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# EB Education Revision Guide


## How to work with Newton's Laws

# Newton's First Law

## What is it?

This states that a **resultant force** is needed to make something start moving, speed up or slow down.

- If the **resultant force** on a **stationary** object is **zero**, the object will **not move.**
- If the **resultant force** on a **moving** object is **zero**, it will **carry on** moving at the **same speed** in the same direction (the same velocity).

## What is a Resultant force?

In most situations there are at least two forces acting on an object.

If there are a number of forces acting at a single point you can replace them with a **single force**, which has the same effect as all the original forces together. This is called the **resultant or net force**.

For **Newton's First law**, the is no resultant force, in other words the **forces are balanced,** so the object **stay still or at a constant speed.**

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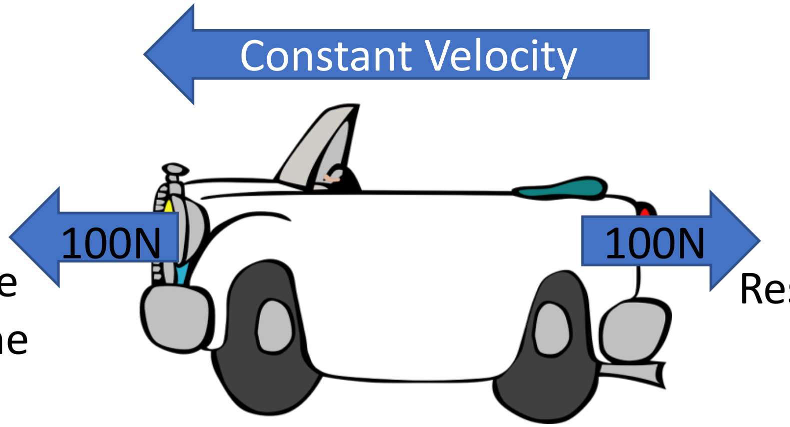
# Newton’s First Law

If an object is **moving at a constant velocity,** the resistive and driving **forces must be balanced.**




Motive force of the engine

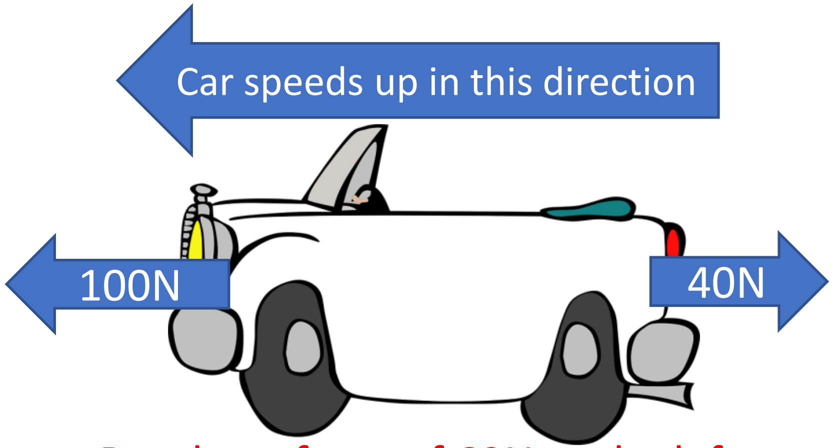
Resistive force

No resultant force

When a vehicle travels at a constant speed the frictional (resistive) force balances the driving force.

If there is a non-zero resultant force acting on the object (the forces are not balanced), the velocity will change. This is Newton's 2nd Law

This will result in **acceleration** in the direction of the resultant force. The “acceleration” can be seen as: starting, stopping, slowing down and changing direction




Resultant force of 60N to the left

These forces are unbalanced. There is a greater force forwards from the engine, so the car accelerates.

# Newton's Second Law

## What is it?

Resultant forces cause acceleration!

The larger the resultant force on an object, the more the object accelerates.

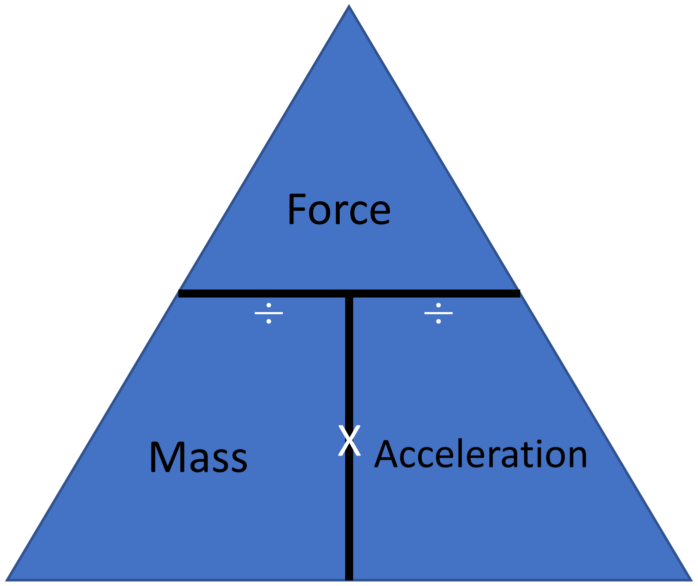
**Force and acceleration are directly proportional.**

An object with a larger mass will accelerate less than an object with a smaller mass (for the same resultant force).

**Acceleration is inversely proportional to the mass of an object.**

This formula describes Newton's Second Law.

**Resultant Force = mass x acceleration**



# Inertia

**What is it?**

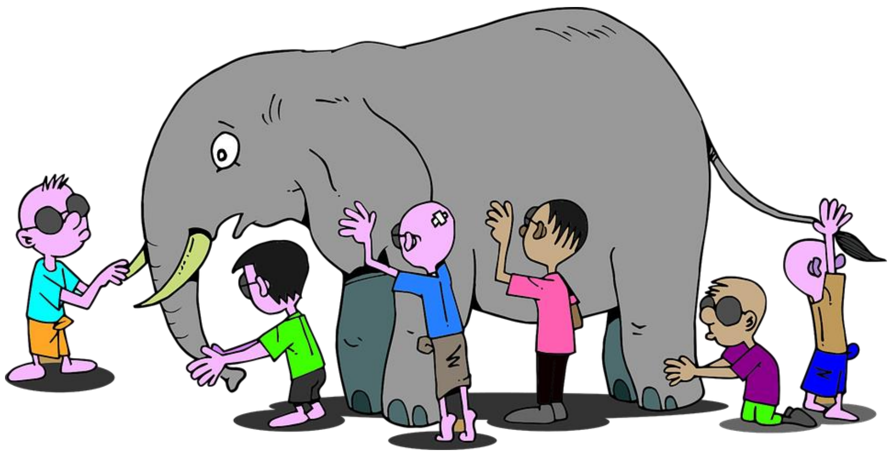
Objects will remain at rest, or move at a constant velocity, unless they are acted on by a resultant force.

The tendency to keep moving with the same velocity is called **inertia,** i.e the tendency to stay the same.

How difficult it is to change the velocity of an object is understood as its inertial mass.

Inertial mass can be found using Newton's Second Law

**mass = Force ÷ acceleration**



The elephant has a greater inertial mass than a human, so it is harder to change an elephant's motion.

# Newton's Third Law

## What is it?

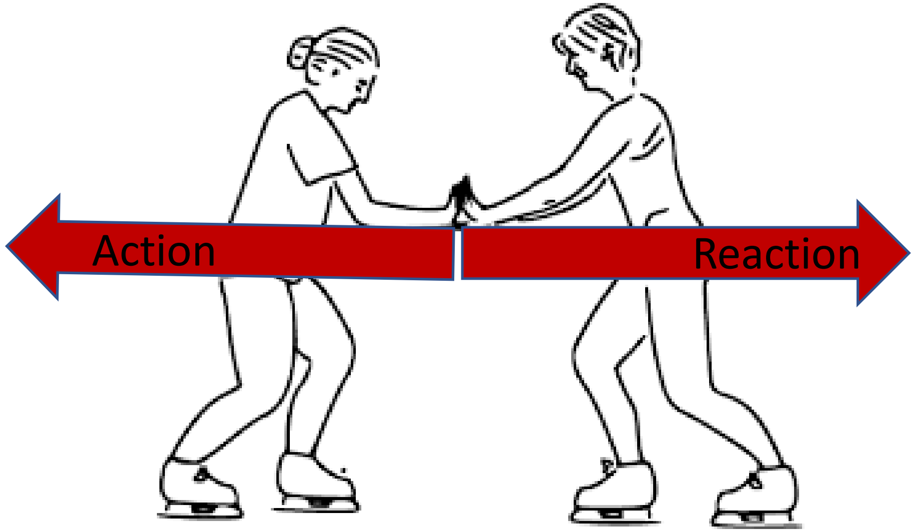
Newton's Third Law states that when **two objects** interact, the force they exert on each other are **equal** and **opposite in direction**.

If you are pushing a pram, there are contact forces between you and the pram:

- you push the pram forwards
- the pram pushes you backwards
- These forces are equal in size and opposite in direction.

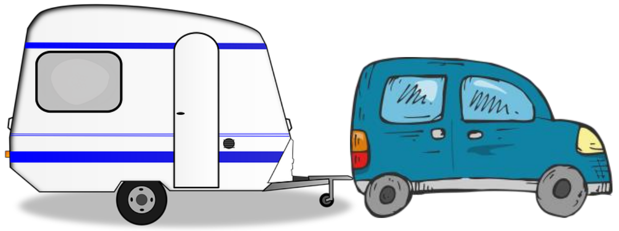
## Diagram

When the person in the diagram pushes the other person, he feels an equal size but oppositely directed force from the other person's hand.

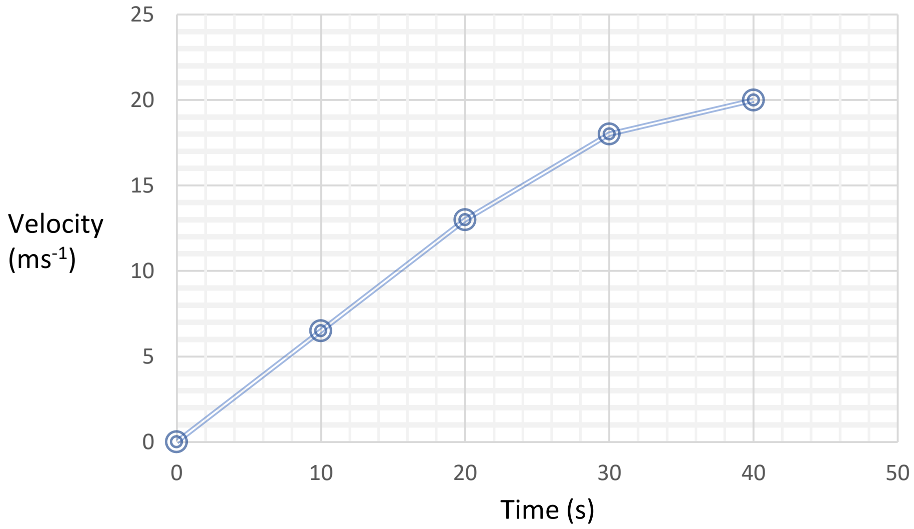


# Your turn:

1. The picture below shows a car with a mass of 1200kg pulling a caravan with a mass of 400kg. The car is travelling along a horizontal road.



The graph below shows the variation with time of the velocity of the car.




For the first 20 seconds of the journey calculate:

a) The acceleration of the car

b) The resultant force acting on the car

c) The resultant force acting on the caravan

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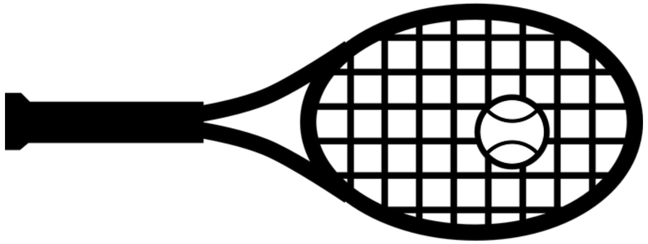
# Your turn:

2. The diagram below shows a ball of mass 0.05kg lying on the strings of a racket held horizontally.



a) Draw and label the two forces acting on it.
b) Calculate the weight of the ball.

c) Explain, using Newton's Laws, what we know about the forces acting on the ball when it is at rest.

3. A car accelerates at a constant rate of 1.83 $m/s^2$ along a flat straight road.
1.870 kN of force is acting on the car.

a) Calculate the mass of the cars, and give your answer to 3 significant figures.

b) The car accelerates from rest for 16 seconds. Calculate the speed of the car after 16 seconds.

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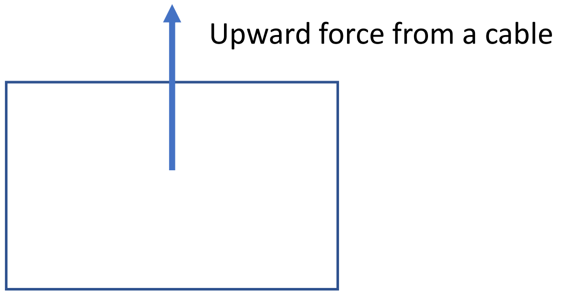
# Your turn:

4. The diagram below shows one of the forces acting on a block.




a) Draw an arrow on the diagram to represent the weight of the block.

b) Complete the sentence by putting a cross next to the correct answer.
When the block is moving upwards at a constant velocity, the resultant on the block is

A upwards and equal to its weight B downwards and equal to its weight
C upwards and more than its weight D zero

5. A van is pulling a broken-down car of mass 1200kg along a straight flat road.
The only force acting which affects the motion of the car is the tension in the horizontal tow bar.

Calculate the acceleration of the car when the tension is 750N

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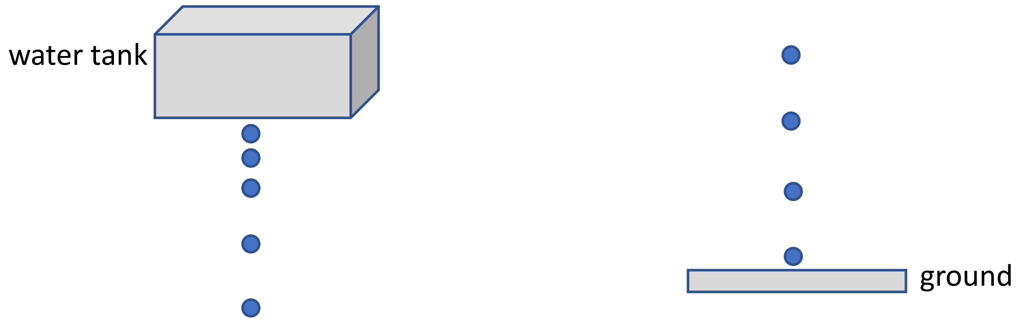
# Your turn:

6. A water tank is a long way above the ground, and drips at a steady rate.

The first drawing below shows water drops which have just left the tank.
The second drawing shows water drops which are near the ground.




Explain why the drops near to the ground are an equal distance apart but the drops which have just started to fall are not.

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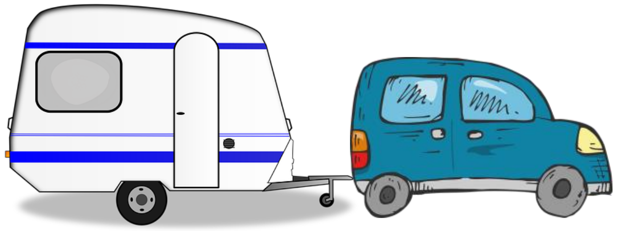
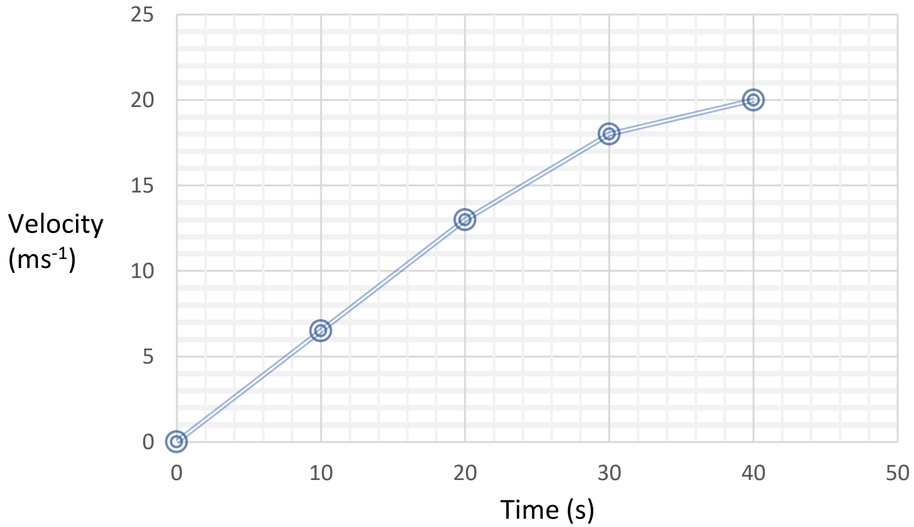
# Answers:

1. The picture below shows a car with a mass of 1200kg pulling a caravan with a mass of 400kg. The car is travelling along a horizontal road.



The graph below shows the variation with time of the velocity of the car.




For the first 20 seconds of the journey calculate:

a) The acceleration of the car

Gradient = 13/20

$0.65ms^{-2}$

b) The resultant force acting on the car

F = ma 1200 x 0.65

780N

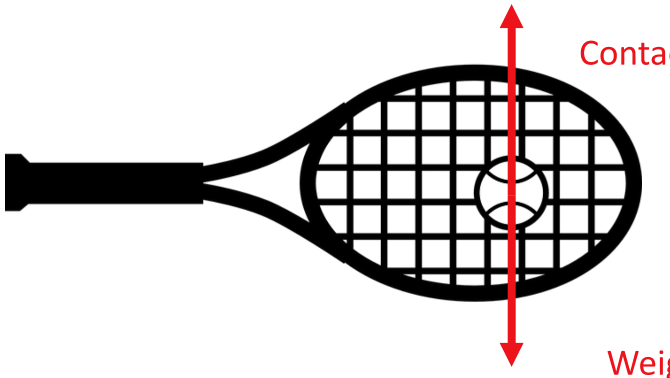
c) The resultant force acting on the caravan

F = ma 400 x 0.65

260N

# Answers:

2. The diagram below shows a ball of mass 0.05kg lying on the strings of a racket held horizontally.




a) Draw and label the two forces acting on it.
b) Calculate the weight of the ball.

Weight = mass x gravitational field strength
0.05 x 9.81 = 0.4905 Newtons

c) Explain, using Newton's Laws, what we know about the forces acting on the ball when it is at rest.

The forces will be balanced. Newton's 1st Law states that unless there is a resultant force, the object will remain stationary.

3. A car accelerates at a constant rate of 1.83 $m/s^2$ along a flat straight road.
1.870 kN of force is acting on the car.

a) Calculate the mass of the cars, and give your answer to 3 significant figures.

$m = \frac{f}{a}$ $\quad \frac{1870}{1.83}$

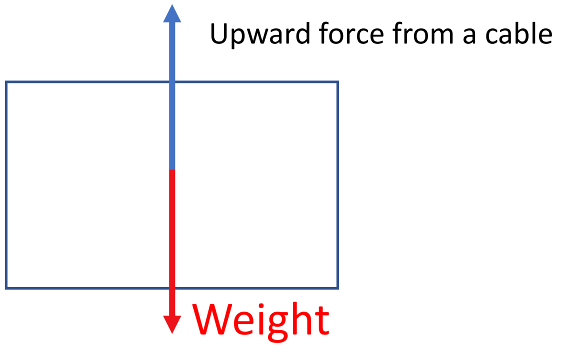
m= 1020 kg

b) The car accelerates from rest for 16 seconds. Calculate the speed of the car after 16 seconds.

v = u + at
v = 0 + (1.83 x 16)
= 29.3 m/s

# Answers:

4. The diagram below shows one of the forces acting on a block.




a) Draw an arrow on the diagram to represent the weight of the block.

b) Complete the sentence by putting a cross next to the correct answer.

When the block is moving upwards at a constant velocity, the resultant on the block is ZERO

A upwards and equal to its weight
B downwards and equal to its weight
C upwards and more than its weight
D zero

5. A van is pulling a broken-down car of mass 1200kg along a straight flat road.
The only force acting which affects the motion of the car is the tension in the horizontal tow bar.

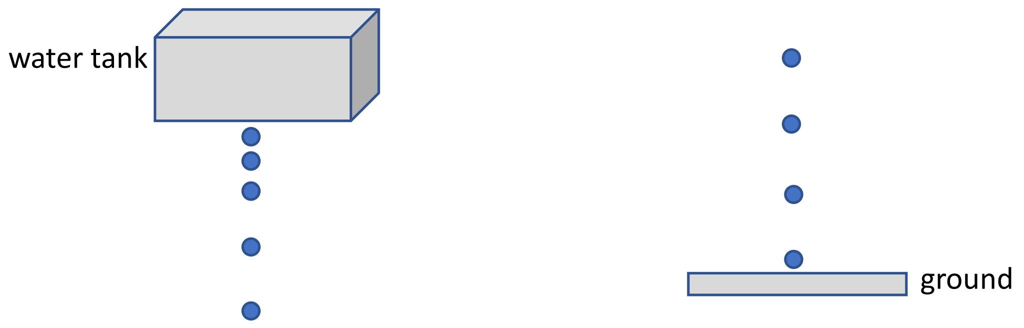
Calculate the acceleration of the car when the tension is 750N

$F = ma$ $a = F/m$ $750/1200$
$0.625\ ms^2$

# Answers:

6. A water tank is a long way above the ground, and drips at a steady rate.

The first drawing below shows water drops which have just left the tank.
The second drawing shows water drops which are near the ground.




Explain why the drops near to the ground are an equal distance apart but the drops which have just started to fall are not.

Drops near the top are accelerating due to the force of gravity, so they continually start to move further each second - They travel a greater distance in a given time.
Air resistance acts on the drops as they fall
This air resistance increases with velocity, so as they travel faster, they start to feel more air resistance.
As the water droplets accelerate, the resultant force is downwards
Eventually the resultant force is zero because the air resistance balances the weight. When this happens, the drops have reached terminal velocity
Drops near the bottom are all travelling at terminal velocity so travel the same distance in a given time

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# For more help and resources, or to work with us as a tutor, please contact us


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