Space Engineering 3

Assignment 1

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Orbit Simulation and Determination

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STUDENT PLAGIARISM: COURSE WORK – POLICY AND PROCEDURE

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Introduction

Write an intro here

1. Simulation of Orbits with Classical Elements

1.1 Introduction

- keplers three laws
- perifocal frame
- The true anomaly θ is the angle taken at the focus of the perifocal frame to the satellite from the perigee. The eccentric anomaly E is the angle taken at the centre of perifocal frame to the satellite from the perigee.
-The mean anomaly M_t is the mean number of orbits per day.
- LEO,MEO
-TLE's

1.2 Methodology

From Kepler's second law, the mean anomaly at time t is calculated using the mean motion n from an epoch time described by $M_0(t_0)$.

$$M_t = M_0 + n(t - t_0) \tag{1}$$

To solve for the eccentric anomaly, newtons method was used

$$E_{i+1} = E_i - \frac{f(E_i)}{f'(E_i)} \tag{2}$$

$$E_{i+1} = E_i - \frac{E - e\sin(E_i) - M_t}{1 - e\cos(E_i)} \tag{3}$$

The true anomaly was calculated using

$$\theta = 2\tan^{-1}\left(\sqrt{\frac{1+e}{1-e}}\tan\left(\frac{E}{2}\right)\right) \tag{4}$$

The general equation for the radius of an ellipse

$$r = \frac{p}{1 + e\cos\theta} \tag{5}$$

The two parameters, θ and r can completely define the orbit in the perifocal frame as polar coordinates. The conversion to cartesian coordinates in the perifocal frame are as follows:

$$\begin{bmatrix} x \\ y \\ z \end{bmatrix}_{perifocal} = \begin{bmatrix} r\cos\theta \\ r\sin\theta \\ 0 \end{bmatrix} \tag{6}$$

$$\begin{bmatrix} v_x \\ v_y \\ v_z \end{bmatrix}_{perifocal} = \begin{bmatrix} -\sqrt{\frac{\mu}{p}}\sin\theta \\ \sqrt{\frac{\mu}{p}}(e + \cos\theta) \\ 0 \end{bmatrix} \tag{7}$$

$$\tag{8}$$

The perifocal parameters were transformed to the ECI frame to animate the 3D model of the satellite orbit around the Earth using the function ***orbit2ECI***. From the ECI coordinates, the ECEF and LLHGD coordinates were calculated for the ground trace.

1.3 Results/Discussion

1.3.1 Van Allen Probes

The satellite RBSP-A, also known as the Van Allen Probes, is in a highly eccentric orbit. RBSP-A has a perigee in LEO at an altitude of 596 km and an apogee in MEO at an altitude of 30421 km assuming a spherical Earth.

1.3.2 Orbital Properties

Table 1.1: Orbital Properties - maybe put in classical parameters

Orbital Properties	Van Allen Probe	Other sat
Period		
Altitude at Perigee		
Altitude at Apogee		

2. Simulating Perturbations

2.1 Introduction

Different perturbing sources acting on Van Allen Probes - earth oblateness, gravity harmonics, solar/lunar gravity forces, aerodynamic drag, solar radiation

2.1.1 Earth oblateness

For the standard simulation model in Question 1, it was assumed that the Earth was spherical. A perfectly spherical mass has an inverse square relation of the gravitational field to the force applied on a body. However, the Earth is slightly oblate, as it is flatter at the poles and wider at the equator than a sphere. As the difference in the force is small compared to the total force, it can be mathematically treated as a perturbation. While this method is only an approximation it works well.

Unlike using the keplerin model of Question 1, the classical orbital parameters change through time.

Newtown's second law and his law of gravitation results in

$$\ddot{\boldsymbol{r}} + \frac{\mu \boldsymbol{r}}{r^3} = a_p \tag{9}$$

2.2 Methodology

2.3 Results/Discussion

3. Orbital Determination

3.1 Introduction

3.2 Methodology

3.3 Results/Discussion

4. Conclusions

References

5. Appendix