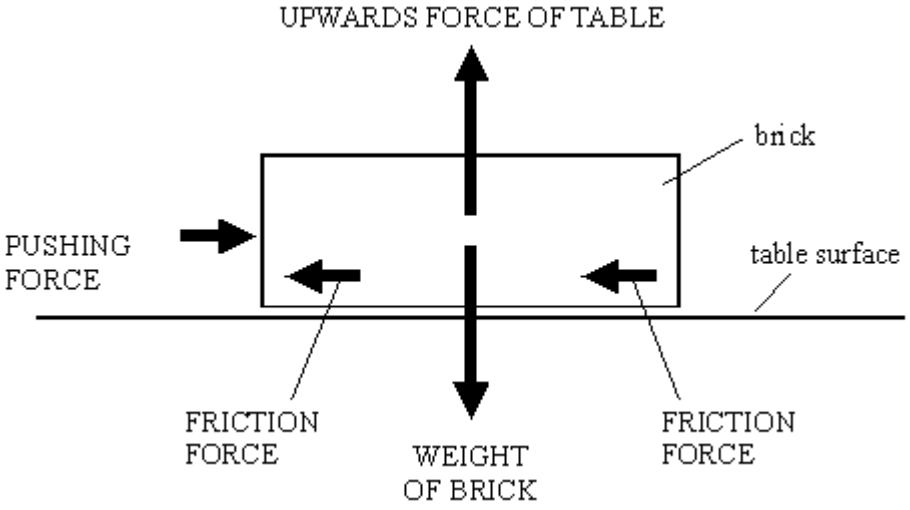
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**(3)**
**(Total 8 marks)**

**Q3.** The brick shown in the diagram is being pushed but it is **not** moving.




(a) The pushing force does **not** make the brick move. Explain why.

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**(1)**

(b) The weight of the brick does **not** make it move downwards. Explain why.

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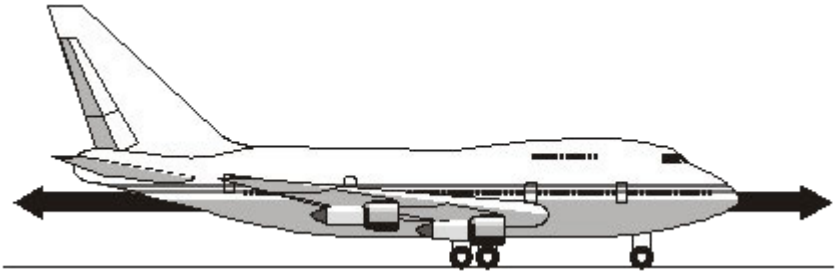
**(1)**

(c) A bigger pushing force **does** make the brick slide across the table.
Write down **one** thing that the sliding brick will do to the surface of the table.

.....

**(1)**
**(Total 3 marks)**

**Q4.** (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.

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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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**(2)**
**(Total 7 marks)**

**Q5.**When two objects interact, they exert forces on each other.

(a) Which statement about the forces is correct?

Tick (✓) **one** box.

| | **Tick (✓)** |
|---|---|
| The forces are equal in size and act in the same direction. | |
| The forces are unequal in size and act in the same direction. | |
| The forces are equal in size and act in opposite directions. | |
| The forces are unequal in size and act in opposite directions. | |

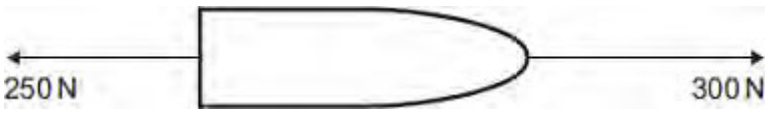
**(1)**

(b) A fisherman pulls a boat towards land.

The forces acting on the boat are shown in **Diagram 1**.

The fisherman exerts a force of 300 N on the boat.
The sea exerts a resistive force of 250 N on the boat.

**Diagram 1**




(i) Describe the motion of the boat.

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.....

.....

.....

**(2)**

(ii) When the boat reaches land, the resistive force increases to 300 N.
The fisherman continues to exert a force of 300 N.

Describe the motion of the boat.

Tick (✓) **one** box.

| | |
|---|---|
| Accelerating to the right | ☐ |
| Constant velocity to the right | ☐ |
| Stationary | ☐ |

**(1)**

(iii) Explain your answer to part **(b)(ii)**.

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**(2)**

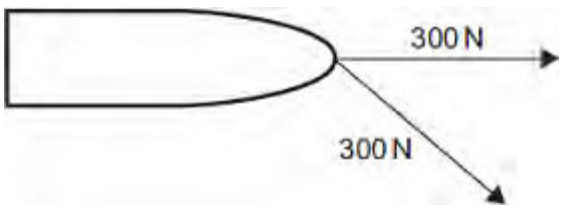
(iv) Another fisherman comes to help pull the boat. Each fisherman pulls with a force of 300 N, as shown in **Diagram 2**.

**Diagram 2** is drawn to scale.

Add to **Diagram 2** to show the single force that has the same effect as the two 300 N forces.

Determine the value of this resultant force.

**Diagram 2**

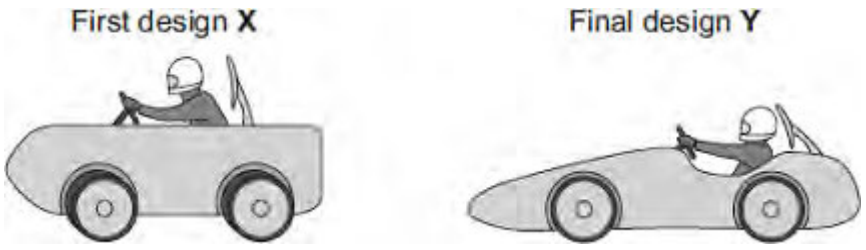



Resultant force = ..... N

**(4)**

**(Total 10 marks)**

**Q6.** (a) Some students have designed and built an electric-powered go-kart. After testing, the students decided to make changes to the design of their go-kart.




The go-kart always had the same mass and used the same motor.

The change in shape from the first design (**X**) to the final design (**Y**) will affect the top speed of the go-kart.

Explain why.

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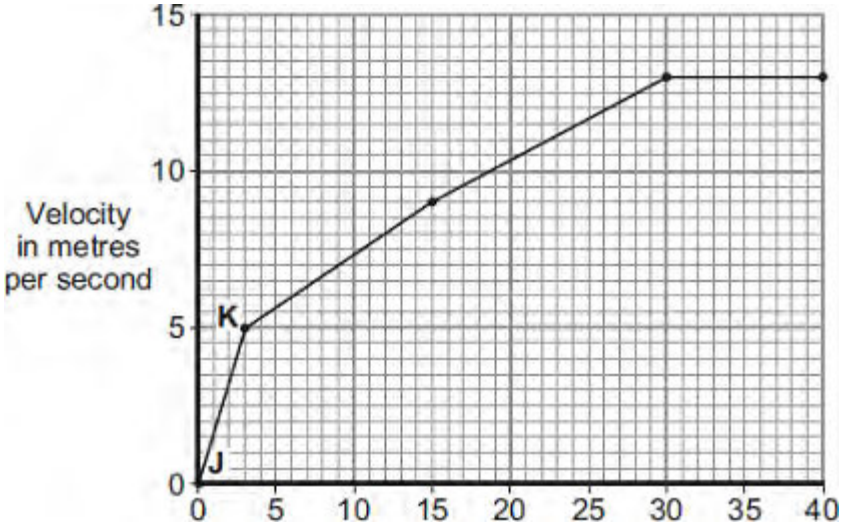
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**(3)**

(b) The final design go-kart, **Y**, is entered into a race.

The graph shows how the velocity of the go-kart changes during the first 40 seconds of the race.



Time in seconds

(i) Use the graph to calculate the acceleration of the go-kart between points **J** and **K**.

Give your answer to **two** significant figures.

.....

.....

.....

Acceleration = ..... $m/s^2$

**(2)**

(ii) Use the graph to calculate the distance the go-kart travels between points **J** and **K**.

.....

.....

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Distance = ..... m

**(2)**

(iii) What causes most of the resistive forces acting on the go-kart?

.....

**(1)**

**(Total 8 marks)**