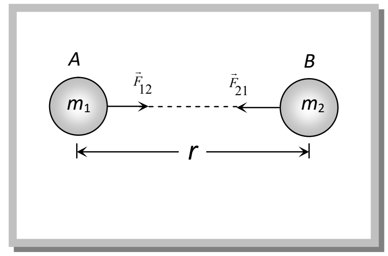
Newton's law of Gravitation.

Newton's law of gravitation states that everybody in this universe attracts every other body with a force, which is directly proportional to the product of their masses and inversely proportional to the square of the distance between their centers. The direction of the force is along the line joining the particles.

Thus the magnitude of the gravitational force F that two particles of masses m_1 and m_2 separated by a distance r exert on each other is given by $F \propto \frac{m_1 m_2}{r^2}$



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

Vector form: According to Newton's law of gravitation

$$\vec{F}_{12} = \frac{-Gm_1 m_2}{r^2}\hat{r}_{21} = \frac{-Gm_1 m_2}{r^3}\vec{r}_{21} = \frac{-Gm_1 m_2}{|\vec{r}_{21}|^3}\vec{r}_{21}$$

$\hat{r}_{12}$ = unit vector from *A* to *B*

$\hat{r}_{21}$ = unit vector from *B* to *A*,

$\vec{F}_{12}$ = gravitational force exerted on body *A* by body *B*

Here negative sign indicates that the direction of $\vec{F}_{12}$ is opposite to that of $\hat{r}_{21}$.

Similarly $$\vec{F}_{21} = \frac{-Gm_1 m_2}{r^2}\hat{r}_{12} = \frac{-Gm_1 m_2}{r^3}\vec{r}_{12} = \frac{-Gm_1 m_2}{|\vec{r}_{12}|^3}\vec{r}_{12}$$

$$= \frac{Gm_1 m_2}{r^2}\hat{r}_{21} \quad [\because \hat{r}_{12} = -\hat{r}_{21}]$$

$\therefore$ It is clear that $\vec{F}_{12} = -\vec{F}_{21}$. Which is Newton's third law of motion.

Here G is constant of proportionality which is called 'Universal gravitational constant'.

If $m_1 = m_2$ and $r = 1$ then $G = F$

i.e. Universal gravitational constant is equal to the force of attraction between two bodies each of unit mass whose canters are placed unit distance apart.

Important points

(i) The value of G in the laboratory was first determined by Cavendish using the torsional balance.

(ii) The value of G is 6.67×10–11 N–m2 kg–2 in S.I. and 6.67×10–8 dyne- cm2-g–22 – t—— in C.G.S. system.

(iii) Dimensional formula $[M^{-1}L^{3}T^{-2}]$.

(iv) The value of G does not depend upon the nature and size of the bodies.

(v) It also does not depend upon the nature of the medium between the two bodies.

(vi) As G is very small hence gravitational forces are very small, unless one (or both) of the masses is huge.