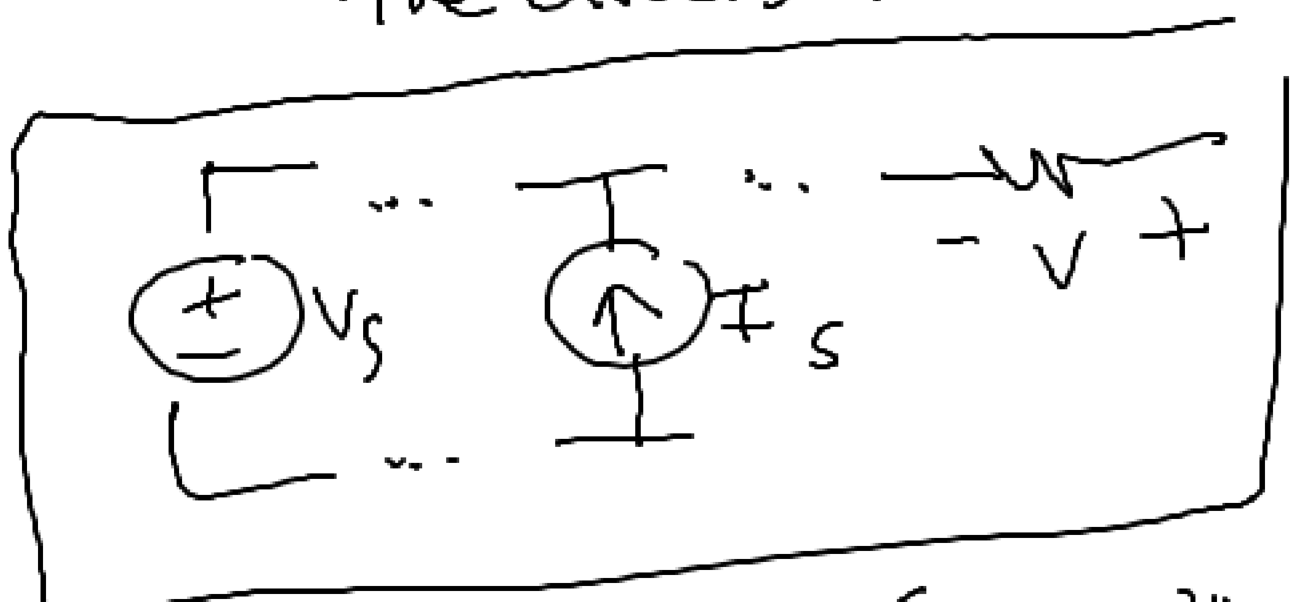
DIS 4A

1. Examples for superposition
2. Techniques for finding Thevenin & Norton equivalent circuits (~3 methods)
3. How to identify series and parallel resistors
   - ↳ How to redraw circuits

Midsemester survey → fill this out

Superposition: method for finding voltages & currents

Consider a voltage or current to be the sum of the effects of all sources acting independently



V_s and I_s work together to produce V

but if calculate effects of V_s & I_s separately, we can add to find V

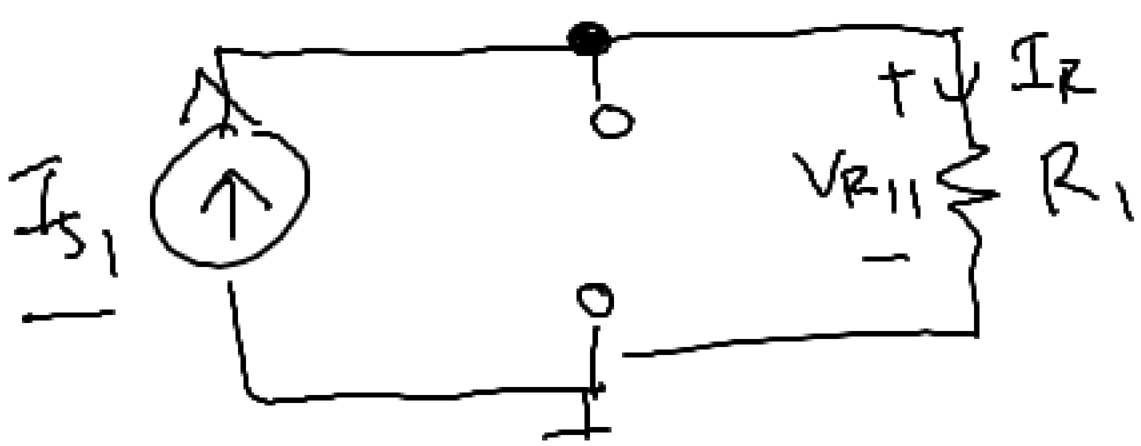
Superposition can't calculate power

$\underline{V} = R\underline{I}$ } linearity

$\underline{I} = \frac{V}{R}$

i) Use superposition to find V_{R_i} (voltages across resistors)

First: turn off all sources except I_{S_1} (current source off ⟺ open)



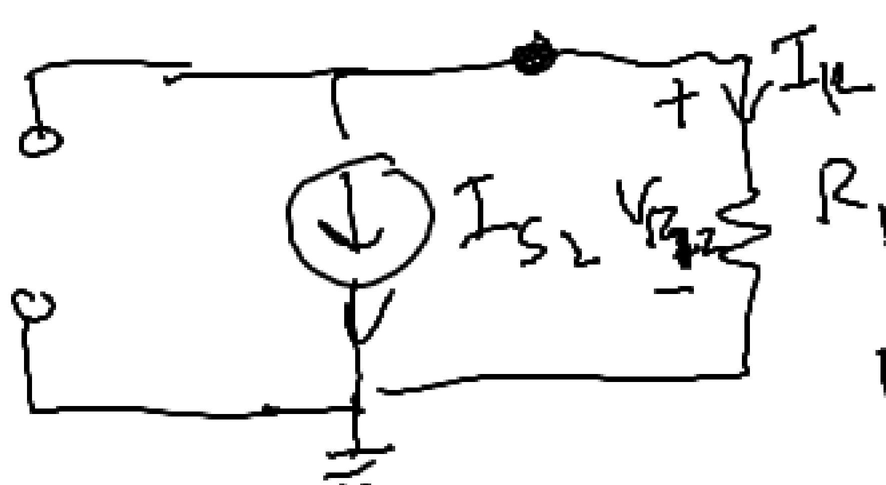
$I_{S_1} = I_R$

$\Rightarrow \boxed{V_{R_{11}} = I_{S_1} R_1}$

Note: maintain the same polarity/direction of desired quantities

Second: turn off all sources except I_{S_2}

$I_{S_2} + I_R = 0$



$I_{S_2} = -I_R$

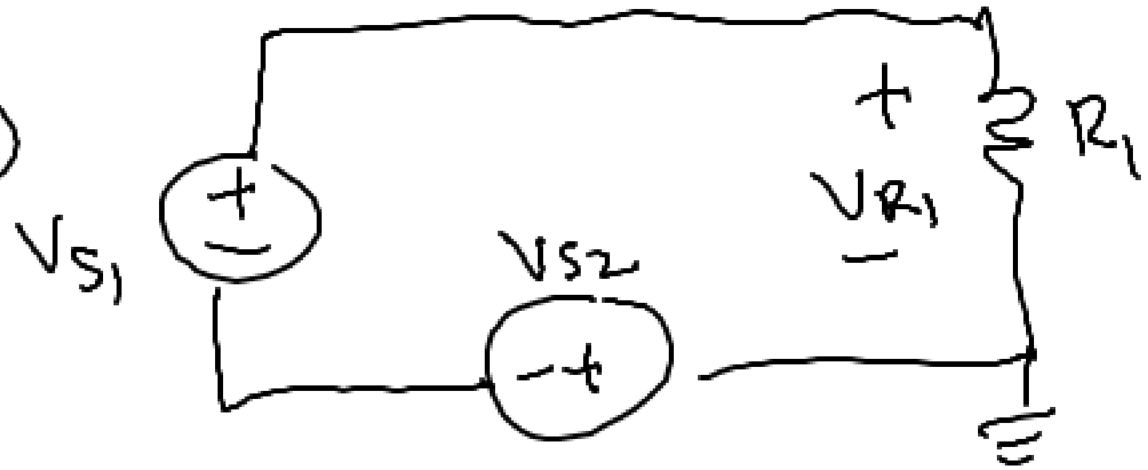
$\Rightarrow \boxed{V_{R_{12}} = -I_{S_2} R_1}$

By superposition $V_{R_1} = V_{R_{11}} + V_{R_{12}} = \boxed{(I_{S_1} - I_{S_2}) R_1}$

For the ii) parts: power of all elements sum to 0

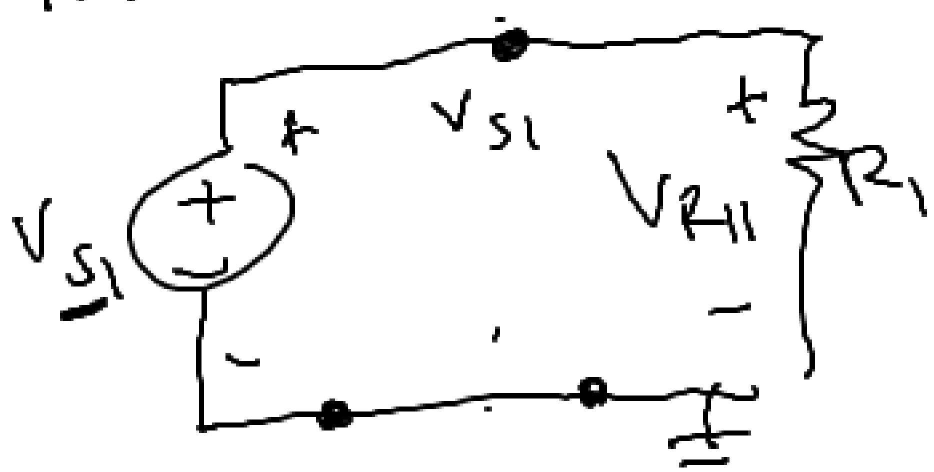
① Turn on one source at a time
② calculate value for subcircuit
③ add

(b) (i)



Find V_{R_1}

① Turn off all sources except V_{S_1} (turning off voltage source → short (wire))



$V_{R11} = V_{S_1} - 0$

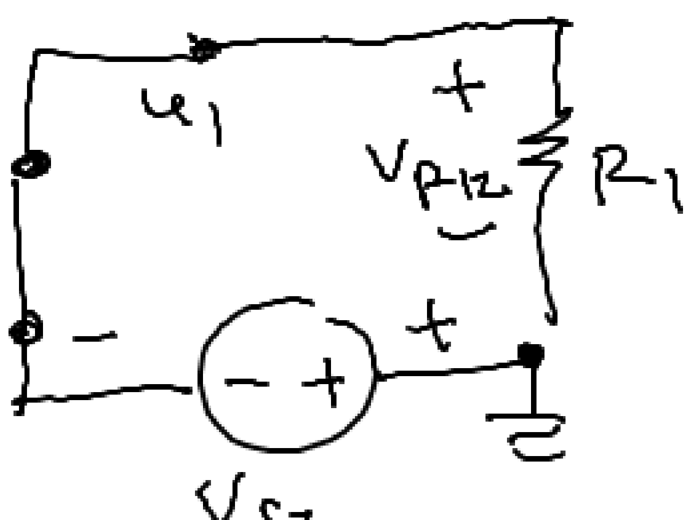
$\boxed{V_{R11} = V_{S_1}}$

By superposition

$V_{R_1} = V_{R11} + V_{R12}$

$= \boxed{V_{S1} - V_{S2}}$

② Turn off all sources except V_{S2}

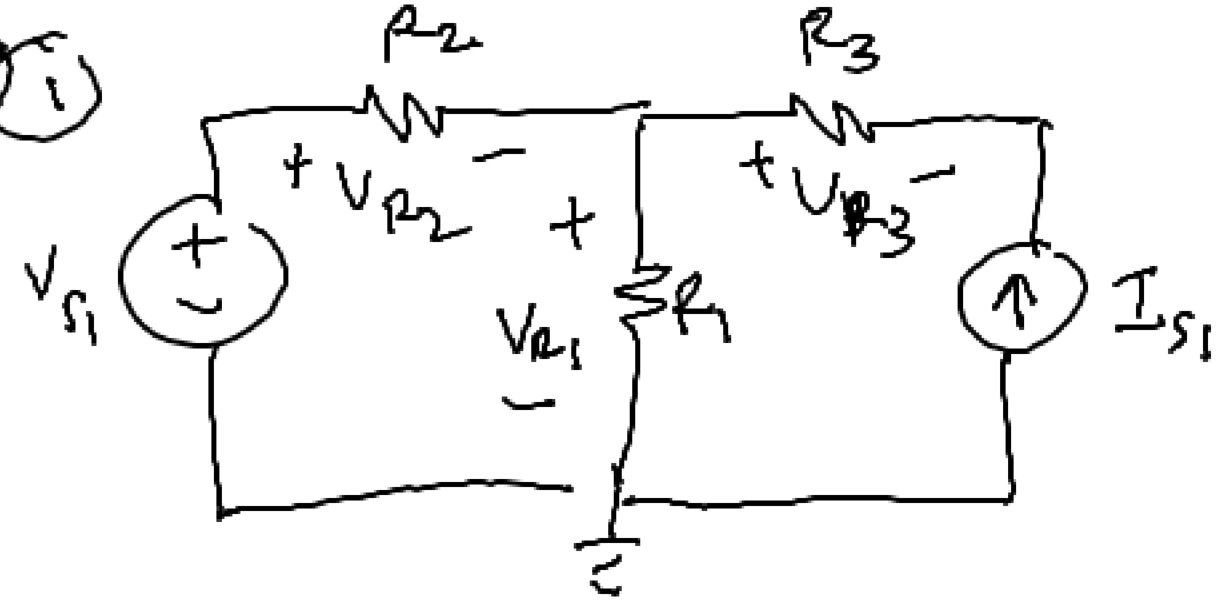


$0V - u_1 = V_{S2}$

$V_{R12} = u_1 - 0$

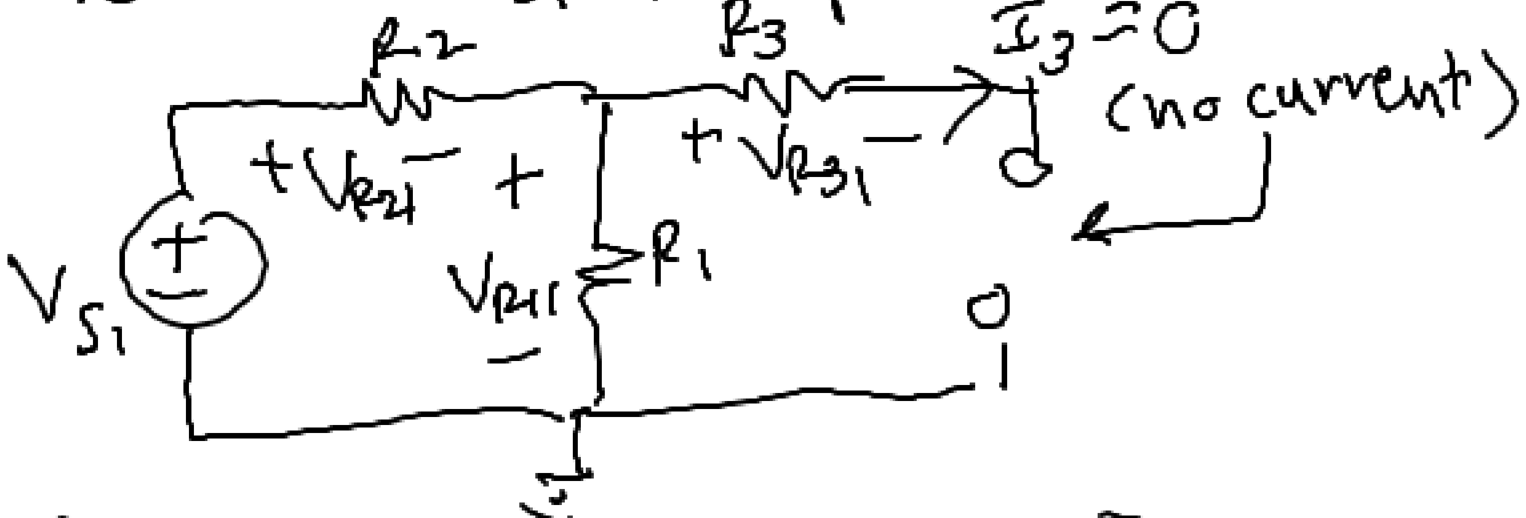
$\boxed{V_{R12} = -V_{S2}}$

Q i



Find $V_{R_1}, V_{R_2}, V_{R_3}$

Turn off I_{S_1}, keep V_{S_1} on



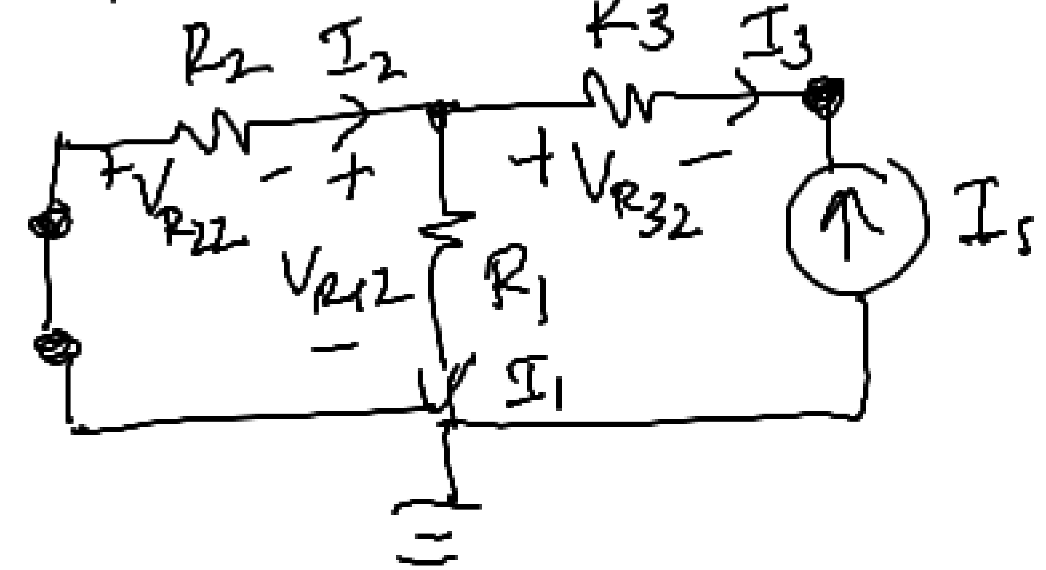
$$V_{R_{31}} = R_3 I_3 = 0V$$

$$V_{R_{11}} = \frac{R_1}{R_1 + R_2} V_{S_1}$$

$$V_{R_{21}} = \frac{R_2}{R_1 + R_2} V_{S_1}$$

When applying formulas, check your assumption

Turn off V_{S_1}, keep I_{S_1} on



current divider

$$I_3 + I_{S_1} = 0 \Rightarrow I_3 = -I_{S_1}$$

$$V_{R_{32}} = R_3 I_3 = -R_3 I_{S_1} \checkmark$$

$$V_{R_{12}} = R_1 I_1 = \frac{R_1 R_2}{R_1 + R_2} I_{S_1}$$

$$I_1 = \frac{R_2}{R_1 + R_2} I_{S_1}$$

$$V_{R_{22}} = R_2 I_2 = -\frac{R_1 R_2}{R_1 + R_2} I_{S_1}$$

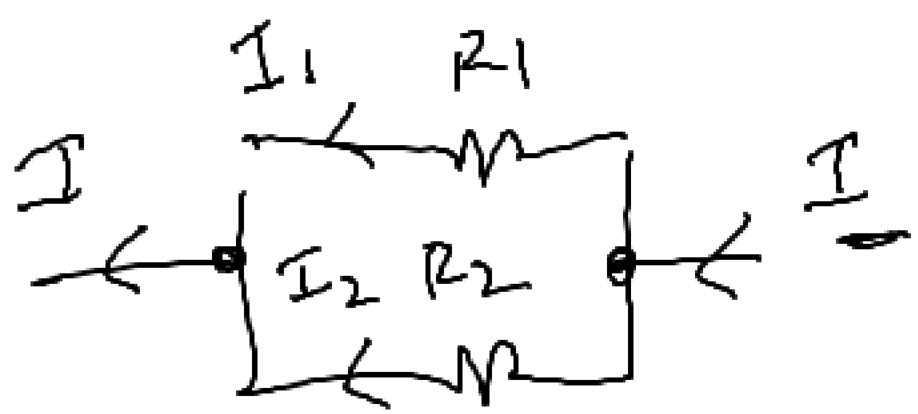
$$I_2 = -\frac{R_1}{R_1 + R_2} I_{S_1}$$

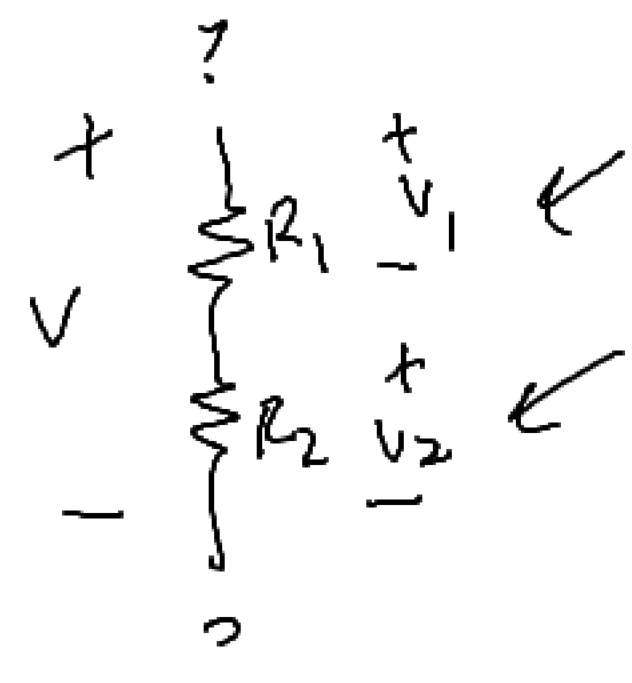
By superposition

$$V_{R_1} = V_{R_{11}} + V_{R_{12}} = \frac{R_1}{R_1+R_2} V_{S_1} + \frac{R_1 R_2}{R_1 + R_2} I_{S_1}$$

$$V_{R_2} = V_{R_{21}} + V_{R_{22}} = \frac{R_2}{R_1+R_2} V_{S_1} + \left(- \frac{R_1 R_2}{R_1 + R_2} I_{S_1}\right)$$

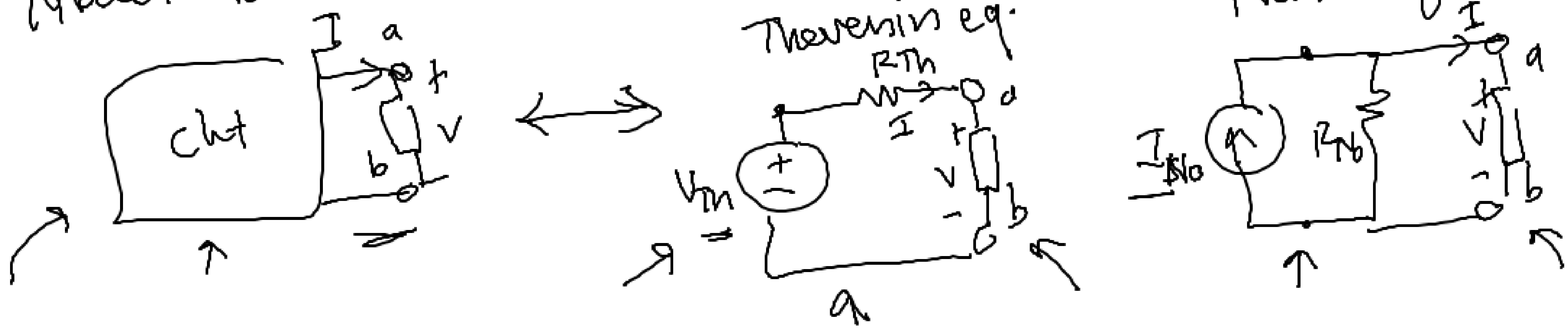
$$V_{R_3} = V_{R_{31}} + V_{R_{32}} = 0V + (-R_3 I_{S_1})$$





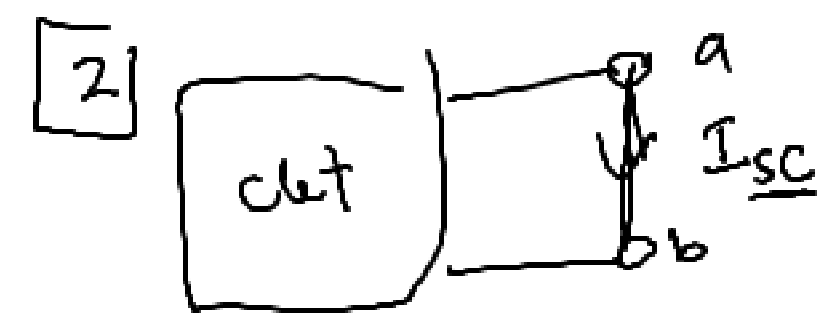
Thevenin & Norton equivalent

- Take a complicated ckt. made of V_s, I_s, and R's
- Simplify to a model of a single source + single resistor
- Model behaves the same way in terms of V, I



How to find? (Just find 2/3 below)

1. $V_{oc} = V_{th}$ (NVA)
2. $I_{sc} = I_{No}$ (NVA)
3. $R_{th} = R_{No} = \frac{V_{th}}{I_{No}}$

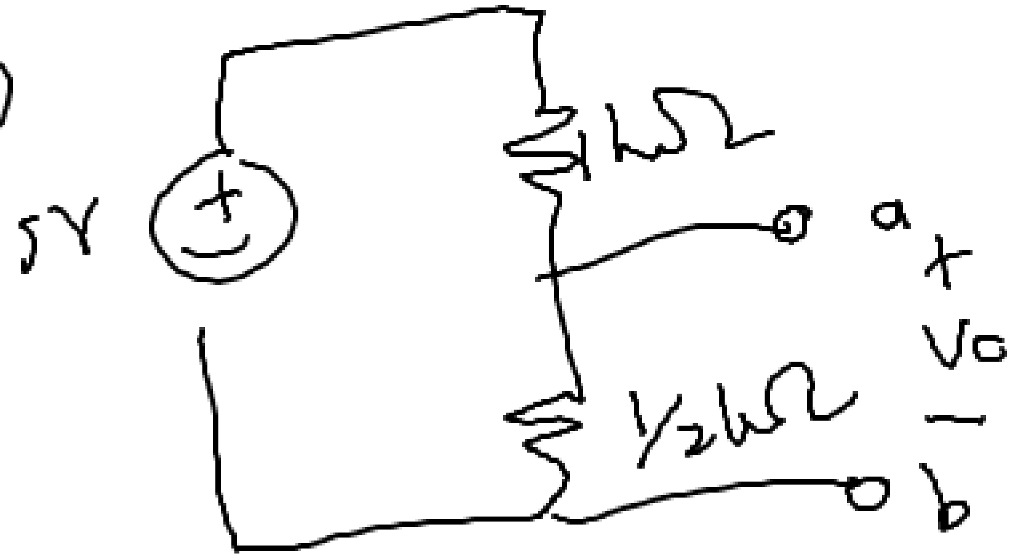


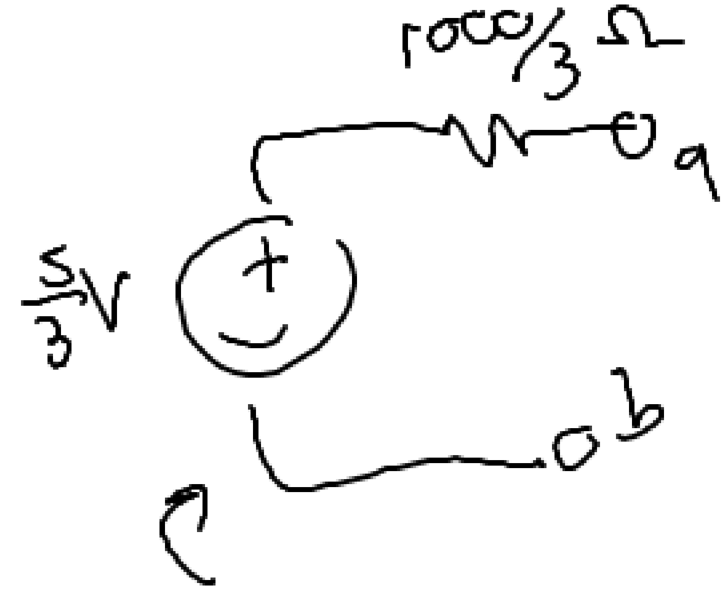
→ 3 (i) Find eq. resistance w/ all sources in ckt. off

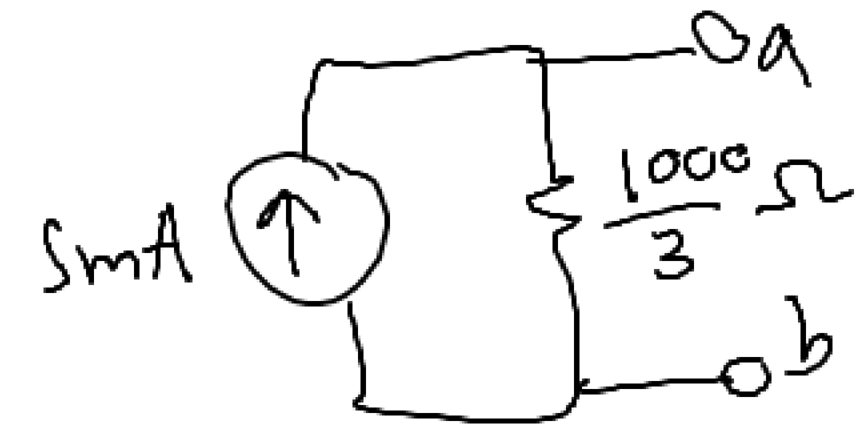
→ 3 (ii) Find test current + test voltage w/ all independent sources off

R_Th = R_No = V_test/I_test

2 (a)







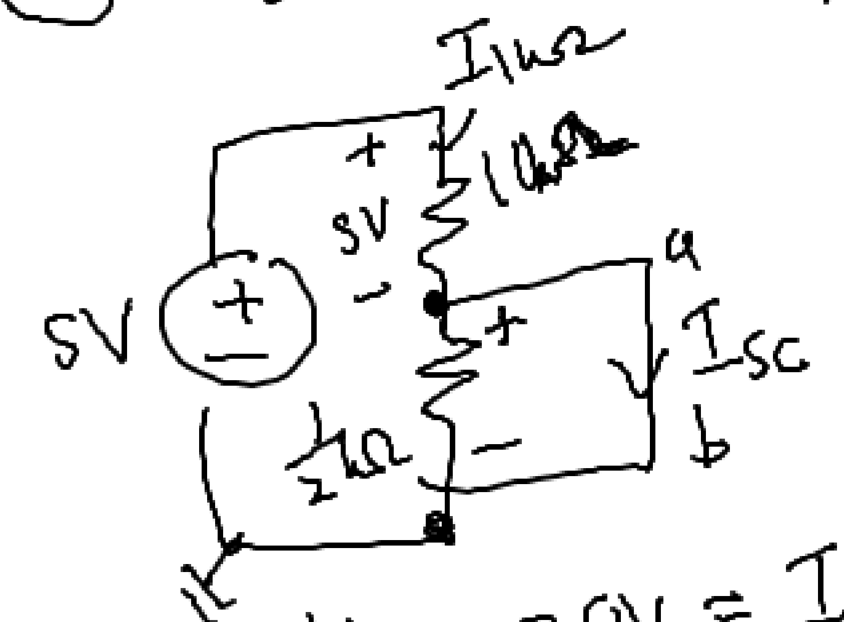
(1) $V_{oc} = V_{th}$

$$V_{oc} = \frac{\frac{1}{2}k\Omega}{\frac{1}{2}k\Omega + 1k\Omega} 5V = \boxed{\frac{5}{3}V = V_{th}}$$

(3) $R_{Th} = R_{No} = \frac{V_{Th}}{I_{No}} = \frac{\frac{5}{3}V}{5mA}$

$$= \boxed{\frac{1000}{3}\Omega}$$

(2) $I_{sc} = I_{No}$

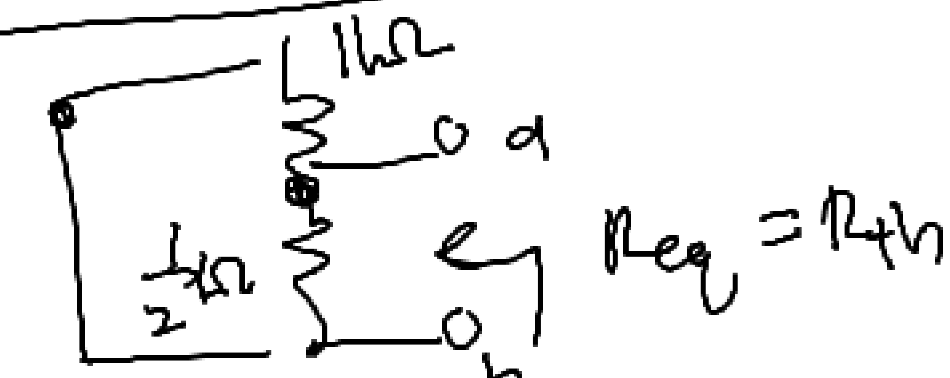


$I_{1k\Omega} = 0 + I_{sc}$

$$I_{sc} = I_{1k\Omega} = \frac{5V}{1k\Omega} = \boxed{5mA}$$

$V_{\frac{1}{2}k\Omega} = 0V = IR$

3 (i)



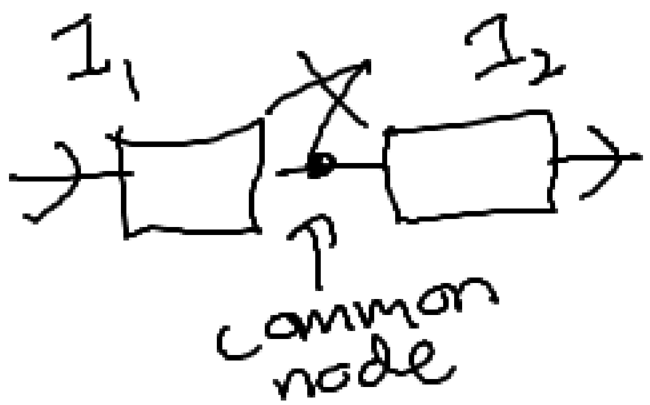
$$R_{th} = R_{eq} = 1k\Omega \,\|\, \frac{1}{2}k\Omega$$

$$= \frac{1000}{3}k\Omega$$

3 Series – two elements are in series if they share a node with nothing else on it.

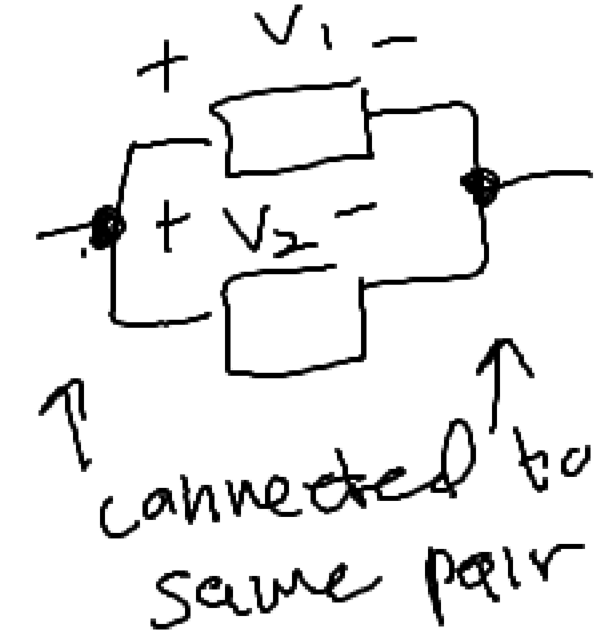
Parallel – two elements share a pair of nodes

Series



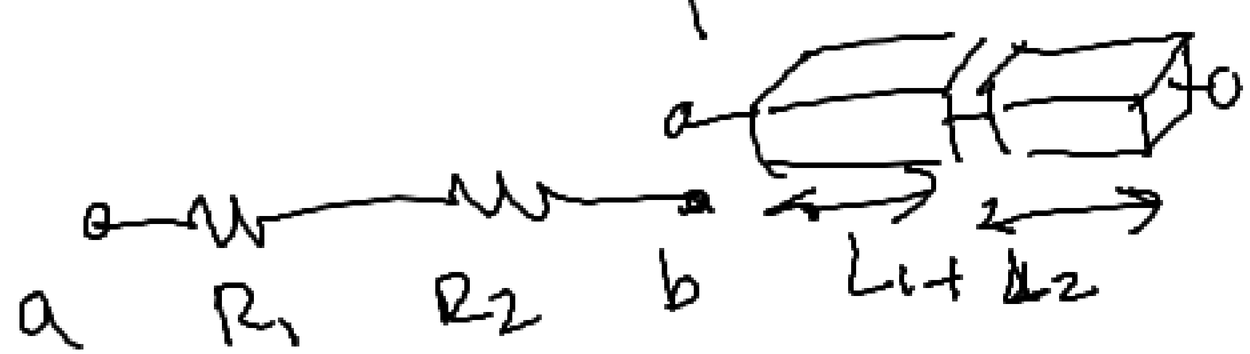
$I_1 = I_2$

Parallel

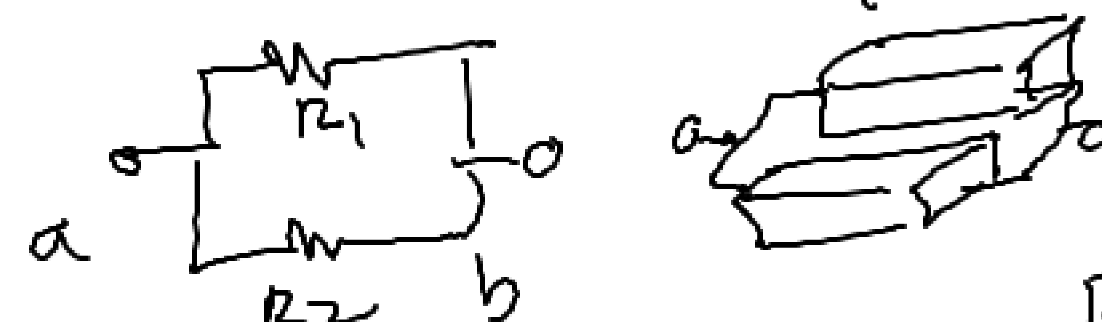


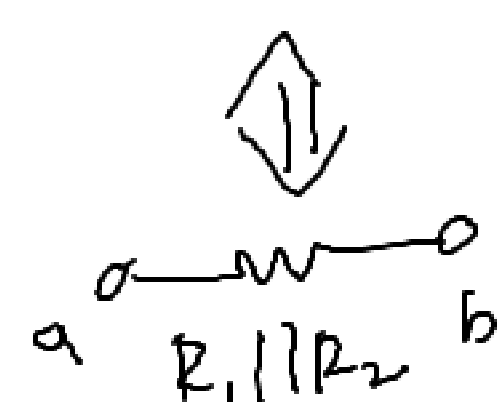
$V_1 = V_2$

Series resistor equivalents

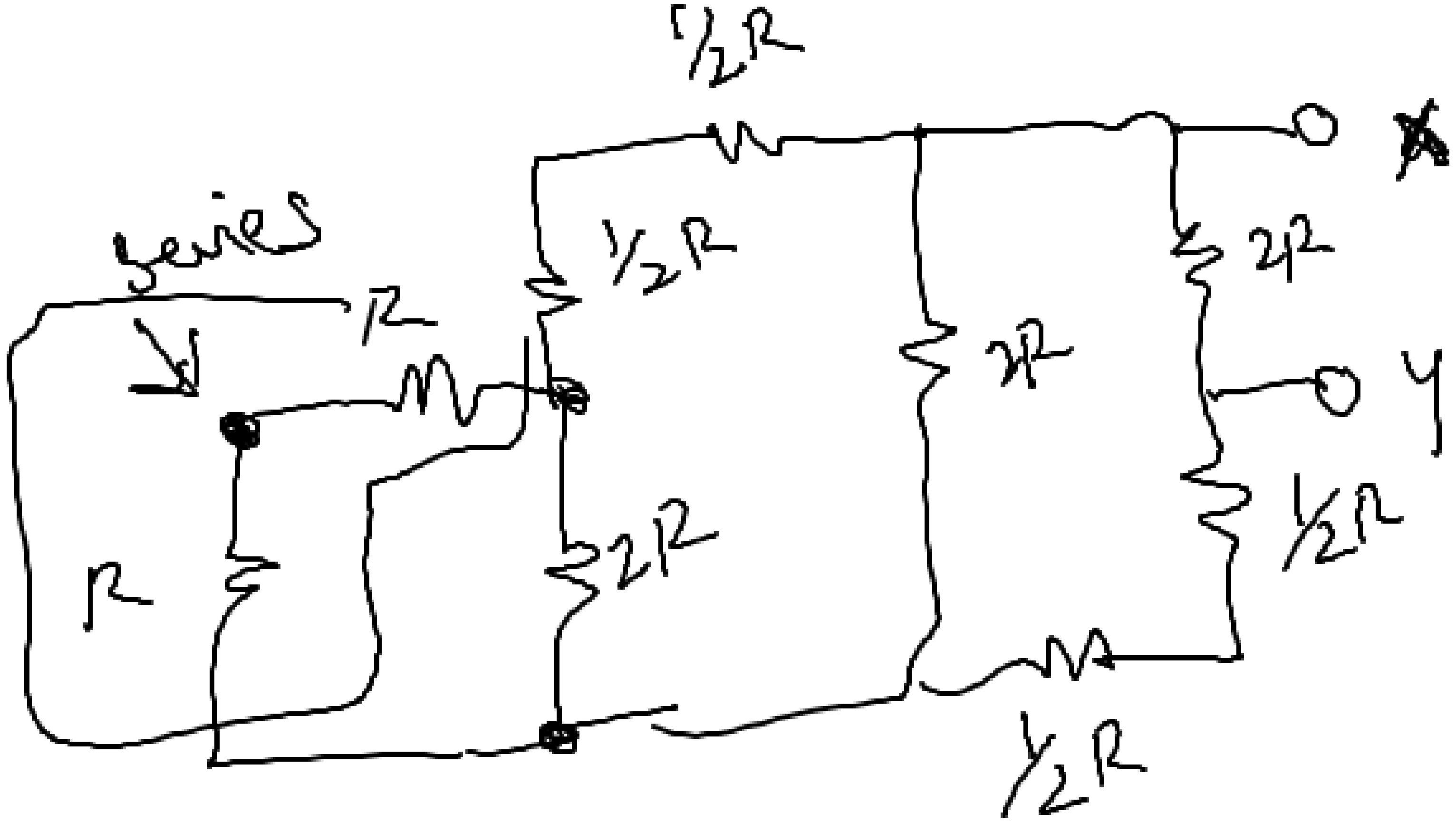


Parallel resistor equivalents



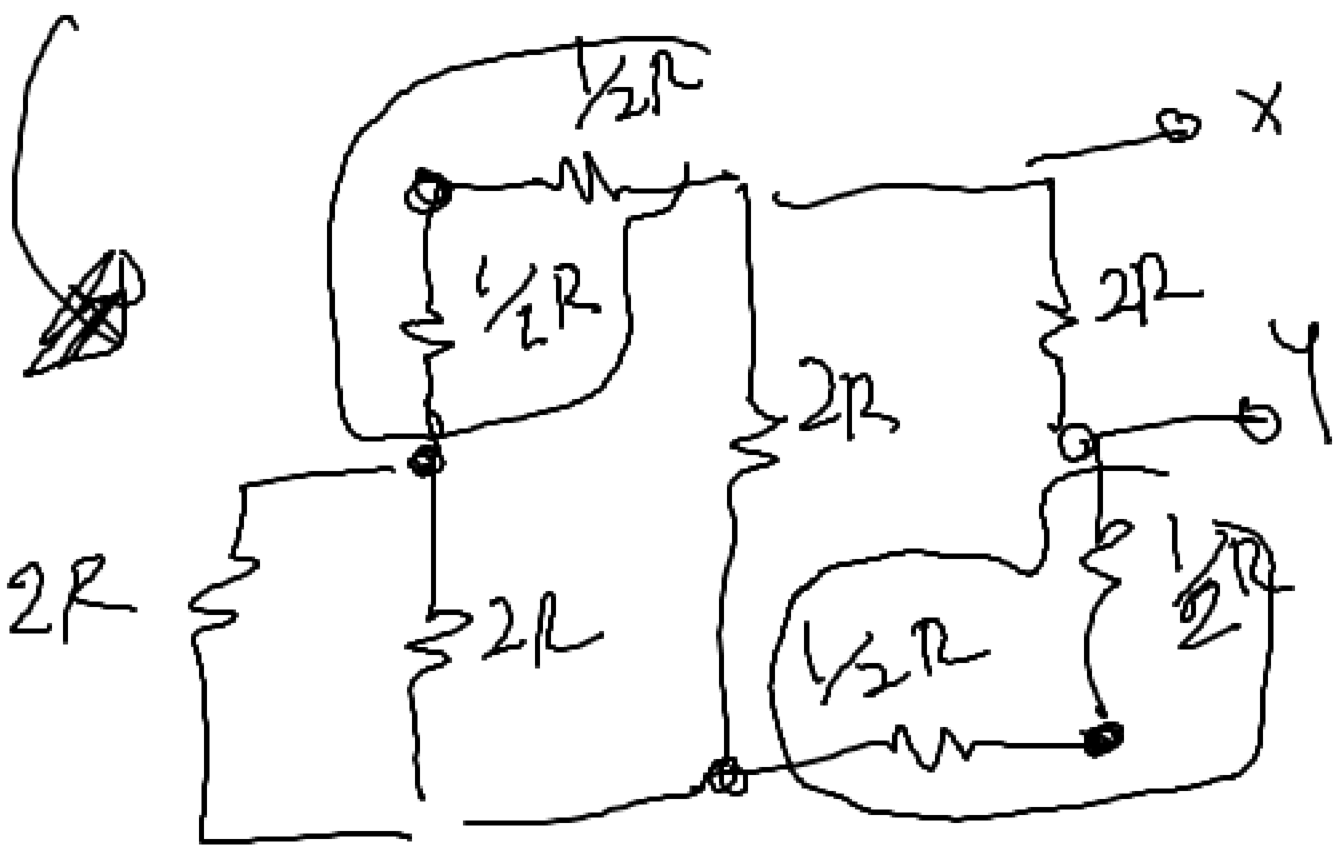


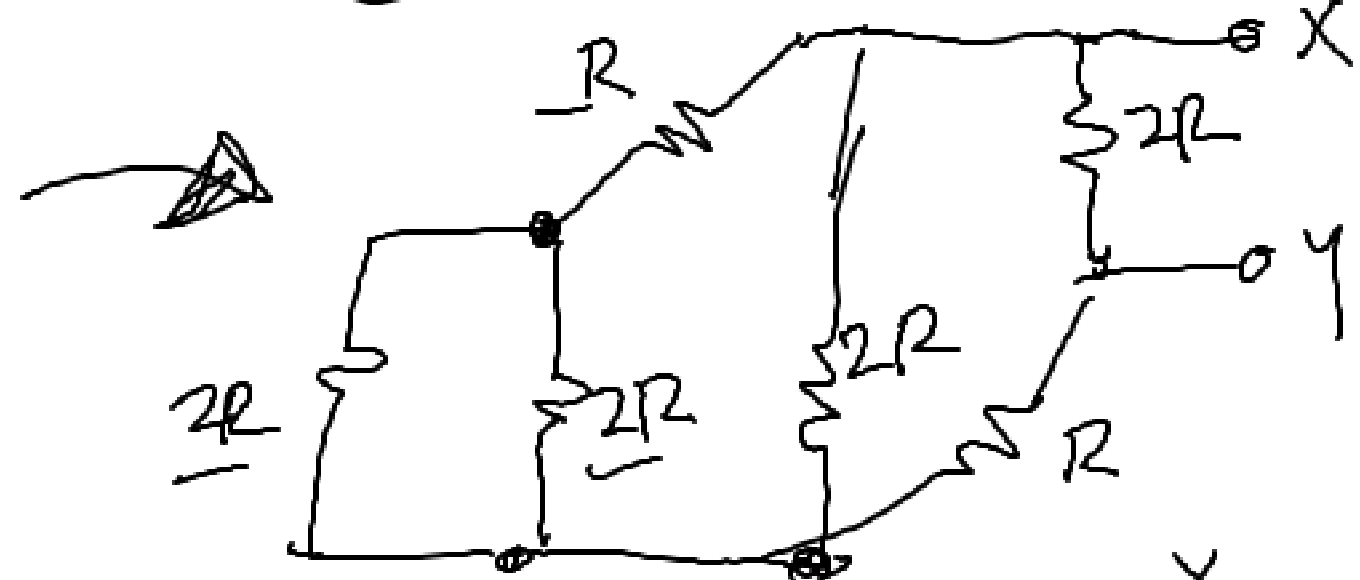
$$R_1 || R_2 = \frac{R_1 R_2}{R_1 + R_2} = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2}}$$



Steps

1. Choose a pair of resistors check if series/parallel
2. If so, combine, calculate
3. Redraw ckt.
4. Repeat until simplified





keep iterating until simplified