MAE3145: Homework 5

Due date: 2 458 085.2395 JD

Problem 1. Neptune is now the furthest "planet" in our solar system (since Pluto is classified as a dwarf planet). Voyager 2 passed by Neptune in 1989 but there have not been other spacecraft missions to Neptune. Consider a Neptune mission by doing a few preliminary calculations.

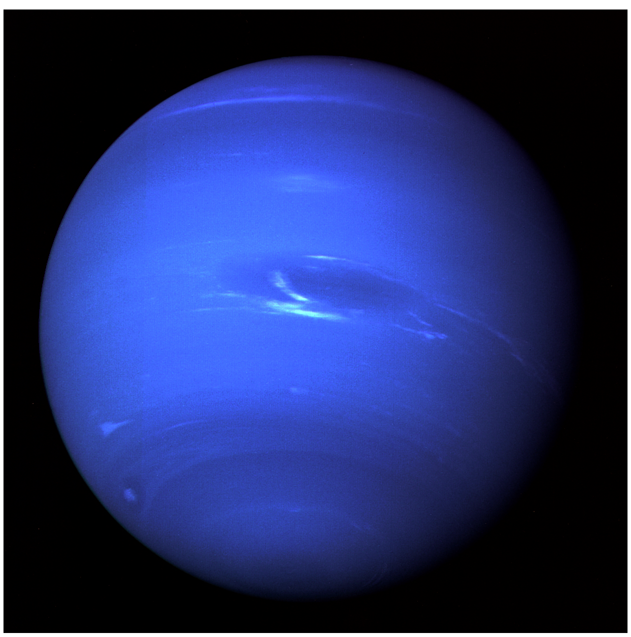
(a) Begin by examining a Hohmann transfer from the Earth to Neptune. Assume that planetary orbits are coplanar and circular. Compute the total $\|\Delta\vec{v}_T\|$ and the TOF (time of flight in years). Ensure you draw proper vector diagrams, and compute $\|\Delta\vec{v}\|$ and α for each maneuver.

(b) What is $\|\Delta\vec{v}_1\|$, i.e. the maneuver necessary at Earth departure? What is $\|\Delta\vec{v}_2\|$ to remain in the Neptune system?

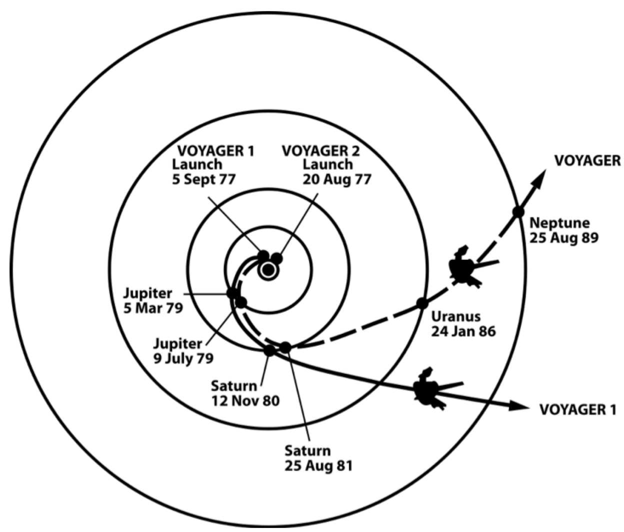
(c) Discuss the feasibility of this mission. Is the total cost ($\|\Delta\vec{v}_T\|$) "a lot"? Is the time of flight reasonable? Even though the Hohmann transfer is the minimum two-impulse transfer, is it likely that we could use this transfer to get to Neptune?

(d) Compare the time of flight you calculated to the actual Voyager 2 transfer. You can use the Julian date functions, `time.date2jd(yr, mo, day, hr, min, sec)`.

(e) Compute the phase angle required at departure for this circle-to-cirle transfer as seen in the heliocentric view.



(a) Voyager 2 Image of Neptune



(b) Voyager 2 Trajectory

Figure 1: Voyager 2

Problem 2. In NASA's original plan for a crewed lunar base (Orion), a ground facility near the Moon's south pole was envisioned, necessitating a polar orbit. The lunar south pole offers areas of continual sunlight, which are ideal locations for continuous power generation, the so called "peaks of eternal light". Thus, the trajectory design (both arrival at the Moon and the Earth return) included a 90° plane change. Consider the plane change maneuver. Assume that the spacecraft arrives in the plane of the lunar equator and is currently in a circular orbit at 100 km altitude. Two options existed for the plane change to the polar orbit.

1. A signle maneuver at the current altitude to shift the orbit to an inclination of 90°.
2. A bi-elliptic strategety that includes three maneuvers: A maneuver to raise apoapsis to 17 000 km, followed by a plane change manuever at apoapsis, and a final maneuver to insert back into the 100 km altitude polar orbit.

(a) Compute and compare the cost, i.e. $\|\Delta\vec{v}\|$, for a 90° plane change accomplished with the two approaches. The single plane change is accomlished instantaneously. How much time (TOF) is devoted to the completion of the bi-elliptic option?