

## Exercises for Course: Basic GPS Theory

1. Make the call `julday(2000,1,1,12)`
2. Make the call `julday(2001,8,2,10)`
3. What is `gps_week` and `sec_of_week` for now?
4. Write a function with input: year, month, day which outputs `day_of_year`
5. Run `comptime('b0810a94.076')` to get a plot of a receiver clock of the resetted type.

6. Determine a satellite's positions one second apart. Calculate the distance between the two positions.

Help: Possible code

```
eph = get_eph('pta.nav');
x1 = satpos(170000, eph(:,1));
x2 = satpos(170001, eph(:,1));
dist = norm(x1 - x2)
```

7. The previous exercise determined satellite positions in an ECEF frame. Now we want to calculate the same quantities but in an inertial frame. This is generally achieved by setting  $\dot{\Omega}_e = 0$ . Determine the positions for a satellite one second apart. Calculate the distance between the two positions. This yields the well known result: the velocity of a GPS satellite is approximately 3.86 km/s.

Help: Possible code

```
eph = get_eph('pta.nav');
x1 = satposin(170000, eph(:,1));
x2 = satposin(170001, eph(:,1));
dist = norm(x1 - x2)
```

8. Calculate the position for a given satellite every 1 second in 100 seconds.

Help: Possible code

```
eph = get_eph('pta.nav');
for t = 1:100, x(t,:) = satpos(170000 + t, eph(:,1)); end
figure(1);
plot(diff(diff(x)));
for t = 1:99, dist(t) = norm(x(t,:) - x(t+1,:));end
figure(2);
plot(dist)
```

The last plot demonstrates that the distance between two one second positions increases with time  $t$  squared.

9. Run

```
satconst
```

10. The file `tropp.m` is created for demonstrational purposes. The *M*-file shows how to master various graphical elements of an object—in this case a figure.
11. Modify `tropp` such that `tkel = 293` is fixed but `hum` varies within reasonable limits. Change the `xlabel` and `xaxis` accordingly.
12. Modify `tropp` such that `tkel = 293` is fixed but let `p` vary within reasonable limits. Change the description of the `xaxis` and `xlabel` accordingly.
13. Change the other parameters to get acquainted with the tropospheric delay function.
14. We want to investigate the correlation between the ambiguities  $N_1$  and  $N_2$ . They are determined from the linear equation  $Ax = b$  or

$$\begin{bmatrix} 1 & 1 & 0 & 0 \\ 1 & -1 & \lambda_1 & 0 \\ 1 & \beta & 0 & 0 \\ 1 & -\beta & 0 & \lambda_2 \end{bmatrix} \begin{bmatrix} \rho \\ I \\ N_1 \\ N_2 \end{bmatrix} = \begin{bmatrix} P_1 \\ \Phi_1 \\ P_2 \\ \Phi_2 \end{bmatrix}.$$

The constants  $\beta$ ,  $\lambda_1$ , and  $\lambda_2$  are defined as follows

$$\begin{aligned} c_0 &= 299792458 \\ f_1 &= 154 \times 10.23 \times 10^6 \\ f_2 &= 120 \times 10.23 \times 10^6 \\ \lambda_1 &= c_0/f_1 \\ \lambda_2 &= c_0/f_2 \\ \beta &= (f_1/f_2)^2. \end{aligned}$$

A realistic weight matrix is

$$C = \begin{bmatrix} 1/0.3^2 & & & \\ & 1/0.003^2 & & \\ & & 1/0.3^2 & \\ & & & 1/0.003^2 \end{bmatrix}.$$

Now compute the covariance matrix for the vector  $x$  of unknowns  $\Sigma_x = (A^T C A)^{-1}$ . The lower right 2 by 2 block matrix is the covariance matrix for  $N_1$  and  $N_2$ .

Compute eigenvalues and eigenvectors of this matrix and sketch the confidence ellipse.

Hint: You may use calls like

```
Sigma_N = Sigma_x(3:4,3:4);
[a,v] = eig(Sigma_N)
support(Sigma_N)
```