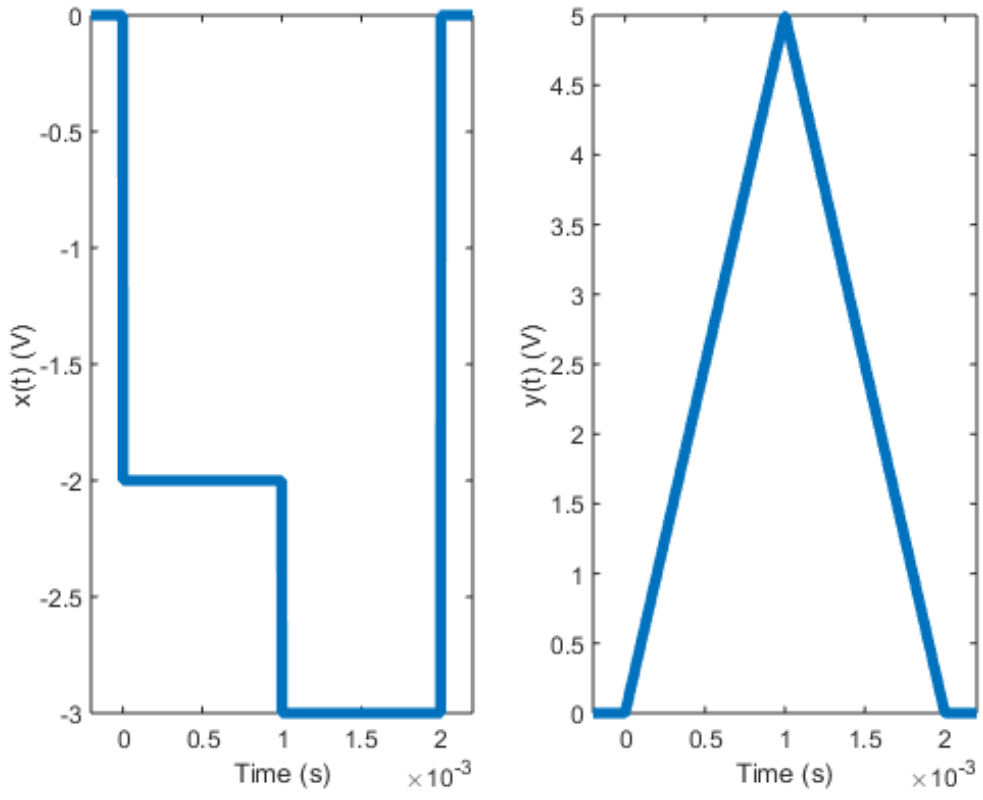
EE-3032 HW-1 Solution, Winter, 2019-20, Dr. Durant

Problem 1

The functions x(t) and y(t) are plotted below.

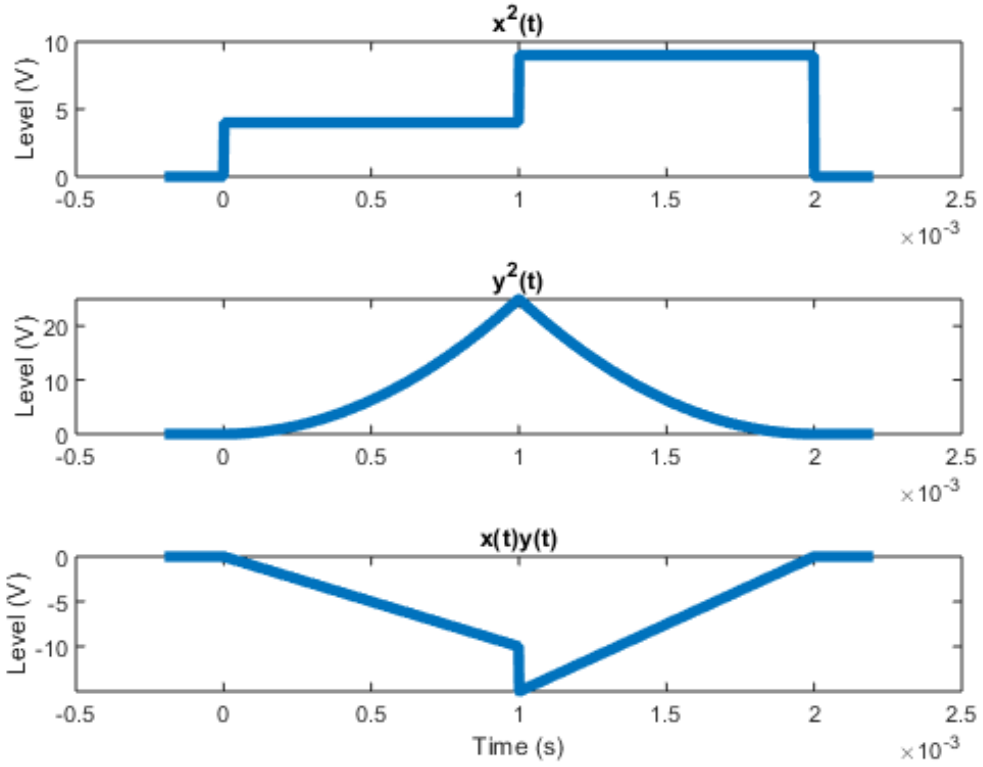
```
t = linspace(-0.0002, 0.0022,1000);
x = (-2 * (t<0.001) + -3 * (t>= 0.001)) .* (t>0 & t<0.002);
y = ( ((5/0.001) * t .* (t<0.001)) ...
     + (10-(5/0.001)*t).*(t>0.001) ...
    ) ...
    .* (t>0 & t<0.002);

set(groot,'defaultLineLineWidth',4)
figure
subplot(121),plot(t,x),xlabel('Time (s)'),ylabel('x(t) (V)')
subplot(122),plot(t,y),xlabel('Time (s)'),ylabel('y(t) (V)')
```



Plot x^{2}(t), y^{2}(t), and the product function x(t)y(t) over the interval 0 ≤ t ≤ 2 ms.

```
x2 = x.^2;
y2 = y.^2;
xy = x.*y;
figure
subplot(311),plot(t,x2),title('x^2(t)'),ylabel('Level (V)')
subplot(312),plot(t,y2),title('y^2(t)'),ylabel('Level (V)')
subplot(313),plot(t,xy),title('x(t)y(t)'),ylabel('Level (V)'),xlabel('Time (s)')
```



Problem 2

Using Euler's formula, write a simplified expression for $x(t) = \mathrm{Im}\left\{ e^{j\left(4\pi t - \frac{\pi}{2}\right)} \right\}$ and evaluate it for

```
t = [0, 0.125, 0.25, 0.375, 0.5];
```

The imaginary part of the complex exponential is the sine. The delay of $\frac{\pi}{2}$ yields the negative of the cosine.

```
x = -cos(4*pi*t);
disp(x)
```

```
    -1.0000   -0.0000    1.0000    0.0000   -1.0000
```

Problem 3

Write an expression for the complex conjugate of the function f(t) = x(t)y(t), where $x(t) = e^{-\mathrm{j}15t}$ and $y(t) = \frac{1}{4}t - \frac{1}{5}j$. Recall that the conjugate of a product is the product of the conjugates. Simplify conjugates.

Answer: f(t) = $e^{+15\mathrm{j}t}\left(\frac{1}{4}t + \frac{1}{5}j\right)$

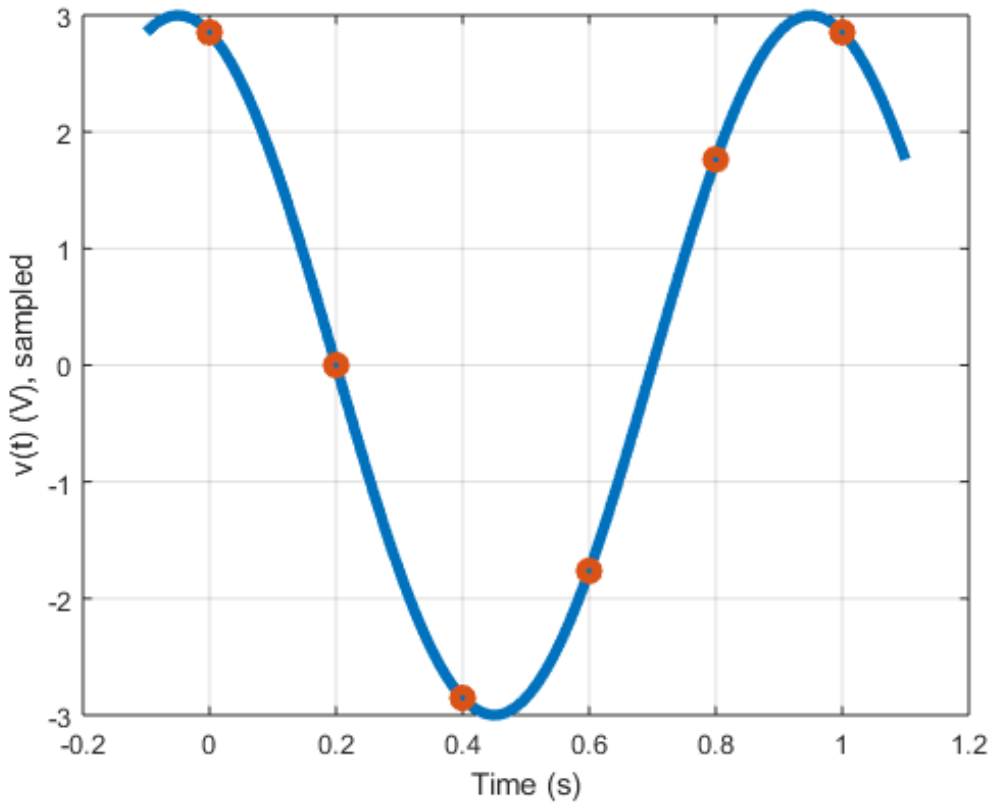
Problem 4

For the analog sinusoidal voltage shown below, illustrate:

```
% Given waveform is...
t = linspace(-0.1,1.1);
hx = @(t)3*cos(2*pi*(t+0.05)); % function handle; call function hx to evaluate
x = hx(t);
```

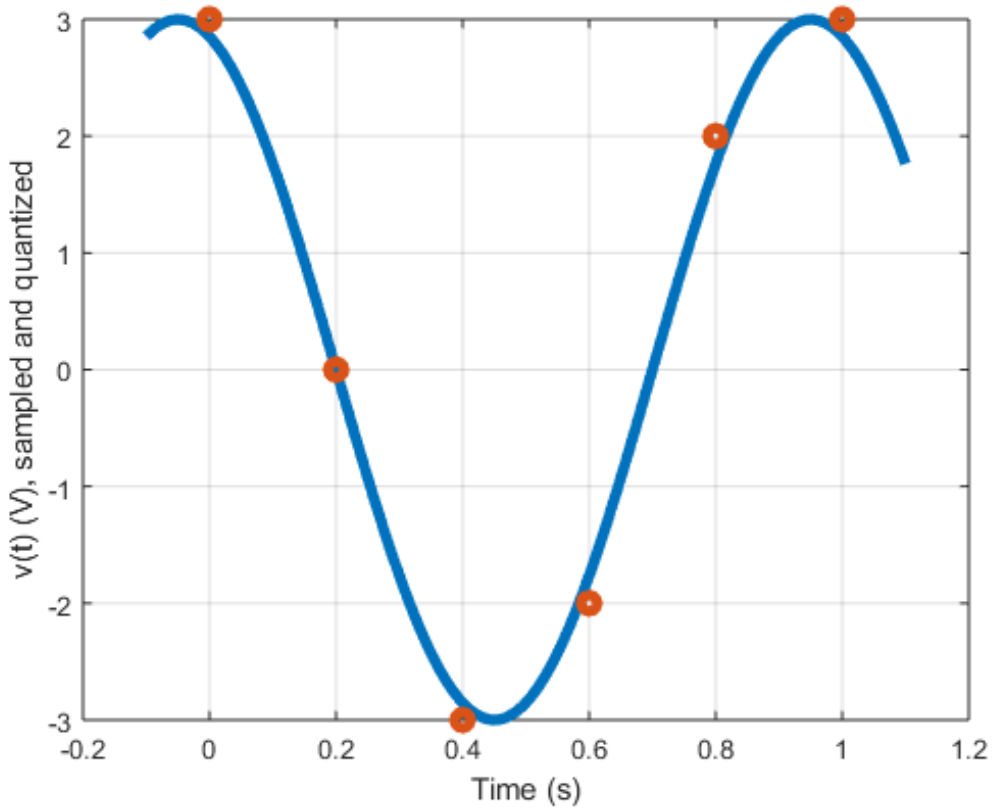
a. Sampling the signal (going from continuous to discrete time) with a period of 0.2 s.

```
Ts = 0.2; % sampling time
ts = 0:Ts:1.1; % all sampled times in range of interest
xs = hx(ts);
figure
plot(t,x,'-',ts,xs,'o'),xlabel('Time (s)')
ylabel('v(t) (V), sampled')
grid
```



b. Then quantizing the signal (going from continuous/analog voltage) with a resolution of 0.5 V.

```
res = 0.5;
xq = round(xs / res) * res; % round gives nearest integer; the step we are on
figure
plot(t,x,'-',ts,xq,'o'),xlabel('Time (s)')
ylabel('v(t) (V), sampled and quantized')
grid
```



Problem 5

How many levels ***and*** how many bits are needed for each sample of the above signal?

```
steps = (max(xq) - min(xq)) / res;
levels = steps+1;
bits = ceil(log2(levels));
fprintf('The voltage takes %g steps, giving %g levels, which requires %g bits.\n',...
    steps, levels, bits)
```

```
The voltage takes 12 steps, giving 13 levels, which requires 4 bits.
```

Problem 6

How much total memory in bits is needed to store the digital version of the signal?

```
samples = length(ts);
totalBits = samples * bits;
fprintf('There are %g samples and each takes %g bits, so %g total bits are needed.\n',...
    samples, bits, totalBits)
```

```
There are 6 samples and each takes 4 bits, so 24 total bits are needed.
```