SGN-11006, Basic Course in Signal Processing

Exercise #1.
The first 4 problems should be solved and returned to the teacher assistant before the deadline: Monday 12.09.2016 at 2pm.
Solutions can be returned either through Moodle or in the post box #527 located in Tietotalo next to the room TC421.
Matlab part is done and checked during the exercise session.
12-16.09.2016

Problem 1: What are the amplitude, frequency and phase shift of the following continuous-time sinusoids? (2 points)

a) $x(t) = \cos(200\pi t)$

b) $x(t) = 3.1\cos(740\pi t + 1.4)$

c) $x(t) = 5\cos(300t - 1)$

d) $x(t) = 32\cos(5\pi(t - 0.05))$

e) $x(t) = \cos(2\pi(t - 1)) + \cos(2\pi(t - 1))$

f) $x(t) = 3\cos(\pi(t - 1) + \pi)$

Problem 2: Consider a system with the following input-output relationship:

a) $y[n] = \frac{1}{x[n]} + x[n-1]$

b) $y[n] = x[n] + 2x[n-5]$

where $x[n]$ is the input to the system and $y[n]$ is the system's output. Is this system linear? Is it time-invariant? Is it stable? Could you determine the output of the system to an arbitrary input by using only the system's impulse response? Is it causal? Prove your answer. (3 points)

Problem 3: (problem 2.48 from the book): A periodic sequence $\tilde{x}[n]$ with a period N is applied as an input to an LTI discrete-time system characterized by an impulse response $h[n]$ generating an output $y[n]$. Is $y[n]$ a periodic sequence? If it is, what is its period? (2 points)

Problem 4: Given a continuous-time signal $x(t)$ with autocorrelation function $\phi_{xx}(\tau)$, find an expression for the aucorrelation function $\phi_{yy}(\tau)$ of a signal $y(t)$ such that:

$$y(t) = x(t) + \alpha x(t - \Delta)$$

where α and Δ are constants. Express your answer in terms of $\phi_{xx}(\tau)$.
(3 points)

Problem 5: (Matlab) Create two or three one-second signals with audible frequencies, and listen to them and their sum. You can generate a signal with single frequency f using the equation

$$x(n) = \cos\left(\frac{2\pi n f}{F_s}\right).$$

Use a sampling frequency (F_s) of 8192 Hz (this also implies that the length of these signals should be 8192 samples). (`help sound`) (3 points)

Problem 6: (Matlab) Create normally distributed noise (`help randn`), multiply it with some small scalar value k (< 1) and add it to the audio sample `handel` (`load handel`), you may want to shorten it: `y = y(1:N)`). Listen to the results. Try different values for k. (3 points)

Problem 7: (Matlab) Using convolution, delay and scale the audio sample `handel`. Create an echo effect using convolution. (`help conv`)
(4 points)