Department of Electrical, Computer & Biomedical Engineering
Faculty of Engineering & Architectural Science

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Lab/Tutorial Report No.	**1**

Report Title	Working with Matlab Functions, Visualization of Signals

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Anonymous functions and plotting continuous functions

Problem A.1: Generate and plot Figures 1.46 and 1.47 on page 127.

Figure 1.46

Code:

```
f = @(t) exp(-t).*cos(2*pi*t);
t=(-2:2);

plot(t,f(t));
title('Figure 1.46');
xlabel('t');
ylabel('f(t)');
```

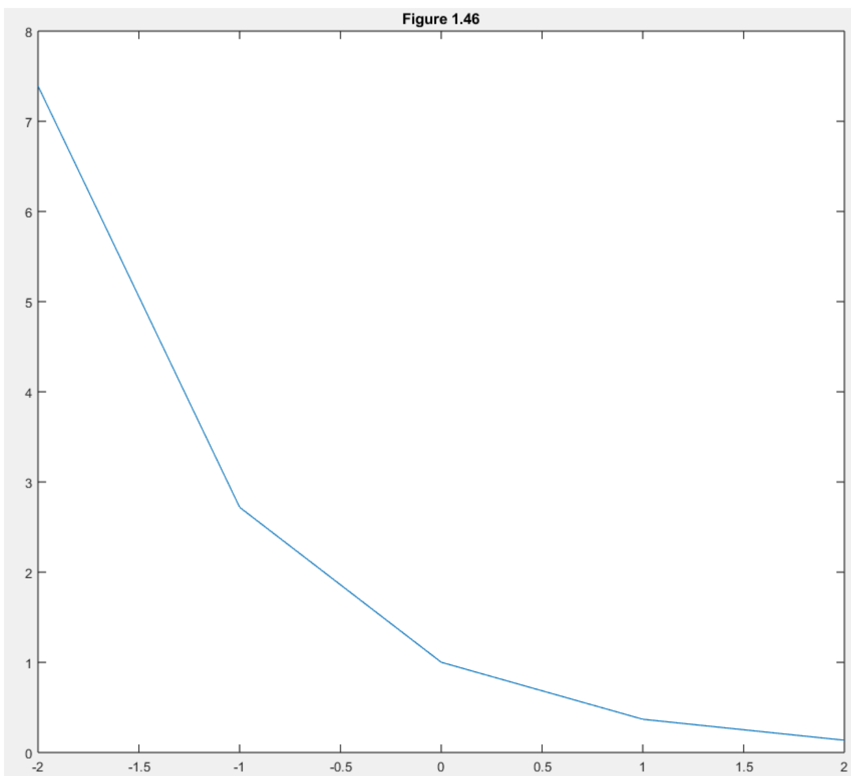
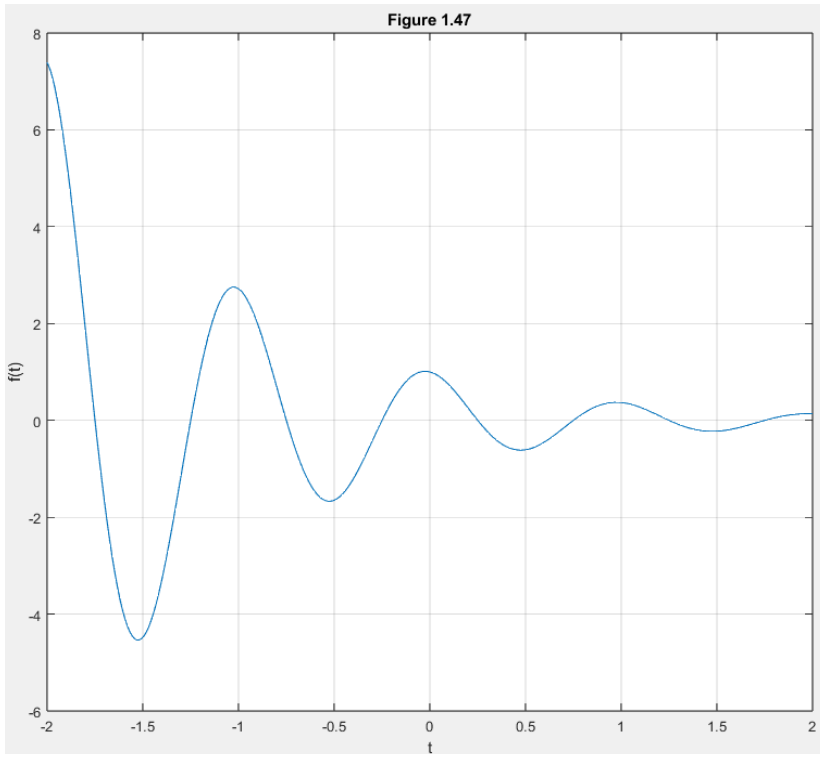


Figure 1.47

Code:

```
f = @(t) exp(-t).*cos(2*pi*t);
t=(-2:0.01:2);

plot(t,f(t));
```

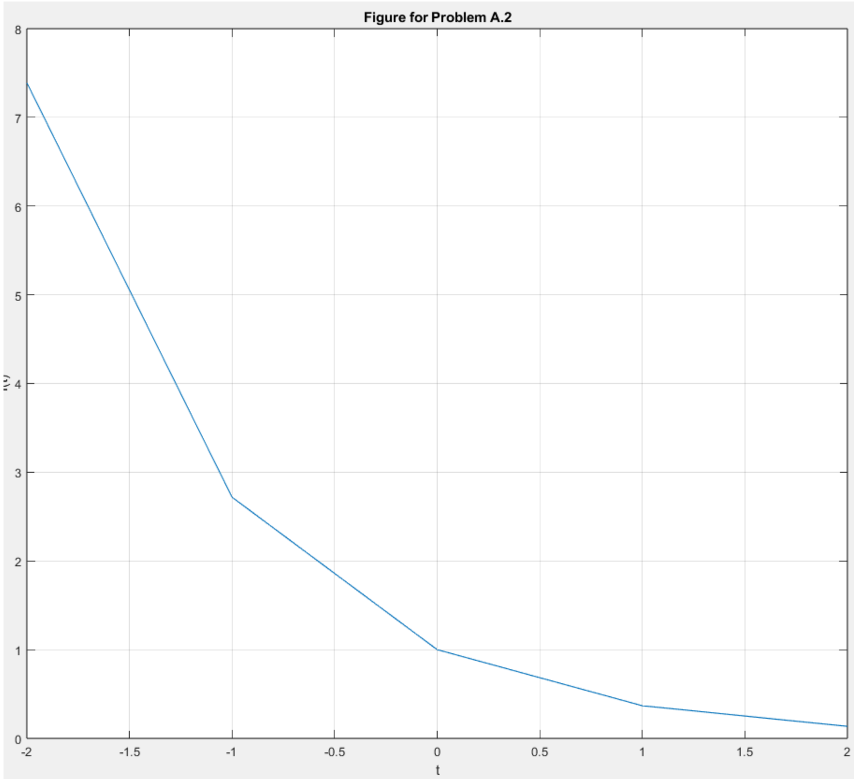
title('Figure 1.47');
xlabel('t');
ylabel('f(t)');



Problem A.2: Plot the function e −t for five points [-2,-1,0,1,2] using t=[-2:2].

Code:
f = @(t) exp(-t);
t = (-2:2)

plot (t,f(t));
title('Figure for Problem A.2');
xlabel('t');
ylabel('f(t)');



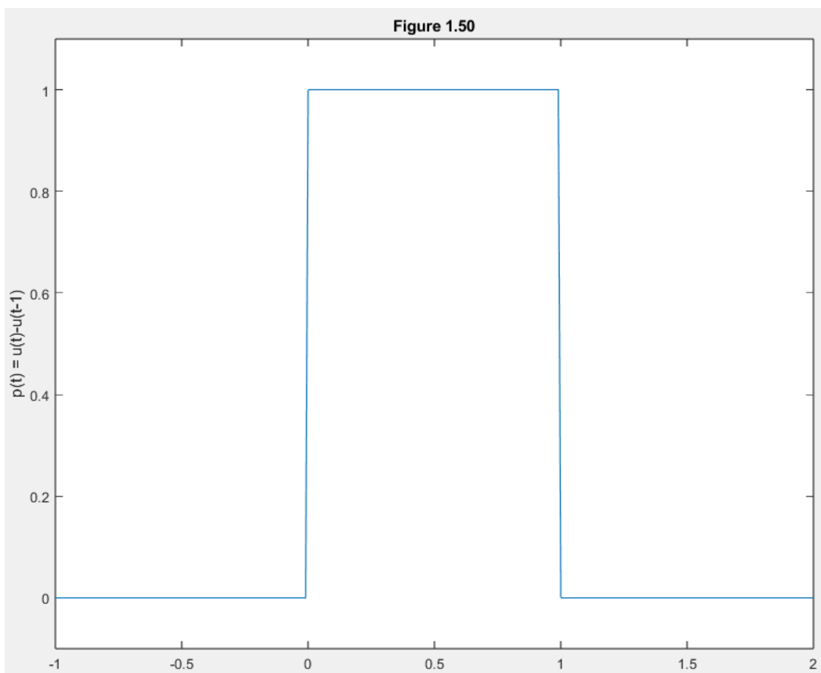
<u>Problem A.3</u>: Compare your result in Problem A.2 with Figure 1.46 in Problem A.1.

The results from both graphs appear to be identical. This is because in figure 1.46 there is a multiplication factor of cos(2πt) which results in 1 in all time intervals specified. All these values equal to 1 so basically the function plotted is e^{-1t} which is the same as the function in Problem A2.

Time shifting and time scaling

Problem B.1: Generate and plot p(t) as shown in Figure 1.50 on page 129.

```
t = (-1:0.01:2);
p = @(t) 1.0.*((t>=0)&(t<1));

plot(t,p(t));
xlabel('t');
ylabel('p(t) = u(t)-u(t-1)');
axis([-1 2 -.1 1.1]);
title('Figure 1.50');
```

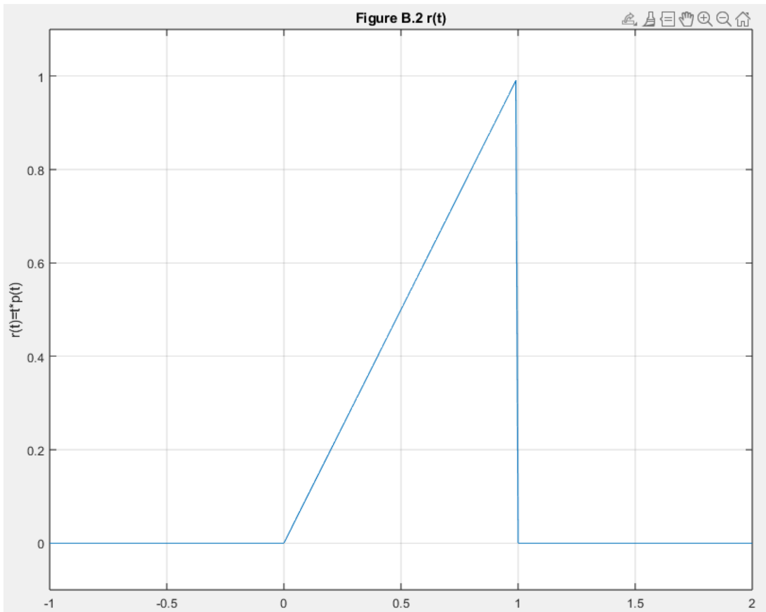


Problem B.2: Use p(t) to generate and plot functions $r(t) = tp(t)$ and $n(t) = r(t) + r(-t + 2)$.

Code:

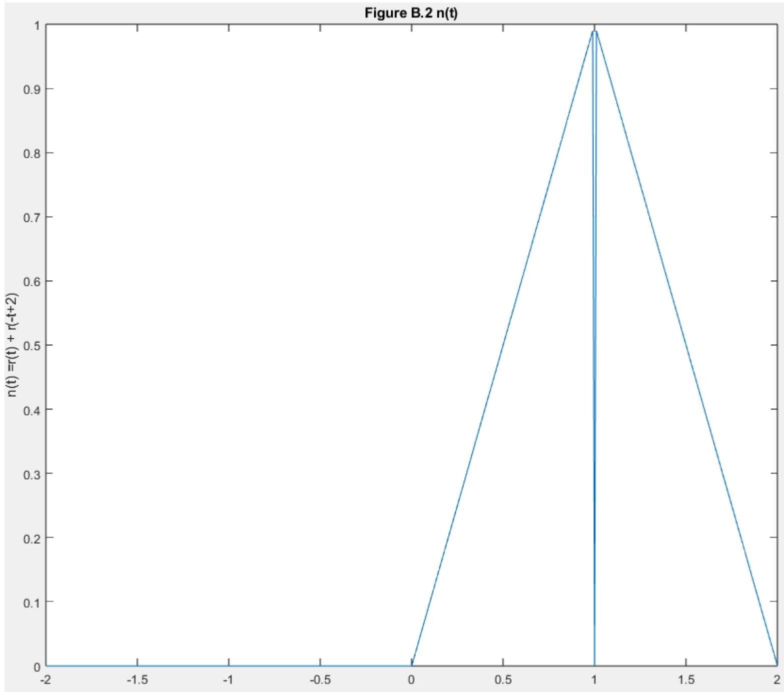
```
t=(-2:0.01:2);
u=@(t) 1.0.*(t>=0);
p=@(t) u(t)-u(t-1);
r=@(t) t.*p(t);
n=@(t) r(t)+r(-t+2);

plot(t,r(t));
```

```
xlabel('t');
ylabel('r(t)=t*p(t)');
title('Figure B.2 r(t)');
axis([-1 2 -0.1 1.1]);
```



Code:

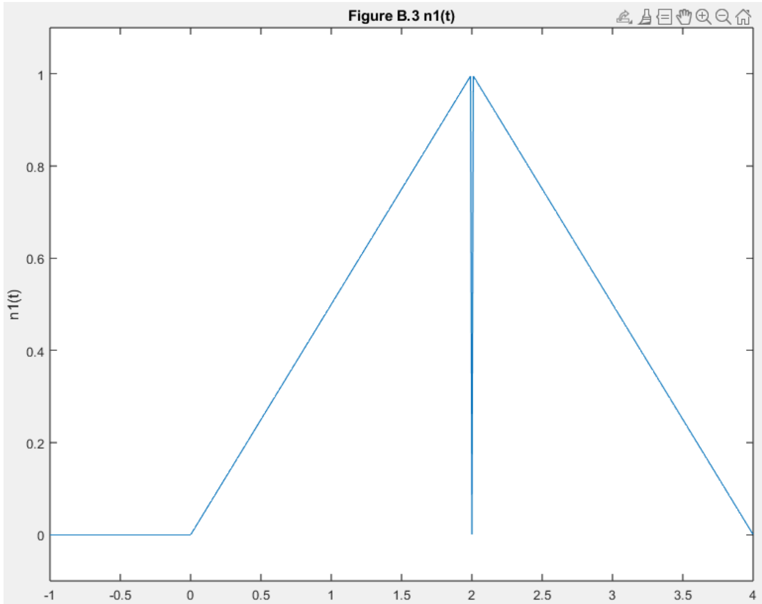
```
t=(-2:0.01:2);
u=@(t) 1.0.*(t>=0);
p=@(t) u(t)-u(t-1);
r=@(t) t.*p(t);
n=@(t) r(t)+r(-t+2);

plot(t, n(t));
xlabel("t");
ylabel("n(t) =r(t) + r(-t+2)");
title('Figure B.2 n(t)');
```



Problem B.3:Plot the following two signals: n1(t) = n(1/2 t), n2(t) = n1(t + 1/2).

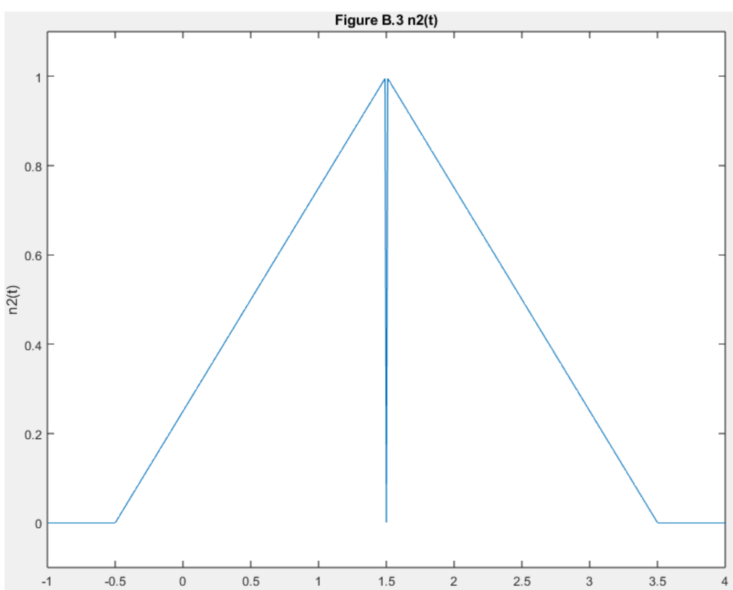
Code:

```
t = (-4:0.01:4);
n1=@(t) n(0.5*t);

plot(t,n1(t));
xlabel('t');
ylabel('n1(t)');
title('Figure B.3 n1(t)');
axis([-1 4 -0.1 1.1]);
```



Code:

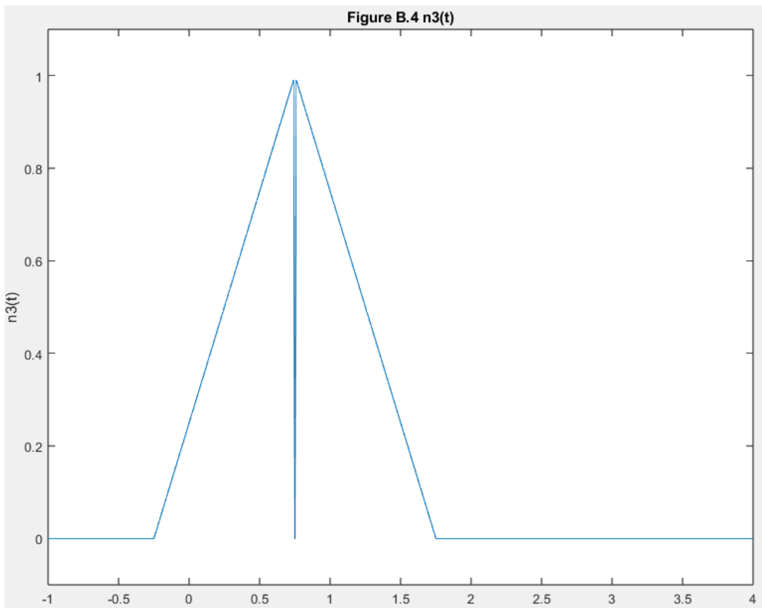
```
t = (-4:0.01:4);
n1=@(t) n(0.5*t);
n2=@(t) n1(t+0.5);

plot(t,n2(t));
xlabel('t');
ylabel('n2(t)');
title('Figure B.3 n2(t)');
axis([-1 4 -0.1 1.1]);
```



Problem B.4: Plot the following two signals: n3(t) = n(t + 1/4), n4(t) = n3(1/2t).

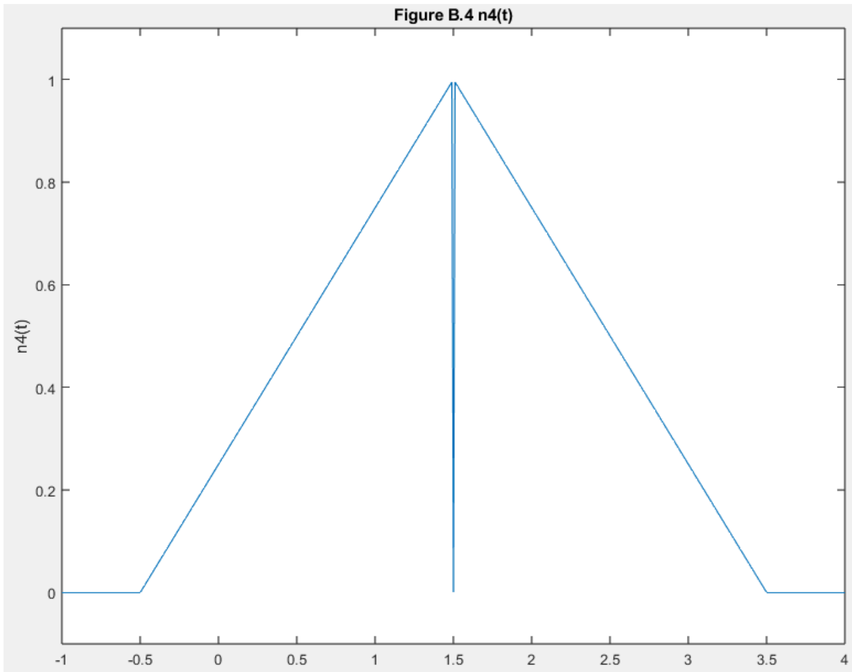
Code:

```
t = (-4:0.01:4);
n1=@(t) n(0.5*t);

plot(t,n1(t));
xlabel('t');
ylabel('n1(t)');
title('Figure B.3 n1(t)');
axis([-1 4 -0.1 1.1]);
```



Code:

```
t = (-4:0.01:4);
n1=@(t) n(0.5*t);
n2=@(t) n1(t+0.5);

plot(t,n2(t));
xlabel('t');
ylabel('n2(t)');
title('Figure B.3 n2(t)');
axis([-1 4 -0.1 1.1]);
```



Problem B.5: Compare n4(t) and n2(t) and explain their differences and/or similarities.

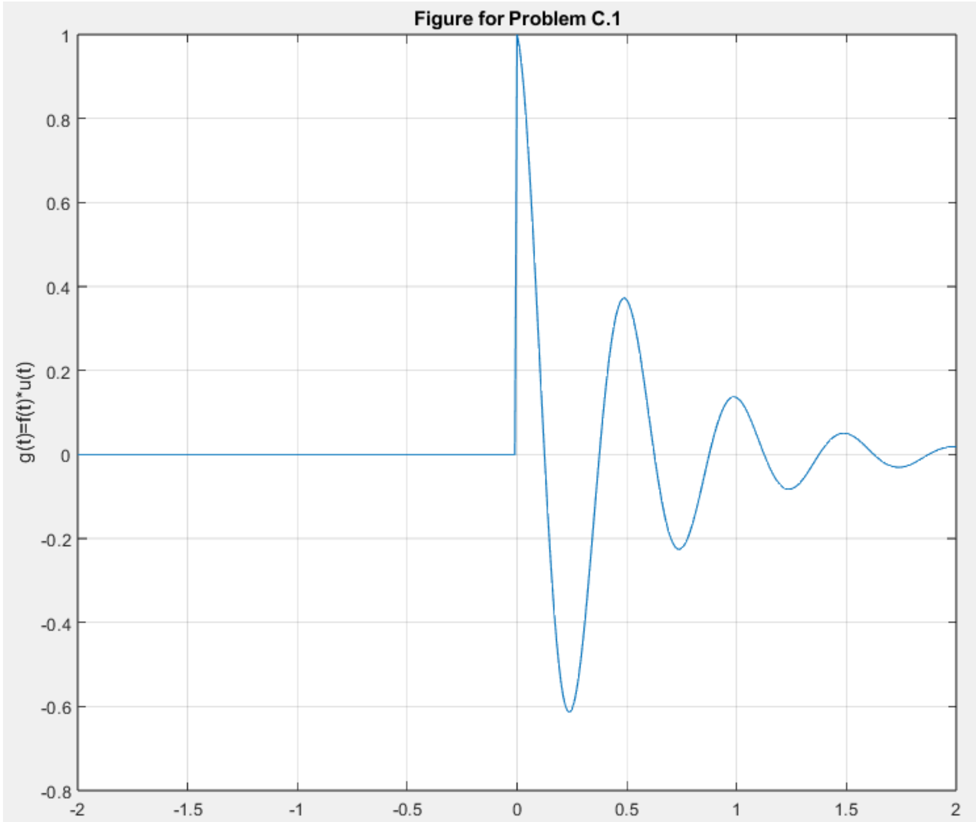
Observing both n4(t) and n2(t) we can see that they produce the exact same graph.

Visualizing operations on the independent variable and algorithm vectorization

Problem C.1: Follow the steps in this exercise, but to instead generate g(t) = f(t)u(t) where f(t) = e −2t cos(4πt).

Code:

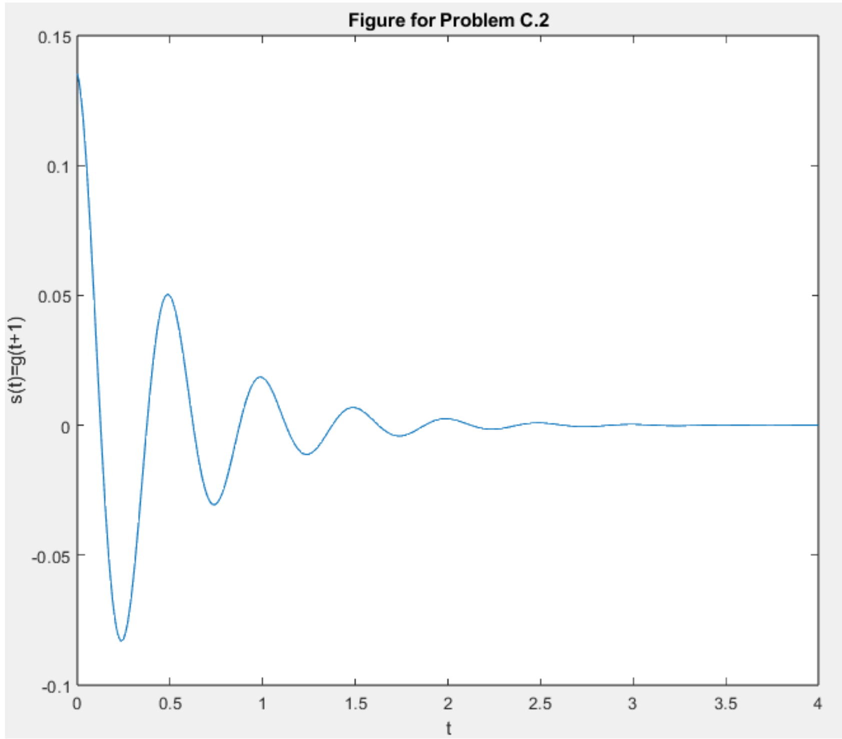
```
t=(-2:0.01:2);
f=@(t) exp(-2*t).*cos(4*pi*t);

u=@(t) 1.0.*(t>=0);
axis([-2 2 -0.1 1.1]);

g=@(t) f(t).*u(t);

plot(t,g(t));
xlabel('t');
ylabel('g(t)=f(t)*u(t)');
title('Figure for Problem C.1');
```



<u>Problem C.2</u>: Using g(t) in C.1, generate and plot s(t) = g(t+1) = e −2 e −2t cos(4πt)u(t+ 1) for t=[-2:0.01:4].

Code:

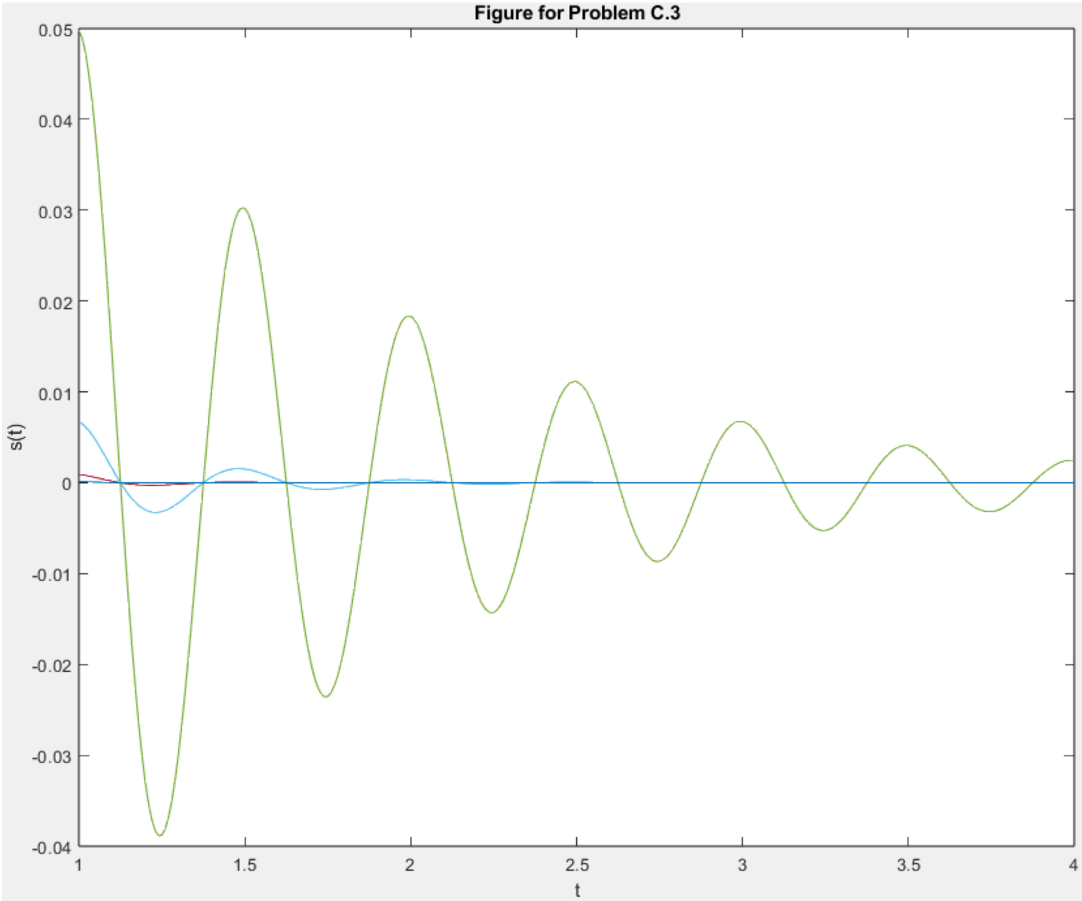
```
f=@(t) exp(-2*t).*cos(4*pi*t);
t=(-2:0.01:2);

u=@(t) 1.0*(t>=0);
axis([-2 2 -0.1 1.1])

g=@(t) f(t).*u(t);
t=(-2:0.01:2);

s=@(t) g(t+1);
t=(0:0.01:4);

plot(t,s(t));
xlabel("t");
ylabel("s(t)=g(t+1)");
title('Figure for Problem C.2');
```



<u>Problem C.3</u>: Plot sα(t) = e −2 e −αt cos(4πt)u(t) for α = [1, 3, 5, 7] in one figure for t=[0:0.01:4].

Code:

```
u=@(t) 1.0.*(t>=0);
t=(1:0.01:4);

for alpha = 1:2:7
	s=@(t) exp(-2).*exp(-alpha*t).*cos(4*pi*t).*u(t);

	plot(t,s(t));
	xlabel('t');
	ylabel('s(t)');
	title('Figure for Problem C.3');

	hold on;
end
```



Problem C.4: Determine the size of the matrix you generated in C.3.

When using the command size(s) the result that MATLAB provides is that it is a [1,1] matrix.

Array Indexing

Problem D.1: Let A be a 5 × 4 matrix array with real-valued elements: For the matrix A in Equation (1) implement the following operations:

a. A(:)

This operation lists all the elements in the matrix in one column.

```
 0.5377
    1.8339
   -2.2588
    0.8622
```

0.3188
-1.3077
-0.4336
0.3426
3.5784
2.7694
-1.3499
3.0349
0.7254
-0.0631
0.7147
-0.2050
-0.1241
1.4897
1.4090
1.4172

b. A([2 4 7])

Lists the second, fourth, and seventh elements of the array.

1.8339   0.8622   -0.4336

c. [A >= 0.2]

Creates a logical matrix by checking if each element in the array is larger or equal to 0.2, and providing a 1 or a 0 accordingly.

5×4 logical array

1	0	0	0
1	0	1	0
0	1	1	1
1	1	0	1
1	1	1	1

d. A([A >= 0.2])

Lists all of the elements in the array that are greater or equal to 0.2.

0.5377
1.8339
0.8622
0.3188

0.3426
3.5784
2.7694
3.0349
0.7254
0.7147
1.4897
1.4090
1.4172

e. A([A >= 0.2]) = 0

Finds all the elements in matrix A that are greater or equal to 0.2 and replaces them with 0. The operation then displays the new matrix.

A =

0	-1.3077	-1.3499	-0.2050
0	-0.4336	0	-0.124
-2.2588	0	0	0
0	0	-0.0631	0
0	0	0	0

Problem D.2: Let B be a 1024 × 100 data matrix representing 100 blocks of non-overlapping 1024-element input samples from a particular data source.

a. Write a simple Matlab program using two nested for loops that will set all elements of the data matrix B with magnitude values below 0.01 to zero: B(i, j) = 0, if |B(i, j)| < 0.01, (2) where B(i, j) is an element of the data matrix B in i-th row and j-th column.

```
tic;
for i = 1:1024
   for j = 1:100
      if B(i,j) < 0.01
         B(i,j) = 0;
      end
   end
end

D2_a=B;
toc
```

b. Repeat part (a) using Matlab's indexing features as described in Problem D.1.

```
tic;
B([ B >= 0.01 ]) = 0;
D2_b=B;
toc;
```

c. Use the Matlab commands tic and toc to compare the execution time of the code you wrote in parts (a) and (b).

Execution time for code in part a:

Elapsed time is 0.009291 seconds.

Execution time for code in part b:

Elapsed time is 0.007445 seconds.

Problem D.3: Let x audio be a 20,000 sample-long row vector representing 2.5 sec of an audio signal sampled at 8 kHz. A simple data compression algorithm can be implemented by setting all elements of the data array x audio with magnitude values below a threshold to zero. Write such a data compression algorithm and listen to the processed audio file.

```
x_audio_copy = x_audio;

count=0;
threshold=0.01;

for i = 1:20000
    if x_audio_copy(i,1) < threshold
        x_audio_copy(i,1) = 0;
        count=count+1;
    end
end
disp(count);
sound(x_audio_copy);
```

Message in processed audio file:
Members of a public service alliance of Canada