Orbital Velocity of Satellite.

Satellites are natural or artificial bodies describing orbit around a planet under its gravitational attraction. Moon is a natural satellite while INSAT-1B is an artificial satellite of earth. Condition for establishment of artificial satellite is that the center of orbit of satellite must coincide with center of earth or satellite must move around great circle of earth.

Orbital velocity of a satellite is the velocity required to put the satellite into its orbit around the earth.

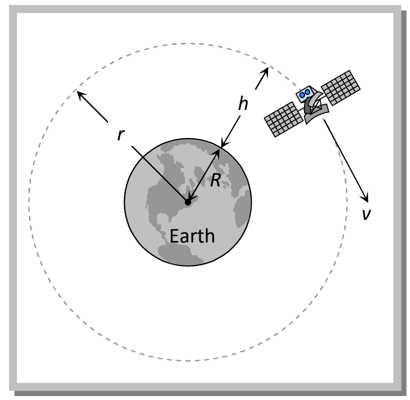
For revolution of satellite around the earth, the gravitational pull provides the required centripetal force.

$$\frac{mv^2}{r} = \frac{GMm}{r^2}$$

$$\Rightarrow \quad v = \sqrt{\frac{GM}{r}}$$

$$v = \sqrt{\frac{gR^2}{R+h}} = R\sqrt{\frac{g}{R+h}}$$

[As $GM = gR^2$ and $r = R + h$]



Important points

(i) Orbital velocity is independent of the mass of the orbiting body and is always along the tangent of the orbit i.e., satellites of deferent masses have same orbital velocity, if they are in the same orbit.

(ii) Orbital velocity depends on the mass of central body and radius of orbit.

(iii) For a given planet, greater the radius of orbit, lesser will be the orbital velocity of the satellite $\left(v \propto 1/\sqrt{r}\right)$.

(iv) Orbital velocity of the satellite when it revolves very close to the surface of the planet

$$v = \sqrt{\frac{GM}{r}} = \sqrt{\frac{GM}{R+h}} \;\therefore\; v = \sqrt{\frac{GM}{R}} = \sqrt{gR}$$

[As $h = 0$ and $GM = gR^2$]

For the earth $v = \sqrt{9.8 \times 6.4 \times 10^6} = 7.9\, km/s \approx 8\, km/\sec$

(v) Close to the surface of planet $v = \sqrt{\frac{GM}{R}}$ [As $v_e = \sqrt{\frac{2GM}{R}}$]

$\therefore$ $v = \frac{v_e}{\sqrt{2}}$ i.e., $v_{escape} = \sqrt{2}\ v_{orbital}$

It means that if the speed of a satellite orbiting close to the earth is made $\sqrt{2}$ times (or increased by 41%) then it will escape from the gravitational field.

(vi) If the gravitational force of attraction of the sun on the planet varies as $F \propto \frac{1}{r^n}$ then the orbital velocity varies as $v \propto \frac{1}{\sqrt{r^n - 1}}$.