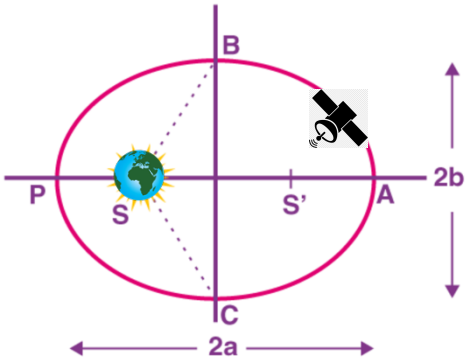
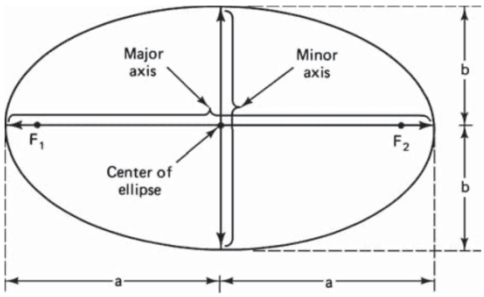
18ECE223T – Satellite Communication and Broadcasting

Unit 1 – Satellite Orbit

Formulas for Problem Solving

1. To find Eccentricity





Eccentricity e is given as

$$e = \frac{\sqrt{a^2 - b^2}}{a}$$

For an elliptical orbit

$$0 < e < 1$$

When e = 0, the orbit becomes circular

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2. Kepler's Third Law Formula

$$a^3 = \frac{\mu}{n^2}$$

$\mu = 3.986005 \times 10^{14}\ m^3/s^2$ the earth's geocentric gravitational constant

n in radians per second, the orbital period in seconds is given by

$$P = \frac{2\pi}{n}$$

Note: To find radius of an orbit with mean period given or to find mean period with radius of an orbit given – use Kepler's third law formula

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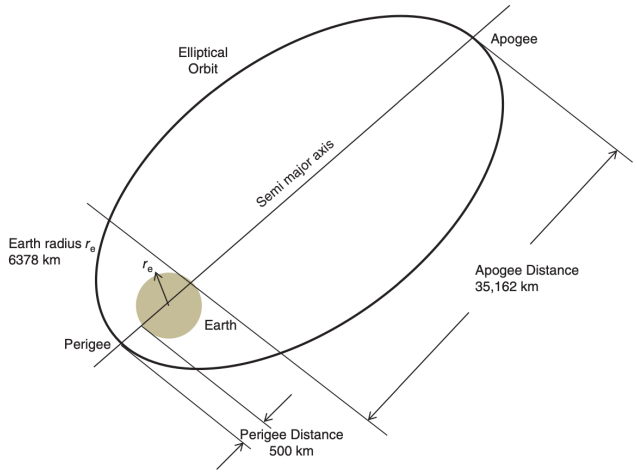
3. To find Apogee and Perigee Heights



$$r_a = a(1+e)$$

$$r_p = a(1-e)$$

a – semimajor axis
e – eccentricity
r_a – Apogee height from earth center
r_b – Perigee height from earth center

$$a = (r_a + r_b)/2$$

Note: To find height of Apogee (h_a) and Perigee (h_b) from earth surface subtract r_a and r_b from mean earth radius (6371 km)

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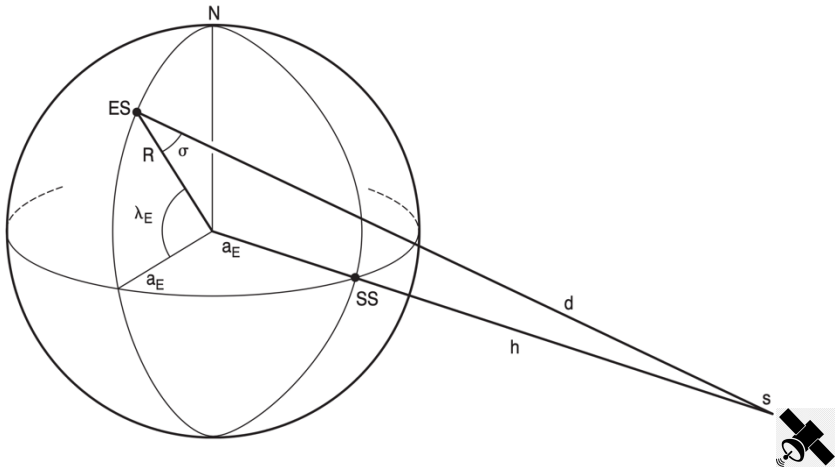
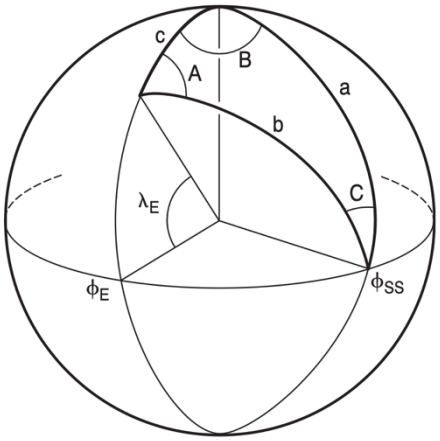
4. To find Look Angles for a Geostationary Satellite

Look angles are **<u>Azimuth and Elevation angles</u>** of Earth Station Antenna aligned to the satellite in orbit.





The three pieces of information that are needed to determine the **look angles for the geostationary orbit** are

- The earth-station latitude, denoted here by $\boldsymbol{\lambda_E}$
- The earth-station longitude, denoted here by $\boldsymbol{\phi_E}$
- The longitude of the subsatellite point, denoted here by $\boldsymbol{\phi_{SS}}$ (often this is just referred to as the satellite longitude)

Latitudes north - **Positive angles (i.e. 100°N is +100°)**
Latitudes south - **Negative angles. (i.e. 100°S is -100°)**
Longitudes east - **Positive angles (i.e. 100°E is +100°)**
Longitudes west - **Negative angles (i.e. 100°W is -100°)**

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$$a = 90°$$

$$c = 90° - \lambda_E$$

$$B = \phi_E - \phi_{SS}$$

$$b = \arccos(\cos B \ \cos \lambda_E)$$

To find Azimuth angle

Note: Check for λ_E and B value and find Azimuth Angle using table below

λ_E	B	A_z, degrees
<0	<0	A
<0	>0	$360° - A$
>0	<0	$180° - A$
>0	>0	$180° + A$

Where A is

$$A = \arcsin\left(\frac{\sin|B|}{\sin b}\right)$$

To find Elevation angle

$$El = \arccos\left(\frac{a_{GSO}}{d}\sin b\right)$$