ECE 210 Review Session

MIDTERM ONE

Complex Numbers

Rectangular Form: $a + bj$

- Use for adding or subtracting complex numbers

Polar Form: $Ae^{j\theta}$

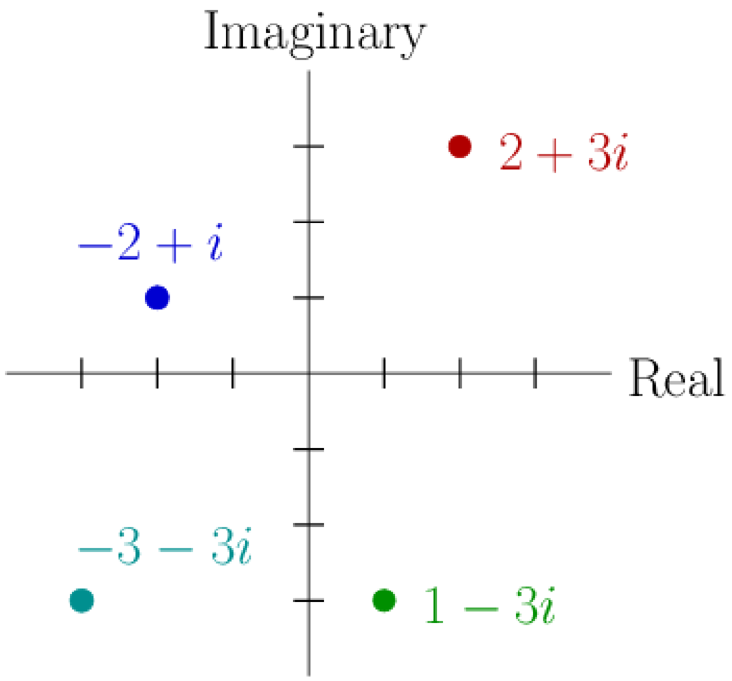
- Use for multiplying or dividing complex numbers

How to convert from one form to another

$$A = \sqrt{a^2 + b^2}$$

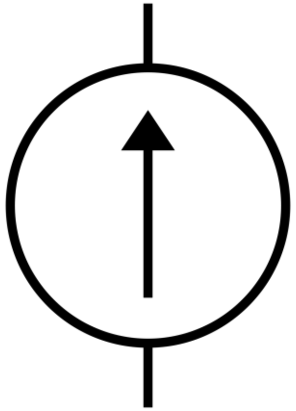
$$\theta = \tan^{-1}(\frac{b}{a})$$

Note: Be mindful of which quadrant your complex number is in



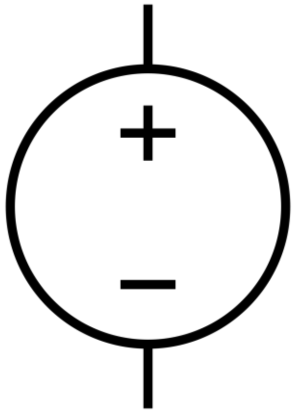
Independent and Dependent Sources

I_s

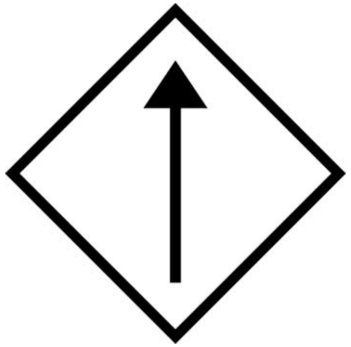


Independent Current Source

V_s

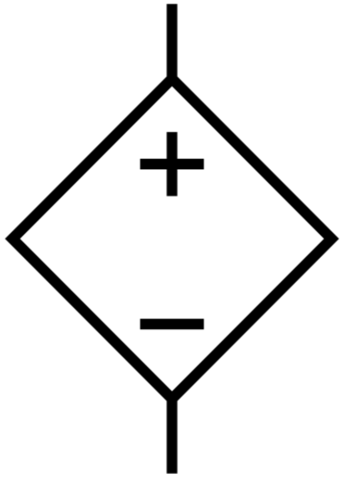


Independent Voltage Source



$I\ = av_x\, or\ bi_x$

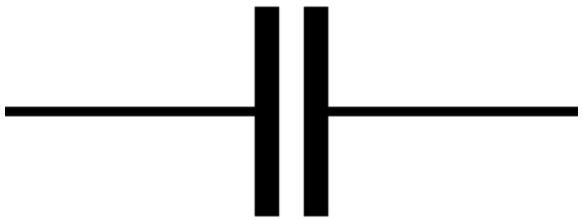
Dependent Current Source



$V\ = av_x\, or\ bi_x$

Dependent Voltage Source

Resistors, Capacitors, and Inductors

Resistor	$V = iR$	
Capacitor	$i = C\frac{dv}{dt}$	
Inductor	$V = L\frac{di}{dt}$	

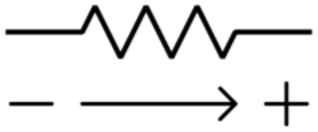
Power

Energy absorbed/gained in a unit time

$P = VI$

From the textbook: where v denotes the voltage drop across the element in the direction of the current i

$$V = I * R \qquad P = I * V$$



$$V = -I * R \qquad P = -I * V$$

When $P > 0$ Power is ABSORBED

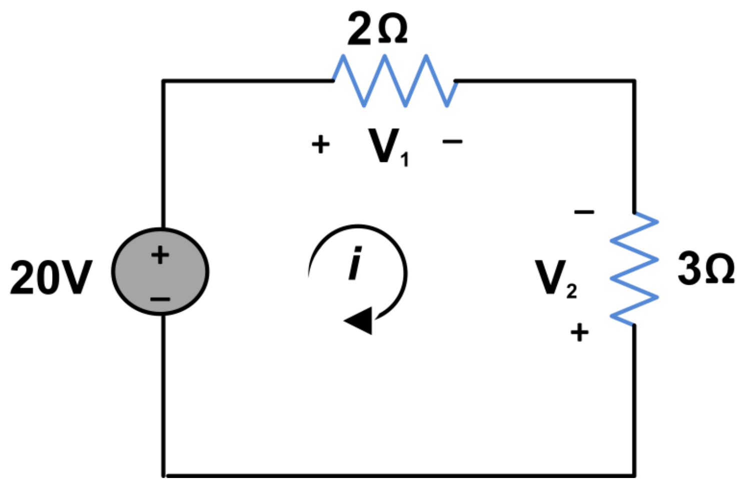
When $P < 0$ Power is INJECTED (SOURCE)

Kirchhoff's Voltage Law

Conservation of Energy

The sum of all voltage rises across a closed loop is equal to the sum of voltage drops

$$\sum V_{rise} = \sum V_{drop}$$



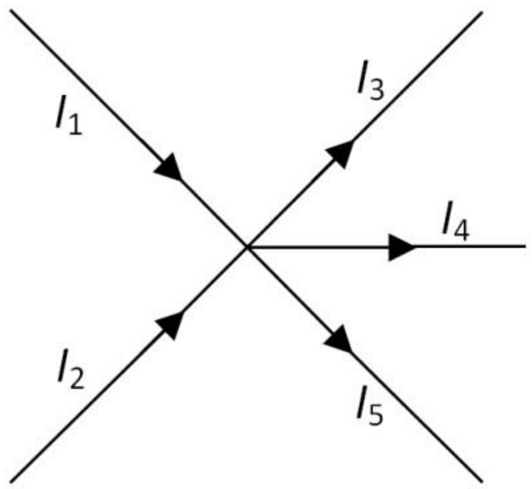
$$V_1 = 20 + V_2$$

Kirchhoff’s Current Law

Conservation of Charge

The sum of all current going in a node is equal to the sum of all current going out

$$\sum i_{in} = \sum i_{out}$$



$$I_1 + I_2 = I_3 + I_4 + I_5$$

Node Voltage Method

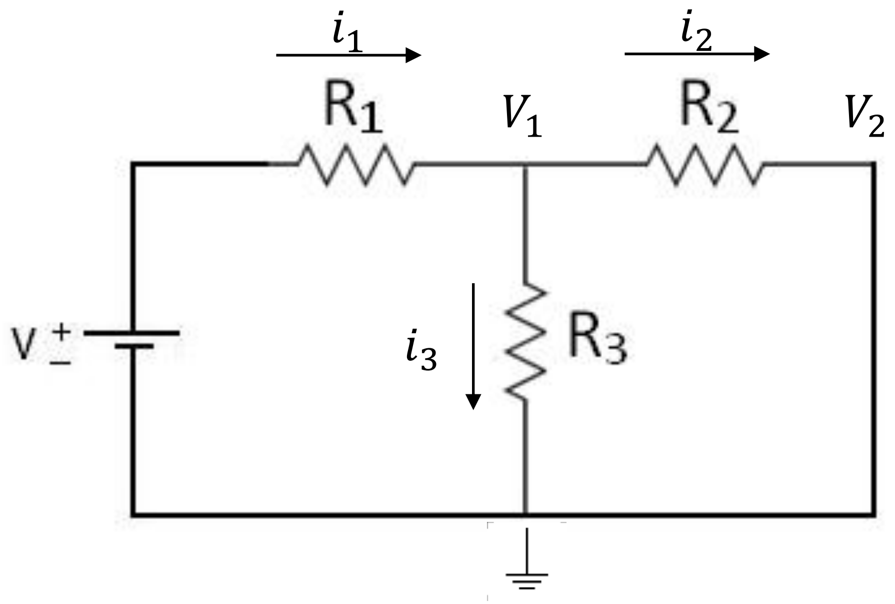
Assign ground (reference) node

Assign names to unknown nodes

Set up KCL equations

$$i_1 = \frac{V - V_1}{R_1}$$

$$i_1 = i_2 + i_3$$



$$i_2 = \frac{V_1 - V_2}{R_2}$$

$$i_3 = \frac{V_1}{R_3}$$

Remember $i = \frac{V_{START} - V_{END}}{R}$

Loop Current Method

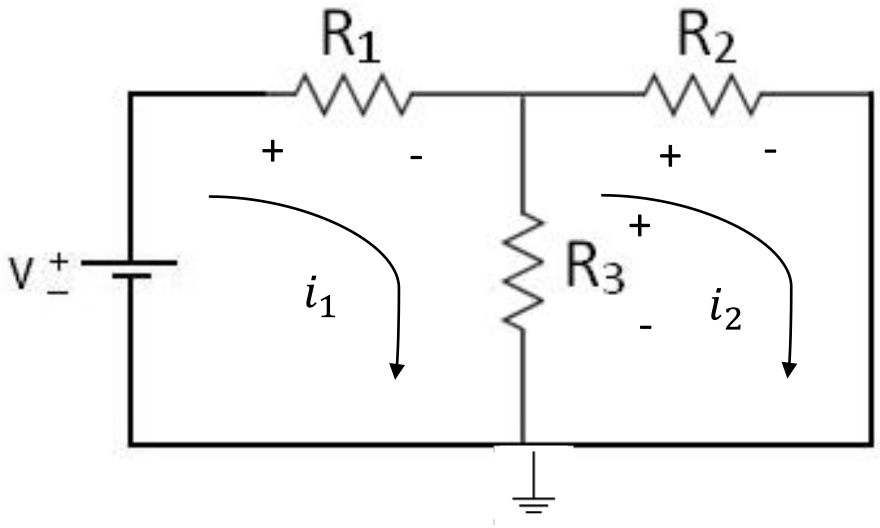
Assign loops in circuit

Assign signs for voltages along elements

Form KVL equations along loops

$$loop\ 1: V = i_1 R_1 + (i_1 - i_2) R_3$$

$$loop\ 2: i_2 R_2 = (i_2 - i_1) R_3$$



Superposition Principle

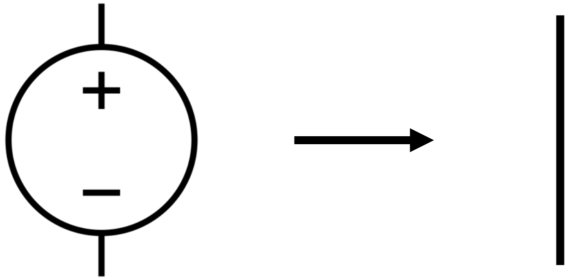
For a circuit with N independent sources, redraw the circuit N times

Suppress all sources but one

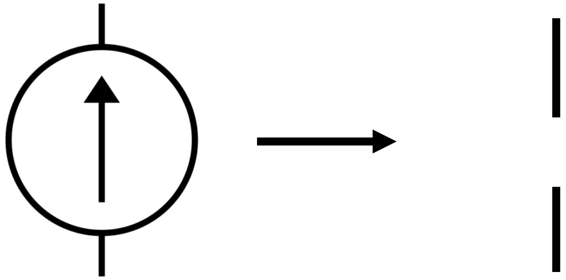
Find the node voltage or current of interest

Add up all the values for each source to get the result

Don't suppress any dependent source



Short Circuit



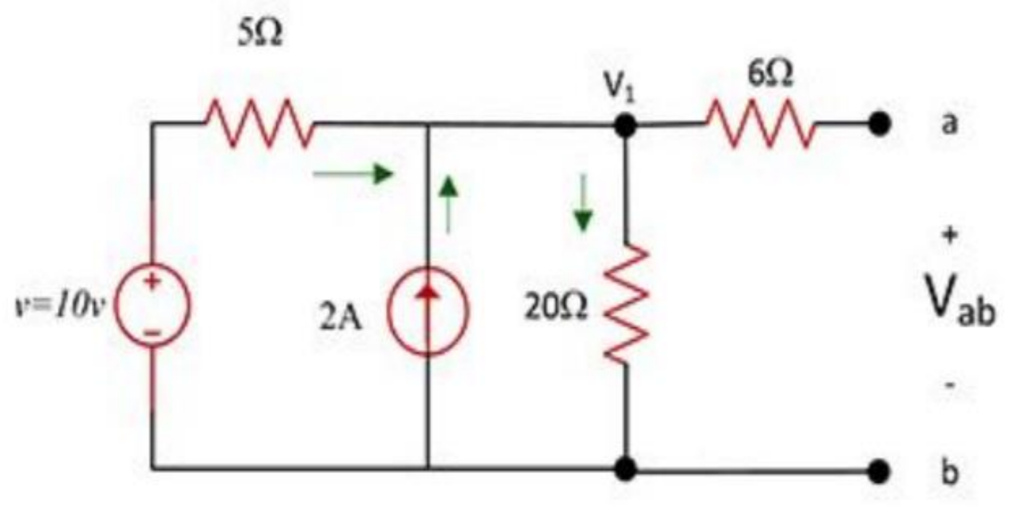
Open Circuit

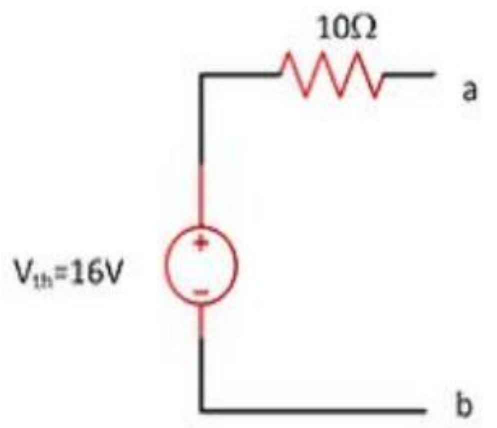
Thevenin and Norton Equivalents

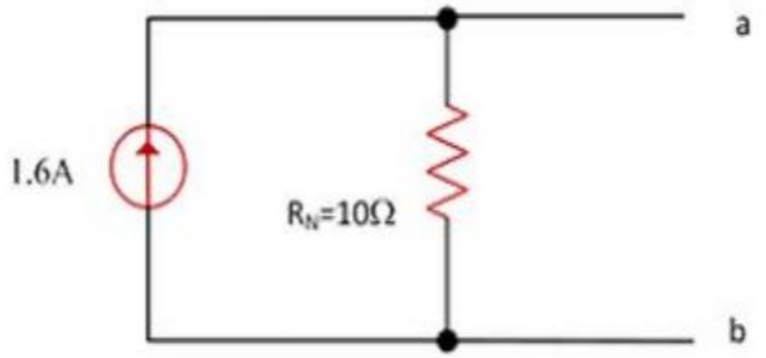
Thevenin Voltage: Leave the output terminal open

Norton Current: Create a short between output terminals

Thevenin/Norton Resistance: Suppress all sources. Calculate the equivalent resistance “looking in” from the output terminals


5Ω
V1
6Ω
a
v=10v
2A
20Ω
+
Vab
-
b


10Ω
a
Vth=16V
b


a
1.6A
RN=10Ω
b

Dependent Sources (Test Signal)

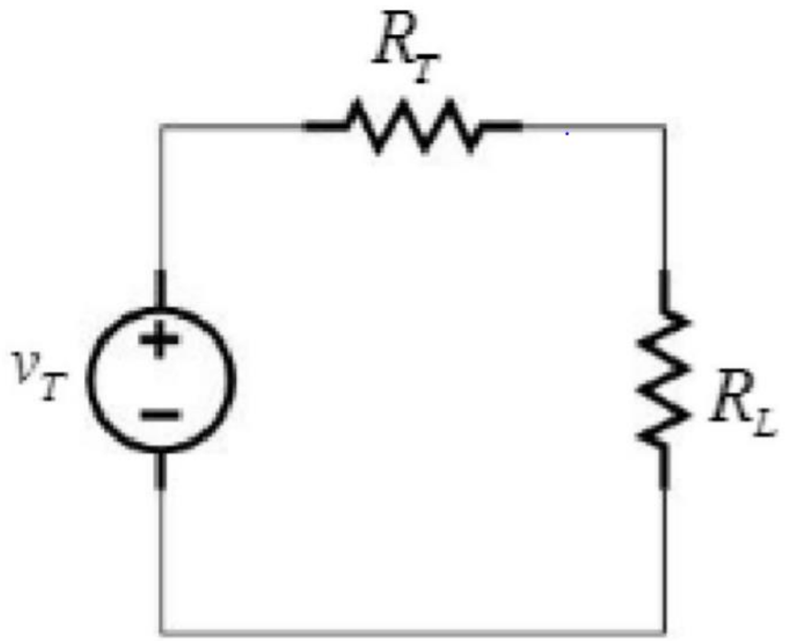
Connect a 1A current source across the output terminals

Suppress all independent sources

Calculate the voltage across the current source

The value of the resistance is equal to the value of the voltage across the current source

Available/Maximum Power

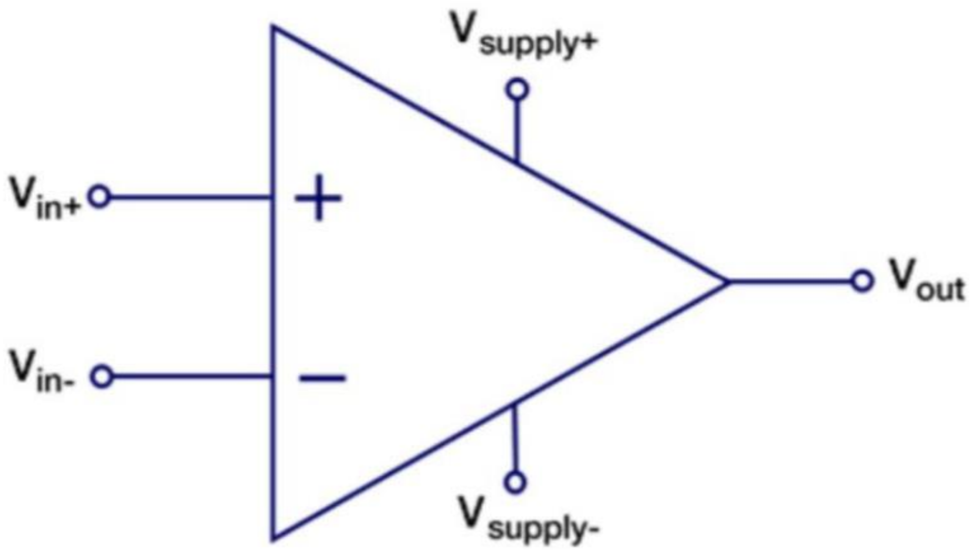


$\boxed{\text{Set } R_L = R_T}$

$$P_a = V_T^2/4R_T$$

Op-Amp

$$v_- = v_+$$
$$i_+ = 0$$
$$i_- = 0$$



First Order Differential Equations

Given equation, where α and β are constants

$$\frac{dy}{dt} + \alpha y(t) = \beta$$

Then, $y(t) = A + Be^{-\alpha t}$, where *A* and *B* are also constants

Get *A* by finding the limit as $t \rightarrow \infty$, and *B* from initial conditions

The limit $t \rightarrow \infty$ is the steady state

Time constant: $\tau = \frac{1}{\alpha}$

1. Homogeneous solution – the exponential term
2. Particular solution – the constant

First Order Circuits

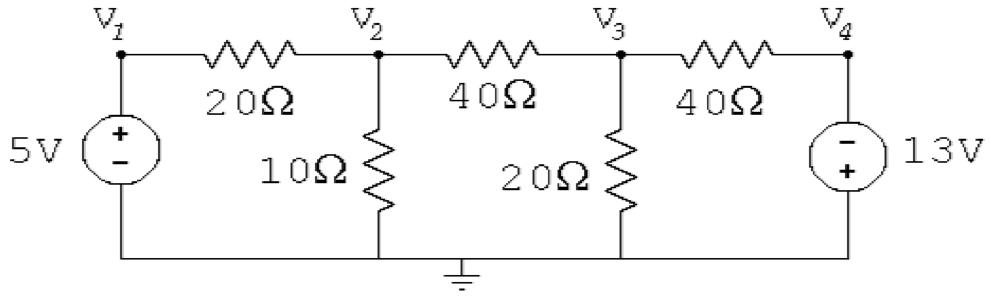
- Zero State Response: Solution to ODE when initial state is 0
- Zero Input Response: Solution to ODE when input is 0

$$y(t) = y_h(t) + y_p(t) = y_{ZSR}(t) + y_{ZIR}(t)$$

- At the steady state,
  - Capacitors act as open circuits
  - Inductors act as wires

Spring 2016 Q2

2. (25 pts) Use the node voltage method to find the node voltages V_1 through V_4 in the following circuit.



$V_1 =$ ____________

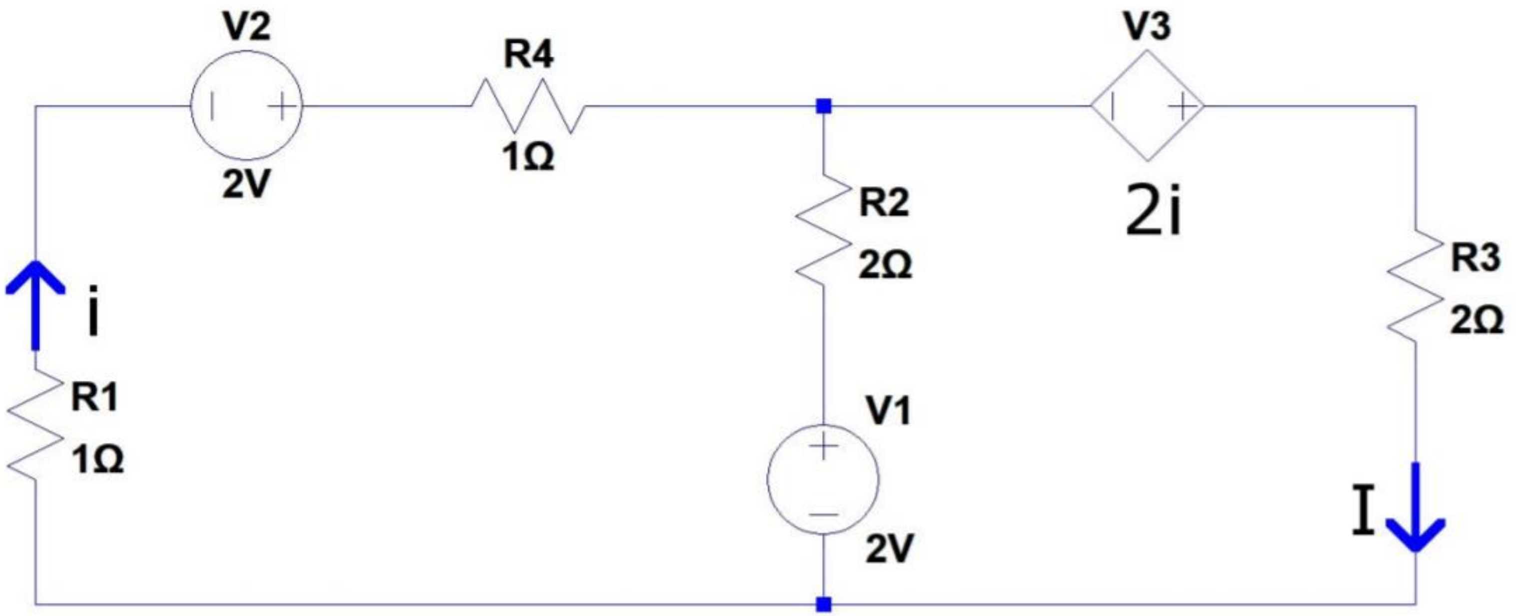
$V_2 =$ ____________

$V_3 =$ ____________

$V_4 =$ ____________

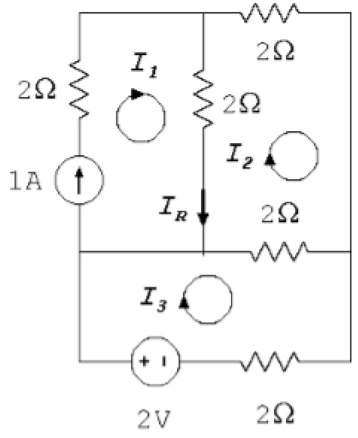
Fall 2016 Q1b

1 b) Find the value of I



Spring 2018 Q2

2. (20 pts) Consider the circuit below. Determine the loop currents I_1, I_2 I_3, as well as the current through the middle vertical 2 Ω resistor, I_R.



$I_1 =$ ____________________

$I_2 =$ ____________________

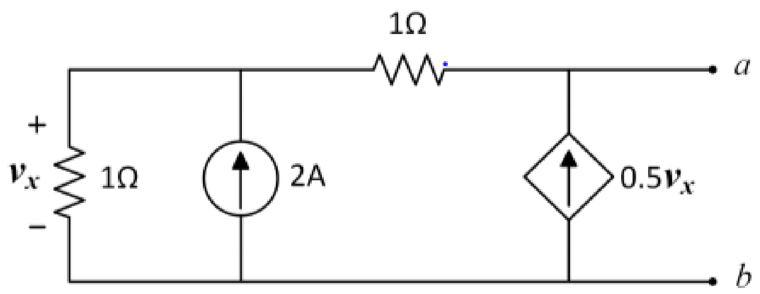
$I_3 =$ ____________________

$I_R =$ ____________________

Fall 2014 Q3

3. (25 pts) The two parts in this problem are unrelated.

   (a) Consider the following network between nodes a and b. Determine the Thevenin voltage, V_T, the Thevenin resistance, R_T, and the available power P_a.



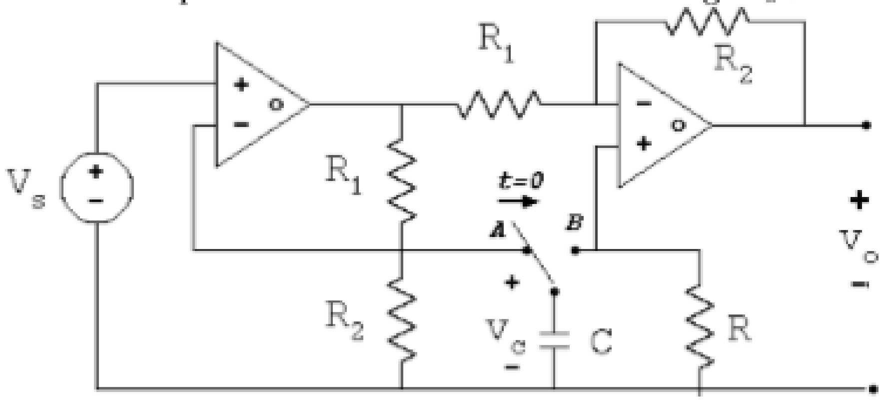
$V_T =$ ______________

$R_T =$ ______________

$P_a =$ ______________

Fall 2017 Q4

4. (25 pts) Assume both op-amps in the following circuit are operating in the linear regime. The switch has been in position A for a long time so that the circuit is in steady-state, and it switches to position B at time $t = 0$. The voltage $V_s > 0$ is constant.



1) $For\ t < 0, obtain\ V_c(t) and\ V_o(t)$

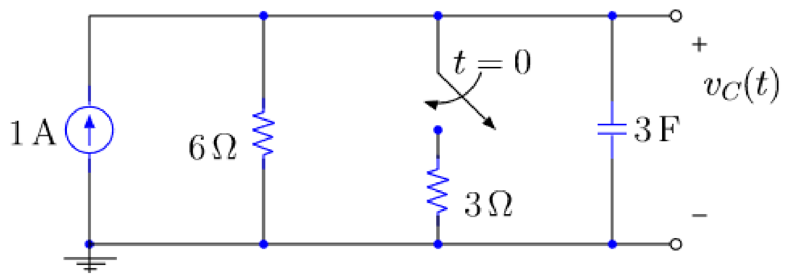
2) $For\ t > 0, obtain\ V_c(t) and\ V_o(t)$

3) $For\ -1 < t, sketch\ V_c(t)\ and\ V_o(t) and\ determine\ their\ discontinuities$

Fall 2010 Q4

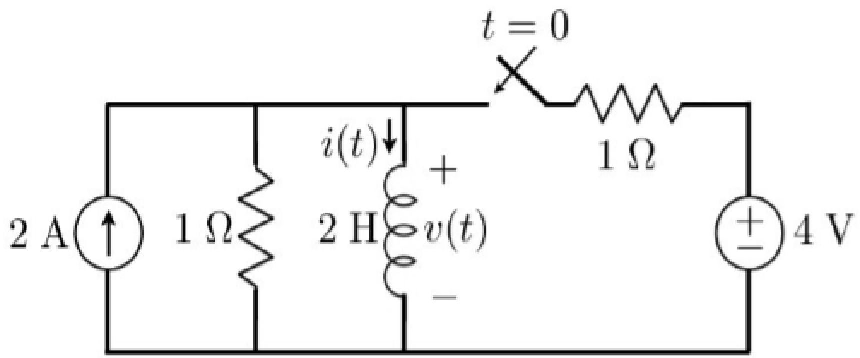
4. Problem 4 (25 points)

   The switch was open for a long time, and the circuit was in steady state. At $t = 0$, the switch is closed. Find $v_C(t)$



Fall 2013 Q7

7. (25 points) Consider the circuit below, with an inductor voltage $v(t)$ and an inductor current $i(t)$. The switch is open until $t=0$, after which time it is closed.



(a) (3 pts) Determine $i(0^-)$, assuming steady state conditions prior to $t=0$.

(b) (3 pts) What is $v(0^-)$? **Explain**.

(c) (4 pts) What is $i(t = \infty)$? **Show your work**.

(d) (5 pts) What is the time constant τ of the system for $t>0$?

(e) (7 pts) Express $i(t)$ for $t>0$.

(f) (3 pts) What is the zero input response $i_{ZI}(t)$ of the inductor current?