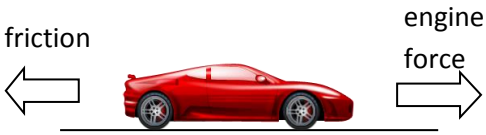
Newton's Laws of Motion (1 and 2)

Balanced Forces

N4

A force is a vector quantity because to describe it properly requires a direction as well as size.

Two forces which are **equal in size** which act in **opposite directions** are called **balanced forces.**



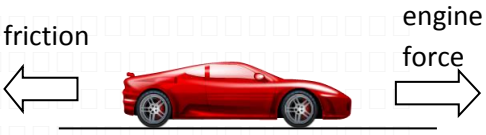
When the engine force = friction on the car the forces are balanced.

Balanced forces have the same effect as having **no** forces acting at all.

Newton's 1st Law of Motion

N4 N5

An object will remain at rest or travel in a straight line at a constant velocity (or speed) if the forces are balanced.



- If we consider the car moving in a straight line. If the engine force = friction, it will continue to move at a constant velocity (or speed) in the same direction.
- If the same car is stationary (not moving) and all forces acting on it are balanced (same as no force at all) the car will not move.

Free Body Diagrams

N4

We can use free body diagrams to analyse the forces on an object. This allows us to determine the motion of the object.

Example: If the bus is travelling with an engine thrust of 12kN and all forces acting on the bus are balanced

a) calculate the size of the frictional force acting

b) determine the motion of the bus.

Solution a) Draw the free body diagram

b) constant velocity (or speed) since the forces are balanced.

Newton's 2nd Law of Motion

N4 N5

This law deals with situations when there is an unbalanced force acting on the object.
The velocity cannot remain constant and the acceleration produced will depend on:

- the mass (**m**) of the object **(a α 1/m) - if m increases a decreases and vice versa**
- the unbalanced force **(F)** **(a α F)** **- if F increases a increases and vice versa**

This law can be summarised by the equation **F = ma**

Force, Mass and Acceleration Equation

N4 N5

A newton is defined as the force which makes a 1 kg mass accelerate at $1ms^{-2}$

From the definition: acceleration = $\frac{\text{unbalanced force}}{\text{mass}}$

In symbol form: $a = \frac{F}{m}$ **F = ma** $m = \frac{F}{a}$

Quantity	Symbol	SI Unit
unbalanced force	F	N
mass	m	kg
acceleration	a	ms^{-2}

Example: Calculate the unbalanced force acting on a 10000 kg bus accelerating at 3.5 ms^{-2}.

F = ?
m = 10000 kg
a = $3.5ms^{-2}$

F = ma
F = 10000 x 3.5
F = 35000 N

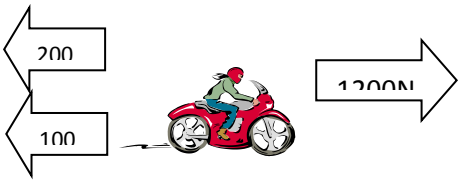
Resultant Forces (1)

N5

When several forces act on one object, they can be replaced by one force which has the same effect. This single force is called the **resultant** or **unbalanced** force.

Example: Horizontal
A motorcycle and rider of combined mass 650 kg provide an engine force of 1200 N. The friction between the road and motorcycle is 100N and the drag value = 200N.
Calculate:

a) **the unbalanced force acting on the motorcycle**
b) **the acceleration of the motorcycle**



Solution

a) Draw a free body diagram

F = 1200 - (200 + 100)
F = 900 N This 900 N force is the resultant of the 3 forces

b) F = 900 N F = ma
a = ? 900 = 650 x a
m = 650 kg a = 1.38 ms^{-2}

Resultant Forces (2) in the vertical direction will be considered in the Space Exploration section