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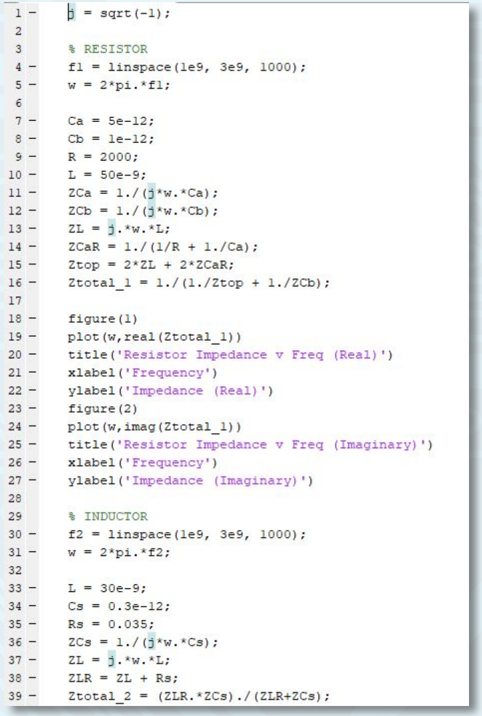
# *Introduction to MATLAB*

MATLAB



```
j = sqrt(-1);

% RESISTOR
f1 = linspace(1e9, 3e9, 1000);
w = 2*pi.*f1;

Ca = 5e-12;
Cb = 1e-12;
R = 2000;
L = 50e-9;
ZCa = 1./(j*w.*Ca);
ZCb = 1./(j*w.*Cb);
ZL = j.*w.*L;
ZCaR = 1./(1/R + 1./Ca);
Ztop = 2*ZL + 2*ZCaR;
Ztotal_1 = 1./(1./Ztop + 1./ZCb);

figure(1)
plot(w,real(Ztotal_1))
title('Resistor Impedance v Freq (Real)')
xlabel('Frequency')
ylabel('Impedance (Real)')
figure(2)
plot(w,imag(Ztotal_1))
title('Resistor Impedance v Freq (Imaginary)')
xlabel('Frequency')
ylabel('Impedance (Imaginary)')

% INDUCTOR
f2 = linspace(1e9, 3e9, 1000);
w = 2*pi.*f2;

L = 30e-9;
Cs = 0.3e-12;
Rs = 0.035;
ZCs = 1./(j*w.*Cs);
ZL = j.*w.*L;
ZLR = ZL + Rs;
Ztotal_2 = (ZLR.*ZCs)./(ZLR+ZCs);
```

***Led by** Nish, Jackie, Will, & Muchen*

# What is MATLAB?

- MATLAB (**mat**rix **lab**oratory) is a numerical computing environment and programming language

- MATLAB allows
  - Matrix manipulations
  - Plotting
  - Implementation of algorithms
  - Symbolic computing
  - Creation of user interfaces

# Basic Syntax

- Very similar to python

- **Operators**: = (assignment), +, -, *, /, ^
- **Useful functions**: sqrt(), exp(), cos(), sin(), sum()
- **Constants**: pi = 3.1415…, eps = 2.2204e-16 (smallest amount by which 2 numbers can differ), inf (infinity), NaN (Not-number)
- **Logical Conditions**: ==, >, <, >=, <=, ~= (not equal), ~ (not), & (Element wise and), |(or)
- % for comments
- **;** at the end of lines
- **help**

# Control Structures

- if

```
if(x==3)
    disp(‘x is 3’)
elseif(x==5)
    disp(‘x is 5’)
else
    disp(‘x is neither 5 nor 3’)
end
```

- for

```
for i=start:increment:end
    loop contents
end
```

- while

```
while(loopCondition)
    loop contents
end
```

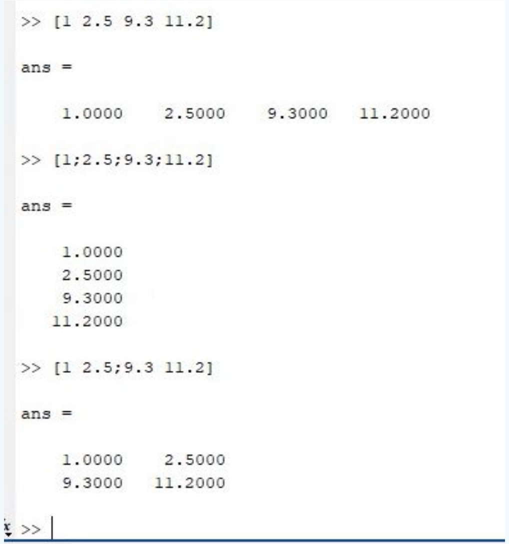
- break used to break out of loops

```
s = 0;

while 1
    if a > limit
        break
    end
    s = s + a;
end
```

# Matrices/Vectors

- Enclosed under []
- Rows separated by ;
- Columns Separated by space
- [1 2 9.3 11.2] is a row vector since it only has one row but 4 columns
- [1; 2.5; 9.3; 11.2] is a column vector since it only has one column but 4 rows
- Vector addressing done with (), so x(3) will be 3rd row of x
- *x(start:increment:end)* will give all elements starting at start skipping everything until the next increment and ending end
- Useful functions: *diag(),eye()* for identity matrix



```
>> [1 2.5 9.3 11.2]

ans =

    1.0000    2.5000    9.3000   11.2000

>> [1;2.5;9.3;11.2]

ans =

    1.0000
    2.5000
    9.3000
   11.2000

>> [1 2.5;9.3 11.2]

ans =

    1.0000    2.5000
    9.3000   11.2000

>> 
```

# Matrices/Vectors

For the vector x = -4 : 2 : 10, use MATLAB to determine

1. length(x)
2. size(x)
3. x’
4. size(x’)
5. min(x)
6. max(x)
7. sum(x)
8. find(x)
9. find(x < 0)
10. find(x,3)

# Plots

- *plot(x,y)* % plot y vs x where x and y are vectors and have equal number of elements
- Labelling can be done using *xlabel()* and *ylabel()*, *title()* (to title the graph)
- “hold on;” to draw several plots in the same window
- figure; to open a new window for plots/graphs
- *legend()* to add legends
- *subplot()* for subplots

# Plot Exercise

***Plot y(t)*** $y(t) = 1 - e^{-t} \quad t \geq 0$

Step 1: Generate a time vector t of 1000 points uniformly spaced between 0 and 10

Step 2: Generate a vector y whose elements represent the values of the response at the time instants in t

Step 3: Plot y versus t, and use the *legend()* to label the curve

- plot(x,y) % plot y vs x where x and y are vectors and have equal number of elements
- Labelling can be done using xlabel() and ylabel(), title() (to title the graph)
- “hold on;” to draw several plots in the same window
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- legend() to add legends
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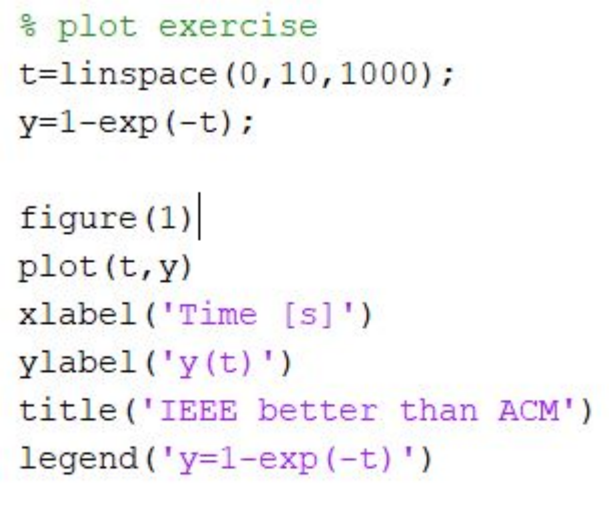
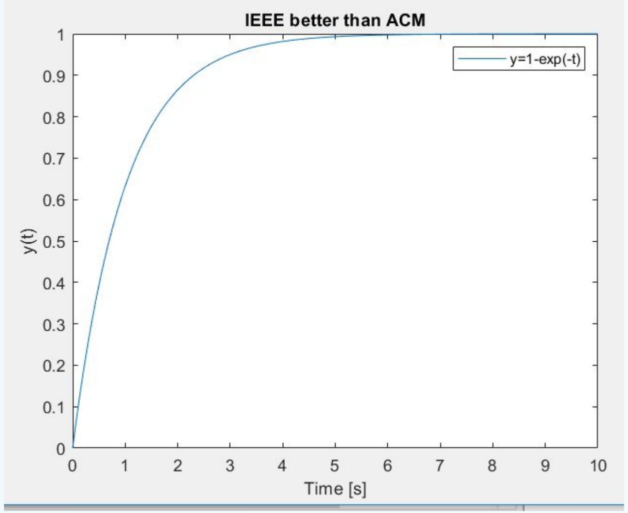


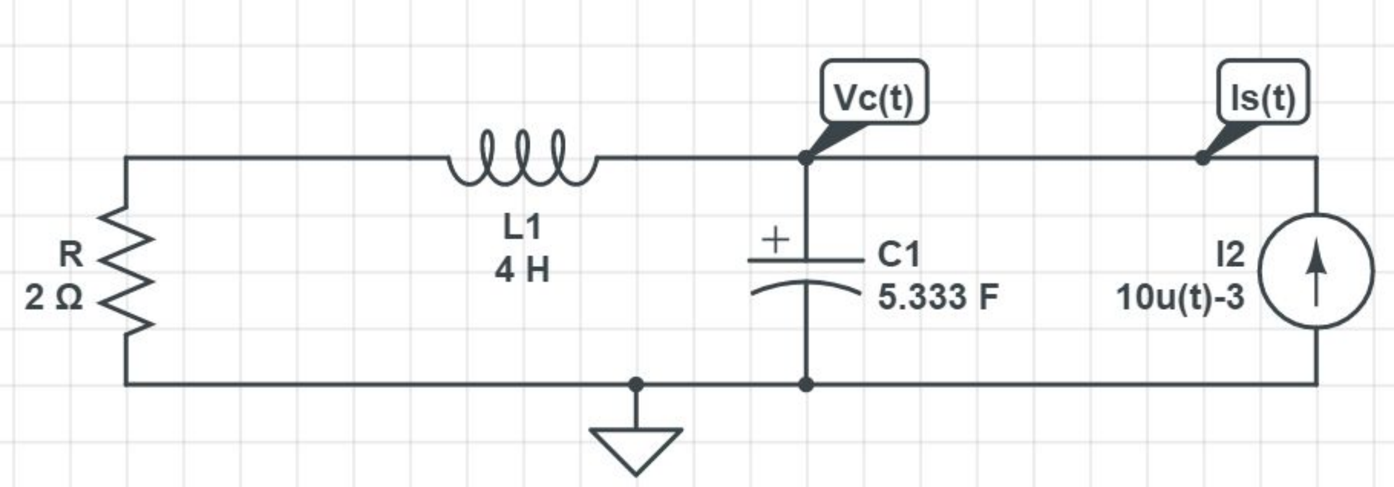
```
% plot exercise
t=linspace(0,10,1000);
y=1-exp(-t);

figure(1)
plot(t,y)
xlabel('Time [s]')
ylabel('y(t)')
title('IEEE better than ACM')
legend('y=1-exp(-t)')
```



# A problem from EE 210

*Determine and Sketch Vc(t)*



Ⓒ **PSU EE210 notes: second-order RLC circuit**

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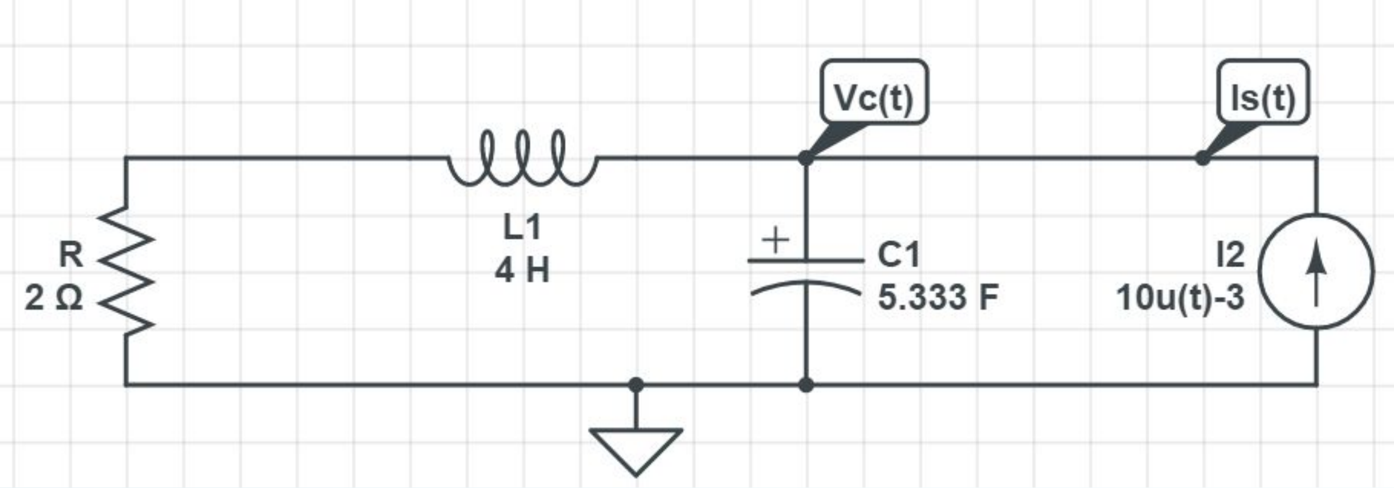

What is the general solution algorithm for driven RLC circuits with a constant source present after t=0?

Ⓒ PSU EE210 notes: second-order RLC circuit

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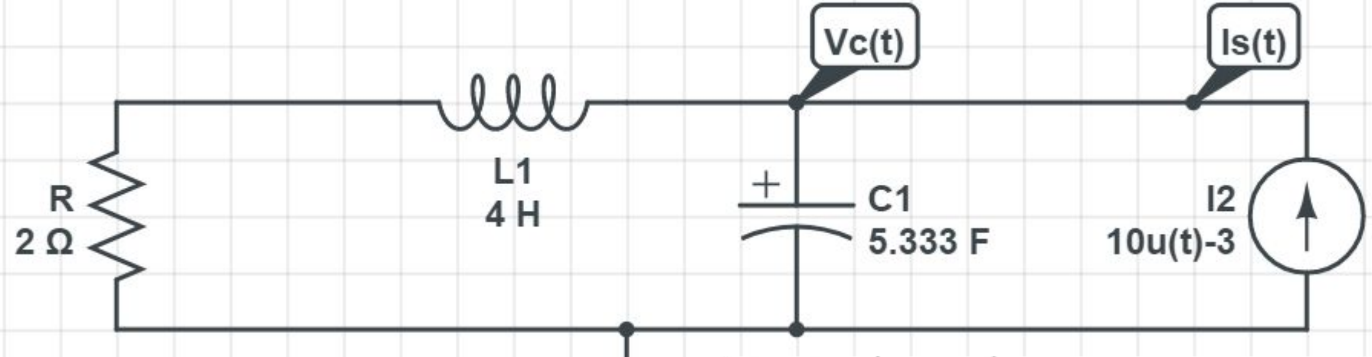

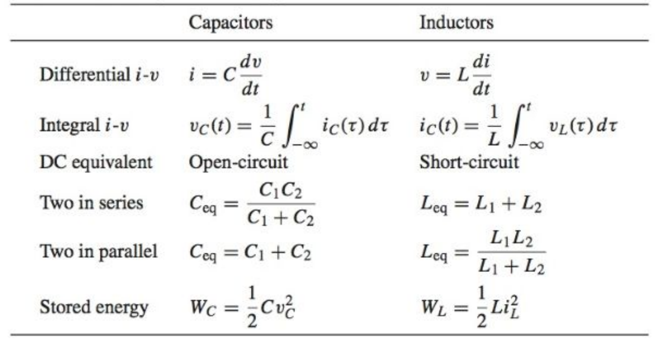

| | Capacitors | Inductors |
|---|---|---|
| Differential $i$-$v$ | $i = C\frac{dv}{dt}$ | $v = L\frac{di}{dt}$ |
| Integral $i$-$v$ | $v_C(t) = \frac{1}{C}\int_{-\infty}^{t} i_C(\tau)\,d\tau$ | $i_C(t) = \frac{1}{L}\int_{-\infty}^{t} v_L(\tau)\,d\tau$ |
| DC equivalent | Open-circuit | Short-circuit |
| Two in series | $C_{\text{eq}} = \frac{C_1C_2}{C_1+C_2}$ | $L_{\text{eq}} = L_1 + L_2$ |
| Two in parallel | $C_{\text{eq}} = C_1 + C_2$ | $L_{\text{eq}} = \frac{L_1L_2}{L_1+L_2}$ |
| Stored energy | $W_C = \frac{1}{2}Cv_C^2$ | $W_L = \frac{1}{2}Li_L^2$ |

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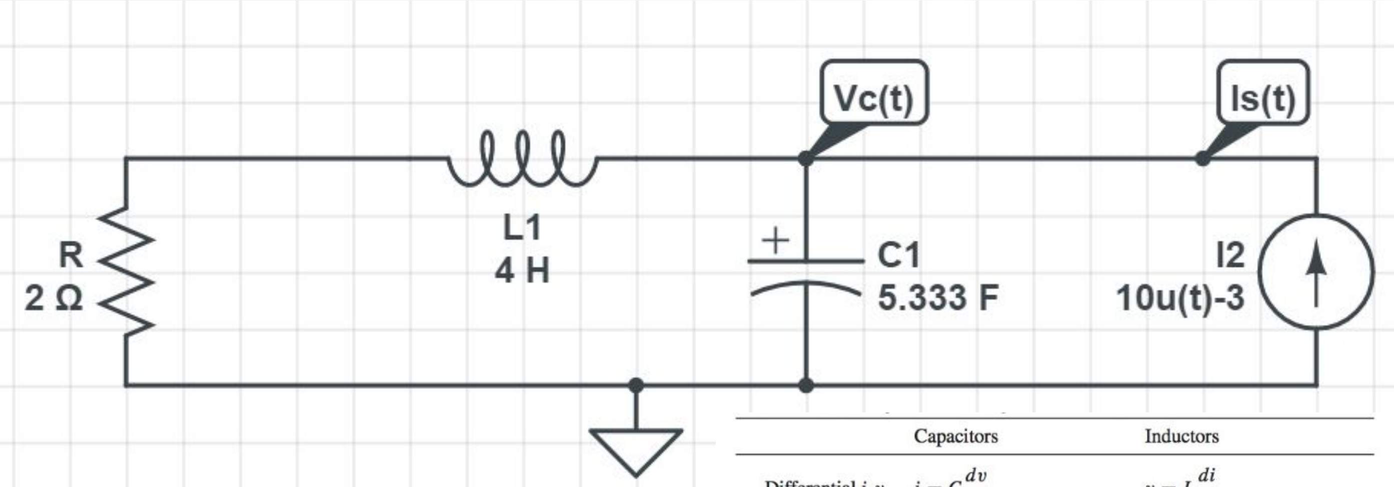

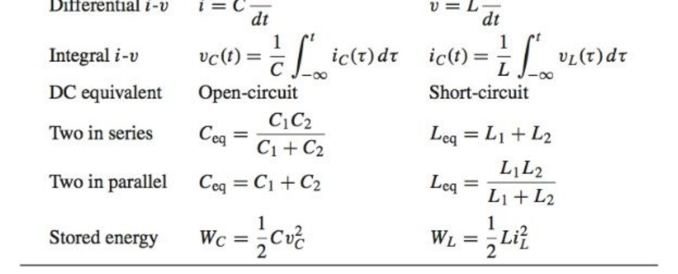

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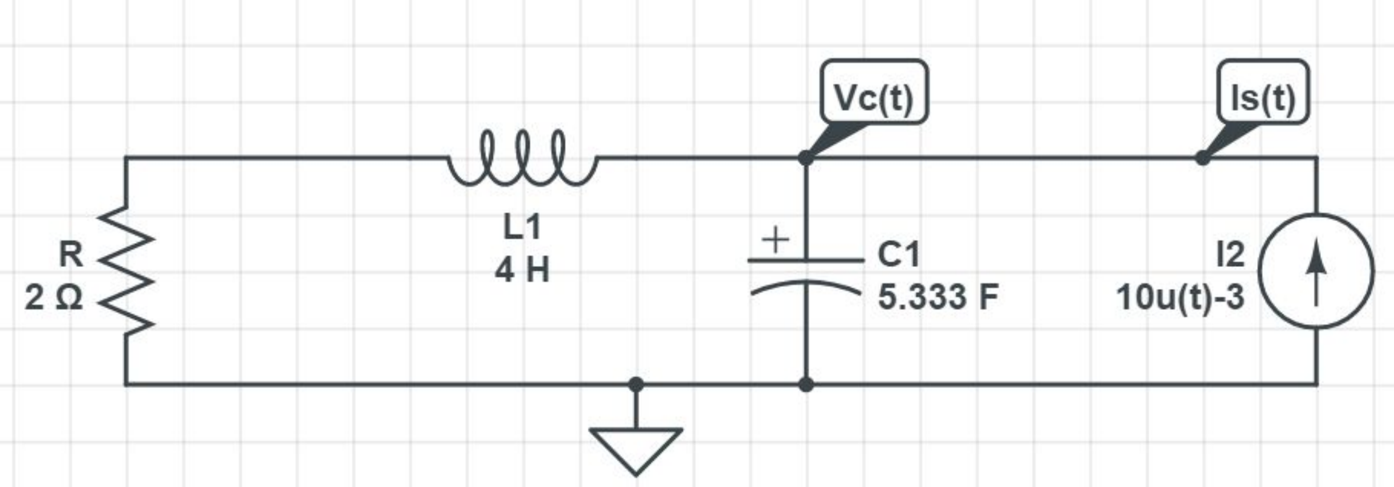
Vc(t) = -6   t<0

= $14 + \frac{5}{2}e^{-\frac{3t}{8}} - \frac{45}{2}e^{-\frac{t}{8}}$   t>0

© PSU EE210 notes: second-order RLC circuit

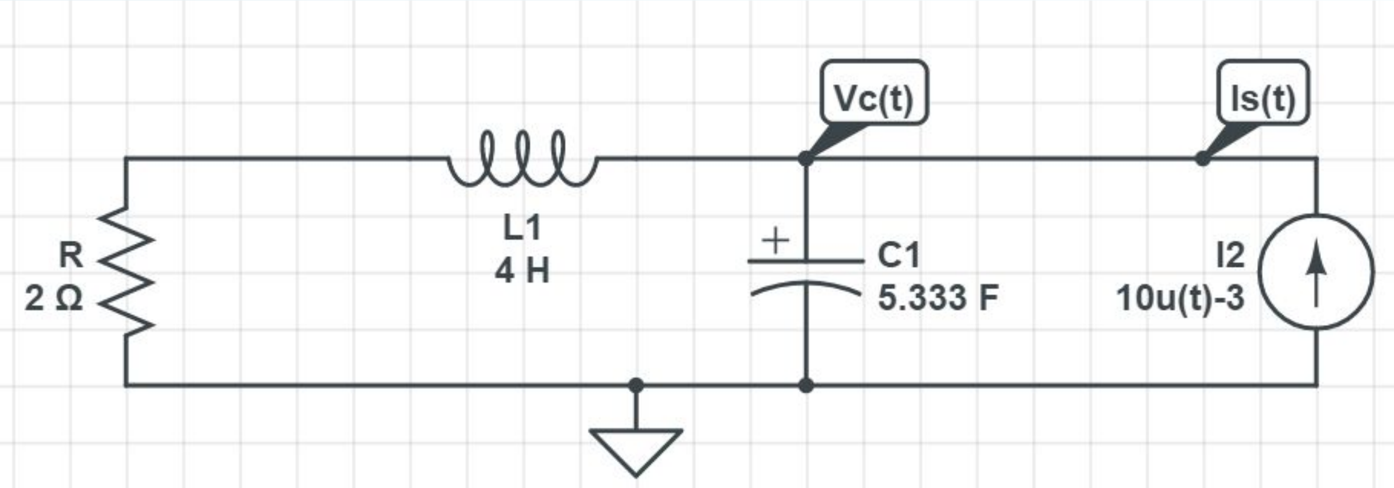
# A problem from EE 210

*~~Determine and~~ Sketch Vc(t)*



# A problem from EE 210

~~Determine and~~ *Sketch Vc(t)*



With MATLAB you can sketch without determining Vc(t)!

# A problem from EE 210

$$\frac{d^2v_c}{dt^2}+\frac{R}{L}\frac{dv_c}{dt}+\frac{1}{LC}v_c=\frac{1}{C}\frac{di}{dt}+i\frac{R}{LC}$$

$$\left(s^2+\frac{R}{L}s+\frac{1}{LC}\right)V=\left(\frac{1}{C}s+\frac{R}{LC}\right)I$$

$$Q=\begin{bmatrix}1 & \frac{R}{L} & \frac{1}{LC}\end{bmatrix}$$

$$P=[\frac{1}{C} \quad \frac{R}{LC}]$$

Step1: define variables R,C,L

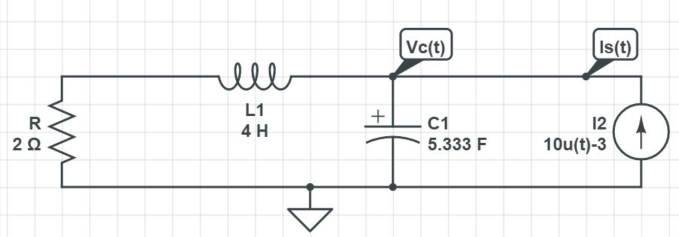
Step2: rewrite ODE with characteristic polynomial

step3: define vectors P,Q

step4: create time vector, input vector and output vector like what we did

step5: use *lsim()* command

step6: just plot!



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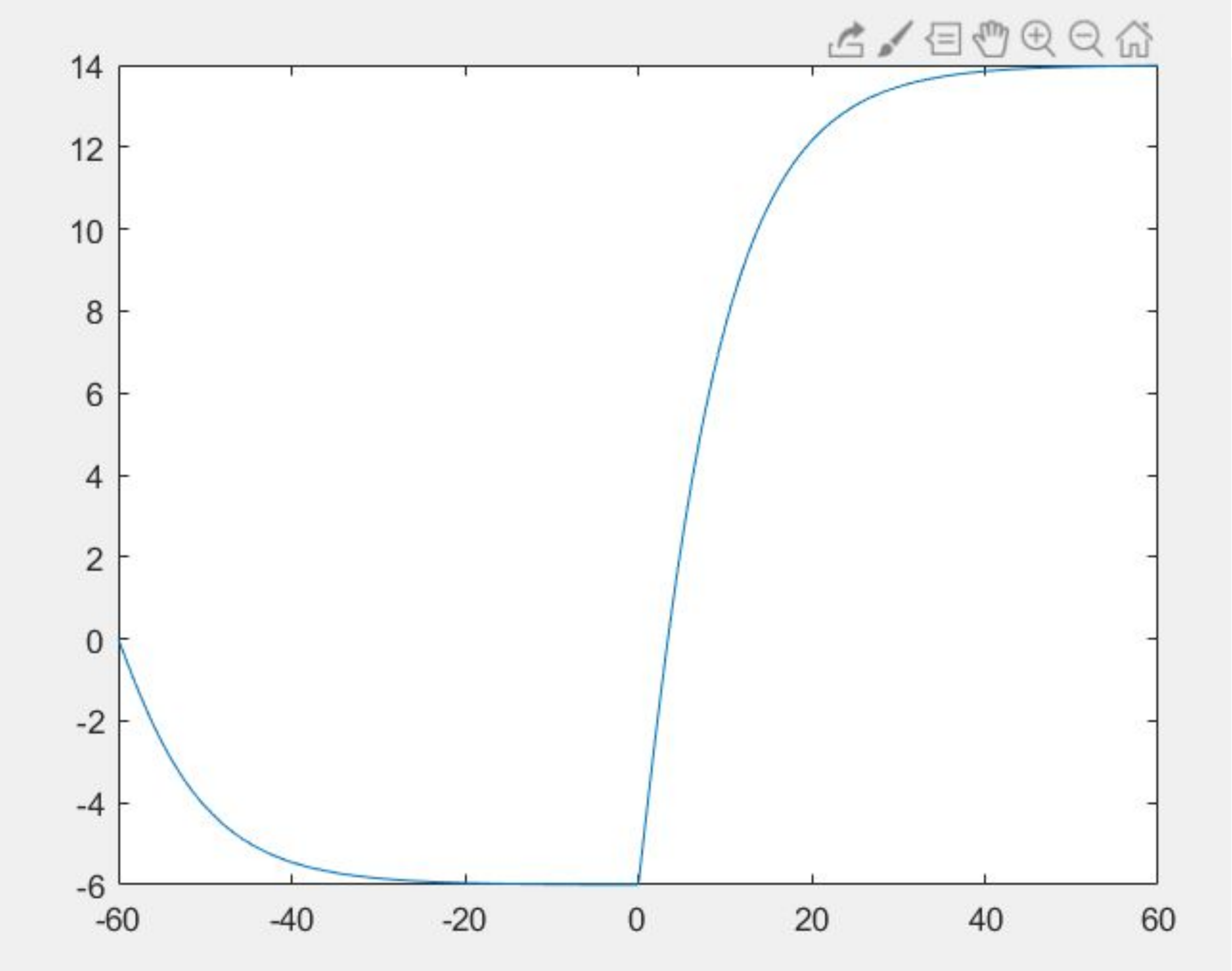
14
12
10
8
6
4
2
0
-2
-4
-6
-60
-40
-20
0
20
40
60

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# Thanks for attending!

*See you next time!*