Tune-Up Tuesday for October 16, 2018

In the time domain, the output (response) of a linear time-invariant (LTI) system is the convolution of the input signal and the impulse response of the LTI system.

(a) Define an impulse response $h[n]$ of an averaging filter of 10 coefficients.

```
h = (1/10)*ones(1, 10);
```

(b) Define $x[n]$ to be a causal rectangular pulse of 5 samples each with value of 1/5.

```
x = (1/5)*ones(1, 5);
```

(c) Define $y[n]$ to be the output of the average filter given the input $x[n]$ in (b):

```
y = conv(h, x);
```

(d) Plot $y[n]$. What is the shape of $y[n]$?

```
n = 0 : length(y)-1;
figure;
stem(n, y);
% Trapezoid
```

(e) How many samples are in $y[n]$?

```
length(y)    % 14 samples
```

(f) Let Nh and Nx be the numbers of samples in $h[n]$ and $x[n]$, respectively. How does the answer relate to the answer to (e)?

```
% Nh + Nx - 1

% This can be computed
```

(g) *Homogeneity*. Scale $x[n]$ in (b) by -1. How does the filter response change?

```
yscaled = conv(h, -x);
n = 0 : length(yscaled)-1;
figure;
stem(n, yscaled);
% Filter response is negated
```

(h) *Time Invariance*. Delay $x[n]$ in (b) by 3 samples. How does the filter response change?

```
xshifted = [ 0 0 0 x ];
yshifted = conv(h, xshifted);
n = 0 : length(yshifted)-1;
figure;
stem(n, yshifted);
% Filter response is y[n] delayed by three samples
```

(i) *All-Zero Input*. Let $x[n]$ be 0 for 5 samples. What is the response (output) of the filter?

```
xzeros = zeros(1, 5);
yzeros = conv(h, xzeros);
n = 0 : length(yzeros)-1;
figure;
stem(n, yzeros);
% Filter response is zero for all samples
```

Please submit your MATLAB code for parts (a)-(d) and (g)-(i) and your answers to the questions in (e)-(i) as comments in your MATLAB code. See next page for the code.

```
% Tune-Up Tuesday #6, Oct. 16, 2018
% Programmer: Prof. Brian L. Evans
% The University of Texas at Austin
%
% Parts (a) - (d)
h = (1/10)*ones(1, 10);
x = (1/5)*ones(1, 5);
y = conv(h, x);
n = 0 : length(y) - 1;
figure;
stem(n, y);    % looks like a trapezoid

% (e)
length(y)    % 14

% (f) Nh + Nx - 1

% (g)
yscaled = conv(h, -x);
n = 0 : length(yscaled)-1;
figure;
stem(n, yscaled);
% Filter response is negated

% (h)
xshifted = [ 0 0 0 x ];
yshifted = conv(h, xshifted);
n = 0 : length(yshifted)-1;
figure;
stem(n, yshifted);
% Filter response is y[n] delayed by three

% (i) All zero input
xzeros = zeros(1, 5);
yzeros = conv(h, xzeros);
n = 0 : length(yzeros) - 1;
figure;
stem(n, yzeros);
% Filter response is zero for all samples
```