What are forces?

26th Feb

A force can either be a PUSH or a PULL.

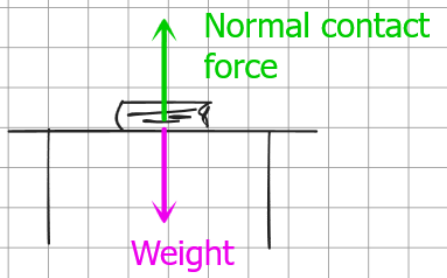
Forces are always exerted (caused) by one object and act on another object.

The size of a force may be measured using an instrument called a newton meter.

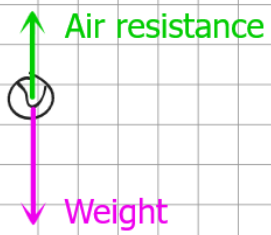
Forces are measured in units called newtons, N.

We represent forces in diagrams with ARROWS. The LENGTH of the arrow can represent the SIZE.

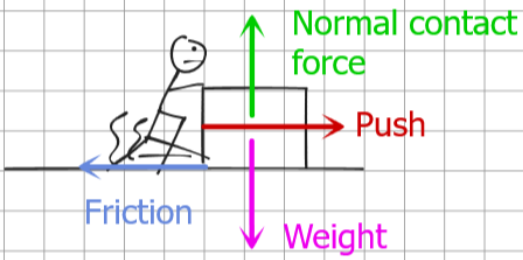
Book on a desk



Falling tennis ball

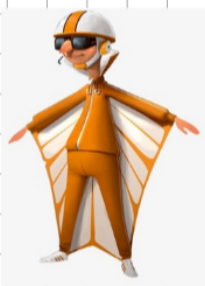


A box being pushed along the floor



Forces always have both a SIZE and a DIRECTION.

They are VECTORS.



Forces that can have an effect a DISTANCE are called NON-CONTACT forces i.e. gravity/weight, magnetism

Forces that require objects to touch are called CONTACT forces i.e. friction, air resistance, normal contact force.

Speed, Velocity, Acceleration

28th Feb

The SPEED of an object is the distance it travels in each unit of time.

The standard unit of speed in physics is metres per second, m/s.

$$\text{Speed} = \frac{\text{distance}}{\text{time}}$$

distance — in metres, m

time — in seconds, s

metres per second, m/s

miles per hour, kilometres per hour, feet per minute, kilometres per minute, metres per millisecond, furlongs per decade, lightyears per century

(Speed =) $\frac{6}{4}$ ✓ ✓ $= 1.5$ m/s ✓

(Speed =) $\frac{50}{5}$ ✓ ✓ $= 10$ m/s ✓

7.5 km = 7500 m ✓

5 min = 300 s ✓

(Speed =) $\frac{7500}{300}$ ✓ $= 25$ m/s ✓

12 km = 12000 m ✓

1 min = 60 s ✓

Speed = $\frac{12000}{60}$ ✓ $= 200$ m/s ✓

SPEED is a SCALAR quantity (it just has a size, not a direction).

The VELOCITY of an object is its SPEED IN A CERTAIN DIRECTION

Velocity is a VECTOR quantity (oh yeah), it has both a SIZE and a DIRECTION.

When an object changes DIRECTION its VELOCITY IS CHANGING, even if its speed stays constant.

When an object's VELOCITY IS CHANGING we say the object is ACCELERATING.

An object is ACCELERATING if it SPEEDS UP, SLOWS DOWN or CHANGES DIRECTION.

Balanced and Unbalanced Forces

5th March

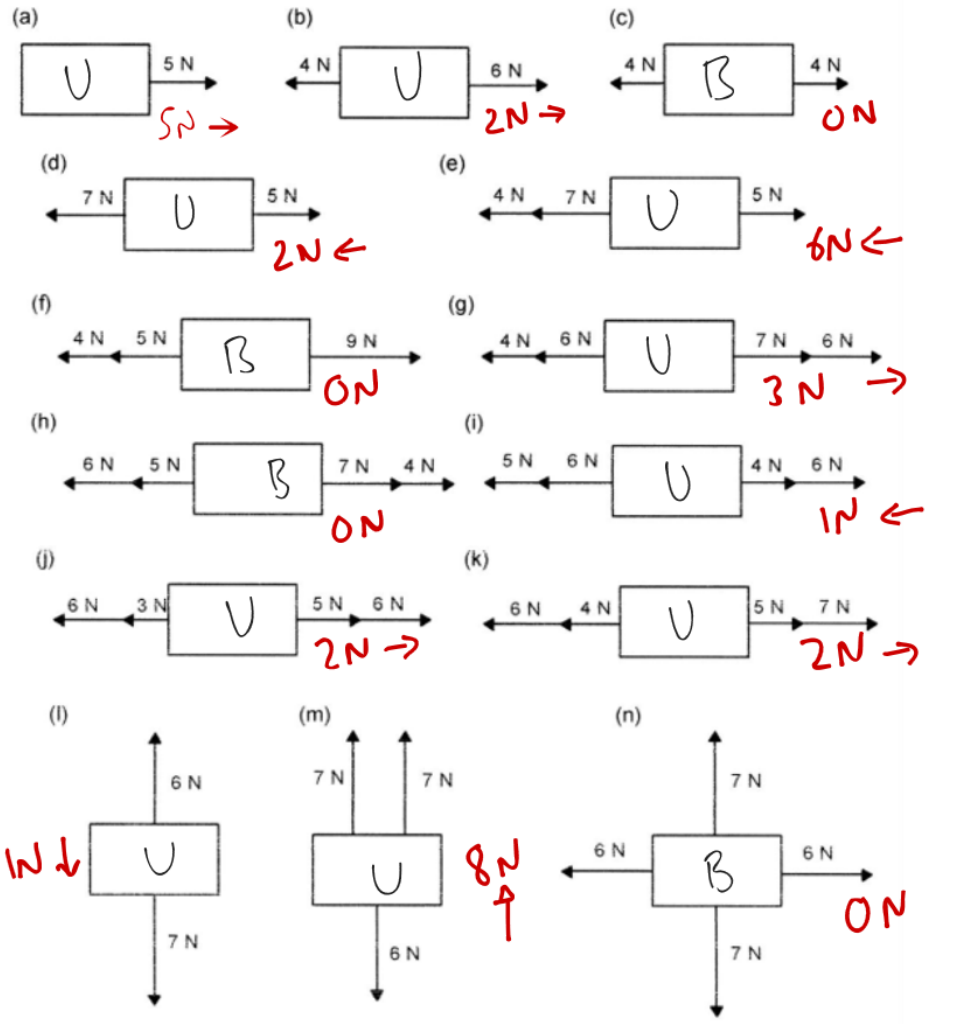
In many situations MULTIPLE FORCES can ACT ON A SINGLE OBJECT.

The RESULTANT FORCE on an object is A SINGLE FORCE that has the SAME EFFECT as all of these multiple forces combined.

Note that forces are VECTORS - so their DIRECTION MATTERS. When we combine forces we ADD UP forces that are in the SAME DIRECTION, and SUBTRACT when forces are in OPPOSITE DIRECTIONS.

If the RESULTANT FORCE on an object is ZERO then we say that the forces acting on it are BALANCED.

If the RESULTANT FORCE is NOT ZERO then the forces are UNBALANCED.



If the forces on an object are UNBALANCED, then the object will ACCELERATE in the DIRECTION of the RESULTANT FORCE.

If the forces on an object are BALANCED (zero resultant force), the object will either remain STATIONARY or keep moving with a CONSTANT VELOCITY.

This is NEWTON'S FIRST LAW OF MOTION.

Mass and Weight

6th March

MASS is the amount of MATTER in an object, and has the unit of kilograms (kg).

WEIGHT is the size of the FORCE due to GRAVITY acting on an object when it is in a particular place. It has the unit of newtons (N) because it is a force.

Weight = mass x gravitational field strength ($W = mg$)

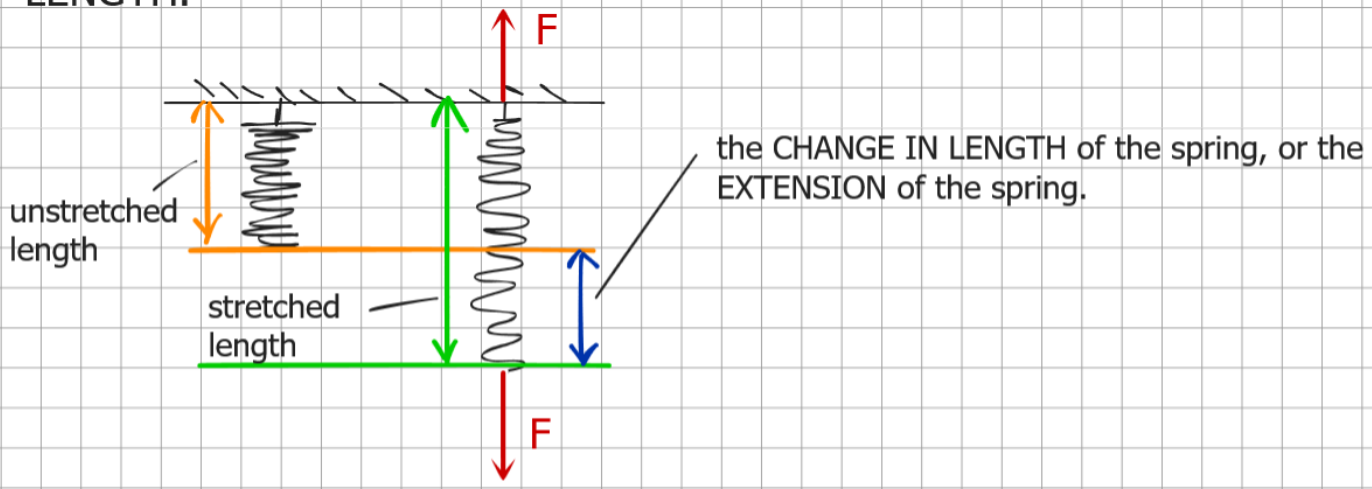
Weight is in newtons, N
Mass is in kilograms, kg
Gravitional field strength is in newtons per kilogram, N/kg

On Earth the gravitational field strength is approximately 10 N/kg.

Springs

7th March

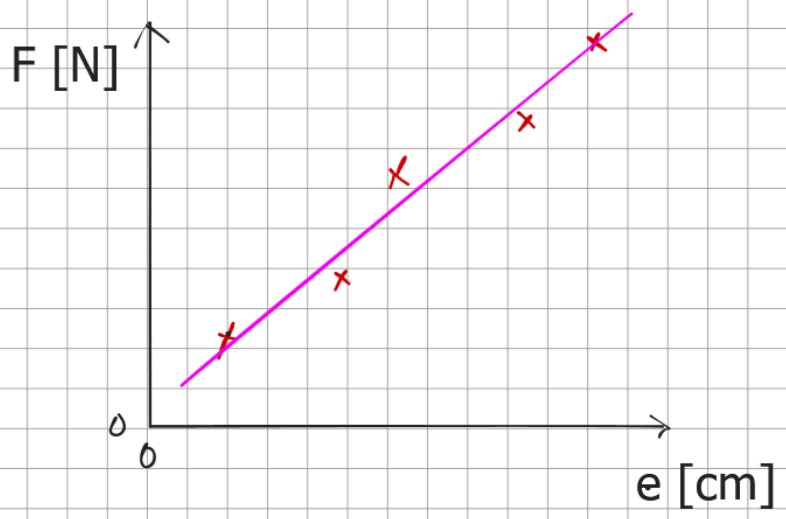
When a pair of forces act in opposite directions on a spring it can CHANGE LENGTH.



Extension = stretched length - unstretched length

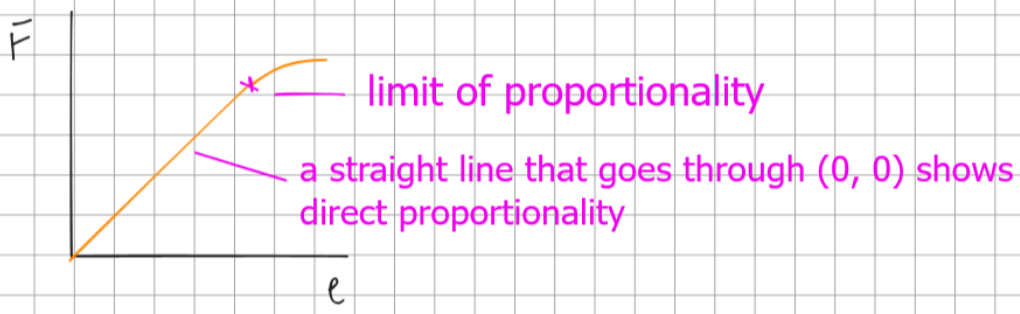
1. Measure weight of mass with newtonmeter
   Record this as 'Force [N]'
2. Measure unstretched length with a ruler
   Record as 'unstretched length [cm]'
3. Carefully add masses to spring, and measure stretched length
   Record as 'stretched length [cm]'
4. Repeat for increasing masses

Force [N]	Unstretched Length [cm]	Stretched length [cm]	Extension [cm]
0	2	2	0
1	2	4	2
2	2	6	4
3	2	8	6
4	2	10	8



Hooke's Law of Elasticity:

- The EXTENSION of a spring is DIRECTLY PROPORTIONAL to the force applied to it, up to the limit of proportionality (elastic limit).
- If two variables are DIRECTLY PROPORTIONAL it means DOUBLING ONE would DOUBLE THE OTHER (or tripling one, triples the other).



Friction

11th March

Friction is generated whenever two surfaces move over each other.

Generally, the rougher the surfaces the greater the amount of friction.

Friction is a RESISTIVE FORCE - it acts in the OPPOSITE DIRECTION to MOTION.

Friction can be useful e.g. walking, brakes on a car/bike

Friction can also waste energy and not be useful e.g. air resistance slowing a car, parts of engine rubbing together wearing them down.

To REDUCE FRICTION we can add a LUBRICANT e.g. oil/grease

To REDUCE DRAG (air/water resistance) we can STREAMLINE an object.

Density

12th March

The DENSITY of a substance (or object) is defined as its MASS PER UNIT VOLUME.

It can be found using the equation: $\text{density} = \frac{\text{mass}}{\text{volume}}$ $\left(\rho = \frac{m}{V}\right)$

The standard units of mass are kilograms, kg
The standard units for volume are cubic metres, m^3

So the standard units for density are kilograms per cubic metre, kg/m^3

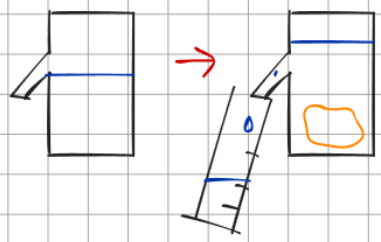
Note: we will often see mass in g, volume in cm^3 and density in g/cm^3.

Material	Mass [g]	h [cm]	d [cm]	w [cm]	V [cm^3]	density [g/cm^3]

$V = h \times d \times w$ $\rho = m/V$

To find the density of an object with an IRREGULAR SHAPE we still need to measure its mass, but we can't measure its dimensions and calculate its volume.

To find the volume we:



- Fill a eureka can with water to just below its spout
- Place the object into the water, and collect any water that is displaced (flows out)
- Measure the volume of the water with a MEASURING CYLINDER
- The volume of this water is THE SAME as the volume of the object.

Upthrust

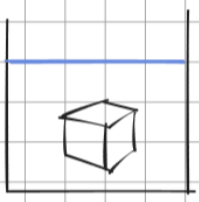
14th March

When an object is immersed (or partly immersed) in a fluid (liquid or a gas), there is a force of UPTHRUST that acts on it.

Weight of object not in fluid [N]	Weight of object immersed in fluid [N]

This tells us the difference between the weight of the object and upthrust

The SIZE of the UPTHRUST an object experiences is equal to the WEIGHT of the FLUID that the object displaces.



This much water is displaced

The upthrust the cube feels will be the same size as the weight of that much water

An object FLOATS when its weight and the force of upthrust are BALANCED.

An object will float in a fluid if the overall DENSITY OF THE OBJECT is LOWER than the DENSITY OF THE FLUID.