E2.5 Signals & Linear Systems

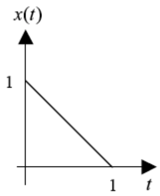
Tutorial Sheet 1 SOLUTIONS

1. (i) Non-causal, because it takes non-zero values for $-\infty < t < \infty$. Periodic with period 1. Odd because $x(-t) = -x(t)$.

(ii) Causal, because it takes non-zero values for $0 \le t < \infty$. Non-periodic. Neither odd nor even.

(iii) Non-causal, because it takes non-zero values for $-\infty < t < \infty$. Non-periodic. Even because $x(-t) = x(t)$.

2.



(i) Left shift by 3.

(ii) Linearly expand by factor of 3.

(iii) $x(t/3+1) = x[(t+3)/3]$. Linearly stress (expand) by factor of 3 and shift left by 3.

(iv) Time reverse and shift right by 2.

(v) $x(-2t+1) = x[-2(t-1/2)]$. Time reverse, linearly compress by factor of 2 and shift right by ½.

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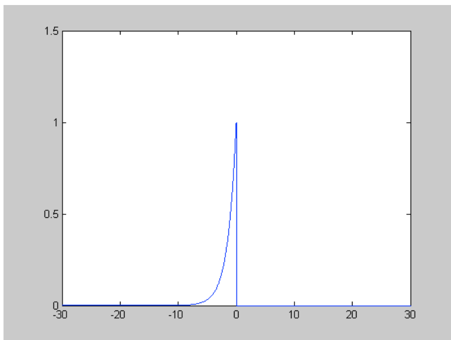
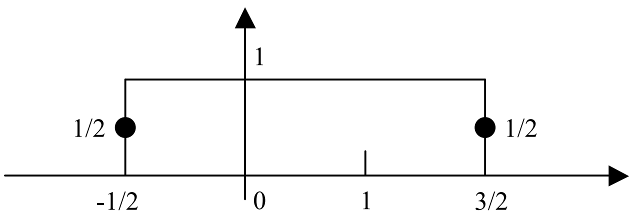
3. (i) Non-causal, because it takes non-zero values for $-\infty < n < \infty$. Periodic with period 2. Even because $x[-n] = x[n]$. We all know how it looks like.

(ii) Non-causal, because it takes non-zero values for $-\infty < n \le 0$. Non-periodic. Neither odd nor even.



4.



(i) $x(t) = \begin{cases} 1, & -1/2 < t < 3/2 \\ 1/2, & t = -1/2, \text{and } t = 3/2 \\ 0, & \text{otherwise} \end{cases}$

(ii) $x(t) = 1$

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5. (i) It is memoryless since the output at time instant n depends on the input only at time instant n and not past or future time instants.
   (ii) It is causal since the output at time instant n depends on the input only at time instant n and not future time instants.
   (iii). No. If the output at time instant n depends on the input at time instant n **and** past time instants the system is causal but not memoryless.
   (iv) $y[n] = \frac{x[n] + (-1)^n x[n]}{2}$.

   From this we see that if the input signal $x_1[n]$ produces an output signal $y_1[n]$ and the input signal $x_2[n]$ produces an output signal $y_2[n]$ then the input signal $a_1x_1[n] + a_2x_2[n]$ produces the output $y_3[n] = \frac{(a_1x_1[n] + a_2x_2[n]) + (-1)^n(a_1x_1[n] + a_2x_2[n])}{2} = a_1y_1[n] + a_2y_2[n])$.

   Therefore, the system is linear.

   However, if the input signal $x[n]$ produces an output signal $y[n]$ then the input signal $x[n-n_o]$ produces the output $y_1[n] = \frac{x[n-n_o] + (-1)^n x[n-n_o]}{2}$.

   We see that $y[n-n_o] = \frac{x[n-n_o] + (-1)^{n-n_o} x[n-n_o]}{2} \neq y_1[n]$

   Therefore, the system is time varying.

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6. (i) Linear, causal, time invariant.
   (ii) Non-linear, causal, time invariant.
   (iii) Linear, non-causal, time varying.

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7. (i) Linear, causal, time varying.
   (ii) Non-linear, causal, time varying.
   (iii) Linear, causal, time invariant.
   (iv) Linear, non-causal, time varying.
   (v) Linear, non-causal, time varying.

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8. Solution to the Matlab Exercises:

```
function [t, sinewave] = sinegen(fsig, fsamp, ncycle)
% Sinewave Generation
%   fsig = signal frequency
%   fsamp = sampling frequency
%   ncycle = number of cycles to generate
%
% This is part of EE2 Computing Lab Session 1, Exercise 2
%
%   Peter Cheung
%   15th October 1998.
%   $Revision: 1.0 $
%
% calculate angular increment per sample
delta_angle = 2*pi*fsig/fsamp;

% create angle vector for 4 cycles
t = 0:delta_angle:4*(2*pi);

% create sine wave
sinewave = sin(t);
```

```
function [noise] = noisegen(rms, nsamp)
% Noise Generation
%   fsamp = sampling frequency
%   nsamp = number of samples
%
% This is part of EE2 Computing Lab Session 1, Exercise 2
%
%   Peter Cheung
%   15th October 1998.
%   $Revision: 1.0 $

noise = rms*randn(nsamp);
```

```
% Model answer to Matlab exercise 2 part 1
%
% Problem: Create and plot a sinewave at 1kHz sampled at 44.1kHz
%                        with an amplitude of 1.0V using the sinegen()

% define sampling frequency
fs = 44100;

% define signal frequency
f = 1000;

% create sine wave
[t,sinewave]=sinegen(f,fs,4);

% plot it
plot(t,sinewave);
grid

% scale axis for suitable max and min values
axis([0 8*pi -1 1]);

% label axes
xlabel('0 \leq \itangle \leq \pi');
ylabel('Amplitude');
title('Sinewave at 1kHz');
```