

Inertial and Gravitational Masses.

(1) Inertial mass: It is the mass of the material body, which measures its inertia.

If an external force F acts on a body of mass m_i , then according to Newton's second law of motion

$$F = m_i a \text{ Or } m_i = \frac{F}{a}$$

Hence inertial mass of a body may be measured as the ratio of the magnitude of the external force applied on it to the magnitude of acceleration produced in its motion.

Important points

(i) It is the measure of ability of the body to oppose the production of acceleration in its motion by an external force.

(ii) Gravity has no effect on inertial mass of the body.

(iii) It is proportional to the quantity of matter contained in the body.

(iv) It is independent of size, shape and state of body.

(v) It does not depend on the temperature of body.

(vi) It is conserved when two bodies combine physically or chemically.

(vii) When a body moves with velocity v , its inertial mass is given by

$$m = \frac{m_0}{\sqrt{1 - \frac{v^2}{c^2}}}, \text{ where } m_0 = \text{rest mass of body, } c = \text{velocity of light in}$$

vacuum,

(2) Gravitational Mass: It is the mass of the material body, which determines the gravitational pull acting upon it.

If M is the mass of the earth and R is the radius, then gravitational pull on a body of mass m_g is given by

$$F = \frac{GMm_g}{R^2} \text{ Or } m_g = \frac{F}{(GM/R^2)} = \frac{F}{E}$$

Here m_g is the gravitational mass of the body, if $E = 1$ then $m_g = F$

Thus the gravitational mass of a body is defined as the gravitational pull experienced by the body in a gravitational field of unit intensity,

(3) Comparison between inertial and gravitational mass

(i) Both are measured in the same units.

(ii) Both are scalars

(iii) Both do not depend on the shape and state of the body

(iv) Inertial mass is measured by applying Newton's second law of motion whereas gravitational mass is measured by applying Newton's law of gravitation.

(v) Spring balance measures gravitational mass and inertial balance measures inertial mass.

(4) Comparison between mass and weight of the body

| Mass (m) | Weight (W) |
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| It is a quantity of matter contained in a body. | It is the attractive force exerted by earth on anybody. |
| Its value does not change with g | Its value changes with g. |
| Its value can never be zero for any material particle. | At infinity and at the center of earth its value is zero. |
| Its unit is kilogram and its dimension is [M]. | Its unit is Newton or kg-wt and dimension are [MLT^{-2}] |
| It is determined by a physical balance. | It is determined by a spring balance. |
| It is a scalar quantity. | It is a vector quantity. |