WELCOME TO EECS16B!

Disc. Time : M/W 9–10 AM, 10–11 AM, 1–2 PM, 7–8 PM [Online]

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↳ Admin Qs direct to Divija / Ali

ASE : Ben

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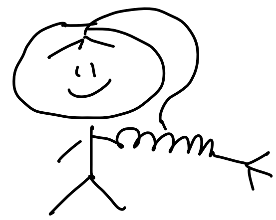


To do : Introduction + 16A Review

1. Self intro + Course Intro + Teaching Style + Zoom
2. Course Logistics
3. 16A Circuits Review (Q2)
4. Discussion Q1, 4 (3 if time)

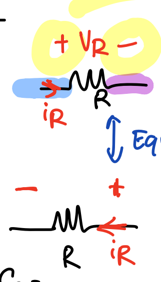
Intro

- Course Intro : Motivating goal :
  - ↳ Module 1 : More Circuits from 16A (Filters, Phasors, SP)
  - ↳ Module 2 : Controls & Linearization
  - ↳ Module 3 : SVD + Applications to ML
- Quick note on teaching style
- Quick note on Zoom + Zoom Participation.

Course Logistics → All information on Website : eecs16b.org

16A Review

1. Resistor



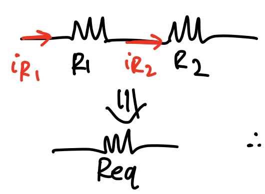
Passive Sign Convention : when labeling currents, label from the "+" to "−"

→ What does V_R mean?

V_R = (blue) − (purple)

Series :

→ same current going through the elements

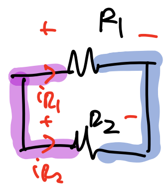


$i_{R_1} = i_{R_2}$

$\therefore R_{eq} = R_1 + R_2$

↳ Parallel :

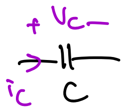
→ voltage drop across the elements are equivalent



⇒ $R_{eq} = R_1 \parallel R_2$ (parallel)

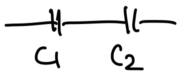
$= \frac{R_1 R_2}{R_1 + R_2}$

② Capacitors



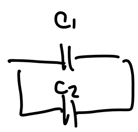
$$i_C = C \cdot \frac{dV_C}{dt}$$

• Series



⇒ $C_{eq} = \frac{C_1 C_2}{C_1 + C_2}$

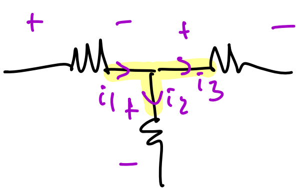
• Parallel



⇒ $C_{eq} = C_1 + C_2$

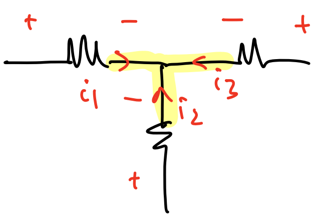
Tools

① KCL : Σ currents going into a node = Σ currents leaving a node



$i_1 = i_2 + i_3$ (KCL tells us)

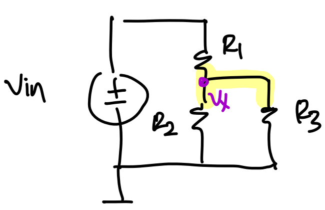
↕ Both valid and equivalent



$i_1 + i_2 + i_3 = 0$

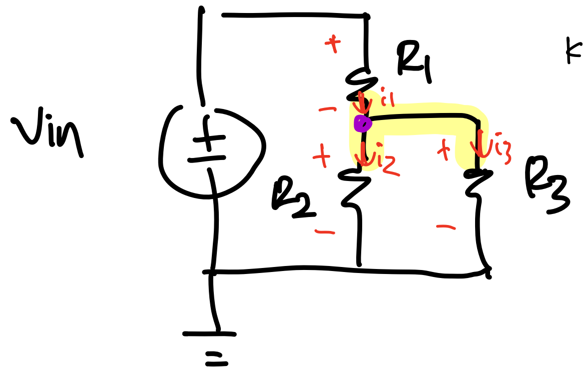
② Nodal Analysis (simplified & better & faster than 16A)

[Disc Q2]



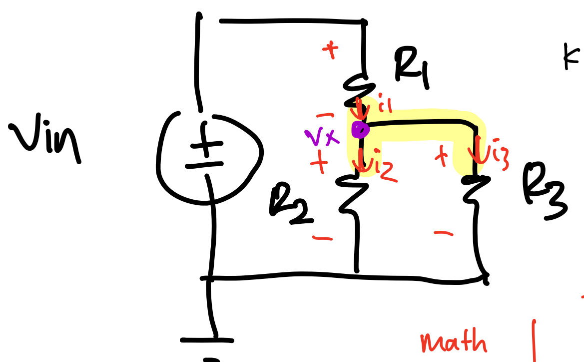
Step 1 : Pick a node to perform KCL on. Pick a node that has the most # of elements connected to it + what we're interested in

Step 2 : Label the currents going the elements on the node you chose. Then perform KCL on the node



KCL : $i_1 = i_2 + i_3$

Step 3 : Convert your KCL equation into V-R relationships or capacitor relationships, etc. $V = IR$, $i_C = C\frac{dv_C}{dt}$



KCL : $i_1 = i_2 + i_3$

$$\frac{V_{R_1}}{R_1} = \frac{V_{R_2}}{R_2} + \frac{V_{R_3}}{R_3}$$

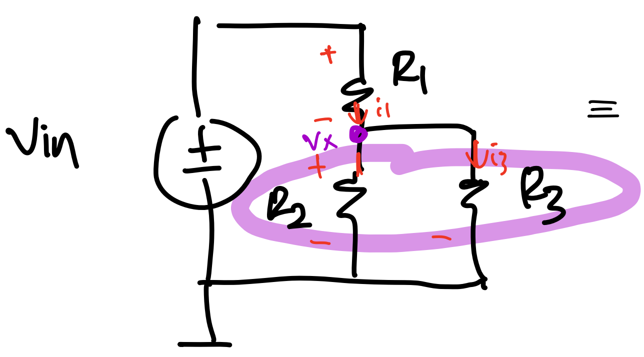
$$\frac{V_{in} - V_x}{R_1} = \frac{V_x - 0}{R_2} + \frac{V_x - 0}{R_3} \quad \Leftarrow ★★$$

math ↓

$$\frac{V_{in}}{R_1} = V_x\left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}\right)$$

$$\therefore V_x = \frac{R_2 R_3}{R_1 R_2 + R_1 R_3 + R_2 R_3} \cdot V_{in}$$

(b) Alternatively, you can realize that $R_2 \parallel R_3$



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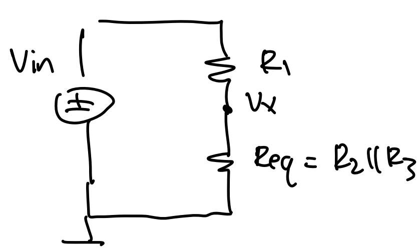
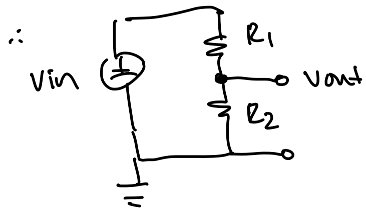


→ voltage divider!

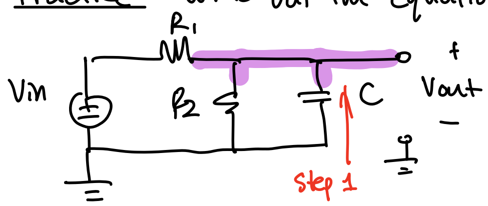


$$V_{out} = \frac{R_2}{R_1+R_2} \cdot V_{in}$$

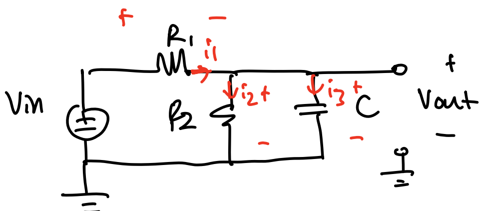
↓

$$V_x = \frac{R_{eq}}{R_{eq}+R_1} \cdot V_{in}$$

Practice: Write out the equation to solve for Vout



Hint: Pick a node to make your life eary



Step 2

KCL: $i_1 = i_2 + i_3$

Step 3: $V = IR$, $i_C = C\frac{dV_C}{dt}$

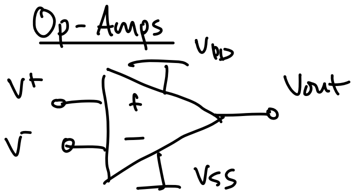
$$i_1 = i_2 + i_3$$

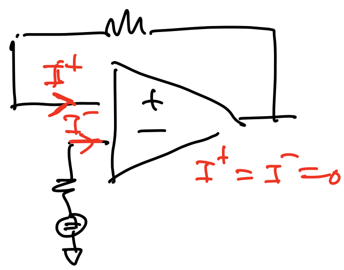
$$\frac{V_{R_1}}{R_1} = \frac{V_{R_2}}{R_2} + i_C$$

$$\frac{V_{in} - V_{out}}{R_1} = \frac{V_{out} - 0}{R_2} + C\frac{dV_C}{dt}$$

$$\frac{V_{in} - V_{out}}{R_1} = \frac{V_{out}}{R_2} + C\frac{dV_{out}}{dt} \quad \text{(done!)}$$

Op-Amps





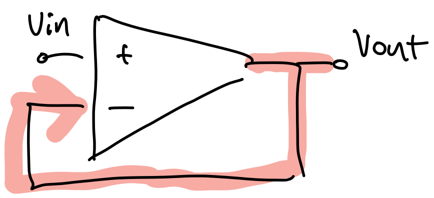
Golden Rules of Op-Amps

① $I^+ = I^- = 0$ for an ideal op-amps

② If in negative feed back (NFB), then

$V^+ = V^-$

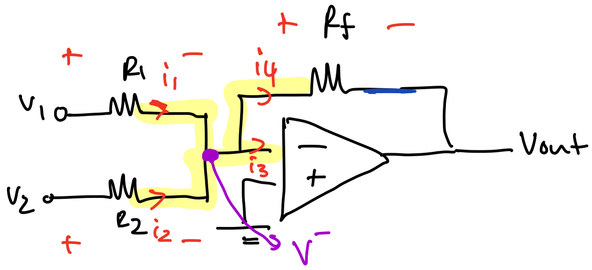
↳ part of the output is fed back into the "−" input e.g. Buffer



$V^+ = V^-$

$V_{in} = V_{out}$

<u>Disc Q4 [3-5 mins]</u>



KCL : $i_1 + i_2 = i_3 + i_4$

$$\frac{V_{R_1}}{R_1} + \frac{V_{R_2}}{R_2} = 0 + \frac{V_{R_f}}{R_f}$$

$$\frac{V_1 - \cancel{V^-}^{\,0}}{R_1} + \frac{V_2 - \cancel{V^-}^{\,0}}{R_2} = \frac{\cancel{V^-}^{\,0} - V_{out}}{R_f}$$

∵ op-amp in NFB, ∴ $V^+ = V^-$

$0 = V^-$

$$\frac{V_1}{R_1} + \frac{V_2}{R_2} = -\frac{V_{out}}{R_f}$$

$$\therefore V_{out} = -R_f\left(\frac{V_1}{R_1} + \frac{V_2}{R_2}\right)$$