GRAVITATION

ACCELERATION DUE TO GRAVITY

Acceleration due to gravity

The acceleration with which a body falls towards the earth due to earth's gravitational pull is known as acceleration due to gravity. It is denoted by 'g'. Thus, all bodies irrespective of their masses fall down with constant acceleration.

Determination of value OF g

When a body of mass m is dropped from a certain distance R from the centre of earth of mass M, then the force exerted by the earth on the body is

$$F = G\frac{Mm}{R^2} \qquad \text{... (i)}$$

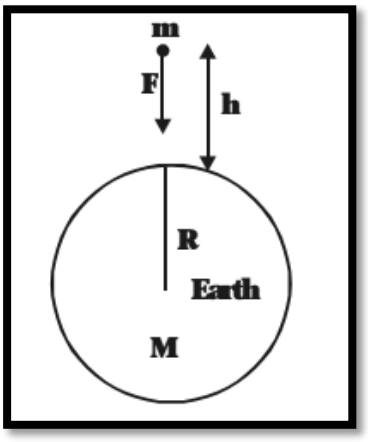
Let this force produces an acceleration a in mass m. h F m R Earth M

$\therefore$ F = ma or F = mg ... (ii)

From (i) and (ii),

$$mg = \frac{GMm}{R^2}$$

$$g = \frac{GM}{R^2}$$



For bodies falling near the surface of earth, this acceleration is called acceleration due to gravity and is represented by g

$$g = \frac{GM}{R^2} \qquad \text{... (A)}$$

where M is the mass of the earth i.e., 6×10^{24} kg and R, the radius of the earth i.e,6.4×10^{6} m

$$g = \frac{GM}{R^2} = \frac{6.67 \times 10^{-11}\left(6\ 10^{24}\right)}{\left(6.4\ 10^{6}\right)^2}$$

or g = 9.8 ms^{-2} or nearly 10 ms^{-2}

Value of g on moon

Mass of moon = 7.4×10^{22} kg and its radius = 1,740 km or R = 1,740,000 m = 1.74×10^{6} m

$$g = \frac{GM}{R^2} = \frac{6.67 \times 10^{-11}\left(7.4 \times 10^{22}\right)}{\left(1.74 \times 10^{6}\right)^2} = 1.63\, ms^{-2}$$

Mass of the earth We can determine mass of the earth from equation (A)

$$g = \frac{GM}{R^2}\ or\ M = \frac{gR^2}{G}$$

$\therefore$ Mass of the earth $M = \frac{9.8\left(6.4\ 10^{6}\right)^2}{6.67\ 10^{11}}$

or M = 6.018×10^{24} kg

Average density of the earth

It can also be determined from equation (A) above.

$$g = \frac{GM}{R^2} \frac{G\frac{4}{3}R^3 d}{R^2} G = \frac{4}{3} Rd \quad volume = \frac{mass}{Density}$$

$$Mass = Volume \times density$$

$$d = \frac{3g}{G4\pi R}$$

Taking the earth to be a sphere of radius R

$$d = \frac{3g}{6.67\ 10^{11}\ 4\ \left(6.4\ 10^{6}\right)}$$

or d = 5.5 × 103 kg m^{-3}

Calculation of acceleration due to gravity on the moon and to prove that it is 1/6th of the acceleration due to gravity on the earth.

Mass of the moon (M) = 7.4×10^{22} kg Radius of the moon (R) = 1.74×10^{6} m

Gravitational constant (G) = 6.7×10^{-11} Nm^2/kg^2

$\therefore$ Acceleration due to gravity on the moon, $g = \frac{Gm}{R^2}$

$$g_{moon} = \frac{6.7 \times 10^{-11} Nm^2 Kg^2 \times 7.4 \times 10^{22} kg}{\left(1.74 \times 10^{6} m\right)^2} \qquad g_{moon} = \frac{6.7 \times 7.4}{1.74 \times 1.74} \times \frac{10^{-11+12}}{10^{12}} N/Kg$$

$$g_{moon} = 1.63\, ms^2 \qquad \frac{g_{moon}}{g_{moon}} = \frac{1.63 ms^{-2}}{9.81 ms^2} \frac{1}{6} approx$$

$$g_{moon} = \frac{1}{6} g\ Earth$$