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 β, λ_1, and λ_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 $\Sigma_x = (A^{\mathrm{T}}CA)^{-1}$. 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)
```