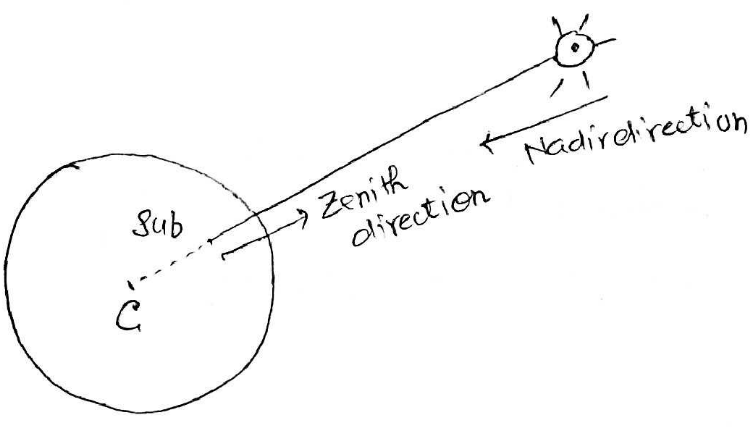
path.

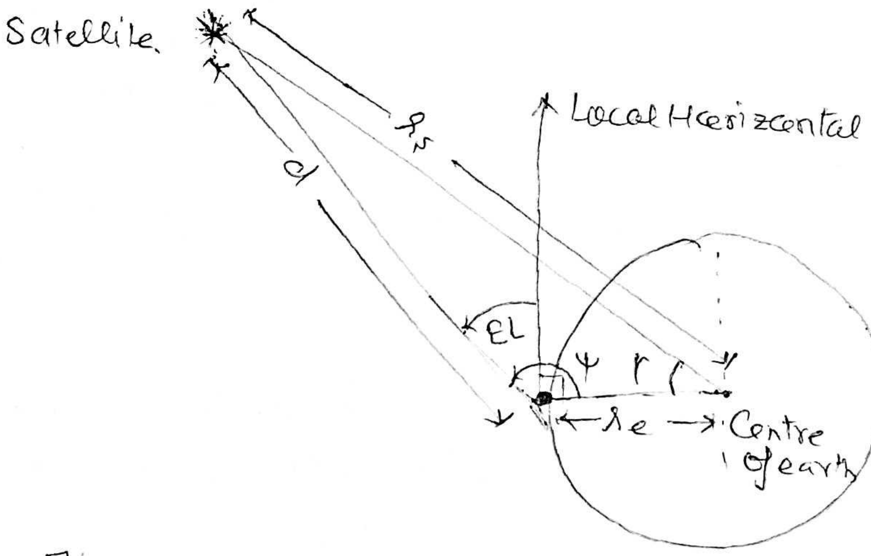
⇒ Subsatellite Point :-

The subsatellite point is the location on the surface of the earth that lies directly between satellite and the centre of the earth. It is nadir pointing direction from the satellite and for a satellite in an equatorial orbit, it will always be located on the equator.

The zenith and Nadir pointing directions. The line joining the satellite and the centre of earth, c, passes through the surface of earth at sub - subsatellite point. The satellite directly overhead at this point, so observer at subsatellite point would see the satellite at zenith {i.e. at elevation angle 90°}.



The pointing direction from satellite to - subsatellite point is Nadir direction. from satellite to sub-station point is zenith direction. The figure shows geometry of elevation angle calculation



in the Figure.

$\vec{r_s}$ = Vector from centre of earth to satellite
$\vec{r_e}$ = vector from centre of earth to earth station.
$\vec{d}$ = vector from earth station to the satellite.

Three three vectors lies in same plane and form a triangle.

Central angle r = measured between $\vec{r_e}$ and $\vec{r_s}$

angle ψ = measured from $\vec{r_e}$ to $\vec{d}$, Defined so that nonnegative.

The angle r related to following four terms -

L_e = Earth station north lattitude

L_e is the number of degrees in lattitude that the earth station is north from the equator.

l_e = West longitude.

l_e is the number of degrees in longitude that an earth station is west from greenwich meridian.

L_s = Substallite point at north lattitude.

l_s = substallite point at West longitude.

Hence angle r related to above four parameters in following ways -

$$\cos r = \cos(l_e) \cos(L_s) \cos(l_s - l_e) + \sin(L_e) \sin(L_s)$$

apply cosine rule in the Figure-

$$d^2 = r_s^2 + r_e^2 - 2 r_e r_s \cos r$$

$$d^2 = \left[1 + \frac{r_e^2}{r_s^2} - \frac{2 r_e}{r_s} \cos r\right] r_s^2$$

$$\therefore d = r_s \left[1 + \frac{r_e^2}{r_s^2} - \frac{2 r_e}{r_s} \cos r\right]^{1/2} \quad \text{------- (i)}$$

since the Local Horigontal plane is perpendicular to the earth station joining vector r_e to centre of earth. Hence elevation angle related to the central angle ψ as:-

$$El = \psi - 90° \quad \text{------- (ii)}$$

By Law of sine we have.

$$\frac{r_s}{\sin \psi} = \frac{d}{\sin r} \quad \text{------- (iii)}$$

From equation (iii) $\Rightarrow$ $$\frac{r_s}{\sin(El + 90°)} = \frac{d}{\sin r}$$

$$\cos El = \frac{r_s \sin r}{d}$$

$$= \frac{\sin r}{\left[1 + \left(\frac{r_e}{r_s}\right)^2 - 2\left(\frac{r_e}{r_s}\right)\cos t\right]^{1/2}}$$

$$\boxed{\cos(El) = \frac{\sin r}{\left[1+(r_e/r_s)^2 - 2\,(r_e/r_s)\cos t\right]^{1/2}}}$$

Hence we see that the an elevation angle calculated by - calculations of knowladge of subsatellite points and earth-station co-ordinates, The orbital radius r_s, earth station radius r_e.

** Accurate value of earth station radius = 6378.137 km

** But a common value is used in the approximate determinations = 6370 km.

→ **Azimuth angle**:- To find the azimuth angle, an intermediate angle α must first be found.

$$\boxed{\alpha = \tan^{-1}\left\{\frac{\tan(l_s - l_e)}{\sin(L_e)}\right\}}$$

After then azimuth angle found by using

* **Sidereal day**:- The sidereal day is defined as one complete rotation of the earth relative to fixed stars. One sidereal day has, 24 sidereal hours. One sidereal hour has 60 sidereal minutes. One sidereal minutes has 60 sidereal seconds.

1 mean solarday = 1.00273 mean sidereal days
= 24 hour, 3 m, 56.55 sec.

1 mean sidereal day = 0.9972 mean solar days
= 23 hour, 56 m, 04.09 sec.