

ENAE 404 - 0101

Homework 05: Prediction Problem and More Maneuvers

Due on April 10, 2025 at 09:30 AM

Dr. Barbee, 09:30

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April 9, 2025

Problem 1:

Conceptual questions:

1. Give the semi-major axis, eccentricity and inclination of an orbit whose ground track is a point.
2. Explain why argument of periapsis equal to 0° or 180° produces equatorial symmetry.
3. Consider the Molniya orbit. Which one orbital element would you change so that the spacecraft would spend a long time viewing the Southern hemisphere (rather than the Northern hemisphere)? Identify the orbital element and the value of this orbital element that would preserve the same structure of the ground track (just flipped to observe the Southern hemisphere).

Solution

Part A

For an orbit whose ground track is a fixed point, the spacecraft must be in a geostationary orbit. This requires:

$$\begin{aligned}a &\approx 42\,164 \text{ km} \quad (\text{from Earth's center}), \\e &= 0 \quad (\text{circular orbit}), \\i &= 0^\circ \quad (\text{orbit in the equatorial plane}).\end{aligned}$$

Part B

The argument of periapsis, ω , defines the orientation of the ellipse within the orbital plane relative to the line of nodes. When ω is 0° or 180° , the line of apsides is aligned with the line of nodes. This alignment causes the orbit to be symmetric about the equatorial plane.

Part C

A standard Molniya orbit is designed with an argument of periapsis $\omega \approx 270^\circ$ so that the apogee is in the Northern Hemisphere. To flip the ground track so that the apogee is over the Southern Hemisphere, one would change the argument of periapsis to $\omega = 90^\circ$.