ECE103-LAB2 CADEN ROBERTS #2082015

1. For the following function:

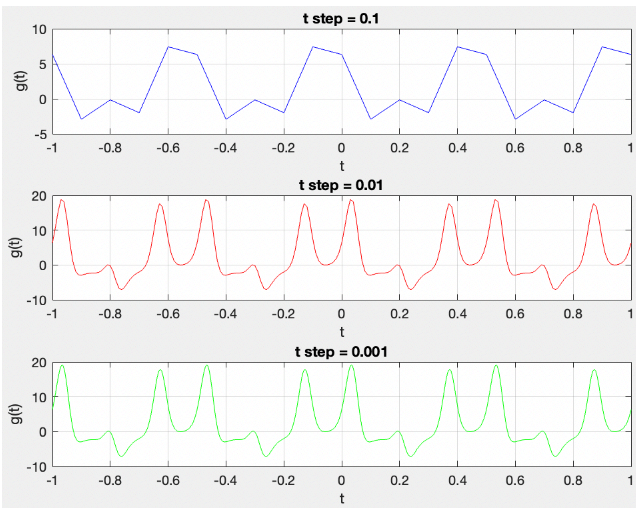
$$g(t) = 3\pi \sin(8\pi t + 1.3)\cos(4\pi t - 0.8)e^{\sin(12\pi t)}$$

create an m-file that plots the function within the window $t \in [-1, 1]$ in a 3-by-1 subplot with steps of t equal to `0.1`, `0.01`, and `0.001`. What is the period of this signal?

Summary:

We define the g(t) function and several intervals of t with the above step sizes. We then use 3 labeled subplots to display the function output. The period is calculated by taking the lcm of $\frac{2\pi}{\text{frequency element}}$, in this case 8π and 4π.

Results:




```
>> lab2problem1
Period of function is 0.50.
```

Code:

```
function y = g(t) % define g(t) according to provided definition
   y = 3*pi*sin(8*pi.*t+1.3).*cos(4*pi.*t-0.8).*exp(sin(12*pi.*t));
end
t = -1:0.1:1; % initialize 0.1 step size t
clf; % clear any remaining figure
subplot(3, 1, 1); % subplot
plot(t, g(t), 'b'); % plot blue
title('t step = 0.1'); % title subplot
xlabel('t'); % label x axis t
ylabel('g(t)'); % label y axis g(t)
grid on; % grid on
t = -1:0.01:1; % initialize 0.01 step size t
subplot(3, 1, 2); % subplot
plot(t, g(t), 'r'); % plot red
title('t step = 0.01'); % title subplot
xlabel('t'); % label x axis t
ylabel('g(t)'); % label y axis g(t)
grid on; % grid on
t = -1:0.001:1; % initialize 0.001 step size t
subplot(3, 1, 3); % subplot
plot(t, g(t), 'g'); % plot green
title('t step = 0.001'); % title subplot
xlabel('t'); % label x axis t
ylabel('g(t)'); % label y axis g(t)
grid on; % grid on
fprintf('Period of function is %.2f.\n', lcm(lcm((2*pi)/(8*pi)*12, (2*pi)/(4*pi)*12),
(2*pi)/(12*pi)*12)/12) % period = 2pi/(3 freq elements) (if all rational) take lcm (scaling
because lcm takes int inputs)
```

2. For the following function

$$x(t) = \begin{cases} -2|t| + 10, & t \in [-5, 5) \\ 10, & t \in [5, 10) \\ 0, & \text{elsewhere} \end{cases}$$

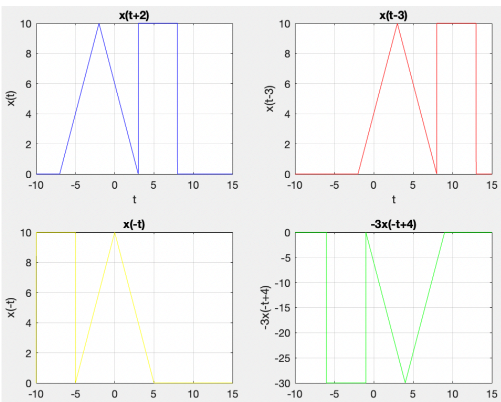
create an m-file that plots the function $x(t)$ within the window $t \in [-10,15]$. Also create a separate figure that has 4 sublpots in 2-by-2 arrangement with the following signals:

(a) $x(t+2)$
(b) $x(t-3)$
(c) $x(-t)$
(d) $-3x(-t+4)$

Summary:

We define the function as above and call it to 4 subplots with the 4 variations.

Results:



Code:

```
function y = x(t) % define function according to provided definition
   y = 10-2*abs(t);
   y(t>=5) = 10;
   y(t>=10) = 0;
   y(t<-5) = 0;
end
t = linspace(-10, 15, 2500);
clf; % clear any remaining figure
subplot(2, 2, 1)
plot(t, x(t+2), 'b'); % plot blue
title('x(t+2)'); % title subplot
xlabel('t'); % label x axis t
ylabel('x(t)'); % label y axis x(t)
grid on; % grid on
subplot(2, 2, 2)
plot(t, x(t-3), 'r'); % plot red
title('x(t-3)'); % title subplot
xlabel('t'); % label x axis t
ylabel('x(t-3)'); % label y axis x(t-3)
grid on; % grid on
subplot(2, 2, 3)
plot(t, x(-t), 'y'); % plot yellow
title('x(-t)'); % title subplot
xlabel('t'); % label x axis t
ylabel('x(-t)'); % label y axis x(-t)
grid on; % grid on
subplot(2, 2, 4)
plot(t, -3*x(-t+4), 'g'); % plot green
title('-3x(-t+4)'); % title subplot
xlabel('t'); % label x axis t
ylabel('-3x(-t+4)'); % label y axis -3x(-t+4)
grid on; % grid on
```

3. Consider the signal $x(t) = te^{-0.15t}, \quad -20 \le t \le 20$. Plot

(a) The signal $x(t)$

(b) The even decomposition $x_e(t)$ of $x(t)$

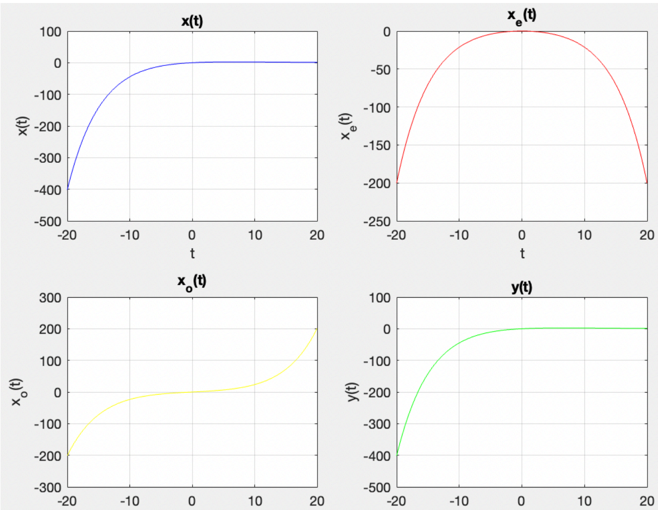
(c) The odd decomposition $x_o(t)$ of $x(t)$

(d) The signal $y(t)=x_e(t)+x_o(t)$

Summary:

We define the functions $x(t)$, $x_e(t) = \dfrac{x(t)+x(-t)}{2}$, $x_o(t) = \dfrac{x(t)-x(-t)}{2}$, and $y(t)$, and plot on 4 subplots.

Results:



Code:

```
function y = x(t)
   y = t.*exp(-0.15*t);
end
t = linspace(-20, 20, 40000);
clf; % clear any remaining figure
subplot(2, 2, 1);
plot(t, x(t), 'b'); % plot blue
title('x(t)'); % title subplot
xlabel('t'); % label x axis t
ylabel('x(t)'); % label y axis x(t)
grid on; % grid on
subplot(2, 2, 2)
plot(t, (x(t)+x(-t))/2, 'r'); % plot even red
title('x_e(t)'); % title subplot
xlabel('t'); % label x axis t
ylabel('x_e(t)'); % label y axis x(t-3)
grid on; % grid on
subplot(2, 2, 3)
plot(t, (x(t)-x(-t))/2, 'y'); % plot odd yellow
title('x_o(t)'); % title subplot
xlabel('t'); % label x axis t
ylabel('x_o(t)'); % label y axis x(-t)
grid on; % grid on
subplot(2, 2, 4)
plot(t, ((x(t)+x(-t))/2 + (x(t)-x(-t))/2), 'g'); % plot green
title('y(t)'); % title subplot
xlabel('t'); % label x axis t
ylabel('y(t)'); % label y axis -3x(-t+4)
grid on; % grid on
```

4. For the signal `g(x)` in problem 1, calculate the energy of the signal in the window `t ∈ [0.25, 0.75]`. Also calculate the power of the signal.

Summary:
We define g(x) as in problem 1. We calculate the integral of |g(x)|^2 to find energy, and we divide energy by range to calculate power.

Results:

```
>> lab2problem4
Energy of the function g(t) is 27.3775 joules.
Power of the function g(t) is 54.7550 watts.
```

Code:

```
function y = g(t) % define g(t) according to provided definiton
   y = 
3*pi*sin(8*pi.*t+1.3).*cos(4*pi.*t-0.8).*exp(sin(12*pi.*t));
end
E = integral(@(t) abs(g(t)).^2, 0.25, 0.75); % calc energy as 
int of |g(t)|^2
fprintf('Energy of the function g(t) is %.4f joules.\nPower of 
the function g(t) is %.4f watts.\n', E, E/(0.75-0.25)); % calc 
power and display results
```

5. Suppose N different musicians in an orchestra are trying to play a pure tone, a sinusoid of frequency 160 Hz. Assume the N players while trying to play the pure tone (160 Hz) end up playing tones separated by Δ Hz, so the overall sound they produced is:

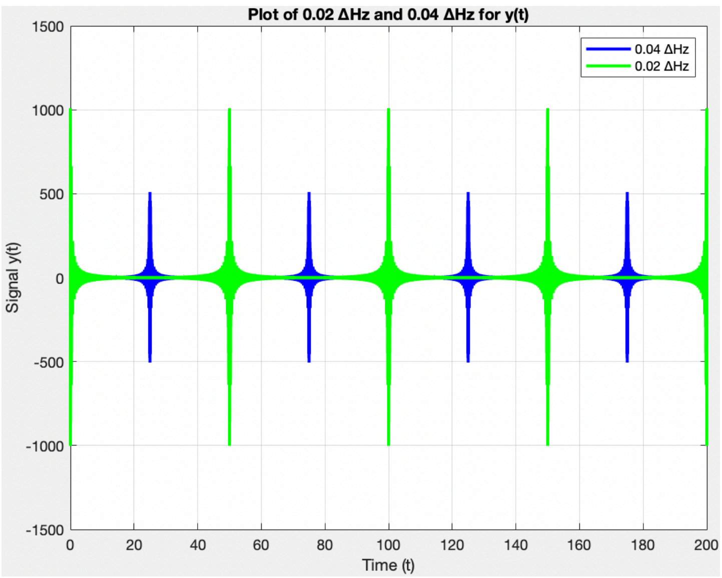
$$y(t) = \sum_{i=1}^{N} 10\cos(2\pi f_i t)$$

where the f_i are the frequencies from 159 to 161 Hz. Generate the signal $y(t)$, $0 \le t \le 200$ sec considering that each musician is playing a unique frequency. First assume the number of musicians to be $N = 51$ with $\Delta = 0.04$ Hz, and then N=101 with $\Delta = 0.02$ Hz. Plot $y(t)$ for the two cases on the same figure.

Summary:

We define the function using ΔHz step size as the input and 2 nested for loops to calculate for each value of t and to sum the varying values of f. We plot both functions on the same graph.

Results:



Code:

```
function x = f(s)
    x = zeros(1, 200001);
    for t = 1:1:200001
        for f = 159:s:161
            x(t) = x(t) + 10*cos(2*pi*f*((t-1)/1000));
        end
    end
end
t = 0:0.001:200; % initialize t range
clf; % clear any previous figure
plot(t, f(0.04), 'b', 'LineWidth', 2); % plot 0.04 ΔHz blue width 2
hold on; % allow multiple plots on the same graph
plot(t, f(0.02), 'g', 'LineWidth', 2); % plot 0.02 ΔHz green width 2
xlabel('Time (t)'); % label x axis
ylabel('Signal y(t)'); % label y axis
title('Plot of 0.02 ΔHz and 0.04 ΔHz for y(t)'); % create title
legend('0.04 ΔHz', '0.02 ΔHz'); % create legend
grid on; % grid on
hold off; % stop allowing multiple plots
```