Exercise Session 2

Problem 1 Multiple Choice Questions

A) An artificial Earth satellite is in an elliptical orbit with an perigee altitude of $h_p = 250$ km and an apogee altitude of $h_a = 800$ km. What is its orbital period ?

(1) 18.0 min
(2) 89.5 min
(3) 95.1 min
(4) 100.9 min

B) A spacecraft is on a free trajectory in the vicinity of the Earth. From which statement can it be deduced that this spacecraft has sufficient energy to leave Earth's gravitational well (i.e. it is not on orbit around the Earth)?

(1) $E_{tot} \geq 0$
(2) $E_{tot} < 0$
(3) $E_{tot} \to \infty$
(4) $E_{tot} \to -\infty$

C) Most of the telecommunication satellites are placed on a geostationary orbit. This means that they are always placed above the same point of the Earth surface, on a circular orbit along the equator. At what altitude are these satellites placed ?

(1) 35'786 km
(2) 20'232 km
(3) 42'241 km
(4) 35'863 km

Problem 2 Mars and Deimos gravitational wells

Determine the gravitational accelerations on the surface of Mars and one of its two satellites, Deimos, and make a scale drawing of the gravitational wells of both of them, normalized on the Earth's gravitational acceleration.

	Mars	Deimos
Mass $M[kg]$	$0.64 \cdot 10^{24}$	$1.48 \cdot 10^{15}$
Mean radius $R[km]$	3397	6.2
Mean distance Mars center – Deimos $d[km]$	23'460	

Problem 3 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 Δv 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 values of Δv ? What is the best strategy for the execution this values of Δv and when ?

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

Problem 4 Ballistic coefficient and lifetime

A) The International Space Station (ISS) has a mass of 450 tons and has an average frontal surface of about 1500 m^2. The ISS orbits the Earth at about 400 km. Russian cargo *Progress* spacecraft reboost the ISS about twice a year. If the maintenance of the ISS were to stop, how long would it take approximately for the ISS to fall back on Earth ? Use a drag coefficient of $C_D = 2$.

B) How long would it take for an uncontrolled CubeSat ($10 \times 10 \times 10$ cm^3, 0.8 kg, $C_D = 2.2$) at the same altitude to fall back on earth?
Hint. You can approximate the CubeSat cross section by the one of a sphere which would have the same surface than the CubeSat.