ECE 210 Midterm 1

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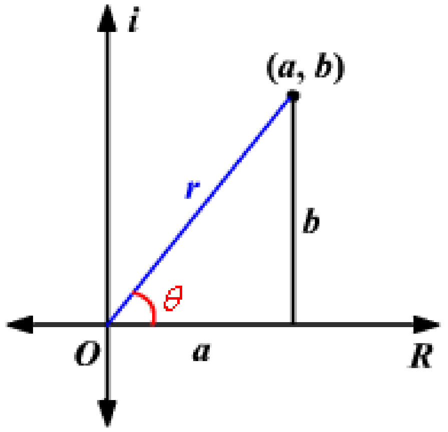
Complex Numbers

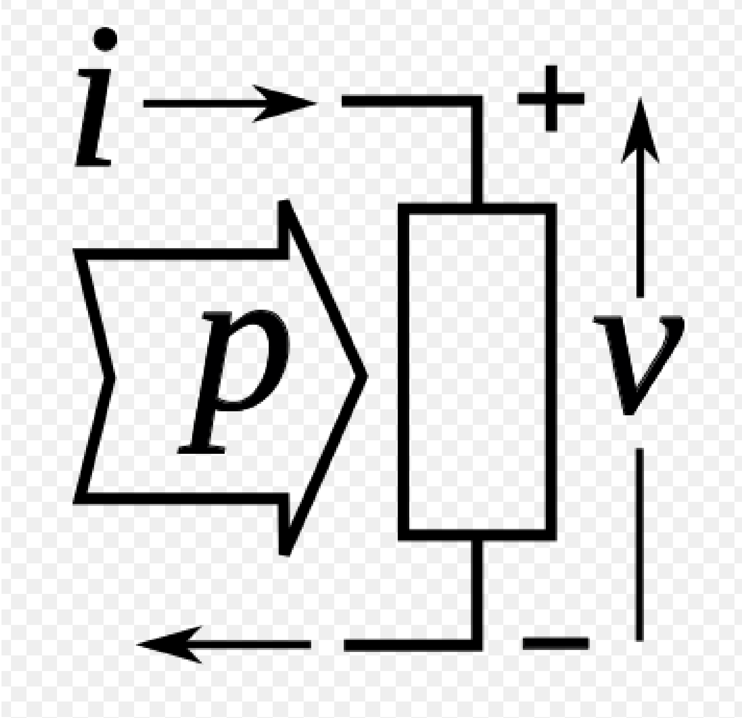
Operation	Rectangular Form	Polar
Addition	Component-wise	Convert to rectangular
Subtraction	Component-wise	Convert to rectangular
Multiplication	FOIL	Magnitudes multiply, angles add
Division	Complex conjugates	Convert to multiplication

$$e^{j\theta} = \cos(\theta) + j\sin(\theta)$$



Sign Convention

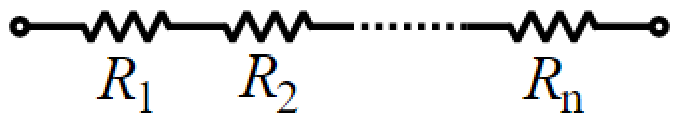
Circuit Element	Voltage-Current Law
Resistor	$v = iR$
Capacitor	$i = C\frac{dv}{dt}$
Inductor	$v = L\frac{di}{dt}$



Resistor Combinations

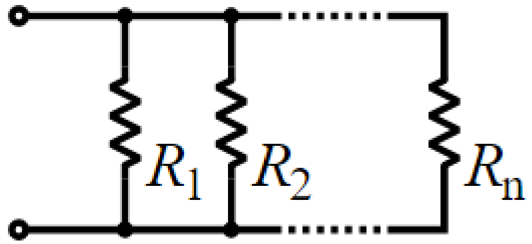
$$R_{eq} = R_1 + R_2 + \; \ldots + R_n$$

Can remove nodes



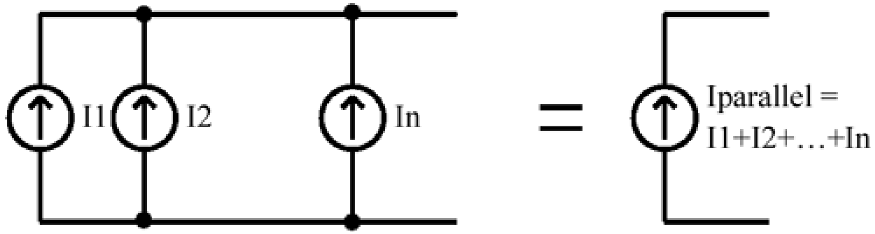
$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \cdots + \frac{1}{R_n}$$

Can remove loops

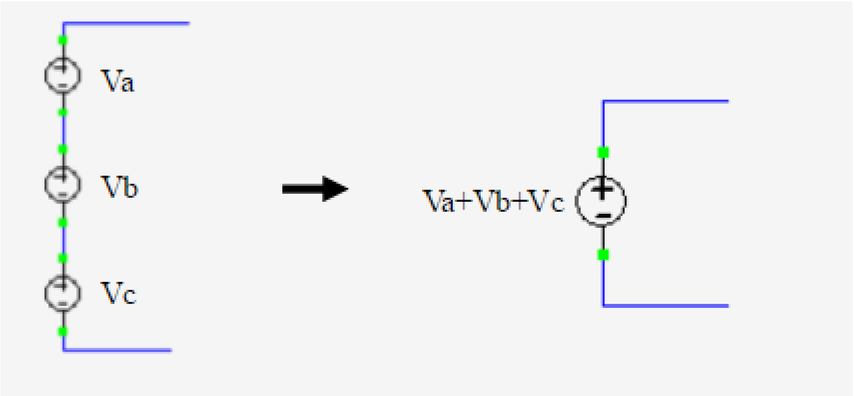


Source Combinations

$$I_{out} = I_1 + I_2 + \cdots + I_n$$



$$V_{out} = V_1 + V_2 + \cdots + V_n$$



Node Voltage & Loop Current

Node Voltage

- Use KCL at each node
- Use supernodes to consolidate nodes separated by voltage sources

Loop Current

- Use KVL on each loop
- Try to select loops such only one loop goes through a current source

In the end, pick the method with easier equations to solve.

Node Voltage & Loop Current

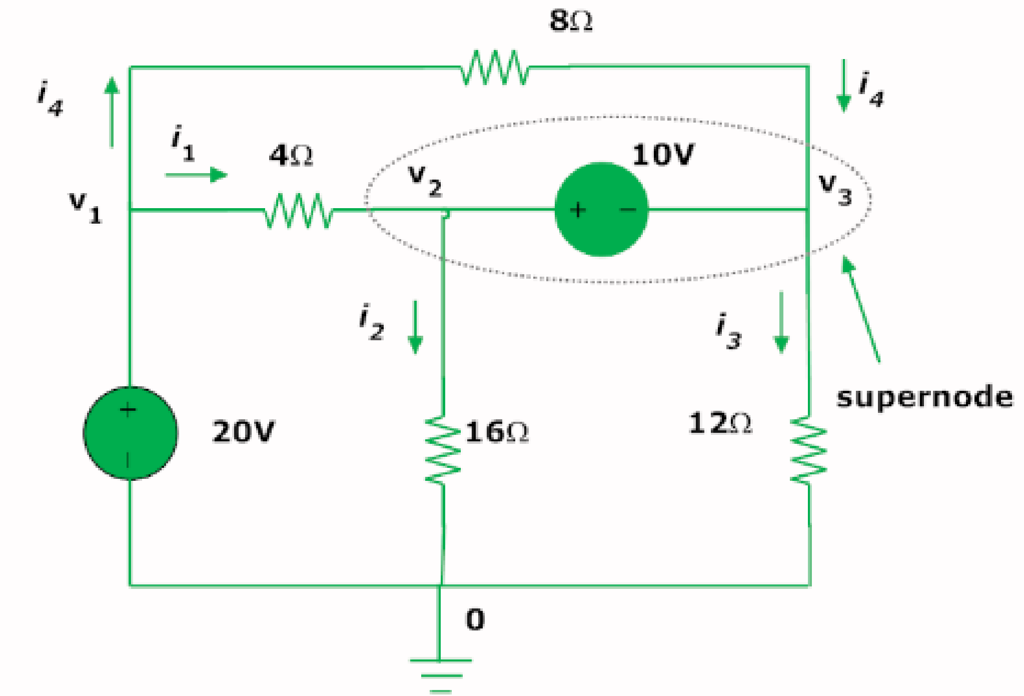


Figure 2

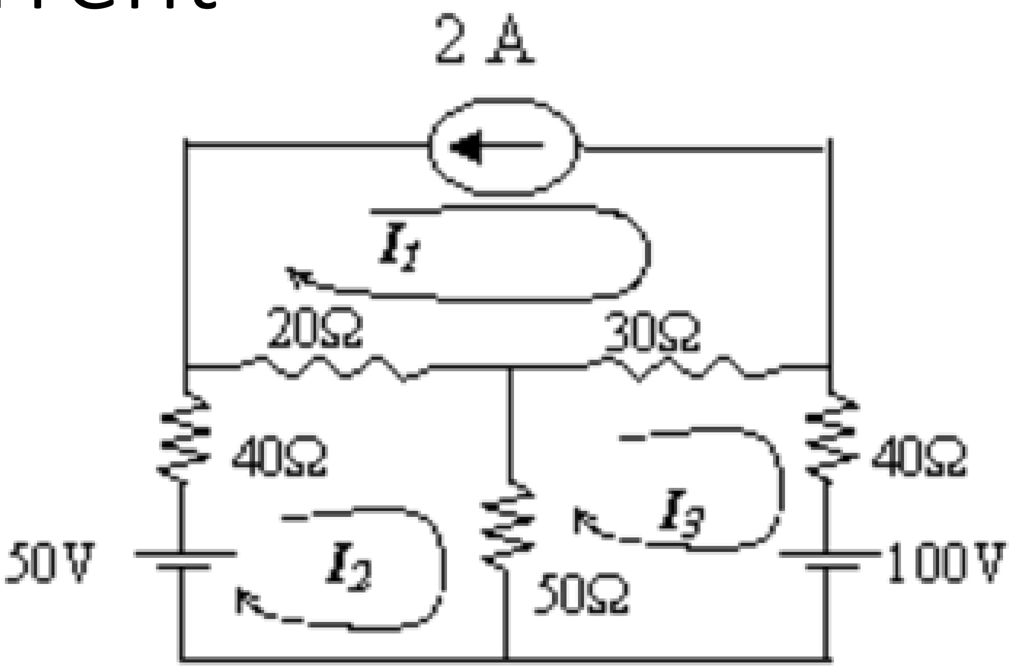
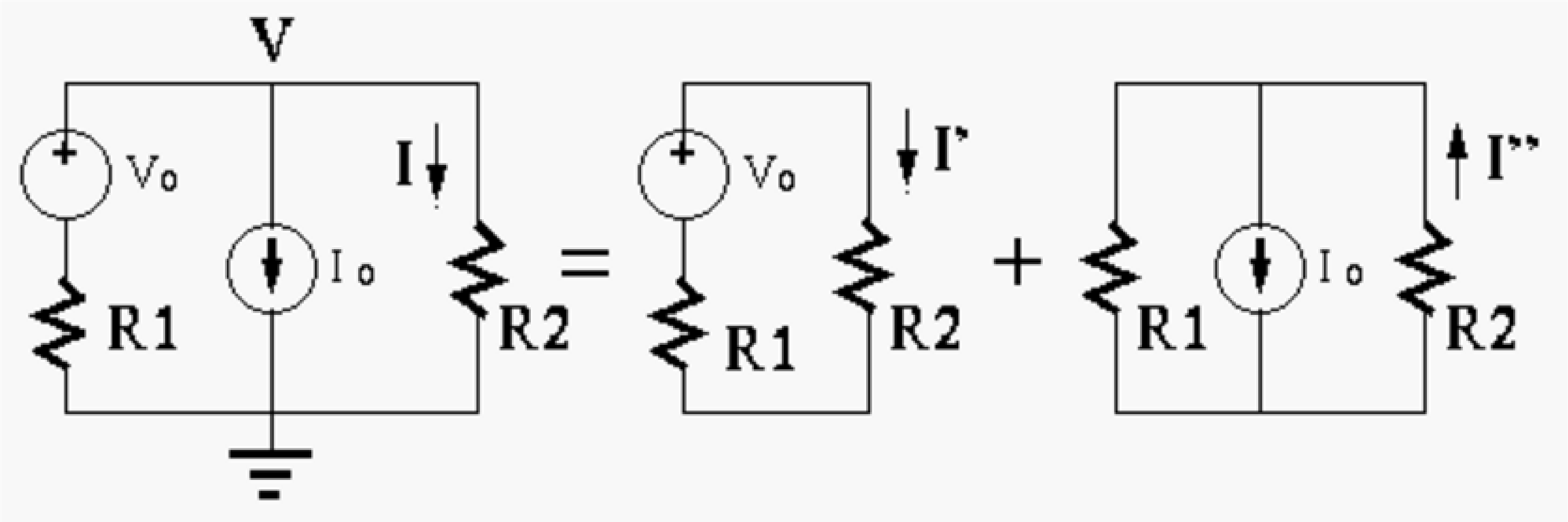


fig.2.5

In the end, pick the method with easier equations to solve.

Superposition



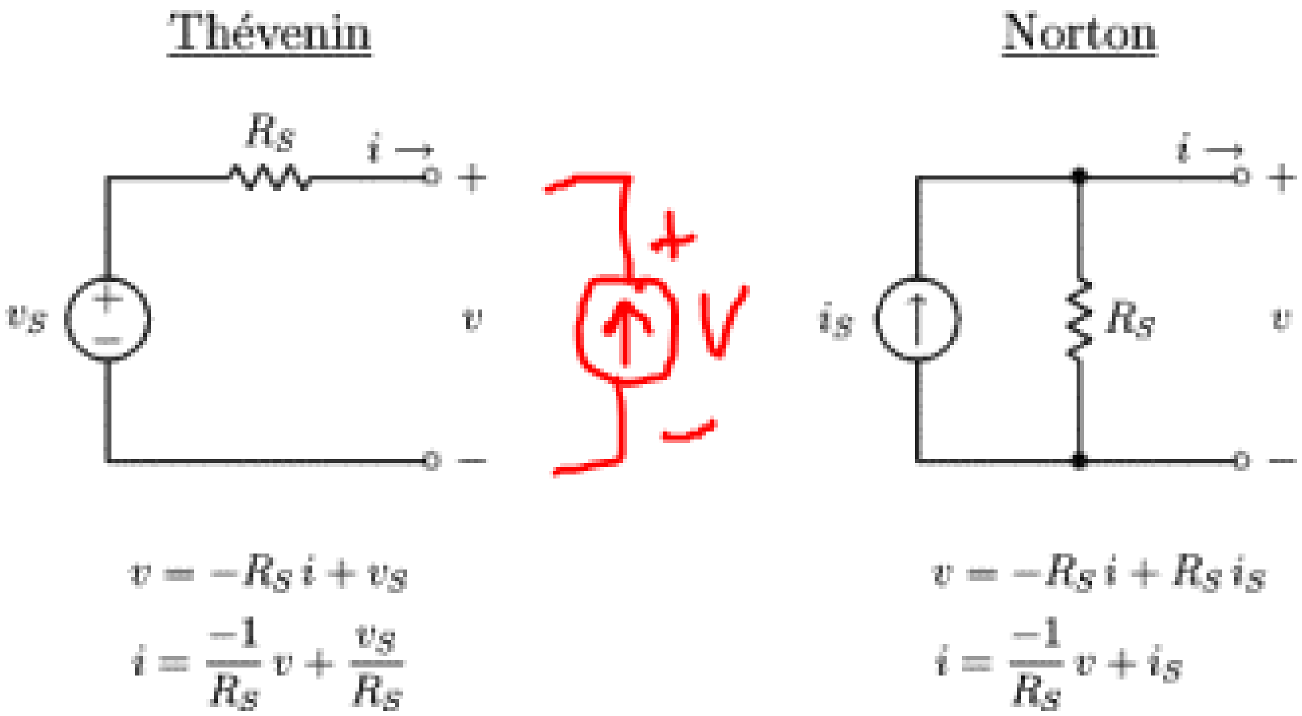
In the end, pick the method with easier equations to solve.

Thevenin Norton Equivalents

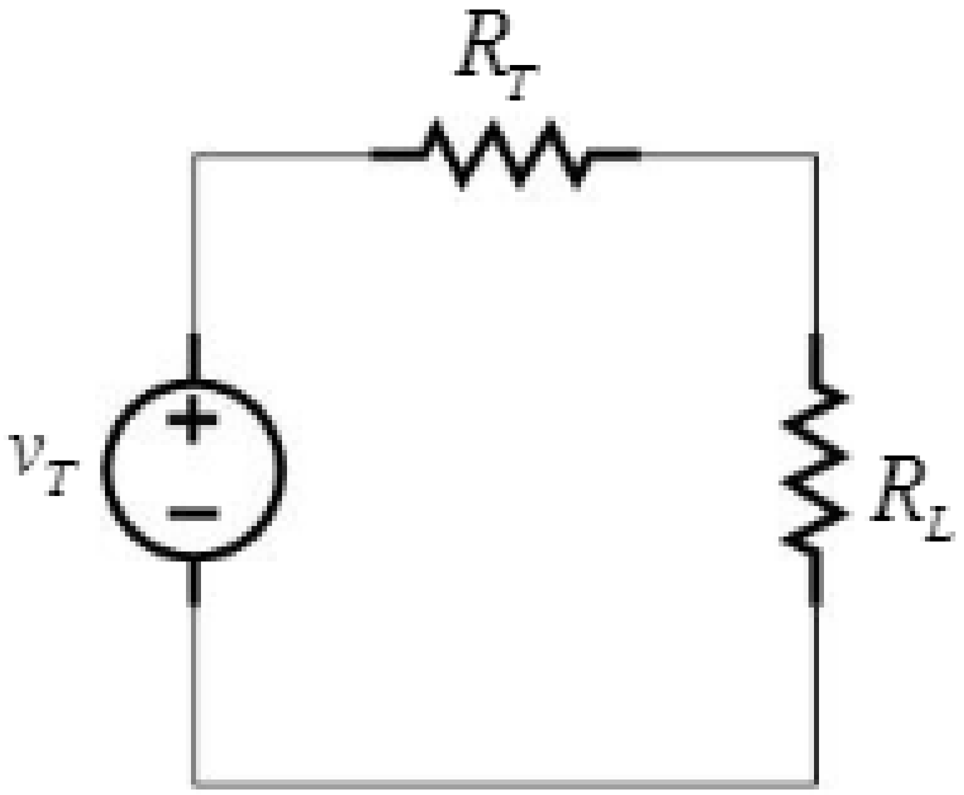
V_{TH} is open circuit voltage

I_N is closed circuit current

- If only independent sources, suppress sources and find R_{eq}
- If exist dependent sources, suppress independent sources and use 1 A test current



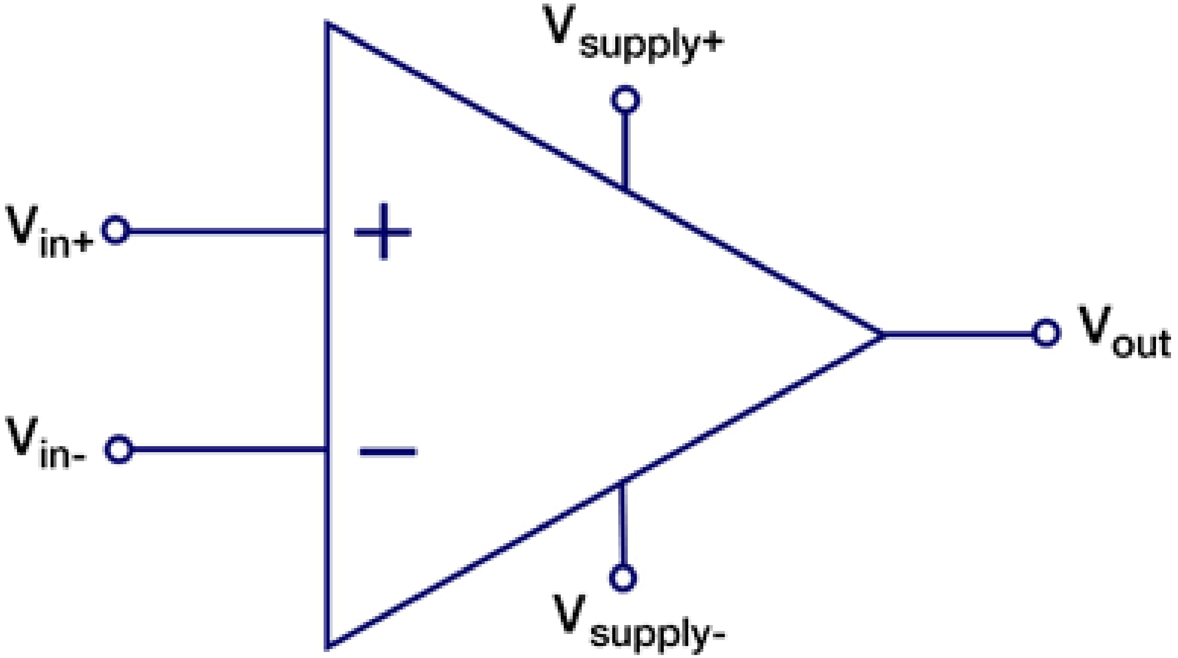
Maximum power of circuit



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

Op Amps

$$\boxed{\begin{gathered} v_- = v_+ \\ i_+ = 0 \\ i_- = 0 \end{gathered}}$$



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

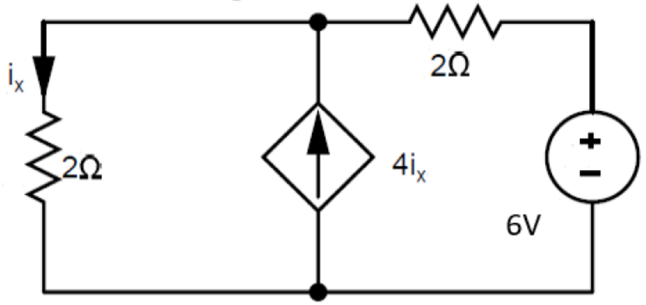
- Zero State Response: Solution to ODE when initial state is 0
- Zero Input Response: Solution to ODE when input is 0

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

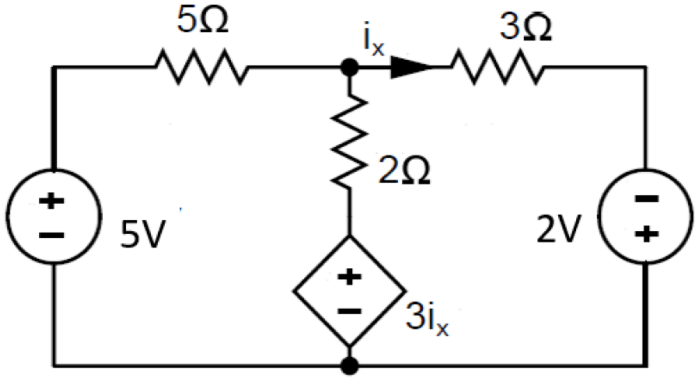
- At the steady state,
  - Capacitors act as open circuits
  - Inductors act as wires
- Discontinuous functions of time:
  - Voltage across a capacitor
  - Current through an inductor

Practice Problems (from last year's HW)!

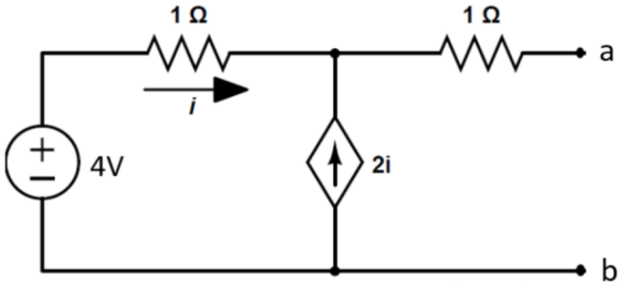
3. Find i_x using nodal analysis



4. Find i_x using loop analysis.

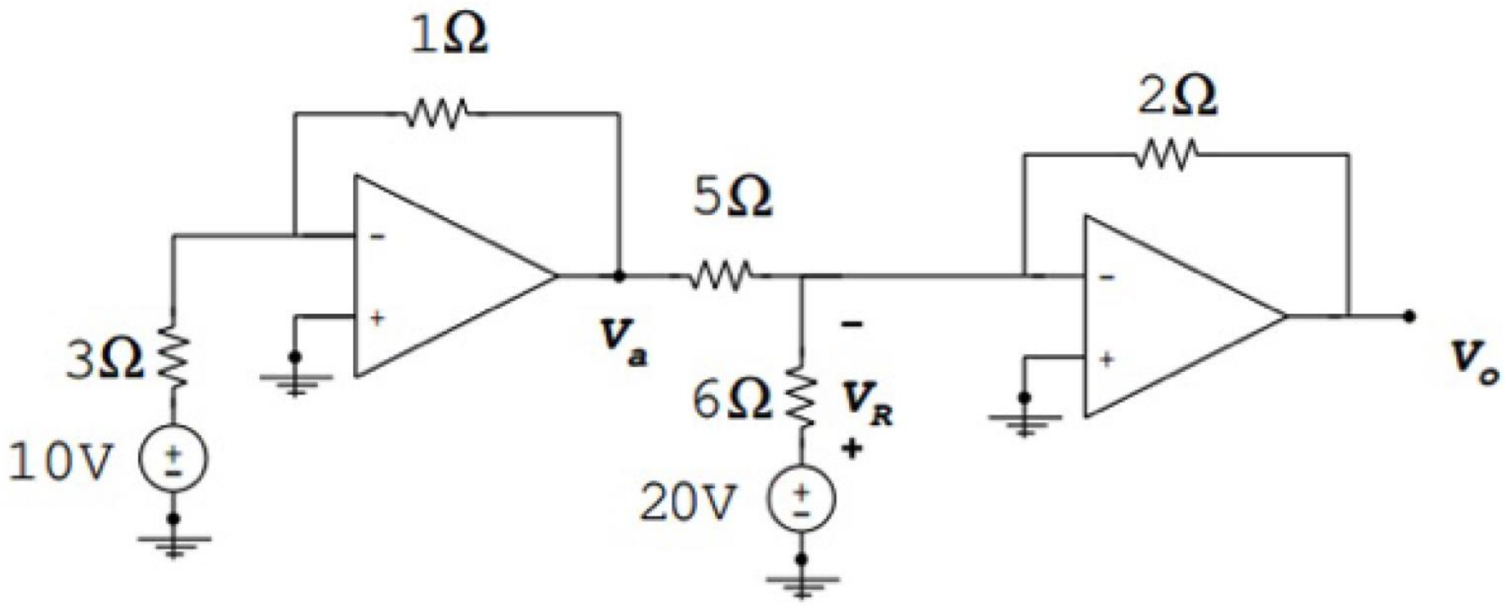


5. In the following circuit, find the open-circuit voltage and the short-circuit current between nodes a and b:



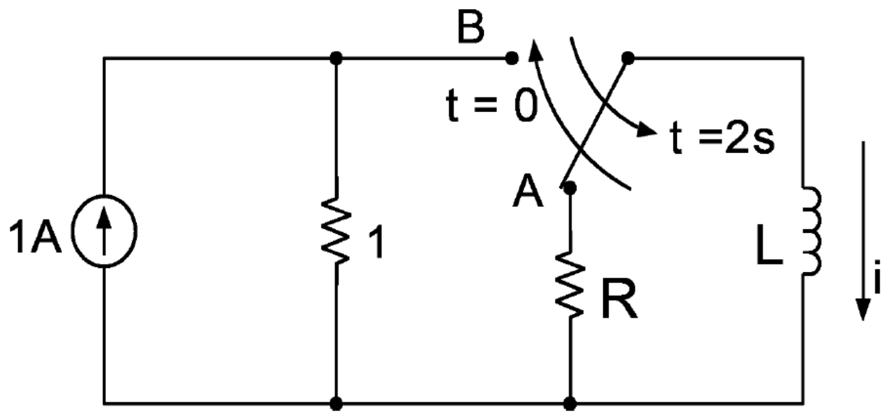
Op-Amps!

5. In the op-amp circuit shown below, determine the voltage V_a , V_R,V_o. Assume the circuit behaves linearly and make use of the ideal op-amp approximation.



RLC with DC sources

2. Assume the switch has been in position A for a long time. It then moves to position B at time $t = 0\,\mathrm{s}$, and back to position A at time $t = 2\,\mathrm{s}$. Find values L and R such that $i(t) = (1 - e^{-1})\,\mathrm{A}$ at $t = 2\,\mathrm{s}$, and $i(t) = \left(1 - e^{-1}\right) e^{-1}\,\mathrm{A}$ at $t = 6\,\mathrm{s}$.



3. The circuit shown below has been in DC steady-state before the switch opens at $t = 0\,\text{s}$. Find and sketch $v_R(t)$, $v_C(t)$, and $i_C(t)$.