Exercise Session 2

Note Problems marked with a ($\star$) are complimentary exercises and will not be solved in class.

Problem 1 Multiple Choice Questions

A) We perform a rendezvous with the ISS, which orbits the Earth in a circular LEO at an altitude of 400 km. During the approach, the chaser (Space Shuttle) is in an elliptical orbit in the same plane as the ISS with an apogee at 400 km and a perigee at 370 km, behind the ISS. On each successive apogee crossing, will the Shuttle get closer to the ISS or further away? By how many kilometers? (Give your answer as measured with respect to the orbit of the ISS).

(1) Closer
(2) Further away

(1) -282 km
(2) 282 km
(3) 7.7 km
(4) -4.3 km
(5) 141 km
(6) -152 km

B) To reach the ISS, the Space Shuttle will have to execute different maneuvers. During rendezvous, a maneuver is performed at apogee, which raises the perigee by 10 km. What is the Δv needed for this maneuver?

(1) 0.22 m/s
(2) 1.43 m/s
(3) 2.86 m/s
(4) 0.32 km/s
(5) 7.11 km/s

C) ($\star$) CHEOPS was launched in 2019. This exoplanet observation satellite, partly designed at EPFL, is in a Sun-synchronous orbit with an inclination of 98.6° to avoid long eclipses, which allows to reduce battery load. To achieve this strategy of minimising eclipses, what are the local mean solar times when the satellite crosses the Equator?

(1) Noon/midnight
(2) 3 pm/9 pm
(3) 6 am/6 pm (sunrise/sunset)
(4) 10 am/4 pm
(5) It does not matter

D) We want to inject a GPS satellite from a circular parking orbit at 230 km altitude to a final circular orbit at 20'000 km altitude, using a Hohmann transfer without orbital plane change. What are the amounts of the two maneuvers Δv_1 and Δv_2 ?

(1) 2.1, 3.7 km/s
(2) 1.4, 1.1 km/s
(3) 1.4, 2.1 km/s
(4) 2.1, 1.4 km/s
(5) 4.7, 4.4 km/s

Problem 2 Hohmann transfer and plane change

A satellite launched from Cape Canaveral (inclination 28.5°) is in a circular low Earth orbit (LEO) at an altitude of 450 km. We want to use the Hohmann transfer technique to raise the altitude to a circular geosynchronous orbit.

A) What are the values of the two Δvs required for this manoeuvre ? What are the orbital velocities for the initial parking orbit in LEO and for the final geosynchronous orbit ?

B) If we want to change to a geostationary orbit, what will be the additional Δv or Δvs ? What is the best strategy for the execution this Δv or Δvs and when ?

C) Using the results of the previous questions, what are the values of the Δvs involved ?

Problem 3 ($\star$) Geostationary orbit

A satellite is launched to a circular geostationary orbit, in the Earth equatorial plane. After receiving the latest position information, the operator realizes that the satellite is orbiting on a circular orbit at an altitude 2 km below the target GEO orbit altitude.

A) Compute the drift in longitude, in °/day, due to the lower altitude.

B) What strategy could the operator use to put the satellite back on the correct GEO orbit?

C) Given the chosen strategy, compute the total ΔV necessary to reach the target orbit.

Problem 4 Chaser and Target

For each of the configurations and initial conditions (i) listed below, draw the trajectory of the chaser (thick line orbit, elliptical orbit semi-major axis a) vs. target (thin line orbit, circular orbit radius r) on the relative motion XZ plot. In all cases the direction of motion is counter clockwise, for both the chaser and the target.