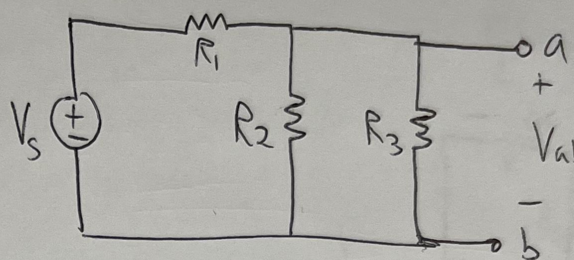
Exam topics

- Thevenin/Norton — {HW5
- Op-amps — {HW6, HW7-9, P1
- RC — {HW7
- RL — {HW8
- RLC — {HW9
- Dependent Sources — {HW5, P3, HW7,8, P2

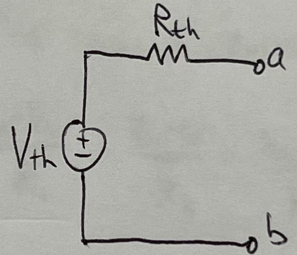
Thevenin/Norton

Given



$V_{ab} = V_a - V_b = V_{th}$

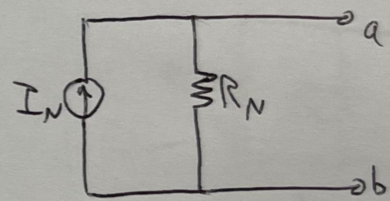
Goal



Thevenin equivalent circuit

or

Goal

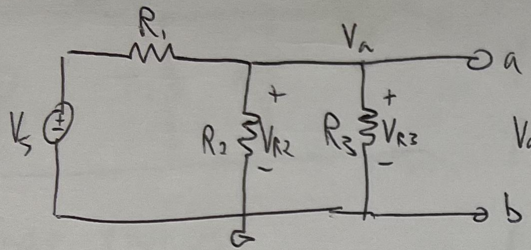


Norton equivalent circuit

$I_N = \frac{V_{th}}{R_{th}}$

$R_N = R_{th}$

① Find V_{th}

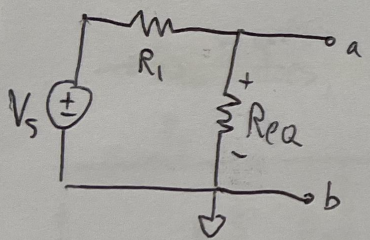


$V_{ab} = V_a - \cancel{V_b}^{\,0} = V_a = V_{th}$

easy way – Voltage divider

- $\underbrace{V_{R3} = V_{R2}}_{\text{in parallel}} = V_{ab} = V_{th}$

in parallel → $R_{eq} = R_2 // R_3$



$$V_{ab} = V_s \frac{R_{eq}}{R_1 + R_{eq}} = V_{th}$$

nodal analysis

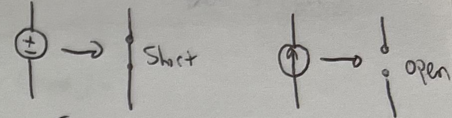
@ V_a node, all currents leaving...

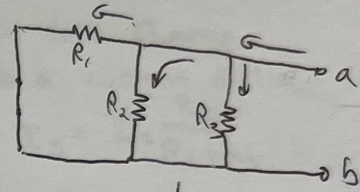
$$\frac{V_a - V_s}{R_1} + \frac{V_a - 0}{R_2} + \frac{V_a - 0}{R_3} = 0$$

$$V_a = \underline{\quad\sim\sim\quad} = V_{th}$$

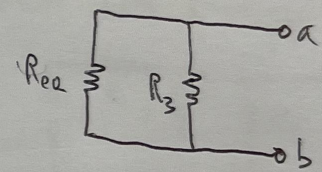
② Find R_{th}

- turn off Sources

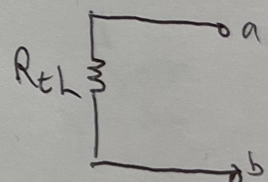




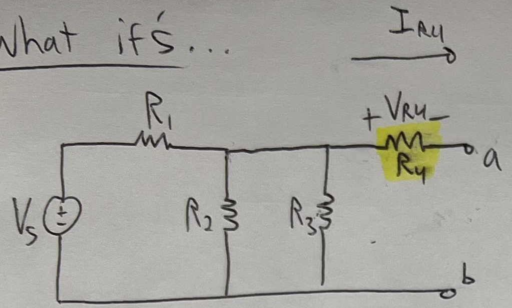
↓ $R_2 // R_3 = R_{eq}$



↓ $R_{eq} // R_3 = \underline{R_{th}}$



What if's...



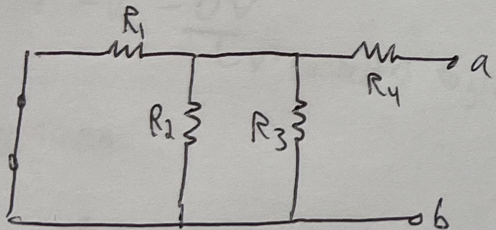
What changes?

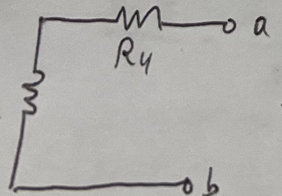
→ V_{th} does not change

- $I_{R4} = 0A$ (dangling wire)
- So, $V_{R4} = 0V$ ($V = IR$)

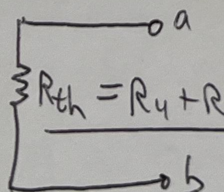
⇒ V_a same as before

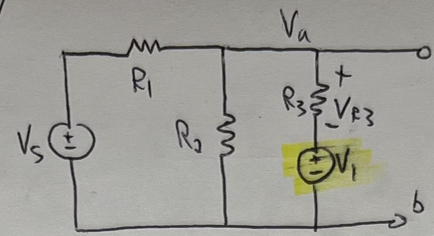
→ R_{th} does change





$R_1 // R_2 // R_3 = R_{eq}$ → $R_{th} = R_4 + R_{eq}$





What changes?

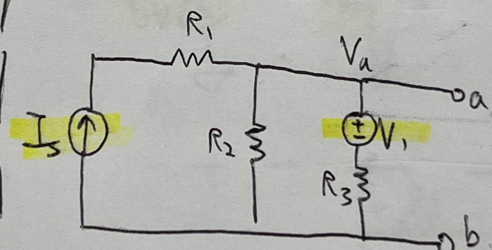
~~[illegible]~~ → V_{th} does change

$V_{ab} \neq V_{R3}$

$V_{ab} = V_1 + V_{R3}$

– do nodal at V_a to find V_{th}

→ R_{th} does not change



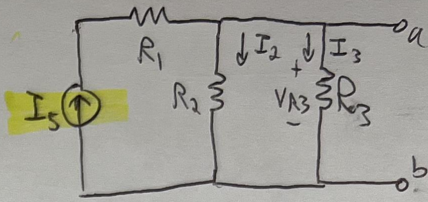
What changes?

→ ~~[illegible]~~ V_{th} does change

- cannot do current divider ~~[illegible]~~

– do nodal at V_a to find V_{th}

→ R_{th} does change



What changes?

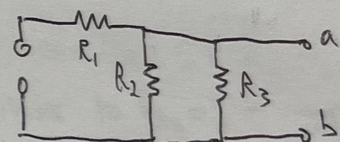
→ V_{th} does change

- do a current divider

$$I_3 = I_s \frac{R_2}{R_2 + R_3}$$

$V_{th} = V_{R3} = R_3 \cdot I_3$

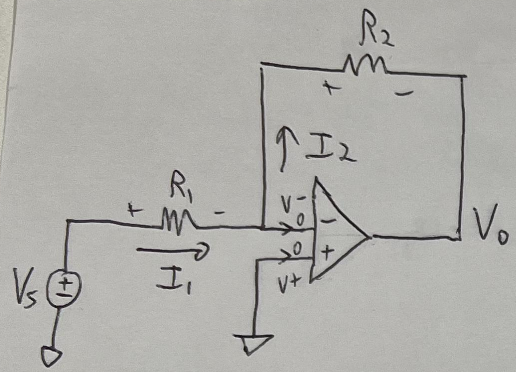
→ R_{th} does change



$R_{th} = R_2 // R_3$

same as this

OP-amps



Goal

-equation for V_o

① apply op-amp rules

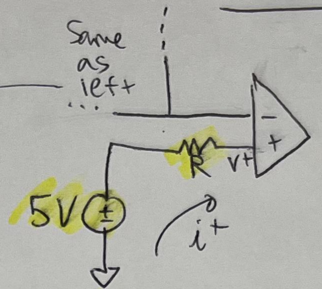
- $V^+ = V^- = \underline{0V}$
  - V^+ connected to ground
- $i^+ = 0A$
- $i^- = 0A \longrightarrow I_1 = I_2$

② KCL

$$\frac{V_s - \cancel{V^-}^{\,0}}{R_1} = \frac{\cancel{V^-}^{\,0} - V_o}{R_2}$$

$$\boxed{V_o = -\frac{R_2}{R_1} V_s}$$

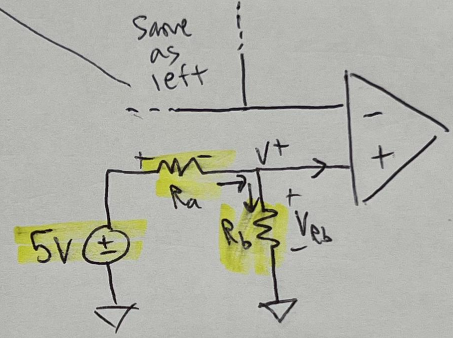
What if?



$V^+ = 5V$ now

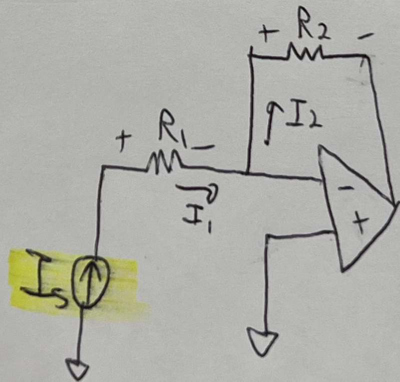
$i^+ = 0A$ (rule)

So $V_R = i^+ R = 0V$



$$V^+ = 5 \cdot \frac{R_b}{R_a + R_b}$$

- $i^+ = 0A$
- nonzero current thru 5V, R_a, R_b
- Voltage divider to $V_{Rb} = V^+$



- V^+ still 0V
- KCL is $I_1 = I_2$,

$$I_s = \frac{\cancel{V^-}^{\,0} - V_o}{R_2}$$

$$\boxed{V_o = -I_s R_2}$$