Energy of Satellite.

When a satellite revolves around a planet in its orbit, it possesses both potential energy (due to its position against gravitational pull of earth) and kinetic energy (due to orbital motion).

(1) Potential energy: $U = mV = \frac{-GMm}{r} = \frac{-L^2}{mr^2}$ $\quad \left[\text{As } V = \frac{-GM}{r}, L^2 = m^2GMr\right]$

(2) Kinetic energy: $K = \frac{1}{2}mv^2 = \frac{GMm}{2r} = \frac{L^2}{2mr^2}$ $\quad \left[\text{As } v = \sqrt{\frac{GM}{r}}\right]$

(3) Total energy: $E = U + K = \frac{-GMm}{r} + \frac{GMm}{2r} = \frac{-GMm}{2r} = \frac{-L^2}{2mr^2}$

Important points

(i) Kinetic energy, potential energy or total energy of a satellite depends on the mass of the satellite and the central body and also on the radius of the orbit.

(ii) From the above expressions we can say that

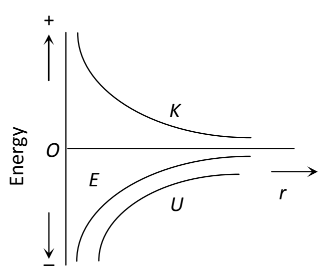
Kinetic energy (K) = – (Total energy)

Potential energy (U) = 2 (Total energy)

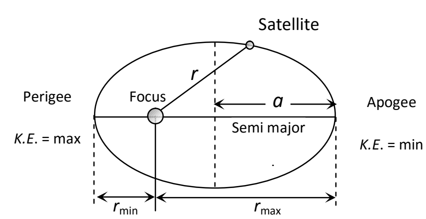
Potential energy (K) = – 2 (Kinetic energy)

(iii) Energy graph for a satellite

(iv) Energy distribution in elliptical orbit



(A)



(B)

(v) If the orbit of a satellite is elliptic then

(a) Total energy $(E) = \frac{-GMm}{2a} =$ constant; wherea is semi-major axis.

(b) Kinetic energy (K) will be maximum when the satellite is closest to the central body (at perigee) and maximum when it is farthest from the central body (at apogee)

(c) Potential energy (U) will be minimum when kinetic energy = maximum i.e., the satellite is closest to the central body (at perigee) and maximum when kinetic energy = minimum i.e., the satellite is farthest from the central body (at apogee).

(vi) Binding Energy: Total energy of a satellite in its orbit is negative. Negative energy means that the satellite is bound to the central body by an attractive force and energy must be supplied to remove it from the orbit to infinity. The energy required to remove the satellite from its orbit to infinity is called Binding Energy of the system, i.e.

Binding Energy (B.E.) $= -E = \frac{GMm}{2r}$