ENME488: Flight and Spaceflight Mechanics

Assignment 2 (Individual): Spaceflight Mission Planning

This is an individual assignment and the work you submit should be your own. Material cited from other sources (including figures) should be appropriately referenced in the text and displayed in the References section using the APA or IEEE format.

Learning Objectives

- Reinforce fundamental orbital mechanics material, particularly orbit geometry, Kepler's Time of Flight, and computing impulsive orbital manoeuvres.
- Write a program containing several functions, input files, generate complex outputs, and validate those functions.

Task:

Consider a mission after launch, where the first stage of a small launch vehicle will deploy a spacecraft in a sub-orbital state (i.e. an orbit with a periapse below the surface of the Earth). This spacecraft is intended to orbit the moon for surface communications. Design the mission to get the spacecraft to a desired orbit around the moon. To do so, will require completion of the following tasks:

Task 1: Determine a sequence of impulsive manoeuvres to get from the initial launch vehicle state ($a = 5137\ km, e = 0.3, i = 39°, \Omega = 90, \omega = 270°, \theta_0 = 160°$) to a circular parking orbit of your design outside of requiring an inclination of $i = 28.58°$.

Task 2: From the parking orbit, determine the first burn of a Hohmann transfer to reach the moon's orbit. Note that the parking orbit from Task 1 should already be in the same plane as the moon's orbit.

Task 3: Determine where in its orbit the moon should be (i.e. at what argument of latitude) when the Task 2 burn is executed such that the spacecraft will rendezvous with the moon at apoapse of the transfer orbit.

Task 4: Determine the orbit elements of the spacecraft relative to the moon when it enters the moon's sphere of influence.

Task 5: Design a final orbit around the moon such that the ground track passes over all latitudes and so that the period is < 14 days. State the orbital elements you chose (a, e, i, Ω & ω) and justify this selection. Describe their effect on what can be observed on the surface of the moon at any given time. Plot the ground track over the moon for 5 orbit periods.

Task 6: Based on Tasks 4 and 5, determine a sequence of impulsive manoeuvres to put the spacecraft into the designed orbit.

Task 7: Numerically simulate the entire trajectory from launch vehicle through the five orbit periods around the moon. Make plots to fully explain the mission design. Report all maneouvring Δv and their timing/location and the total Δv.

Assumptions

- The Earth has a gravitational parameter of $\mu_E = 398600\ km^3/s^2$.
- The moon has a gravitational parameter of $\mu_{selene} = 4905\ km^3/s^2$.
- Model the moon's orbit around the Earth as a circular orbit with $a_{selene} = 384400\ km$ and $i = 28.58°$ with respect to the Earth's equatorial plane (the ECI frame). Use $\Omega = 90°$.
- The sphere of influence of the moon should be taken as $r_{SOI} = 66200\ km$.
- The moon centered inertial frame is parallel to the Earth centered inertial frame, just with a different origin.

Reporting: 20%

Submit your assignment as a short report (< 10 pages not including References or Appendices) in .pdf format via Learn by *23.55 NZST Thursday, 17th of October*. The report will be assessed using the standard Masters Thesis/Research Portfolio rubric, available on Learn.

The report should include the following:

- An Executive Summary, briefly describing the mission design, including the target orbit and total Δv.
- A Methodology section that outlines the equations used to design the mission
- A Results section illustrating the mission design and each component discussed in the Task descriptions. Include a brief discussion of how the project could be extended.
- A Conclusions section summarizing the

  findings.
- A References section in APA format.
- Appendices documenting the code used to produce the mission design results.

A list of acronymns can be included if necessary.