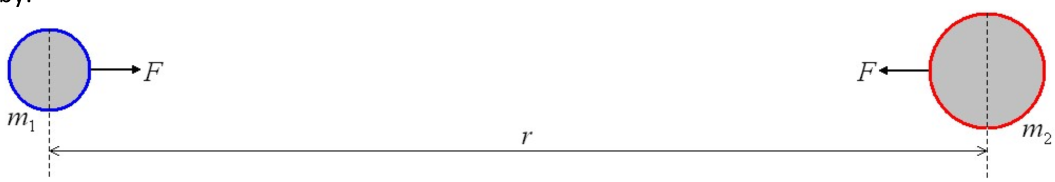
# Newton's Law of Gravitation and Gravitational Fields

## Newton's Law of Gravitation (Gravity)

Gravity is an attractive force that acts between all masses. It is the masses themselves that cause the force to exist. The force that acts between two masses, $m_1$ and $m_2$, whose centres are separated by a distance of $r$ is given by:




$$F \propto \frac{m_1 m_2}{r^2}$$

This was tested experimentally in a lab using large lead spheres and was refined to become:

$$\boxed{F = -\frac{G m_1 m_2}{r^2}}$$

**G is the Gravitational Constant, $G$ = 6.67 x 10$^{-11}$ N m$^2$ kg$^{-2}$**

When one of the masses is of planetary size, $M$, the force between it and a test mass, $m$, whose centres are separated by a distance of $r$ is given by:

$$\boxed{F = -\frac{GMm}{r^2}}$$

The minus sign means that the force is attractive, the force is in the opposite direction to the distance from the mass (displacement). This will become clearer when we look at the electric force.

Negative = Attractive

Positive = Repulsive

**Force is measured in Newtons, N**

## Gravitational Fields

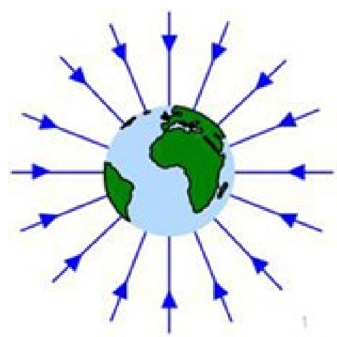
A gravitational field is the area around a mass where any other mass will experience a force. We can model a field with field lines or lines of force.

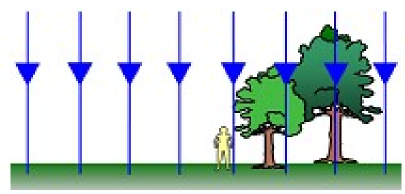
***Radial Fields***

The field lines end at the centre of a mass and tail back to infinity. We can see that they become more spread out the further from the mass we go.

***Uniform Fields***

The field lines are parallel in a uniform field. At the surface of the Earth we can assume the field lines are parallel, even thou they are not.





## Gravitational Field Strength, g

We can think of gravitational field strength as the concentration of the field lines at that point. We can see from the diagrams above that the field strength is constant in a uniform field but drops quickly as we move further out in a radial field.

The gravitational field strength at a point is a vector quantity and is defined as:

*The force per unit mass acting on a small mass placed at that point in the field.*

We can represent this with the equation: $\boxed{g = \frac{F}{m}}$

If we use our equation for the gravitational force at a distance $r$ and substitute this in for $F$ we get:

$g = -\frac{GMm}{r^2 m}$ which simplifies to: $\boxed{g = -\frac{GM}{r^2}}$

**Gravitational Field Strength is measured in Newtons per kilogram, N kg$^{-1}$**