Hohmann Transfer

Note: Please download the notebook to input parameters for other spacecraft. For this section, I will show the results for SpaceX Starship.

Here are the calculated parameters for a LEO to GEO Hohmann transfer:

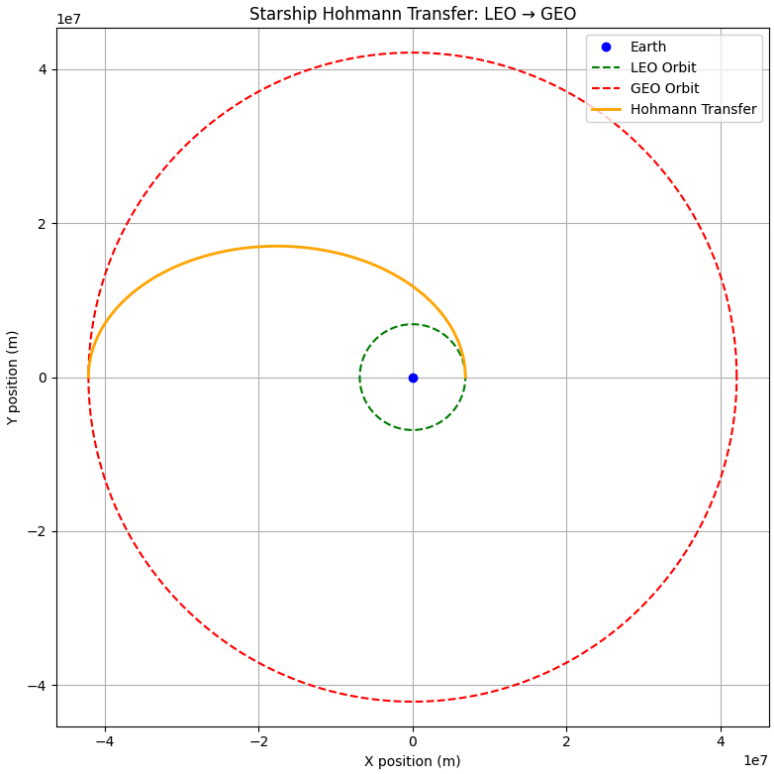
Parameters taken from the web:

```
mass_starship_dry = 120_000       # kg, dry mass of Starship (empty)
mass_starship_fuel = 1_200_000    # kg, full propellant load (Starship only)
mass_super_heavy = 3_300_000      # kg, mass of Super Heavy booster (not in orbit)
mass_starship_wet = mass_starship_dry + mass_starship_fuel  # full mass at orbit start
Isp_vac = 380     # s, vacuum specific impulse (approx Starship Raptor Vacuum)
Isp_sl  = 330     # s, sea-level Isp (for booster stage, not used here)
LEO = 6871.0 # km
GEO = 42157.0 # km
```

Calculated values:

```
=== Orbital Parameters ===
Delta-v for transfer burn 1 (LEO → transfer orbit): 2371.6 m/s
Delta-v for transfer burn 2 (transfer orbit → GEO): 1447.0 m/s
Total delta-v required: 3818.6 m/s

Transfer time (half elliptical orbit): 5.31 hours

Propellant mass for burn 1: 621.3 metric tons
Mass after burn 1: 698.7 metric tons

Propellant mass for burn 2: 224.8 metric tons
Mass after burn 2 (final dry mass): 473.9 metric tons

Total propellant used: 846.1 metric tons
Remaining mass fraction: 0.359

Starship has enough propellant for the transfer burns.
```

Trajectory plot for LEO to GEO:



Trajectory plot should a spacecraft return to LEO the moment after reaching GEO.