

- Whenever **two objects interact**, the forces they exert on each other are **equal and opposite**.
- A number of forces acting at a point may be replaced by a single force which has the same effect on the motion as the original forces all acting together. This single force is called the **resultant force**.
- Determining the resultant of opposite or parallel forces acting in a straight line.
- A resultant force acting on an object may cause a change in its **state of rest or motion**.
- If the **resultant force** acting on a **stationary object** is :
 - **zero**, the object will **remain stationary**.
 - **not zero**, the object will **accelerate in the direction of the resultant force**.
- If the **resultant force** acting on a **moving object** is :
 - **zero**, the object will **continue to move at the same speed in the same direction**.
 - **not zero**, the object will **accelerate in the direction of the resultant force**.

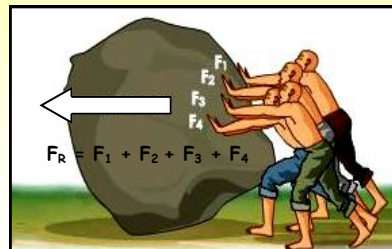
FORCES

Forces are :

- Either **pushes** or **pulls**.
- Measured in **newton (N)**.
- **Vector** quantities, involving both **size** and **direction**.
- Either **balanced** or **unbalanced**.

RESULTANT FORCE

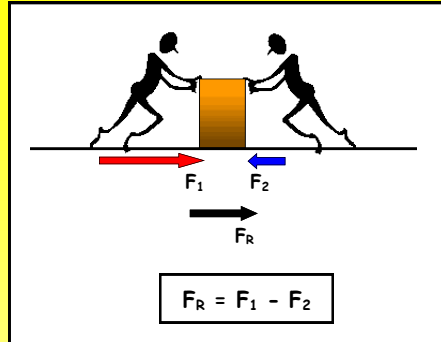
A number of forces acting on a body may be replaced by a single force, called the **resultant force**, which has the same effect as all the forces acting together. In the picture opposite the **resultant force (F_R)** is the sum of all the forces because they are acting in the same direction.



In the diagram shown opposite the forces F_1 and F_2 are acting in opposite directions, and $F_1 > F_2$.

The resultant force (F_R) is then given by :

$$F_R = F_1 - F_2$$

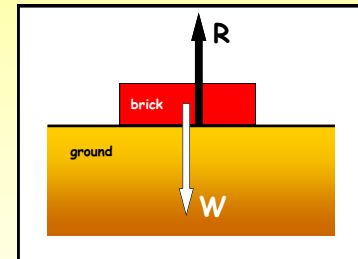


BALANCED FORCES

When two objects push or pull on each other, the forces they exert on each other are **equal** and **oppositely directed**. The forces are said to be **balanced**.

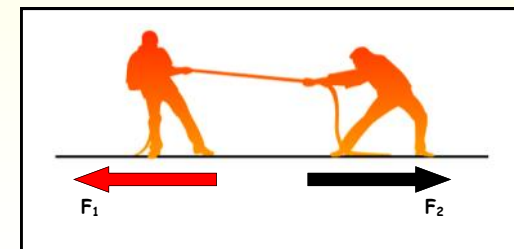
The downward force due to the **weight (W)** of the brick is balanced by an equal, upward **reaction (R)**.

$$W = R$$



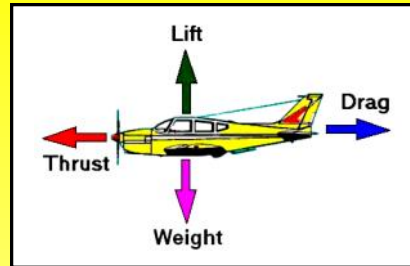
The diagram shows two equally-matched men having a tug of war.

$$F_1 = F_2$$



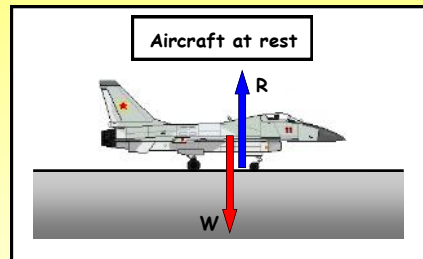
When an aircraft is flying at **constant speed** and **constant altitude** :

Lift = weight
Thrust = drag



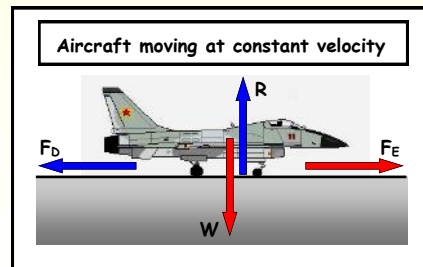
If the **resultant force** acting on a **stationary** object is **zero**, the object will remain **stationary**.

The aircraft shown opposite has **zero resultant force** acting on it (since its **weight (W)** balanced by the upward **reaction Force (R)** exerted by the ground) and so it will remain **stationary**.



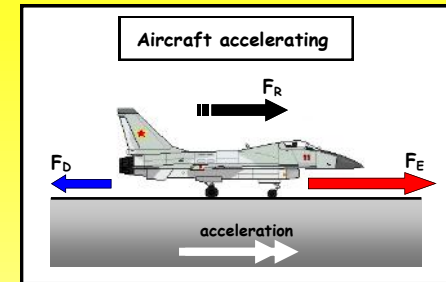
If the **resultant force** acting on a **moving** object is **zero**, the object will carry on moving at the **same speed in the same direction** (i.e. at **constant velocity**).

The aircraft will taxi along the runway at **constant velocity** when the **frictional drag force (F_D) = the engine force (F_E)**, so that the **resultant force acting is zero**.

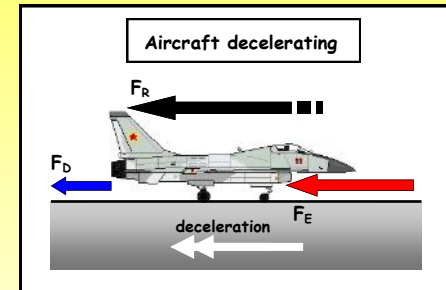


If the **resultant force** acting on an object (stationary or moving) is **not zero**, the object will **accelerate** or **decelerate** in the **direction of the resultant force**.

When an aircraft is taking off, the **engine force (F_E) > the drag force (F_D)** so there is a **resultant force, F_R = F_E - F_D** which gives the aircraft a forward **acceleration**.



When an aircraft is landing, the engines are put into reverse thrust. The **engine force (F_E) plus the drag force (F_D)** will then give the aircraft a **resultant force (F_R)** which will cause it to **decelerate** to rest.



SUMMARY

Object at the start	Resultant force	Effect on the object
Stationary	zero	Object remains stationary
moving	zero	Object's velocity stays the same.
moving	Non-zero and in the same direction as the object's direction of motion.	Object accelerates.
moving	Non-zero and in the opposite direction to the object's direction of motion.	Object decelerates.

• PRACTICE QUESTIONS

- 1 State whether the **forces** acting on these objects are **balanced** or **unbalanced**. In each case, **explain why**.
- (a) A football slowing down as it is passed from one player to another.
- (b) A stone which falls off the edge of a cliff.
- (c) A car travelling at constant velocity along a straight motorway.
- 2 Complete the sentences using the words below :
- acceleration** **resultant force** **mass** **velocity**
- (a) A moving object decelerates when a acts on it in the opposite direction to its
- (b) The greater the of an object, the smaller its acceleration will be when a acts on it.
- (c) The of a moving object increases when a acts on it in the same direction as it is moving.
- 3 A jet plane lands on a runway and **decelerates to rest**.
- (a) What can you say about the **direction of the resultant force** on the plane as it decelerates?
- (b) What can you say about the **resultant force** acting on the plane once it has come to rest?
- 4
- (a) What happens to an object which is initially **stationary**, if the resultant force acting on it is **zero**?
- (b) What happens to a **moving** object, if the resultant force acting on it is **zero**?
- (c) What happens to an object which is initially **stationary**, if a **non-zero** resultant force acts on it?