$$\therefore T^2 = \frac{4\pi^2 a^3}{\mu}$$

$$\boxed{T^2 = \frac{4\pi^2 a^3}{\mu}}$$

$$\Rightarrow T^2 \propto a^3 \quad \text{------ } (*)$$

(*) Keplers third Law of planet Motion.

The orbital period of a GEO satellite is exactly equal to the period of the earth that is 24 hour = 23 hour, 56min, & 4.1 sec. But, to an observer on the ground, the satellite appears to have an infinite orbital period. It always stays in the same place in the sky.

Locating the Satellite in the Orbit :- The equation of the orbit of satellite can be written as-

$$r_0 = \frac{p}{1 + e\cos\phi_0} = \frac{a(1-e^2)}{1 + e\cos\phi_0} \quad \text{------ (i)}$$

The angle ϕ_0 is measured from x_0 axis and called — anomaly. x_0 such that passes through perigee. The angle ϕ_0 measured from perigee to the instaneous position of the satellite. The rectangular co-ordinates of the satellite are given by-

$$x_0 = r_0 \cos\phi_0$$

$$y_0 = r_0 \sin\phi_0$$

The angular velocity η of satellite can be given as-

$$\boxed{\eta = \frac{2\pi}{T} = \mu^{1/2} a^{-3/2}}$$

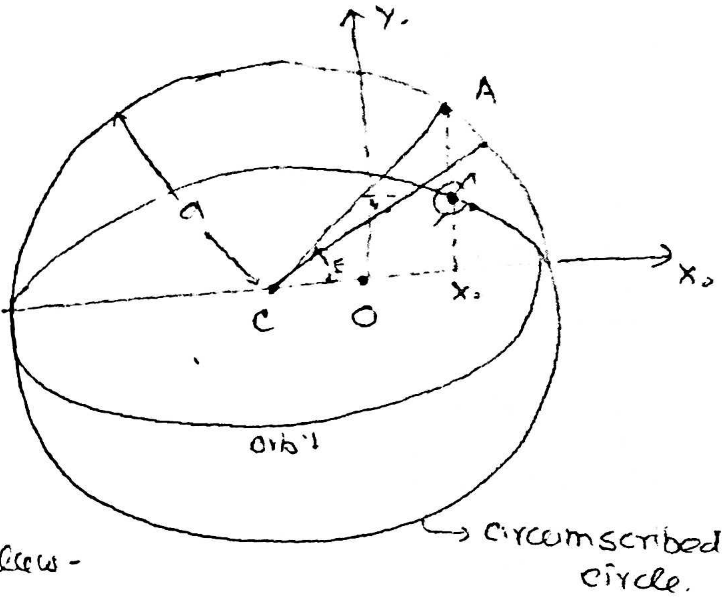
average angular velocity

$$\boxed{\eta = \frac{1}{a}\sqrt{\frac{\mu}{a}}}$$

where T = Orbit period of Satellite
- Time taken by Satellite to complete a revolution.

In the Figure C is centre of both ellipse and circumscribed circle. Point O is the centre of earth

E = is the angle from the X_0 axis to the line joining C and A.



Now the r_0 given as bellow -

$$r_0 = a(1 - e\cos E)$$

$$a - r_0 = ae\cos E$$

Now we can develope an relation between eccentric anomaly E and angular velocity η -

$$\eta\, dt = (1 - e\cos E)\, dE, \quad \text{------------} \quad (ii)$$

Let t_p is the time at perigee. This is simultaneously the time of closest approach to the earth $\longrightarrow$ The time when satellite crossing the x_0 axis

$\longrightarrow$ The time when E is zero

t_p = time at perigee
= The time when satellite crossing the X_0 axis.
= The time when E is zero.

Integrating equation (ii) both side we get-

$$\underbrace{\eta\,(t - t_p)} = E - e\sin E \quad \text{------- -(iii)}$$

The term $\eta\,(t - t_p)$ called mean anomaly M.
Hence equation (iii) becomes-

$$\boxed{M = \eta\,(t - t_p) = (E - e\sin E)}$$

The mean anomaly M is the arc length that the satellite would have travel since the perigee passage. If satellite moving on the circumscribed circle at the mean velocity angular velocity η.

→ If we know that the time of perigee t_p, the eccentricity e, and the length of semimajor axis a,

→ Now we have the necessary equations to determine the co-ordinates (r_0, ϕ_0) and (x_0, y_0) of the satellite in the orbital plane. The process is follows-

* ⇒ Calculate avg. angular velocity by using-

$$\eta = \frac{1}{a}\sqrt{\frac{\mu}{a}}$$

* ⇒ Calculate mean anomaly M by using -

$$M = \eta\,(t - t_p)$$

* ⇒ Calculate eccentric anomaly E by using.

$$M = E - e\sin E$$

* → Calculate r_o by using following equation-

$$a - r_o = ae \cos E$$

$$r_o = a - ae \cos E$$

$$r_o = a(1 - e\cos E)$$

* → Calculating value of ϕ_o from following equation-

$$r_o = \frac{a(1-e^2)}{1 + e\cos\phi_o}$$

* → Calculate values of x_o & y_o by using following equations

$$x_o = r_o \cos\phi_o$$

$$y_o = r_o \sin\phi_o$$

Velocity of Satellite:- *. Let us consider Satellite moving with velocity v in orbit. The velocity v can be given as bellow-

$$v^2 = \left(\frac{dx_o}{dt}\right)^2 + \left(\frac{dy_o}{dt}\right)^2 \quad \text{------------ (i)}$$

where. $x_o = r_o \cos\phi_o$ &

$y_o = r_o \sin\phi_o$

$$\Rightarrow \quad \frac{dx_o}{dt} = \cos\phi_o \frac{dr_o}{dt} - r_o \sin\phi_o \frac{d\phi_o}{dt} \quad \text{------------ (ii)}$$

$$\Rightarrow \quad \frac{dy_o}{dt} = \sin\phi_o \frac{dr_o}{dt} + r_o \cos\phi_o \frac{d\phi_o}{dt} \quad \text{------------ (iii)}$$

Squaring and adding equation (ii) & (iii), we get

$$v^2 = \left(\frac{dr_o}{dt}\right)^2 + r_o^2 \left(\frac{d\phi_o}{dt}\right)^2 \quad \text{------ (iv)}$$