E2.5 Signals & Linear Systems

Tutorial Sheet 2 SOLUTIONS

1. (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) $y[n] = \dfrac{x[n] + (-1)^n x[n]}{2}$.

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 $a_1 x_1[n] + a_2 x_2[n]$ produces the output

$$y_3[n] = \frac{(a_1 x_1[n] + a_2 x_2[n]) + (-1)^n (a_1 x_1[n] + a_2 x_2[n])}{2} = a_1 y_1[n] + a_2 y_2[n]) .$$

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 $y_1[n] = \dfrac{x[n - n_o] + (-1)^n x[n - n_o]}{2}$.

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

Therefore, the system is time varying.

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

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3. (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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4. Matlab exercise

M-file:
```
function [ y n] = discretecosine( f_0 )
%The function [y n]=discretecosine(f0) generates a discrete-time
%cosinewave of frequency f0.

n=0:1:50;
y=cos(2*pi*f_0*n);
end
```

to plot the function:
```
plot(n,y)
% scale axis for suitable max and min values
axis([0 50 -1 1]);

% label axes
xlabel('n');
```

```
ylabel('Amplitude');
or use
stem(n,y,'.')
% scale axis for suitable max and min values
axis([0 50 -1 1]);

% label axes
xlabel('n');
ylabel('Amplitude');
```