Problem 4. Perturbing forces

Perturbing forces, i.e. forces that deviate from the central gravity field term, cause a satellite's orbit around the Earth to deviate from a perfect Keplerian orbit. These perturbing forces can sometimes be advantageous for certain satellite orbits around the Earth.

Sun-synchronous satellite orbits:

a. What is a sun-synchronous orbit?

b. Give at least three possible advantages of flying a sun-synchronous orbit (consider especially so-called "dawn-dusk" orbits with a local time of 6 AM or 6 PM at equator crossings).

c. Compute the inclination of a sun-synchronous circular orbit at 250 km altitude above the Earth.

d. Does the inclination of a circular sun-synchronous orbit decrease or increase with higher altitudes?

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a) Sun-synchronous orbit.

Is a circular polar orbit, where angle between orbital plane and sun vector is constant

b) - The satellite can continually see the Sun: as reference for attitude control, for observations of the Sun, for near-continuous energy supply by solar panels

- In a circular orbit the satellite overflies a certain latitude always at the same local solar time: when making observations from space, illumination conditions are the same

- Instruments looking outward can cover the entire celestial sphere in half a year (no disruption by the Sun)

c) $$\dot{\Omega} = \frac{\Delta\Omega}{T} = \underbrace{\left(-3\pi J_2 \left(\frac{R_e}{r}\right)^2 \cos i\right)}_{\Delta\Omega \text{ (per orbital revolution)}} \underbrace{\left(\frac{1}{2\pi}\sqrt{\frac{\mu}{r^3}}\right)}_{T}$$

$J_2 = 1.082627 \cdot 10^{-3}$

$\mu = 398600 \text{ km}^3/\text{s}^2$

$R_e = 6371 \text{ km}$

$r = R_e + \text{Altitude given} = 6371 + 250 = 6621$

$$\dot{\Omega} = \frac{360^\circ}{\text{jaar}} = \frac{2\pi}{365.25 \cdot 24 \cdot 60 \cdot 60} = 1.99102 \cdot 10^{-7} \text{ rad/s}$$

Make $\cos i$ the subject of the equation and fill in.

d) see 6.4: Nodal Regression (Summary).

higher altitude → ΔT becomes bigger → so $\dot{\Omega}$ becomes smaller, but it should stay the same, so $\Delta\Omega$ becomes bigger → so $\cos i$ must be bigger → so i must smaller, so: an decrease