ASTD_CompuLab1

April 8, 2021

Computational Astrodynamics (ΥΦΥ204)

Implemented by: **Anastasios-Faidon Retselis (AEM: 4394)**

Language: **Python**

1 Problem 1

A communication satellite was carried into low earth orbit (LEO) at a height of 322 km above the sea.

1.1 Exercise 1.1

Compute the period of the LEO

[1]:
```
import numpy as np

R_earth = 6371000 # meters
G = 6.67*pow(10, -11)
M = 5.977 * pow(10, 24)
mu = G*M

# Exercise 1

height = 322000
T = 2*np.pi*np.sqrt(pow(R_earth+height, 3)/mu)
T = T/60  # Convert to minutes
print('Period = %.2f minutes' % T)
```

```
Period = 90.81 minutes
```

1.2 Exercise 1.2

Compute the Δv_1 and Δv_2 maneuvers of a Hohmann transfer to a geostatic orbit.

The impulses are given by:

$$\Delta v_1 = v_P - v_{c1}$$
$$\Delta v_2 = v_{c2} - v_A$$

where

$$v_P = \sqrt{\frac{\mu}{a}\frac{1+e}{1-e}}$$
$$v_A = \sqrt{\frac{\mu}{a}\frac{1-e}{1+e}}$$

and the circular orbit is given by the formula:

$$\Delta v_{c1} = \sqrt{\frac{\mu}{R_1}}$$

[2]:
```
# Exercise 2

R1 = R_earth + height
R2 = R_earth + 35786000  # Target Geostatic

v_c1 = np.sqrt(mu/R1)
v_c2 = np.sqrt(mu/R2)

a = (R1+R2)/2
e = (R2-R1)/(R2+R1)
v_p = np.sqrt((mu/a)*((1+e)/(1-e)))
v_a = np.sqrt((mu/a)*((1-e)/(1+e)))

Delta_v_1 = v_p - v_c1
Delta_v_2 = v_c2 - v_a

print('Delta_v_1 = %.2f m/s' % Delta_v_1)
print('Delta_v_2 = %.2f m/s' % Delta_v_2)
```

```
Delta_v_1 = 2421.58 m/s
Delta_v_2 = 1465.41 m/s
```

1.3 Exercise 1.3

Compute the TOF

The time of flight is given by:

$$TOF = \frac{T}{2} = \frac{\pi}{n} = \pi\sqrt{\frac{a^3}{\mu}}$$

[3]:
```
# Exercise 3

TOF = np.pi*np.sqrt(pow(a, 3)/mu)
```

```python
print('Time of Flight = %.2f seconds' % TOF)
```

```
Time of Flight = 18993.16 seconds
```

1.4 Exercise 1.4

Above which place of the Earth, the first maneuver should take place in order the satellite to be placed in a geostatic orbit above Greece?

Let us consider a geostationary satellite already in orbit above Greece. In order for our satellite to get in a geostatic orbit above Greece, the satellite must start at an angle θ before greece, namely:

$$\theta = \pi \left(1 - \frac{1}{2\sqrt{2}} \left(1 + \left(\frac{R_1}{R_2} \right)^3 \right)^{1/2} \right)$$

We can then subtract θ from the longitude of Greece to get the desired starting longitude above which we should start the maneuver in order to be placed in a geostationary orbit above Greece.

[4]:
```python
# Exercise 4

lon_greece = 23.7275
theta = np.pi*(1-((1/(2*np.sqrt(2)))*np.sqrt(1+pow((R1/R2), 3))))
desired_longitude = lon_greece - np.rad2deg(theta)
print('Start longitude = %.3f degrees' % desired_longitude)
```

```
Start longitude = -92.506 degrees
```