```
% BME671L
% Lab #2: colon notation, anonymous functions, concatenation, clear,
 size,
% whos, stem

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clear, close all

% In matlab one of the most useful operations is the colon. It can
 create
% vectors as well as be used for indexing. For more information see
 the
% matlab documentation on colon or type 'help colon' in the command
 line.
% EXAMPLES:
numbers = 1:10      % creates a vector with the integers 1:10;
even = 2:2:10       % creates a regularly spaced vector using 2 as the
 increment between elements
odd = numbers (1:2:end) % starts at the first value in numbers and
 takes every 2nd value until reaching the end
```

```
numbers =

     1     2     3     4     5     6     7     8     9    10


even =

     2     4     6     8    10


odd =

     1     3     5     7     9
```

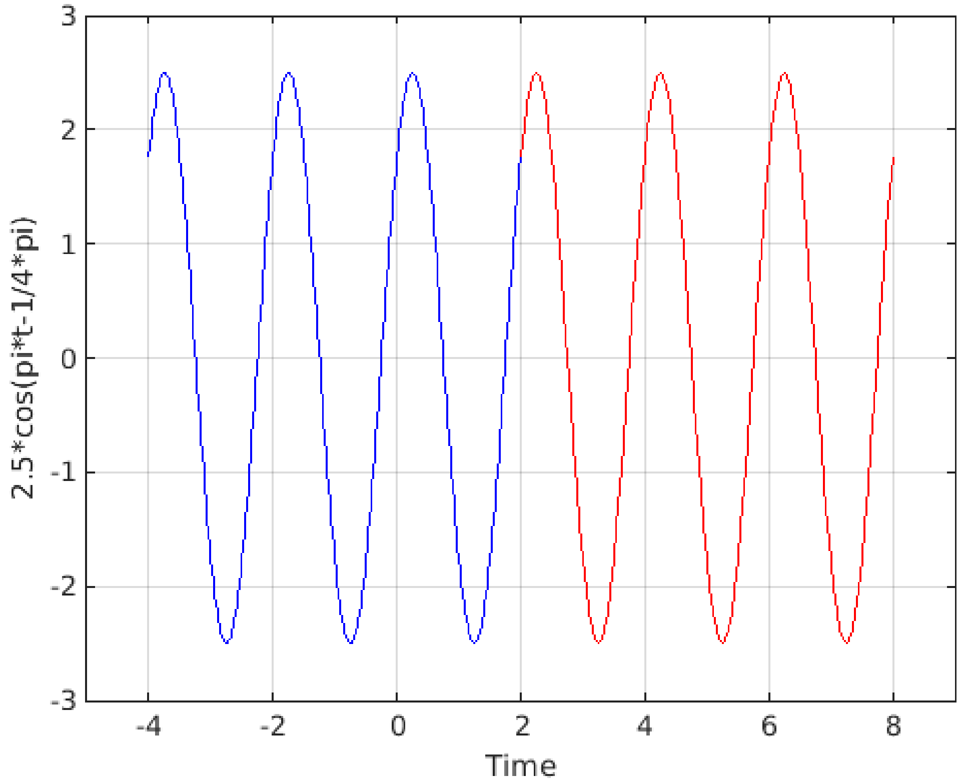
Q1: What is the sampling period for these two time vectors?

```
t1 = -4:1/50:2;
t2 = 1/20*(40:160);

% Your answer:
% The sampling period is the difference between two consequtive time
% samples. If the difference is same across all the time samples, the
% sampling period will be same as difference between any two samples.
% However, if the time difference varies across different samples, we
 take
% the mean of the difference between each sample.

st1 = mean(diff(t1))
```

```
st2 = mean(diff(t2))

% Therefore, the sampling period for t1 is 0.0200
% and sampling period for t2 is 0.0500


st1 =

    0.0200


st2 =

    0.0500
```

Q2: We define an anonymous function below. What is the amplitude, frequency, radian frequency, and time shift of the sinusoid?

```
y = @(t) 2.5*cos(pi*t-1/4*pi);

% A = 2.5
% f = 0.5
% w = pi
% ts = 1/4

% %
% Q3: We can now use y as a command and compute y for any value(s) of
% interest. EXAMPLE: x = y(1:10). Compute the values of this function
 at
% all the time points in t1, save this vector as x1. Repeat for t2,
 save as
% x2. Plot x1 and x2 as dots connected by a line using a single plot
% command. Turn the grid on and verify the parameters you calculated
 in Q2.
% Label the x-axis.

x1 = y(t1);
x2 = y(t2);

figure(1), clf
plot(t1, x1, 'b', t2, x2, 'r')
xlabel('Time')
ylabel('2.5*cos(pi*t-1/4*pi)')
xlim([-5 9])
ylim([-3 3])
grid on
```



Q4: We would prefer to have all the time values in a single vector. Use concatenation to construct vectors t3 that holds all of the time instances and y3 with all of the function values. HINT: run the command 'help cat' to see two different ways of putting the vectors together. With 2D matrices I tend to use the shorter method that does not require 'cat'

```
t3 = [t1, t2];
x3 = [x1, x2];
% or
t3 = cat(2, t1, t2);
x3 = cat(2, x1, x2);
```

Q5: Verify that the vectors the concatenated correct using the Matlab commands "size" and "whos". What are the dimensions of t3 and y3? Are they row or column vectors?

```
 size(t3)
 size(x3)

% YOUR ANSWER:
% The dimensions of t3 and y3 are 1x422 for both. This is a
 representation
% of the row vectors for the given input.
```

```
ans =

     1    422
```

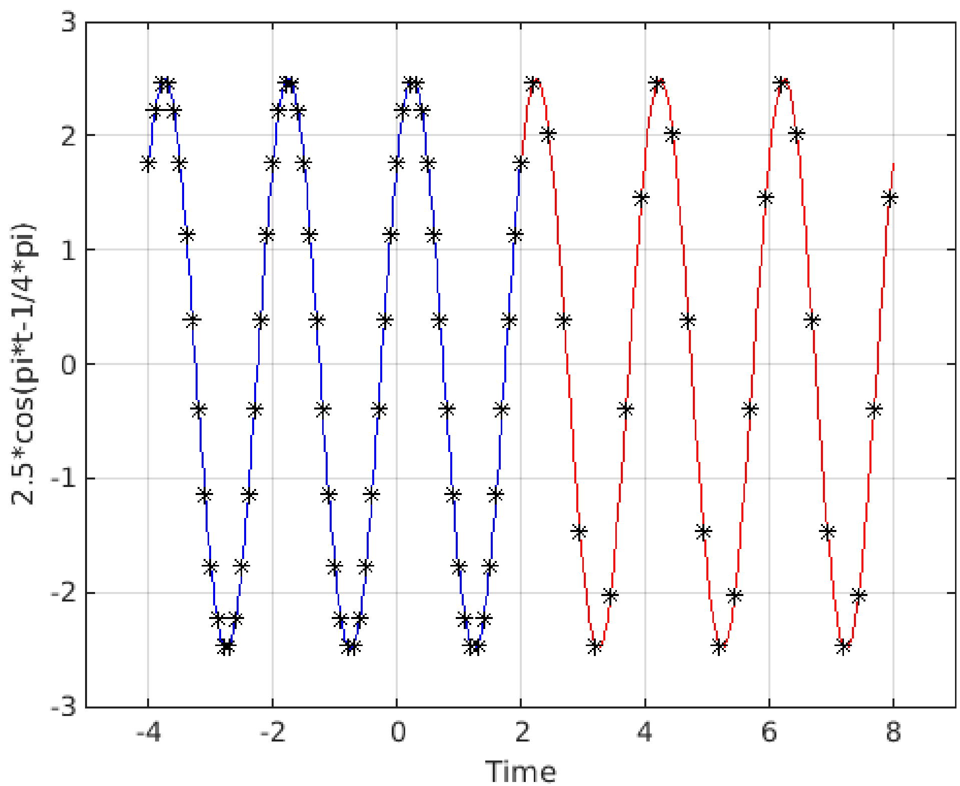
```
ans =

     1   422
```

Q6: We want to create two new vectors, t4 and x4, that are comprised of every 5th point from t3 and x3. This can be done using a for loop. For example: for k = 1:101 t4(k) = t3((k-1)*5+1); x4(k) = x3((k-1)*5+1); end However, one power of matlab is vectorization. Write this for loop in two lines using colon notation. Hint: think about matrix indexing.

```
t4 = t3(1:5:end);
x4 = x3(1:5:end);
```

Q7: On the same plot as Q3 (use hold on), add the subsampled results as black asterisks.

```
hold on
plot(t4, x4, 'k*')


% ************************************************************************
%   SHOW FIGURE 2 TO THE TA TO RECIEVE CREDIT FOR THE LAB
% ************************************************************************
```

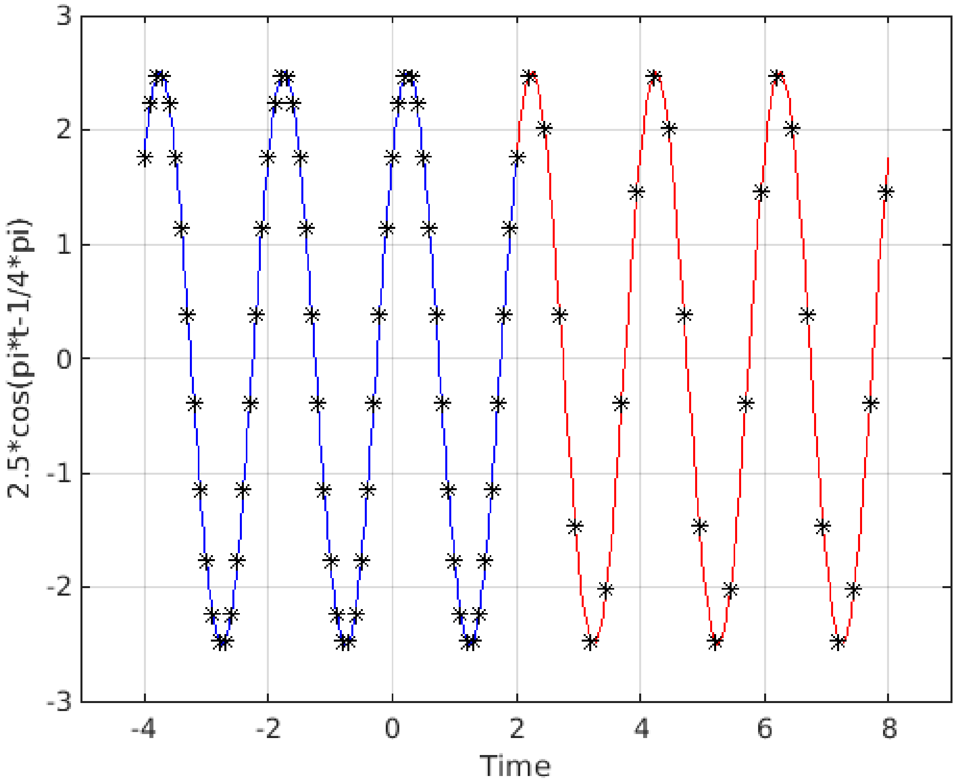


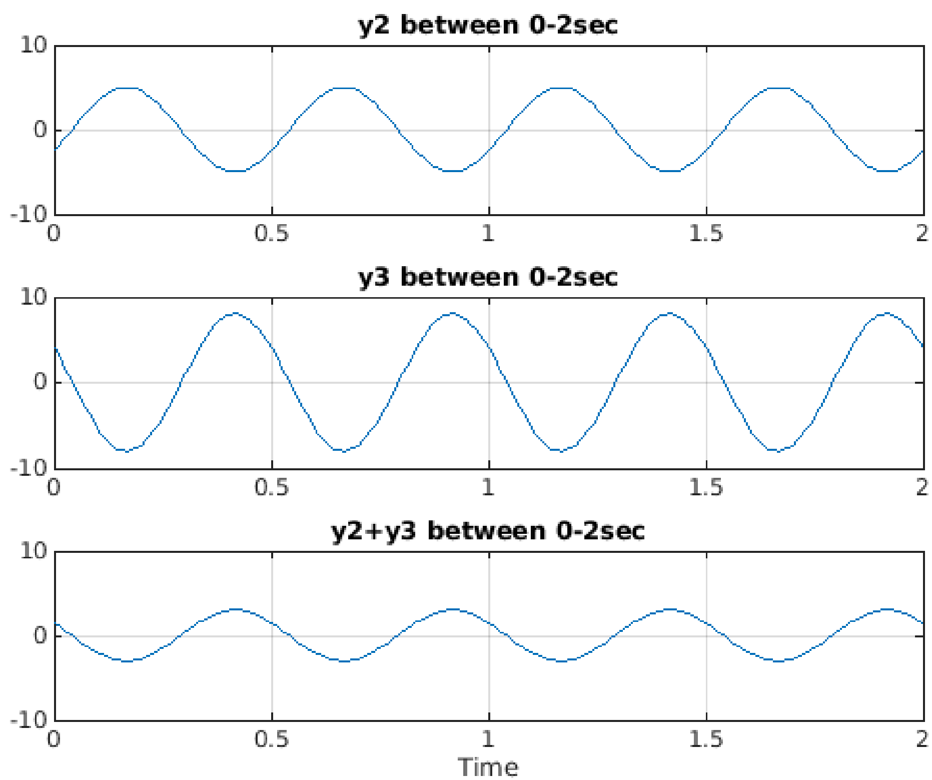
Q8: Define two new anonymous functions y2 and y3 that are sinusoids with the following parameters: y2: A = 5, f = 2 Hz, time shift = 1/6 s y3: A = 8, f = 2 Hz, time shift = -1/12 s additionally define a new time vector tt that contains about 4 cycles of the sinusoids with a sampling period of 0.01 s.

```
y2 = @(t) 5*cos(4*pi*t-2/3*pi);
y3 = @(t) 8*cos(4*pi*t+1/3*pi);
tt = 0:0.01:2;

x5 = y2(tt);
x6 = y3(tt);
```

Q9: Using the subplot command create a single figure with 3 plots in a single column. Plot y2 in the first plot, y3 in the second, and y2+y3 in the bottom plot. Add a title and grid to each plot, and label the bottom x-axis. Set the y-axis range from -10 to 10.

```
figure(2), clf
subplot(3,1,1)
plot(tt, x5)
title('y2 between 0-2sec')
ylim([-10 10]);
grid on

subplot(3,1,2)
plot(tt, x6)
title('y3 between 0-2sec')
ylim([-10 10]);
grid on

subplot(3,1,3)
plot(tt, x5+x6)
title('y2+y3 between 0-2sec')
ylim([-10 10]);
grid on
xlabel('Time')
```


3
2
1
0
-1
-2
-3
2.5*cos(pi*t-1/4*pi)
-4
-2
0
2
4
6
8
Time

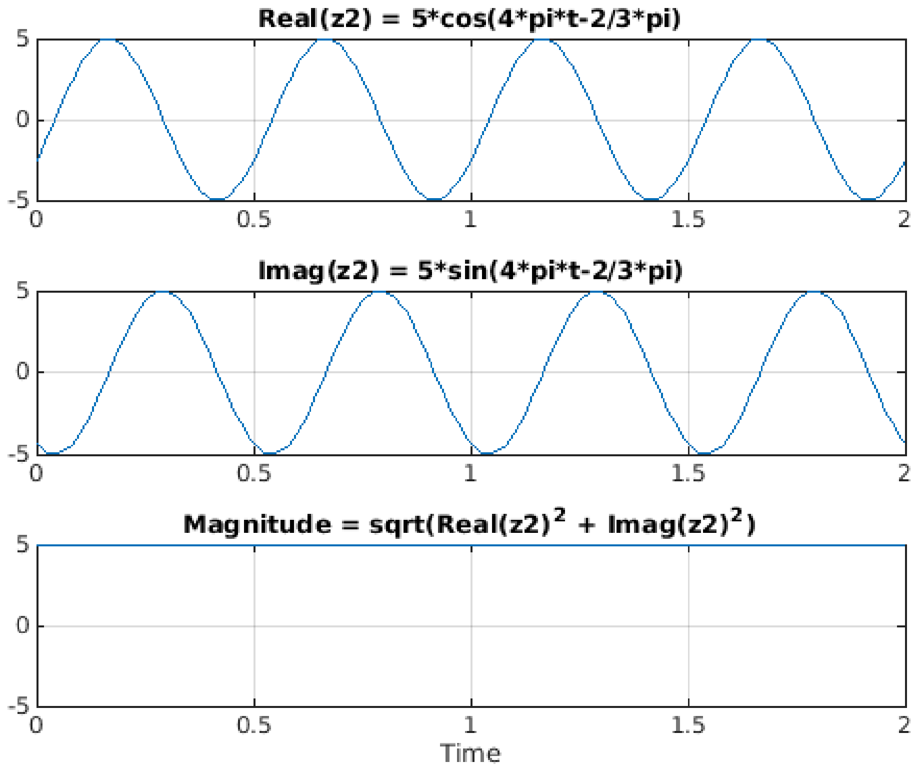

y2 between 0-2sec
10
0
-10
0
0.5
1
1.5
2
y3 between 0-2sec
10
0
-10
0
0.5
1
1.5
2
y2+y3 between 0-2sec
10
0
-10
0
0.5
1
1.5
2
Time

Q10: Using your plot estimate the amplitude, frequency, and time shift of y2+y3. You might find the "min" or "max" functions useful here.

```
% YOUR ANSWER
% The Amplitude is approximately 3 for the y2+y3 wave.
% The frequency of y2 and y3 is same, so the frequency of y2+y3 is
 also
% same at 2Hz (4*pi*t)
% Phaseshift of the sum y2+y3 appears to be pi/3 = 1.0472
% therefore, the timeshift is 4*pi*t_s = pi/3
% => t_s = -1/12 sec
% Therefore, the timeshift is -1/12 seconds
```

Q11: y2 is the real part of a rotating complex exponential, z2. Write z2 as an anonymous function. What is its phase shift? In a single figure create 3 plots that show the real, imaginary, and magnitude of z2. Use the same y-axis scaling for every plot. Add titles to each plot that describe the signal using trig functions such as 'cos(\omegat + \phi)'.

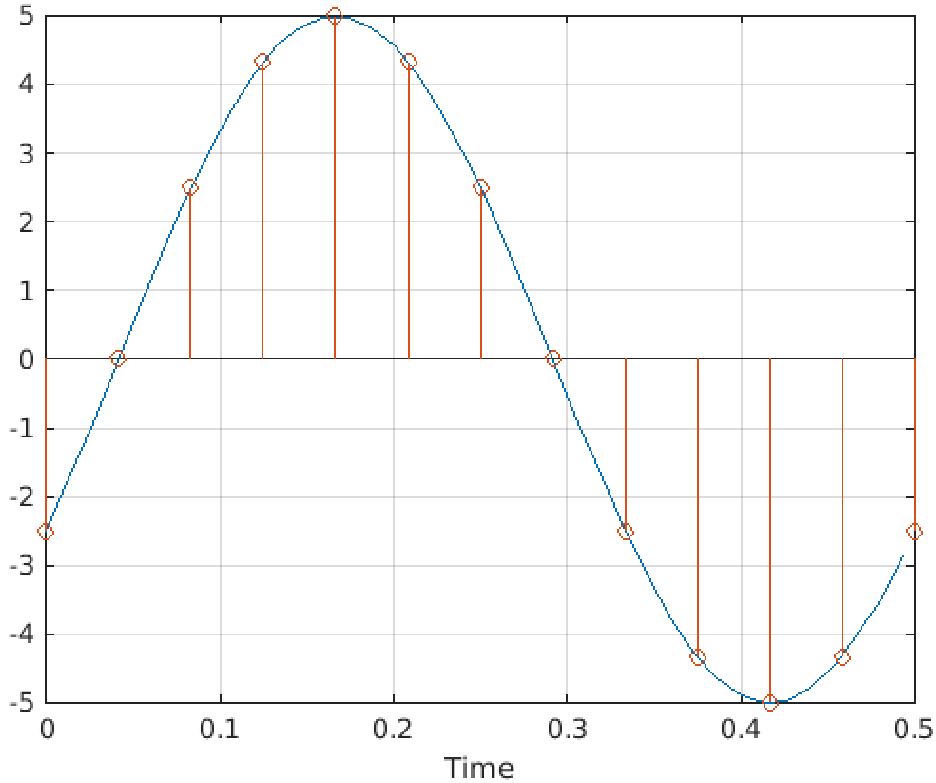
```
% Your answer:
z2 = @(t) 5*cos(4*pi*t-2/3*pi) + j*5*sin(4*pi*t-2/3*pi);
%z2 = @(t) 5*exp(j*(4*pi*t - 2/3*pi))

x7 = z2(tt);

figure(3), clf
subplot(3,1,1)
plot(tt, real(x7))
title('Real(z2) = 5*cos(4*pi*t-2/3*pi)')
grid on

subplot(3,1,2)
plot(tt, imag(x7))
title('Imag(z2) = 5*sin(4*pi*t-2/3*pi)')
grid on

subplot(3,1,3)
plot(tt, abs(x7))
title('Magnitude = sqrt(Real(z2)^2 + Imag(z2)^2)')
ylim([-5, 5])
grid on
xlabel('Time')
```



Q12: Plot one period of the real signal corresponding to the complex signal z2(t). Use a fine enough sampling period that the curve looks smooth. Then create a new time vector with a sampling period of 1/24 s. Use the stem function to mark the samples in red on the same plot. Grid on, label x-axis.

```
% sampling with 1/75sec for curve to look smooth
t_one = 0:1/75:0.5;
z2_s = z2(t_one);

t_new = 0:1/24:0.5;
z2_new = z2(t_new);

figure(4), clf
plot(t_one, real(z2_s))
hold on
stem(t_new, real(z2_new))
grid on
xlabel('Time')

% When you are done:
% * Make sure to send the indicated result/figure to the TA before
 11:59
% PM on Friday (Aug 28)
% * upload your script to Sakai
%   * upload a pdf containing your script and outputs before 11:59 PM
 on
%   next Tuesday.
```

```
return
```



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