Unit 6
Forces and Pressure

Lesson Objectives:

- Mass and weight
- Gravitational field and field strength
- describe the effect of balanced and unbalanced forces on a body
- describe the ways in which a force may change the motion of a body
- identify forces acting on an object and draw free body diagram(s) representing the forces acting on the object (for cases involving forces acting in at most 2 dimensions)
- recall and apply the relationship resultant force = mass x acceleration to new situations or to solve related problems
- explain the effects of friction on the motion of a body

Lesson Objectives

- State that a force is a push or a pull.
- List different forces, namely, pushing, pulling, lifting, stretching, twisting, pressing, gravitational, frictional and magnetic forces.
- Explain what gravitational force of gravity is.
- State the effects of gravitational force of gravity.
- Define weight.
- Use the newton as the unit of force, with a clear idea of its magnitude.
- Use a forcemeter or spring balance to measure force.
- Deduction of net force acting on a body.
- Being able to solve simple problems involving various forces acting on a body such as applied force, weight & frictional force.

Watch Video

http://www.youtube.com/watch?v=IVVonLbkTXw&feature=related

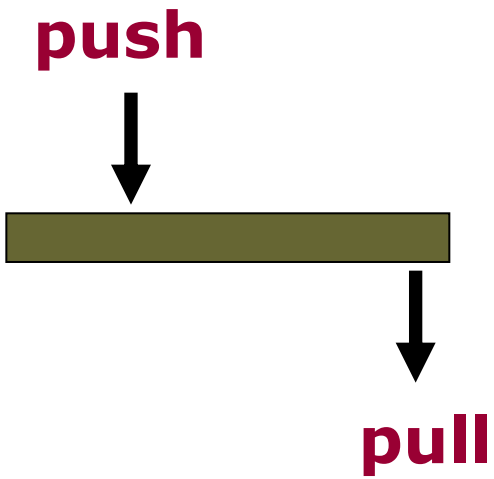
Question:

Discuss in pair and list at least 3 effects of a force on your worksheet.

What is Force?

Definition:

A force is a push or a pull.



- **S.I. unit : newton (N)**
- **Named after Sir Isaac Newton (1642 – 1727) who did a lot of important work on forces.**

Effects of Forces

change the shape of an object

change the size of an object

change the direction of a moving object

force

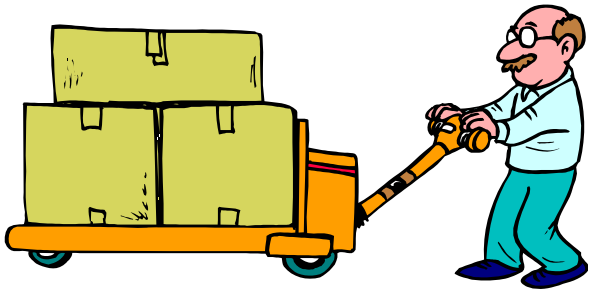
start an object moving

change the speed of a moving object

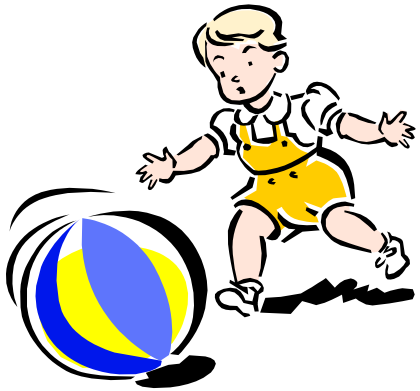
stop a moving object

Misconception about Forces

- **Our experience seems to tell us that a force is needed to keep an object moving.**



- **trolley stops moving when it is no longer pushed**



- **pushed ball stops rolling on the ground after sometime**

- **In fact, many objects stop moving because of friction (a force which we do not observe).**

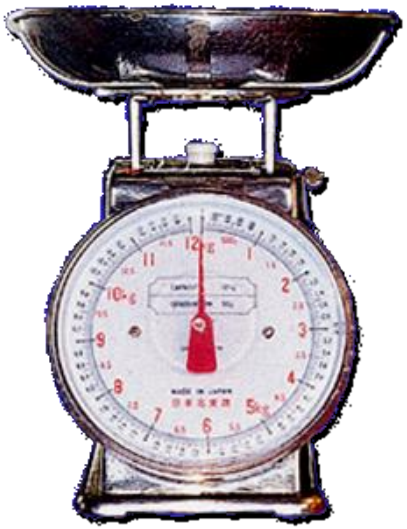
Measuring Forces

Forces are measured with spring balance (also known as force-meters).

Two types of spring balances:

Extension spring balance

(spring stretches when a pulling force acts on it)



compression spring balance

(spring is compressed when a force acts on it)

Check point

On your own, give two examples of what a force can do to a moving object.

What is a Gravity?

Definition:

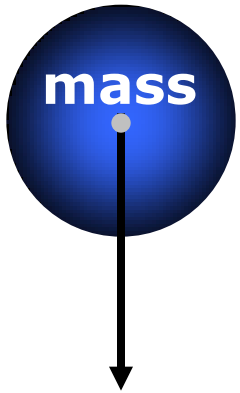
It is the force of attraction that pulls the objects towards the Earth.

Another term for gravity is gravitational force. Force of gravity is always pulling (attraction) objects together, but never pushing (repelling) them apart.

It is gravity that gives us our weight!

Weight

- Weight is a force due to gravity on an object or the pull of Earth that acts on an object.
- Earth's gravity causes all bodies to fall towards the centre of the Earth



weight towards Earth

weight = mass x acceleration due to gravity

$W = mg$

- $g=10\ m/s^2$

Check point

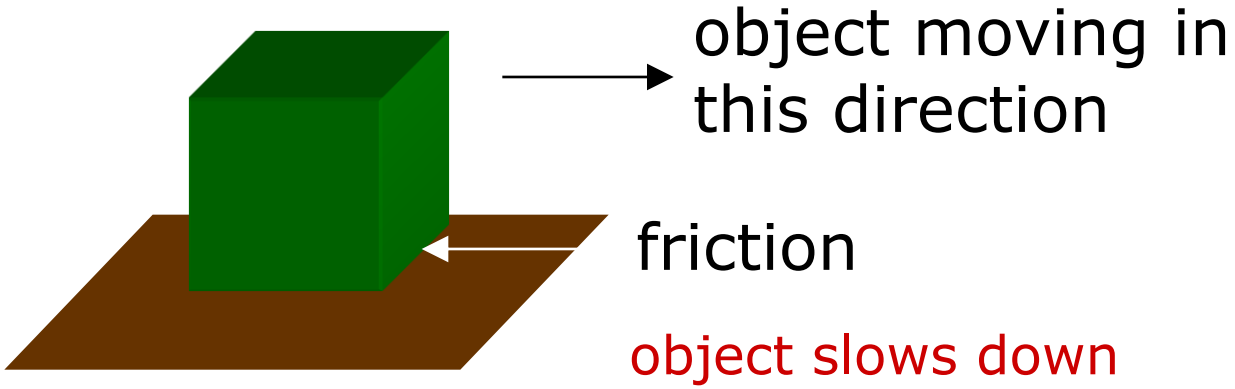
A man has a mass of 72 kg.

a) What is his weight on earth?

b) Assuming the acceleration due to gravity on the Moon is one-sixth that of the earth's, what is the weight of the man on the Moon?

Friction

- Friction acts along the contact surfaces.
- Friction opposes motion of a body.



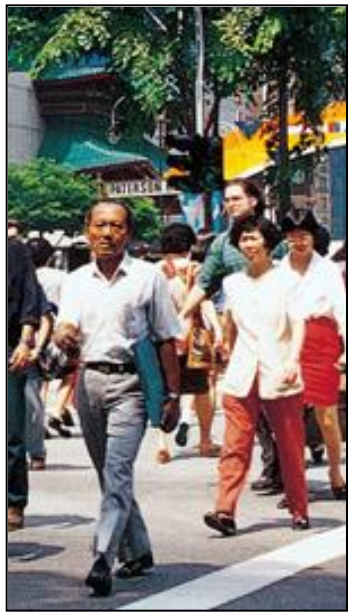
Factors affecting friction

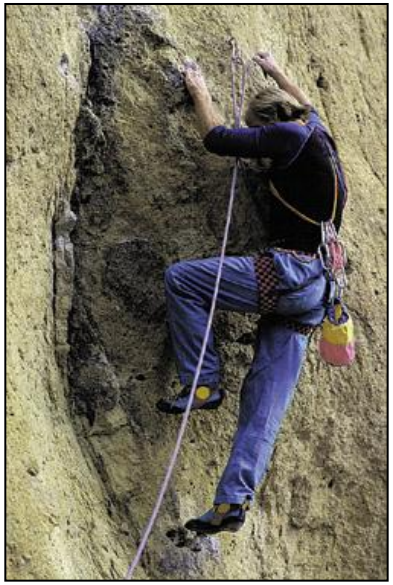
Frictional force between two surfaces on a horizontal plane	Less friction	More friction
depends on the materials in contact	glass	wood, leather, rubber
depends on the nature (texture) of the surfaces in contact	smooth	rough
proportional to the force pressing the surfaces together	less force	more force
independent of the area of contact	-	-

Friction as a useful force

friction holds a nail in a wall

friction between the wheel and the brakes slows down the bicycle





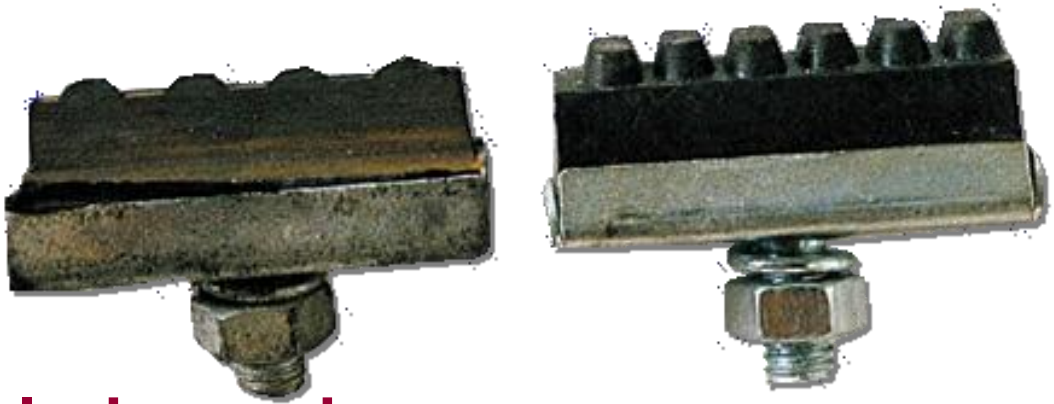
friction stops hands from slipping off the rock

friction is needed between our feet and the ground to give the grip needed

Friction as a nuisance force

- rubbing of surfaces wears away materials
- friction produces heat (loss of energy)

friction has worn out the rubber on the top tyre



brakes pads and brake blocks need to be replaced regularly

Ways to reduce friction

Can you list some ways in which you reduce friction in your daily life?

E.g.

- removing a tight fitting ring
- a door that squeak
- moving a large cupboard

Methods to reduce friction	Examples
Moving parts are made as smooth as possible	The piston and cylinders of an engine made of highly polished steel or aluminium

smooth surface gives the child a smooth ride

Wax is also used to smoothen contact surface e.g. new zips

Methods to reduce friction	Examples
Materials with very low frictional resistance are used	Slippery graphite used for contact points in motors and dynamos
Ball and roller bearings are placed between the moving parts	In the hubs of bicycle wheels

conveyor belt moves on wheels or rollers to reduce friction

Methods to reduce friction	Examples
Surfaces are separated by a lubricant	Engine oil and grease used to lubricate engines
Surfaces are separated by air cushion	A hovercraft travel over rough land, swamp or sea

oil allows door to turn easily

a hovercraft uses a layer of air to move about easily

Methods to reduce friction	Examples
Streamlined design to reduce air friction (drag)	Design of sports car, aeroplane, swim suit

Body of a fish has a streamlined shape

Name the common design features in aeroplanes and sports cars?

High tech swimsuits that are streamlined!

http://www.dailytech.com/Speedos+TechnoSwimsuit+Ignites+Olympic+Controversy/article12636.htm

http://www.youtube.com/watch?v=dvMdqvO3R9g

Air resistance

Types of Forces

1. On Earth, falling objects always experience some air resistance
2. Air resistance is a form of frictional force and opposes motion (horizontally and vertically) in the air.
3. Air resistance increases with the speed of the moving object in the air.
4. Air resistance increases with the surface area of the object moving in the air.

air rubs against the inside of a parachute causing it to fall slowly

Air resistance

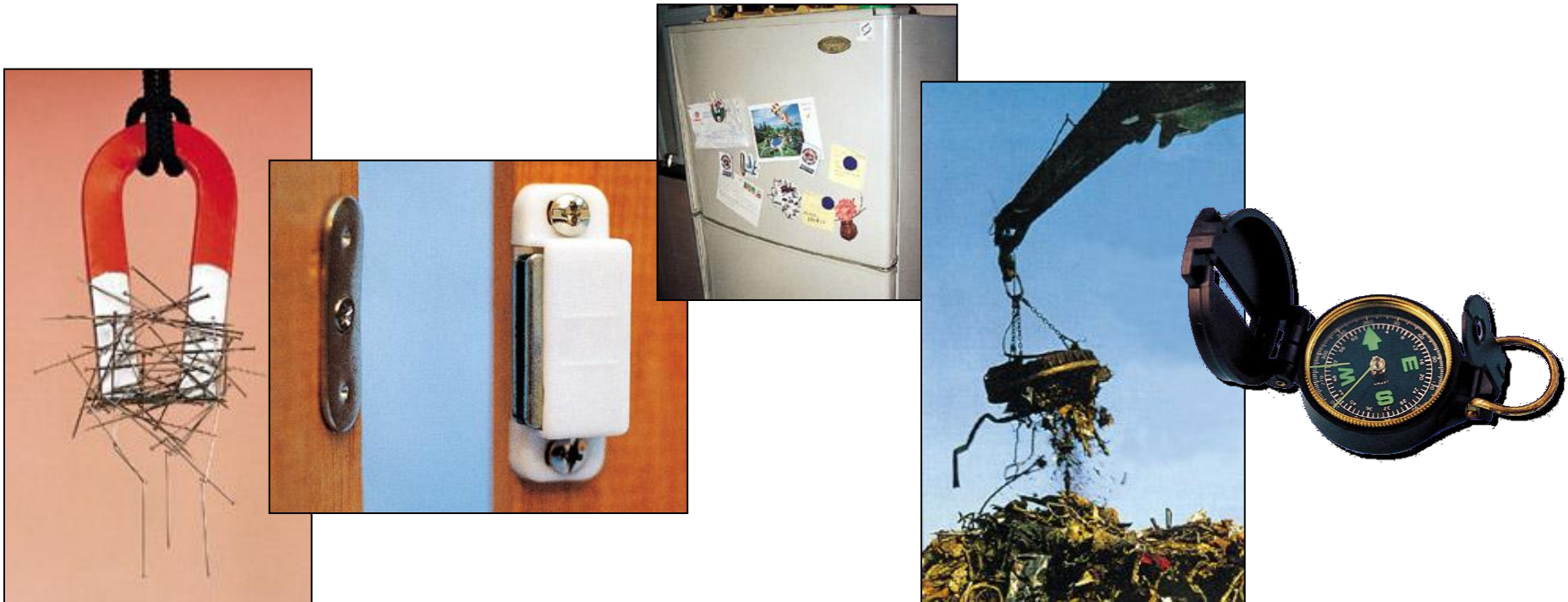
Why do cyclists wear caps?

Caps help to reduce the air resistance.

What is a Magnetic Force?

It is the non-contact force exerted by a magnet.

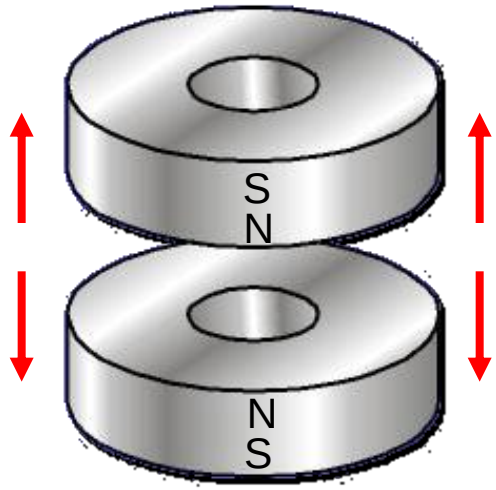
A magnet can attract materials such as iron and steel.



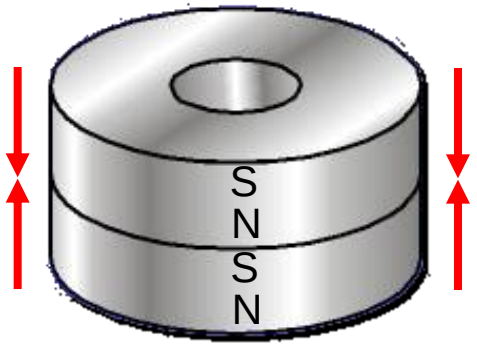
Law of Magnetism

Types of Forces

Like poles repel.
Unlike poles attract.



repulsion (push)
due to like poles facing each other



attraction (pull)
due to unlike poles facing each other

Magnetic Force

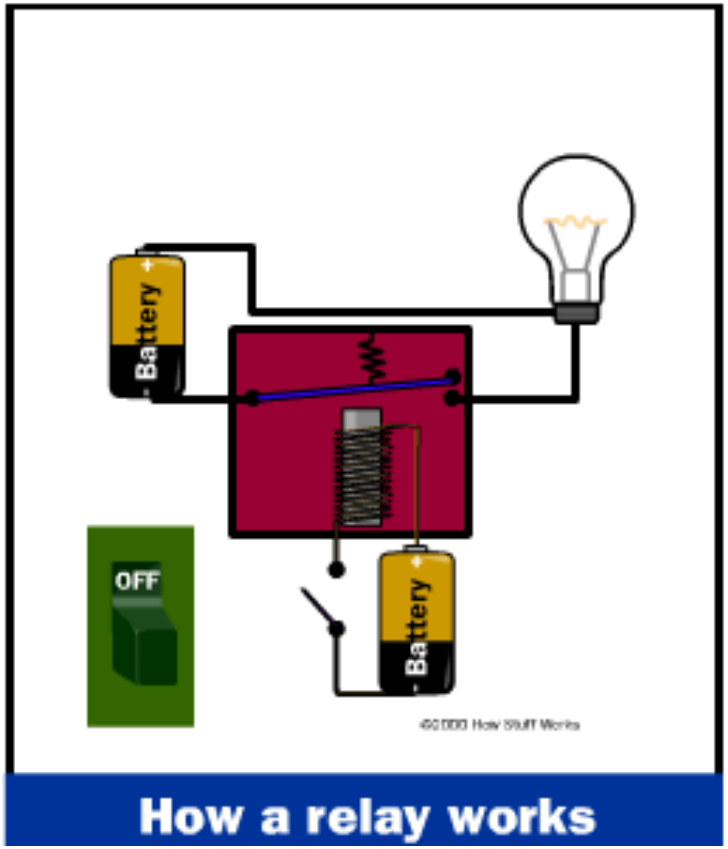
Magnets are used to make trains move. How are the magnets used to make train move?

Maglev trains stay above the tracks by repelling the magnets on the track. This allows them to travel faster in the absence of friction.

'Maglev' comes from the term magnetic levitation.

Magnetic Force

Magnetic relay switch and remote control



demo

http://electronics.howstuffworks.com/relay1.htm

Newton's 1st law of motion

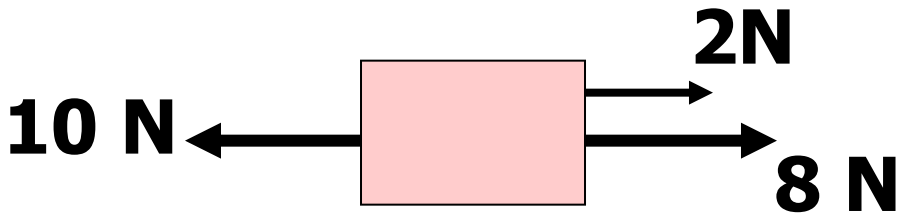
If a balanced force is acting on a body, then

1. if it is at rest, it remains at rest;
2. if it is moving, it will keep moving at the same speed in a straight line in the same direction.

Balanced Forces

When all the forces acting on an object add up to zero, the forces acting on the object are balanced.

For example,



2+8 = 10 N to the right

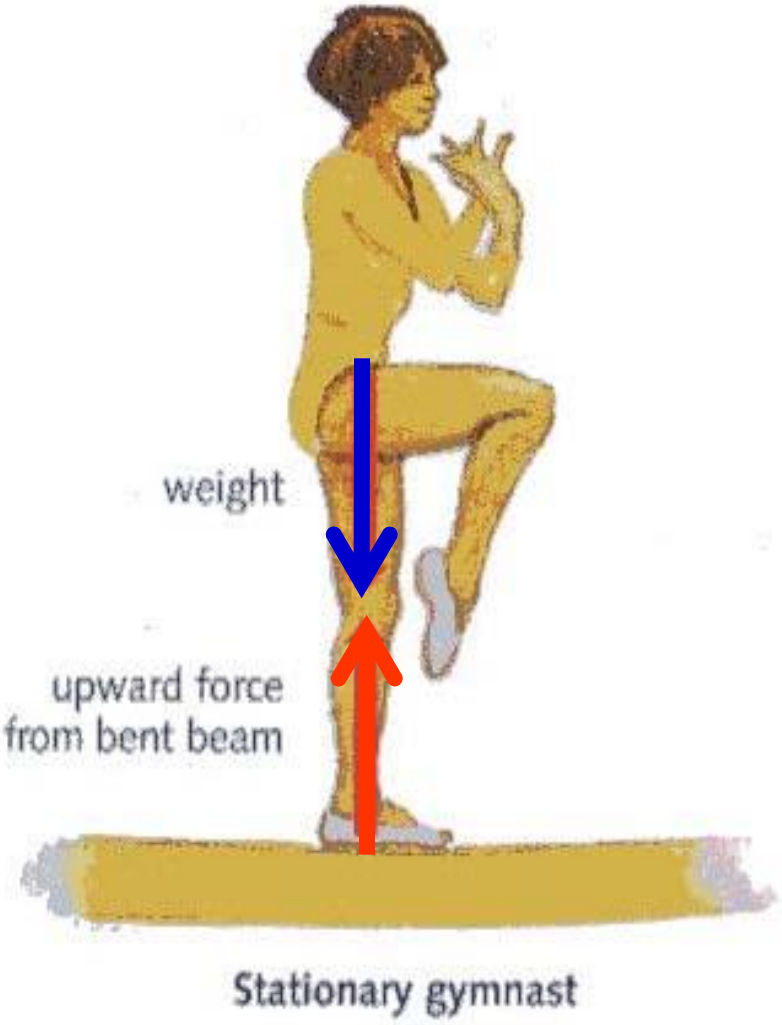
There is a 10 N force to the left

Therefore the forces are **balanced**

The object experiences no resultant force; i.e. NO unbalanced force.

The motion of the object remains unchanged as Resultant force equals to zero.

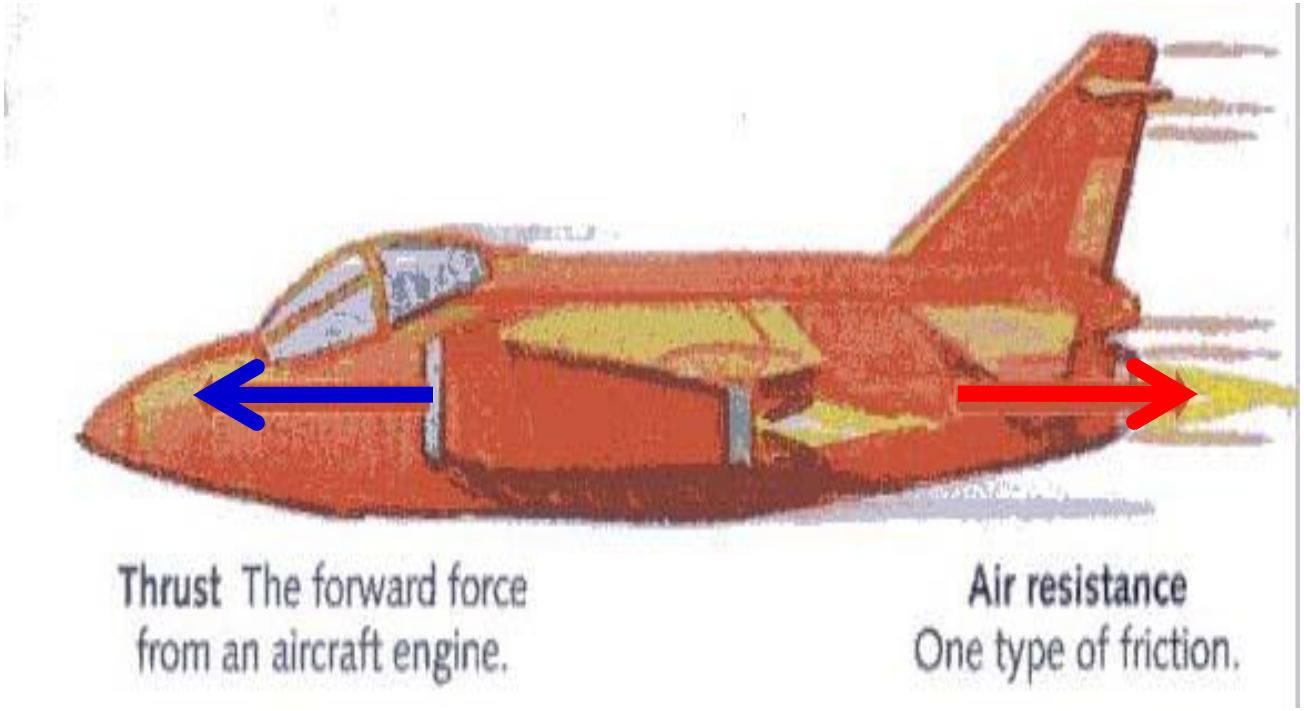
Other examples of balanced forces



The gymnast experiences NO unbalanced force. i.e the forces acting on her are balanced.

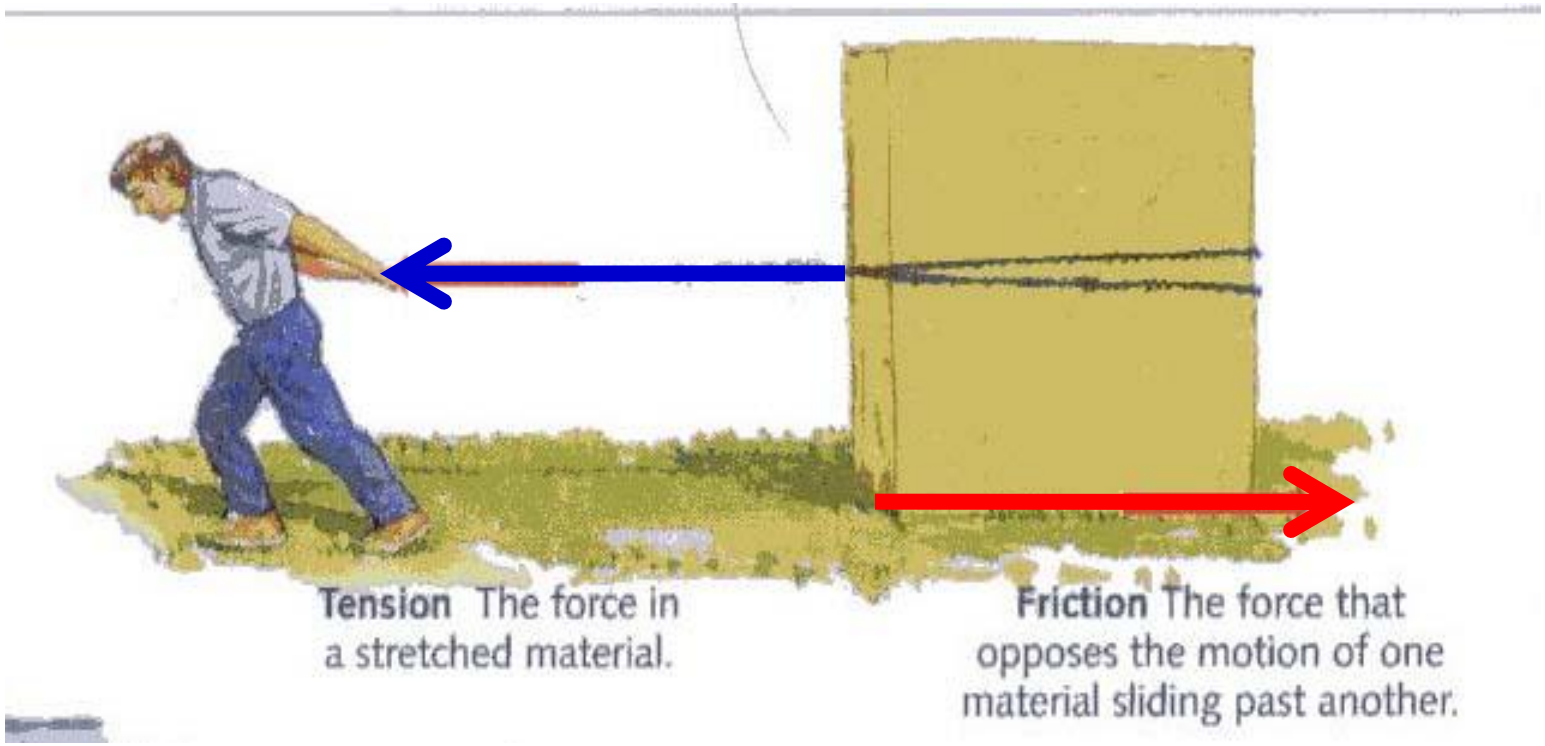
She remains stationary.

Examples of balanced forces



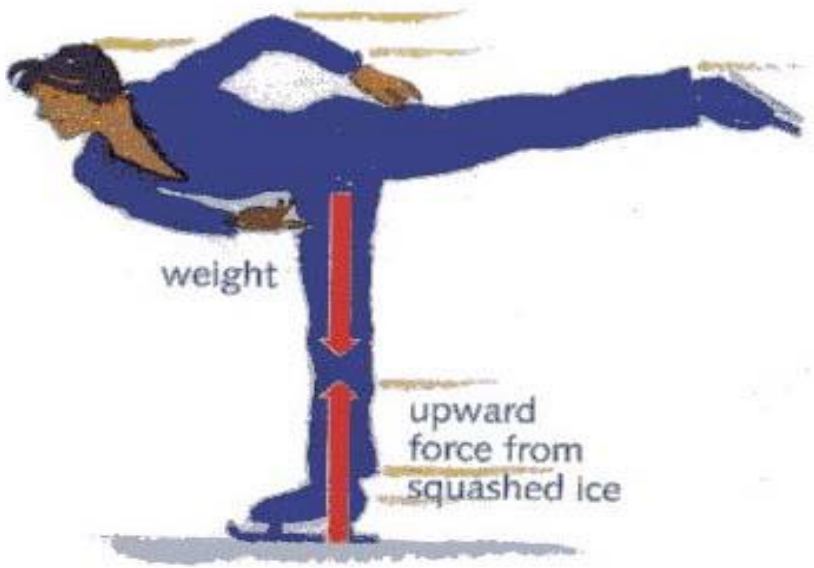
The aircraft moves with constant speed as the forward thrust equals to the air resistance. i.e the resultant force is zero.

Examples of balanced forces



The object remains at rest unless an unbalanced force acts on it.

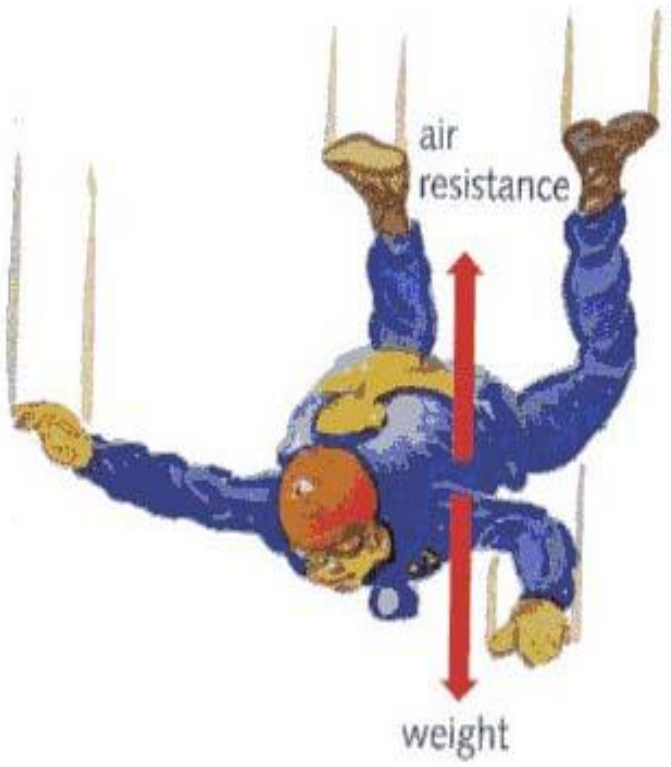
Examples of balanced forces



Skater with steady velocity

The forces are balanced. i.e the resultant force on the skater is zero.

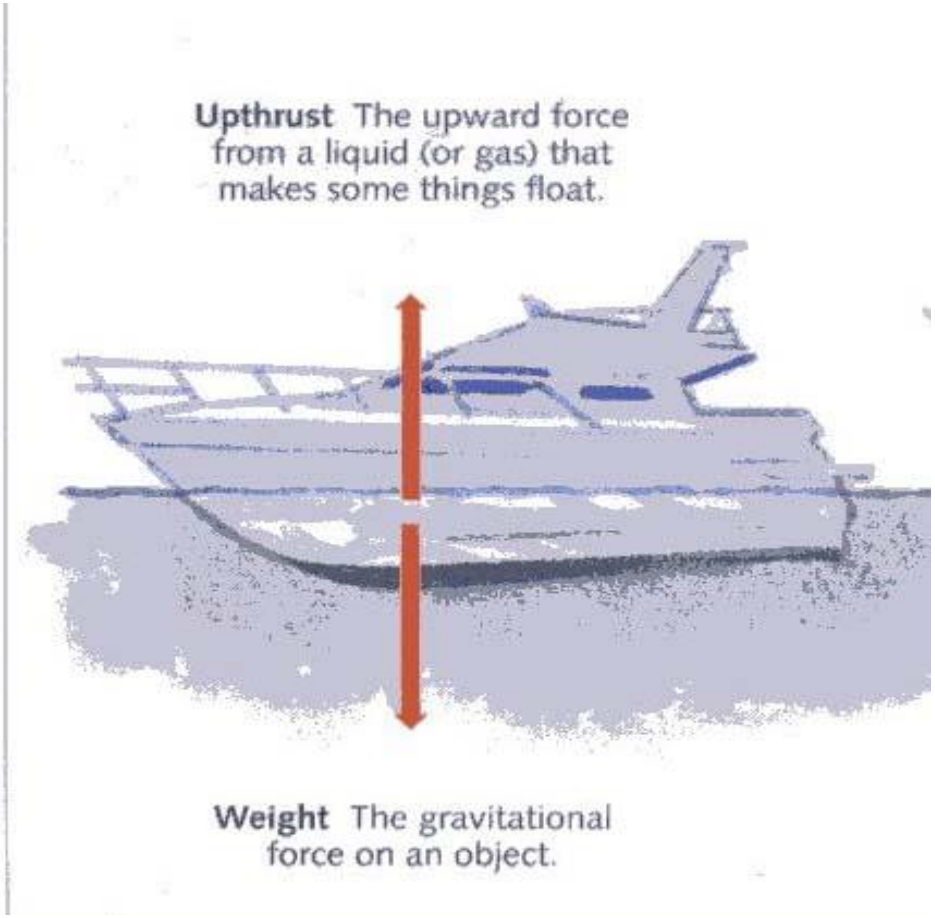
Examples of balanced forces



The parachutist experiences an increasing air resistance as he falls with increasing speed.

When the air resistance equals his weight, he falls with a constant velocity, the terminal velocity.

Balanced forces

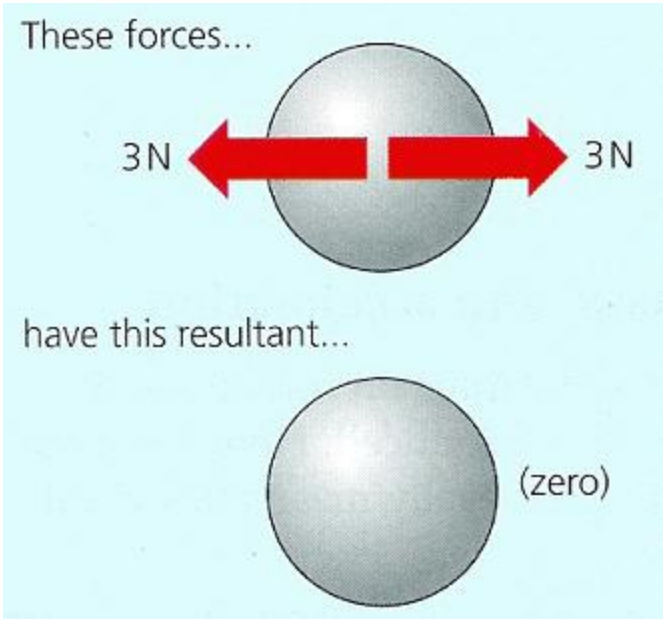


The upthrust acting on the boat and its weight balanced.

The boat remains floating.

Does no resultant force mean that an object has no forces acting on it?

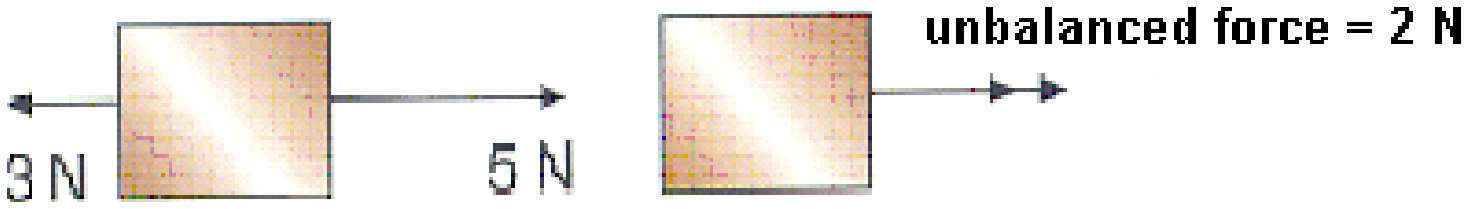
- No.



Unbalanced force :

When all the forces acting on an object do not balance out, then, there is an unbalanced force acting on the object.

For example,

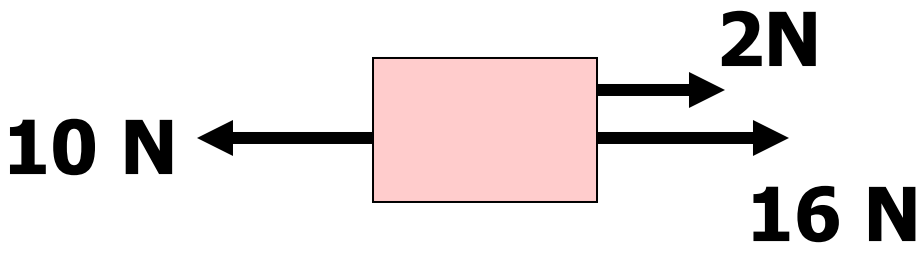


- Object accelerates in the direction of unbalanced force.

Unbalanced Forces

Unbalanced forces cause

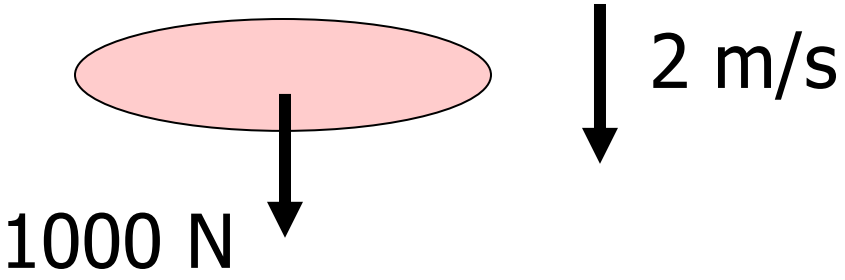
1. A stationary object to move
2. A moving object to change its speed or direction



There is an unbalanced force of **8 N** to the right that changes the motion of the object.

Question

A submarine of weight 1000 N is sinking at constant speed of 2 m/s.



What is the upthrust (upward force) acting on the submarine?

The submarine is not accelerating. There is no unbalanced force.

Therefore,

upthrust = weight
= 1000 N

Newton's 2nd Law of Motion

- When an unbalanced force, i.e Resultant **F**orce (F) acts on object of constant mass (m), the object will accelerate (changes its velocity over time) in the same direction of the resultant force.
- The acceleration (a) of the object is directly proportional to the resultant force:

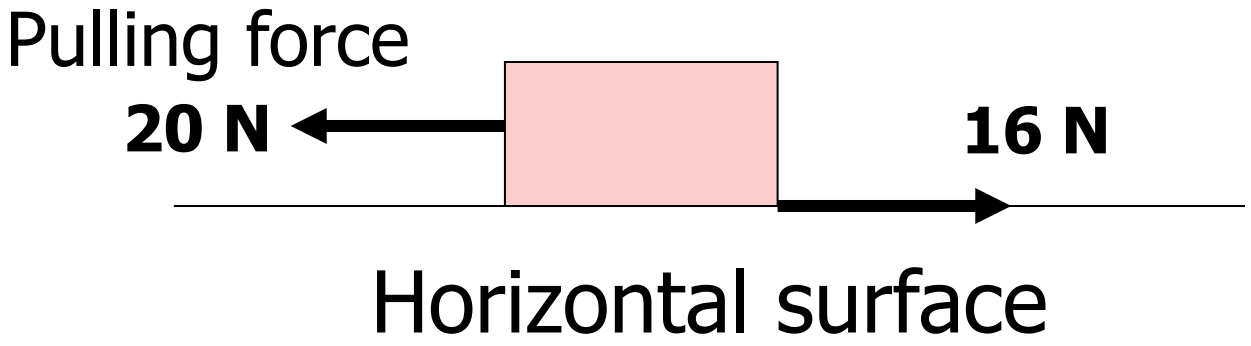
$$F = ma$$

Relationship between unbalanced force and acceleration

- Resultant Force = mass x acceleration
- **F = ma**
- If m=1kg, a=1m/s^2, then
- F = 1 kg m/s^2 = 1 N
- Therefore, 1 newton is the force required to produce an acceleration of 1m/s^2 in a body of mass 1kg.

Examples

A block of wood of mass 2 kg is pulled along a flat horizontal surface as shown.



What is the acceleration of the wood and in which direction is the wood accelerating?

Unbalanced force = 20-16 = 4 N to the left.

$F = ma$

$a = F/m = 4/2 = 2\ m/s^2$

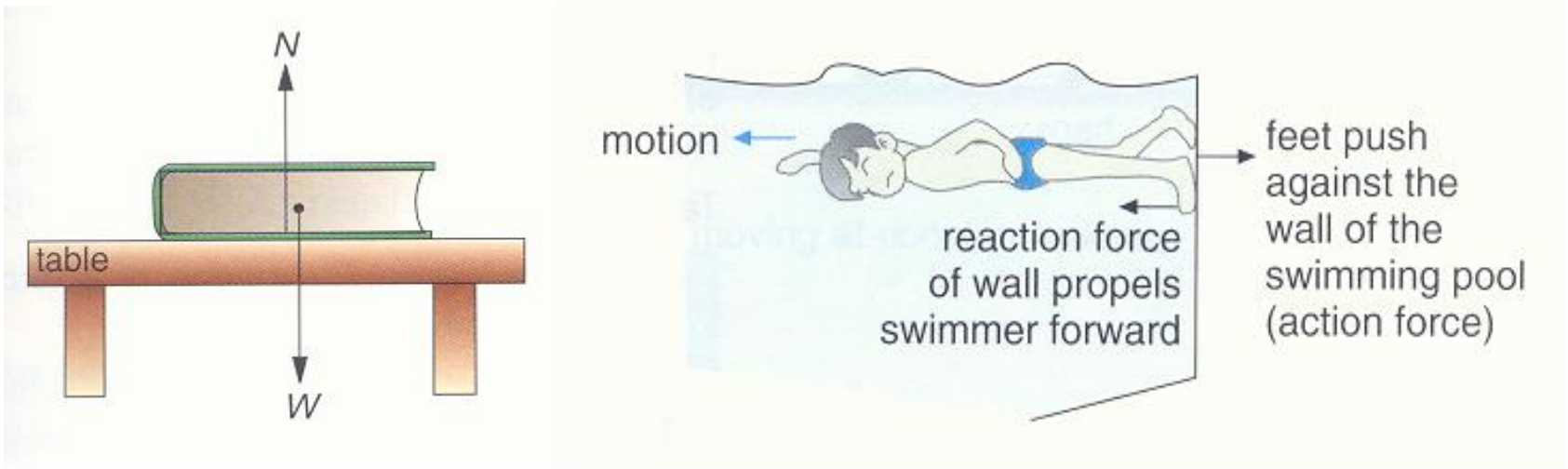
Direction of the acceleration is to the left and is in the direction of unbalanced force.

Newton's 3rd Law of Motion

If body A exerts a force F on body B, then body B exerts a force (-F) on body A.

Or

Action and reaction are always equal and opposite.

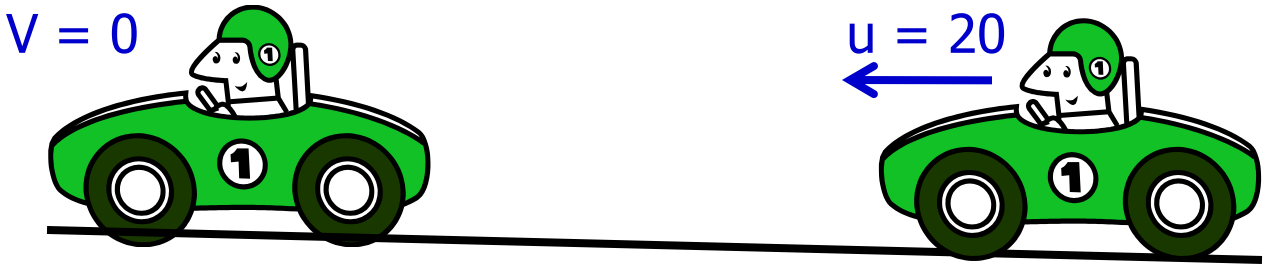


More Questions on F=ma

1. A boy pushes a box of mass 20kg with a force of 50N. What is the acceleration of the box? (Assume no friction)
2. Now assume there is friction of 10N between the box and the ground. What is the acceleration of the box?

More Questions on F=ma

1. A car of mass 1000kg decelerates from 20m/s to rest in a time of 5s. Calculate the braking force of the car.



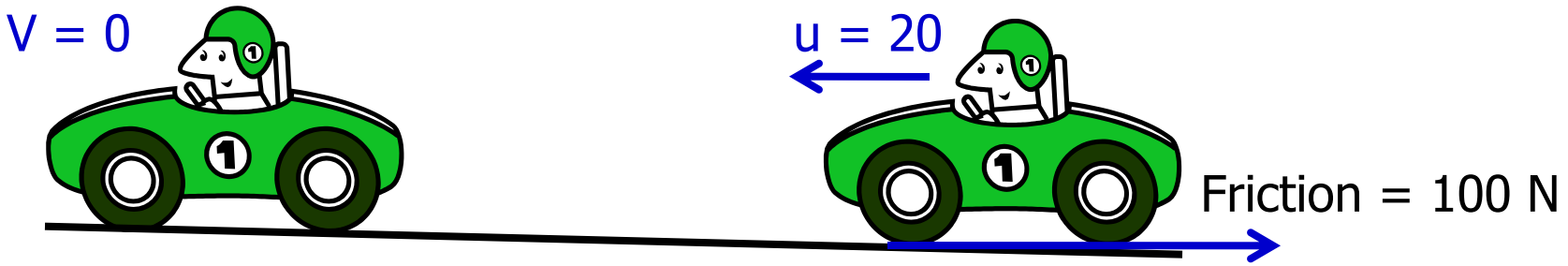
$$a = \frac{v - u}{t} = \frac{0 - 20}{5} = -4\,m/s^2$$

F= ma =1000 x 4

= 4000 N

Braking force = 4000 N

1. **A car of mass 1000kg decelerates from 20m/s to rest in a time of 5s. Calculate the braking force of the car. (Assume no friction) Assume there is friction of 100N. Calculate the braking force of the car.**



F= ma =1000 x 4

= 4000 N

Braking force + friction = 4000 N

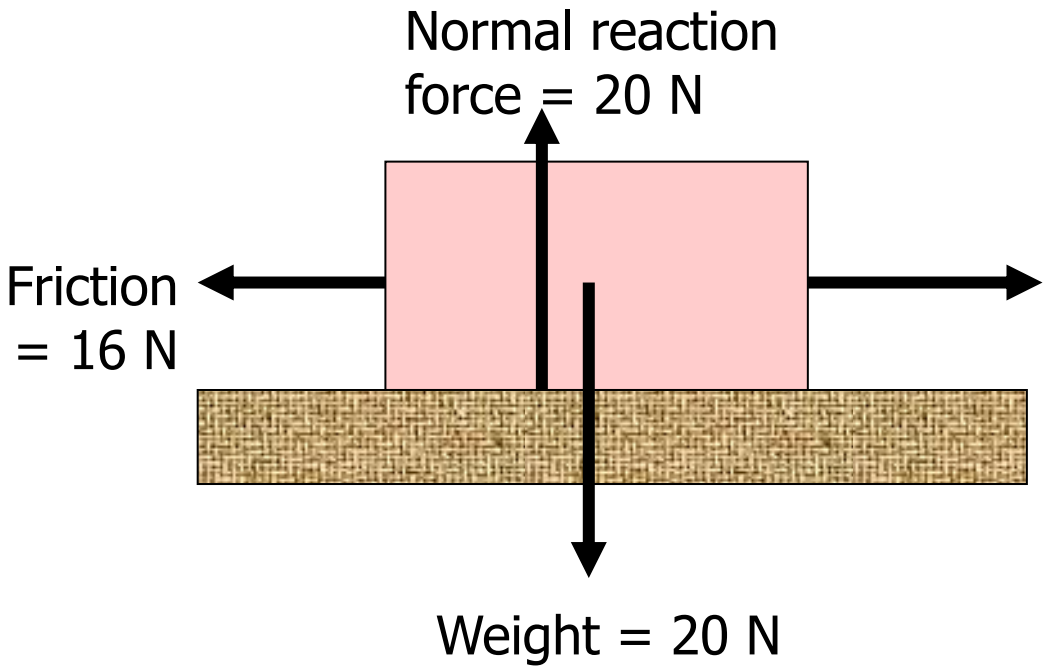
Braking force + 100 = 4000 N

Braking force = 4000 - 100

= 3900 N

Question

What is the acceleration produced?
Where is the object moving?



W= mg
m= W/g = 20 /10
= 2 kg

Unbalanced force = 24-16 = 8 N to the right.

$a = F/m = 8/2 = 4\ m/s^2$

The object moves to the right.

Pressure

Force acting on a surface produces a pressure.

Pressure is force acting normally on unit area

Formula:

$$P = F/A$$

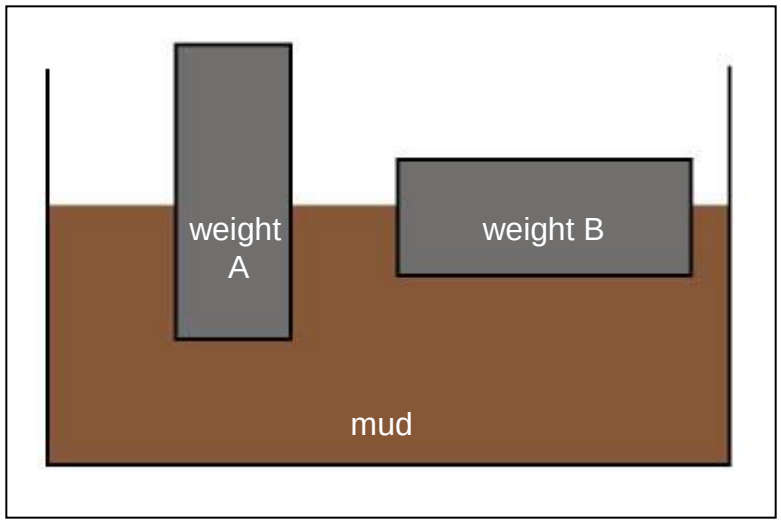
Unit : N/m^2

Pressure depends on:

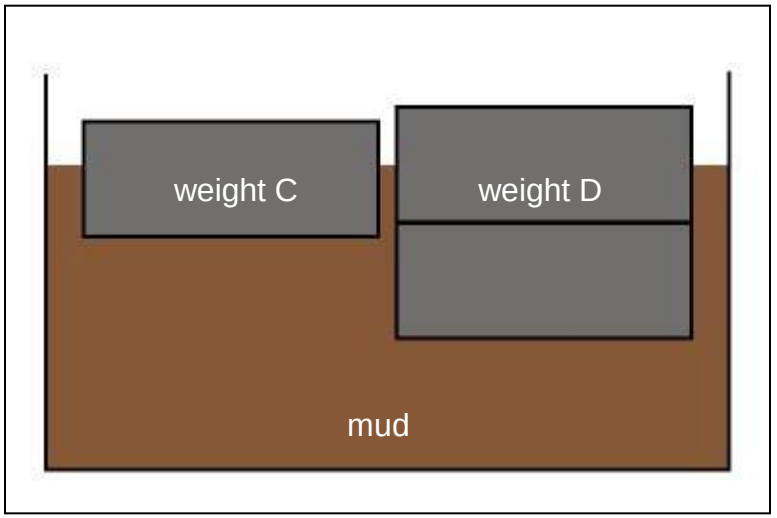
- **force**
- **area**

The pressure increases when

- **force increases**
- **area decreases**

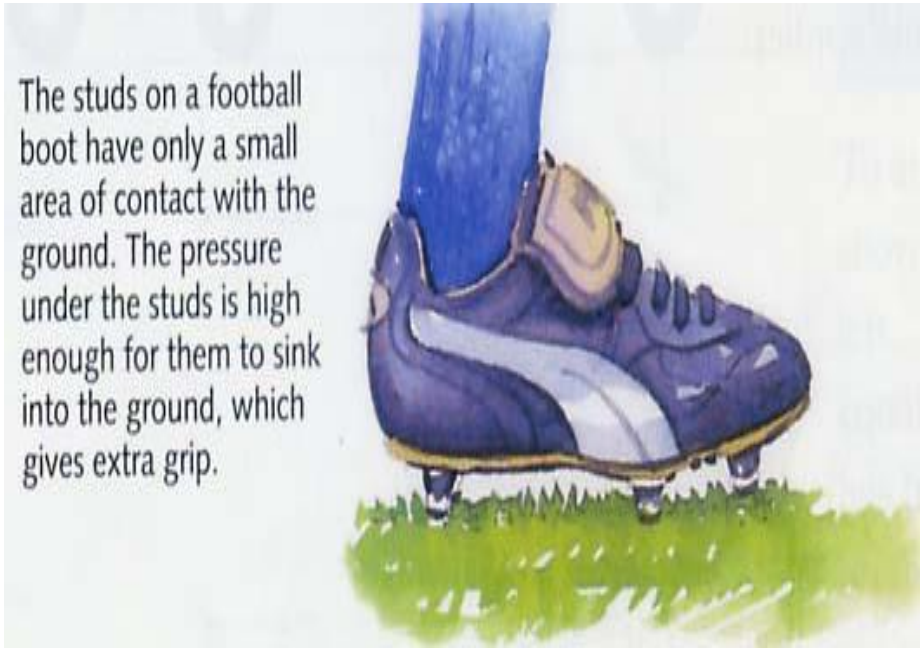


- **weight A sinks further than weight B**



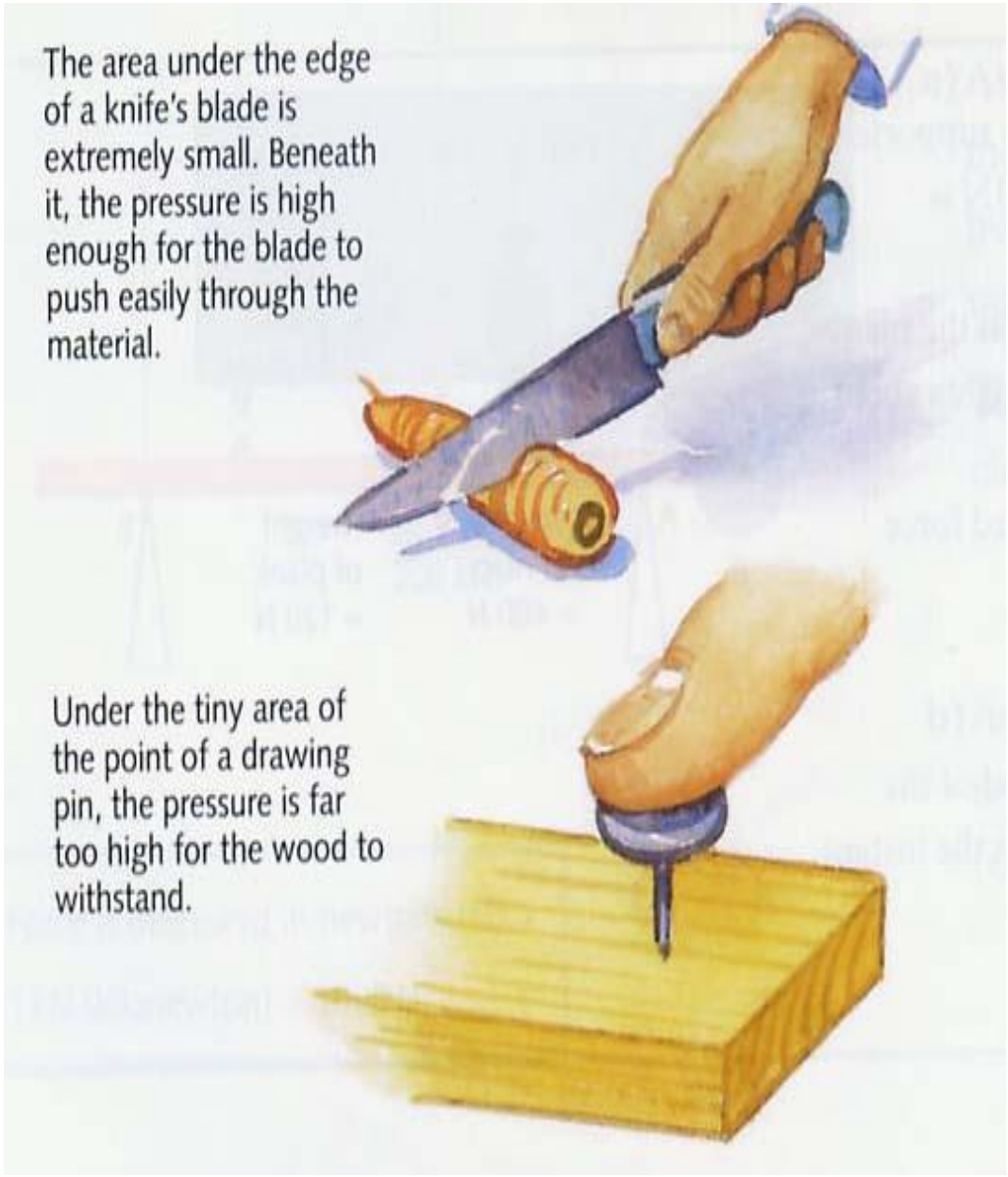
- **weight D sinks further than weight C**

Examples



Pressure is large on the ground as the area of stud is small.

$$P = F/A$$



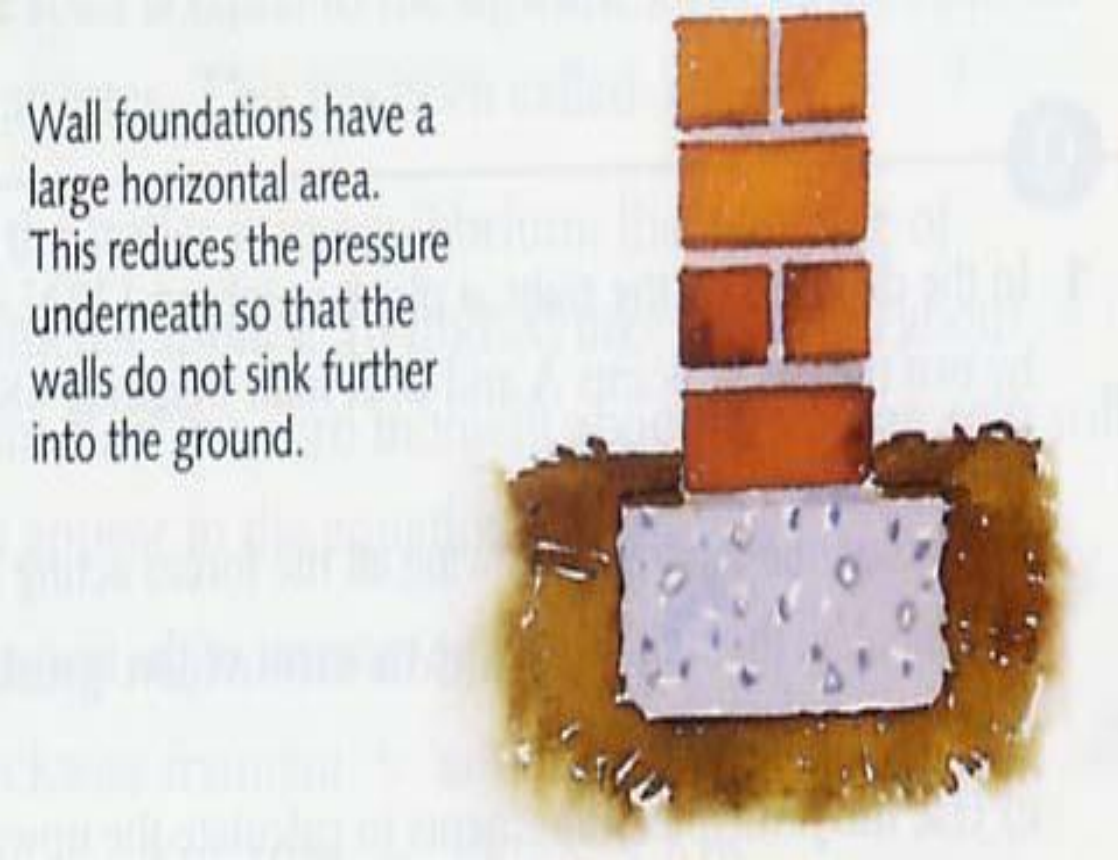
The pressure in both cases are very large as the area of contact is very small.

Why skis has a large area?

Question:

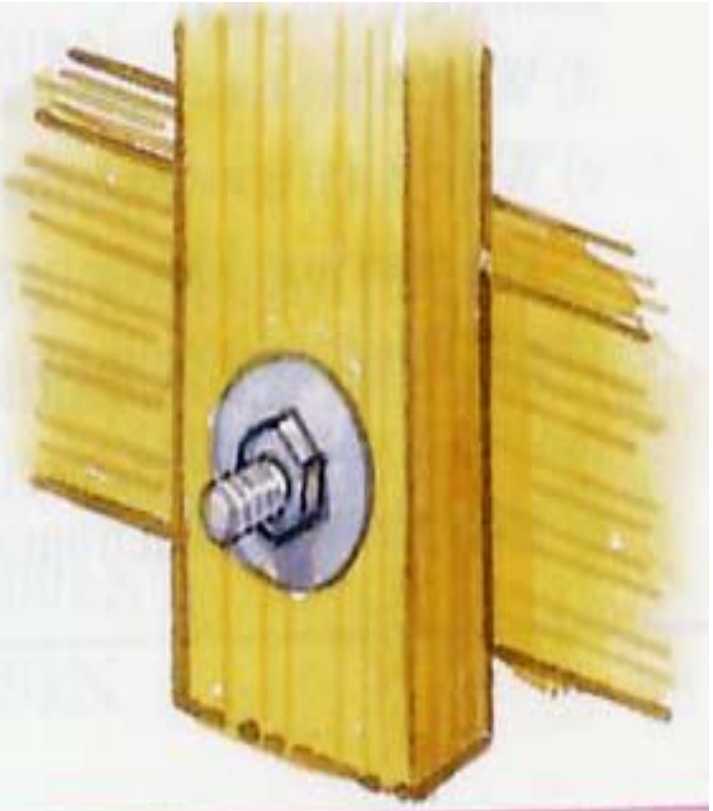
Give any example in daily life that apply the same concept as skis.

Why does the wall foundation have a large horizontal area?



Have you notice this?

A load-spreading washer ensures that the nut is not pulled into the wood when tightened up.



Why is it easier to walk on soft sand if you wear flat shoes rather than shoes with high heels?

Example

A girl weighing 600 N stands on one heel of dimensions 1 cm x 1 cm. What is the pressure exerted by the girl?

$$\text{Pressure} = \frac{\text{force}}{\text{area}}$$

$$= \frac{600\ \text{N}}{0.01\ \text{m} \times 0.01\ \text{m}}$$

$$= 6\,000\,000\ \text{N/m}^2$$

Example

A girl weighing 600 N stands on one flat shoe of dimensions 8 cm x 20 cm. What is the pressure exerted by the girl?

$$\text{Pressure} = \frac{\text{force}}{\text{area}}$$

$$= \frac{600\ \text{N}}{0.08\ \text{m} \times 0.20\ \text{m}}$$

$$= 37\,500\ \text{N/m}^2$$