To be prepared for the exercises on Nov 27, 2019
(10 points total)

Task 1 (5 points)

A satellite moves in an elliptical orbit, which can be described by 6 Keplerian Elements. For any particular epoch t in this case, Cartesian coordinates $\boldsymbol{r_i}(t)$ and velocities $\boldsymbol{v_i}(t)$ can be computed by the transformation (*kep2cart*). Suppose a communication satellite has the following orbital elements: semi-major axis $= 2,6371\,km$, eccentricity $= 0.4$, inclination $= 45°$, argument of perigee $= 110°$ and right ascension of the ascending node $= 50°$. Your task is now to:

a) compute its positions and velocities for 1 day (sampling rate $\Delta t = 10\,s$) and plot its orbit and velocity components. (Hint: $t_0 = 0\,s$ and $M_0 = 0°$)

b) write another MATLAB function *cart2kep* to convert the Cartesian coordinates and velocities computed in (a) into five Keplerian Elements (a, e, I, Ω, ω).

c) transform the satellite orbit into the ECEF coordinate system by using this simplified formula:

$$\boldsymbol{r_e} = \boldsymbol{R_3}(\theta_{gr})\boldsymbol{r_i}, \text{ with Greenwich Apparent Sidereal Time } \theta_{gr} = \omega_E t$$

and plot the orbit in the system $\boldsymbol{r_e}$.

d) plot the Keplerian orbits for 1 day (sampling rate $\Delta t = 30\,s$) of the GNSS satellites: GPS, Galileo and GLONASS. Their orbit informations are provided at GPS.txt, Galileo.txt and GLONASS.txt in ILIAS. The GNSS constellation is summarized below:

	GLONASS	GPS	Galileo
number of satellites	24	24	27
number of orbits	3	6	3
inclination	64.8°	55°	56°
semi-major axis [km]	25400	26500	29600

Task 2 (5 points)

The folder on ILIAS contains two Matlab scripts as well as one so-called RINEX NAV file (`test.18n`), which provides the orbital elements at a particular epoch for all GPS satellites in view. Please use the script `main.m` to load this information in Matlab and have a look at the orbital elements for different satellites (you can access the information of satellite `XX` via the struct `SV(XX).navData`). Your task is now to

a) compute the distance (in meters) between GPS satellites 14 and 18 for GPS week number (WN) 2016 and time of the week (TOW) 561600 s.

b) compute the WGS84 position and the velocity vector of GPS satellite 10 at epoch $t_0 =$ (WN 2016, TOW 564600).

c) compute the WGS84 position of GPS satellite 10 at epoch $t_1 = t_0 - 1$s.

d) compute the WGS84 position of GPS satellite 10 at epoch $t_2 = t_0 + 1$s.

e) compute the velocity of satellite 10 at epoch numerically by

$$v = \frac{\boldsymbol{x}(t_2) - \boldsymbol{x}(t_1)}{2.0}$$

with the positions computed in (c) and (d) and compare to the result obtained in (b).