Problem 1.

(a) $\langle N(t), g(t)\rangle$ is a Gaussian random variable with zero mean and $P \times \|g(t)\|^2$ variance.

(b) `z * p'` is a zero-mean Gaussian random variable of variance $\|p\|^2$.

(c) $\|\psi\|^2 = T_s\|\texttt{psi}\|^2$. To have unit norm, `psi` has to be normalized by $\frac{1}{\sqrt{T_s}}$

(d) For simplicity we consider `length(normpsi)` $= 2mn$ and not `length(normpsi)` $= 2mn+1$ (you also obtain full credit if you used $2mn+1$). `length(normpsi2)` $= 4mn$.

$$\texttt{length(q)} = \texttt{length(normpsi2)} + \texttt{length(normpsi)} - 1 = 6mn - 1$$

The convolution has value 1 when at indices $j = 2mn$ and $j = 4mn$. It has value 0 for indices $j = 2mn + km$, where k is an integer such that $2mn < j < 4mn$. We can not say anything if $j < 2mn$ or $j > 4mn$, as the pulses do not overlap.

Problem 2. (c), (f), (d), (a), (g), (b), (e)

(c) is the only operation performed for all satellites

Problem 3. From the middle of the graph (equivalent to 0 Hz because of the use of `fftshift`) to the two spikes there are 400 samples. Therefore the two spikes are at frequencies $f = 400 * F_s/NFFT = 600$ Hz and -600 Hz.

(a) $s(t) = Ae^{2\pi jft}$ — false

(b) $s(t) = A\cos(2\pi ft)$ — true, $f = 600$ Hz

(c) $s(t) = A_1\sin(2\pi f_1 t) + A_2\sin(2\pi f_2 t)$, with $f_1 \neq f_2$ — false if the Nyquist condition is respected; there is one exception if $f_1 = -f_2 = 600$ of $f_1 = -f_2 = -600$ and $A_1 \neq A_2$

(d) $s(t) = A_1\sin(2\pi 100t) + A_2\sin(2\pi 900t)$ — false

(e) $s(t) = A_1e^{2\pi jf_1 t} + A_2e^{2\pi jf_2 t}$, with $f_1 \neq f_2$ — true, $f_1 = 600$, $f_2 = -600$

(f) $s(t) = A\sin(2\pi ft)$ — true, $f = 600$ Hz

(g) $s(t) = 100t + 900t$ — false

(h) $s(t) = A_1\sin(2\pi 100t) + A_2\sin(2\pi 900t)$ — false

(i) $s(t) = A_1e^{2\pi f_1 t} + A_2e^{2\pi f_2 t}$, with $f_1 \neq f_2$ — false

Problem 4.

```
% Simulate binary uncoded PSK transmitted over the AWGN channel
% Specific instructions:
%
% Set NrBits to E5;
% Set Es_sigma2 to 3 dB
% Produces a binary random sequence of length NrBits taking values in {0,1}
% Map the bit sequence into a symbol sequence where 0 --> 1 and 1 --> -1
% Create the output of the AWGN channel that has the symbol sequence as input
% The energy per symbol over the noise variance shall be Es_sigma2 in dB
% Determine the bit sequence estimate (maximum likelihood decoding)
% Compute and print the error probability

clear all

NrBits=1E5; % number of transmitted bits
Es_sigma2=3; % Energy per symbol to noise variance in dB

bits=randi([0,1],NrBits,1); % random bits generation
symbols=1-2*bits; % symbols
receivedSymbols = awgn(symbols, Es_sigma2); % noisy received signal
bits_est_uncoded = receivedSymbols<0; % decoded bits
ber = sum(bits_est_uncoded ~= bits)/length(bits) % bit error probability
```

Problem 5.

```
% Load data.mat.
% Knowing that satellite 9 has Doppler frequency 1030 Hz,
% find the first sample that contains the start of the C/A code of satellite 9.

clear all;
close all;
clc;

%load GPS parameters
gpsConfig();
global gpsc;

sat_number=9;
doppler=1030;

%load the data (you do not need to use the getData instruction)
load data;

%determine the sample from which the first code starts
% get C/A code for this sat and upsample it to the sampling rate
p = kron(satCode(sat_number), ones(1, gpsc.spch));

% Read a chunk of data: we need twice the length of the C/A code, minus one sample
samples_per_code = length(p);
y = data(1:2*samples_per_code-1);

 % generate the time axis
 t = (0 : length(y)-1) * gpsc.Ts;

 correction=exp(-2*pi*1j*t*doppler);
 yc=y.*correction;

 c=xcorr(yc,p);
 c=c(length(yc):end);
 [m,tau]=max(abs(c));
```