Gravitational Field.

The space surrounding a material body in which gravitational force of attraction can be experienced is called its gravitational field.

Gravitational field intensity : The intensity of the gravitational field of a material body at any point in its field is defined as the force experienced by a unit mass (test mass) placed at that point, provided the unit mass (test mass) itself does not produce any change in the field of the body.

So if a test mass m at a point in a gravitational field experiences a force $\vec{F}$ then

$$\vec{I} = \frac{\vec{F}}{m}$$

Important points

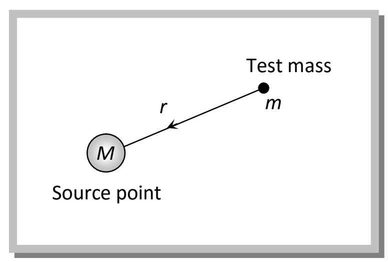
(i) It is a vector quantity and is always directed towards the center of gravity of body whose gravitational field is considered.

(ii) Units: Newton/kg or m/s2

(iii) Dimension: [M0LT–2]

(iv) If the field is produced by a point mass M and the test mass m is at a distance r from it

then by Newton's law of gravitation $F = \frac{GMm}{r^2}$

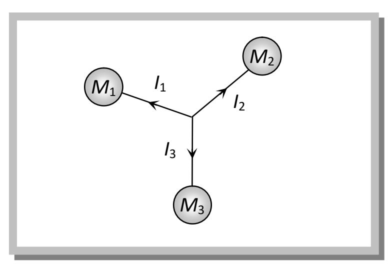


Then intensity of gravitational field $I = \frac{F}{m} = \frac{GMm/r^2}{m}$

$\therefore$ $I = \frac{GM}{r^2}$

(v) As the distance (r) of test mass from the point mass (M), increases, intensity of gravitational field decreases

$$I = \frac{GM}{r^2} \; ; \; \therefore \; I \propto \frac{1}{r^2}$$



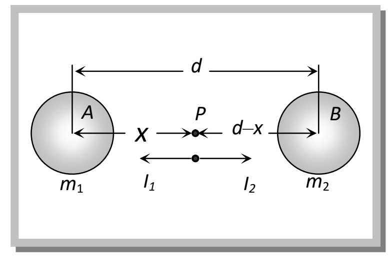
(vi) Intensity of gravitational field $I = 0$, when $r = \infty$.

(vii) Intensity at a given point (P) due to the combined effect of different point masses can be calculated by vector sum of different intensities

$$\overrightarrow{I_{net}} = \overrightarrow{I_1} + \overrightarrow{I_2} + \overrightarrow{I_3} + \ldots\ldots$$

(viii) Point of zero intensity: If two bodies A and B of different masses m_1 and m_2 are d distance apart.

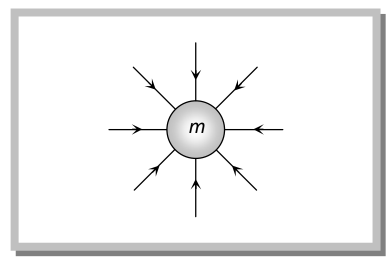
Let P be the point of zero intensity i.e., the intensity at this point is equal and opposite due to two bodies A and B and if any test mass placed at this point it will not experience any force.



For point P $\overrightarrow{I_1} + \overrightarrow{I_2} = 0 \Rightarrow \frac{-Gm_1}{x^2} + \frac{Gm_2}{(d-x)^2} = 0$

By solving $x = \frac{\sqrt{m_1}\, d}{\sqrt{m_1} + \sqrt{m_2}}$ and $(d-x) = \frac{\sqrt{m_2}\, d}{\sqrt{m_1} + \sqrt{m_2}}$

(ix) Gravitational field line is a line, straight or curved such that a unit mass placed in the field of another mass would always move along this line. Field lines for an isolated mass m are radially inwards.



(x) As $I = \frac{GM}{r^2}$ and also $g = \frac{GM}{R^2}$ $\therefore \quad I = g$

Thus the intensity of gravitational field at a point in the field is equal to acceleration of test mass placed at that point.