Lec 2-4 → ECE110 review, V-dv, I-dv, KCL, KVL, Thev Norton, source xforms, Phasors, Filters + Bode Plots.

Lecture 2 -
V-divider, I-divider, KCL, KVL, Thev + Norton

Review of circuit Analysis - part 1:

$$P_{ower} = \text{rate that work is done} = \frac{dW}{dt} = \frac{\text{work}}{\text{charg}} \cdot \frac{\text{charge}}{\text{time}}$$

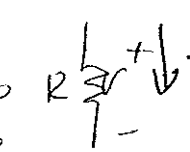
dW ← work; $\frac{\text{work}}{\text{charg}} \to V$; $\frac{\text{charge}}{\text{time}} \to i$

$$= \frac{dW}{dq} \cdot \frac{dq}{dt} = vi$$

$$\frac{\text{Joules}}{\text{Coul}} \cdot \frac{\text{Coul}}{\text{sec}} = \frac{J}{S} = \text{Watt}$$

Power is conserved! convention: Power delivered < 0 "Source"
Power dissipated > 0 "Load"

passive sign convention: Power dissip. by Load as a positive quantity

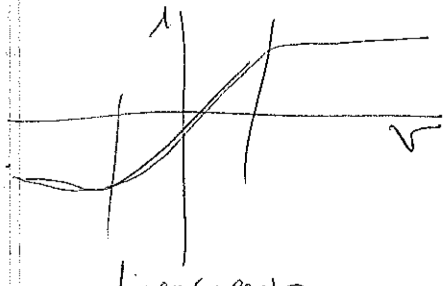
current flow from plus to minus  power dissipated as positive.

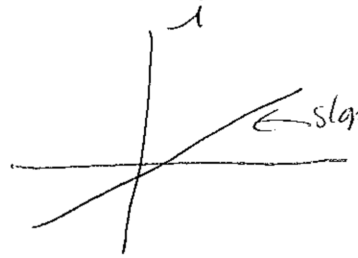
$$\sum_{n=1}^{N} P_n = \phi$$

KCL: $\sum_{n=1}^{N} i_n = \phi$ @ node

KVL: $\sum_{n=1}^{N} v_n = \phi$ around a loop

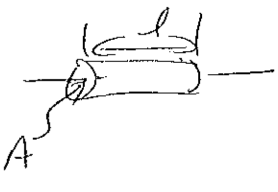
Resistive Loads:





$v = iR$

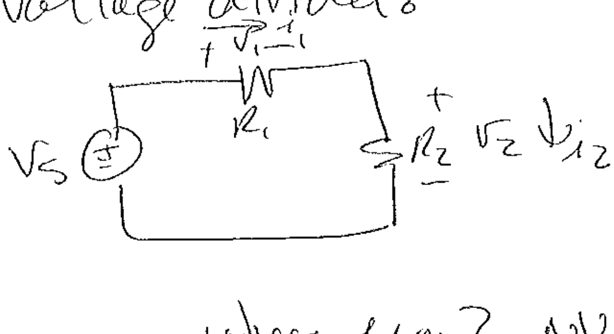
$R = \frac{l}{\sigma A}$



Practical considerations:
- length of wire
- gage of wire
- material: (Cu, Al, platinum)

(2) $P_R = i^2 R = \frac{v^2}{R}$ quadratic, not linear..

Voltage divider:



(1) eqns $v_1 = v_s \frac{R_1}{R_1+R_2}$

$v_2 = v_s \frac{R_2}{R_1+R_2}$

where from? NVA KCL + $\frac{v_s - v_2}{R_1} = \frac{v_2}{R_2}$ (3) derive

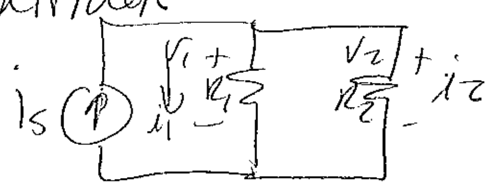
Ohm's law $v \propto R$

$\frac{v_s}{R_1} = v_2\left(\frac{1}{R_1}+\frac{1}{R_2}\right) = v_2\left(\frac{R_2+R_1}{R_1R_2}\right)$

$v_2 = \frac{R_1R_2}{R_1+R_2}\frac{v_s}{R_1} = v_s\frac{R_2}{R_1+R_2}$ ✓

(2) extremes: if $R_1 \to \phi$, $v_2 = v_s$
$R_1 \to \infty$, $v_1 = v_s$

i-divider



(1) eqns $i_1 = i_s \frac{R_2}{R_1+R_2}$; $i_2 = i_s \frac{R_1}{R_1+R_2}$

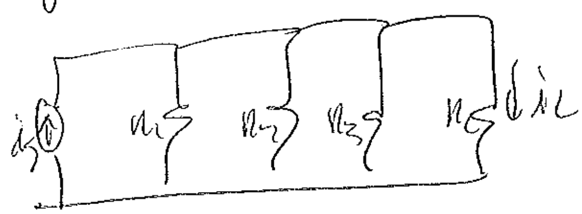
Ohm's law $v \propto 1/R$

③ доит

i-divider comes from : KCL $i_S = i_1 + i_2$
and ~~[illegible]~~ $i_1 R_1 = R_2 R_2$
b/c $V_1 = V_2$

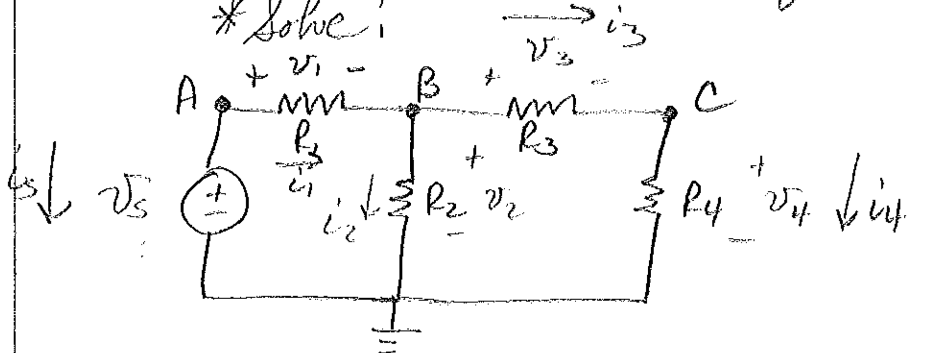
① extras if $R_2 \to \phi$ then $i_1 \to \phi$
if $R_2 \to \infty$ the $i_1 \to i_S$

if more than 2 Resistors,



$$i_L = i_S \frac{\frac{1}{R_L}}{1/R_1 + 1/R_2 + 1/R_3 + 1/R_L} \quad \ldots$$

NVA:
* Label nodes + ground + polarities
* Write element voltages in terms of node voltages
* Apply KCL @ each node (except source + GND)
* Ohm's Law: "i" in terms of "v"
* Solve!



$v_s = v_A$

$v_1 = v_A - v_B$

$v_2 = v_B$

$v_3 = v_B - v_C$

$v_4 = v_C$

B: $i_1 = i_2 + i_3$

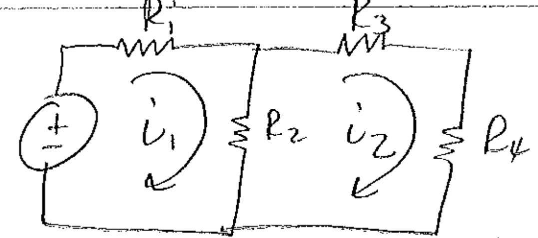
C: $i_3 = i_4$

$$i_1 = \frac{v_A - v_B}{R_1} = \frac{v_s - v_B}{R_1}$$

$$i_2 = \frac{v_B}{R_2} \qquad i_3 = \frac{v_B - v_C}{R_3} \qquad i_4 = \frac{v_C}{R_4}$$

$$\left.\begin{aligned} \frac{v_s - v_B}{R_1} &= \frac{v_B}{R_2} + \frac{v_B - v_C}{R_3} \\ \frac{v_B - v_C}{R_3} &= \frac{v_C}{R_4} \end{aligned}\right\} \text{Solve!}$$

MCA:



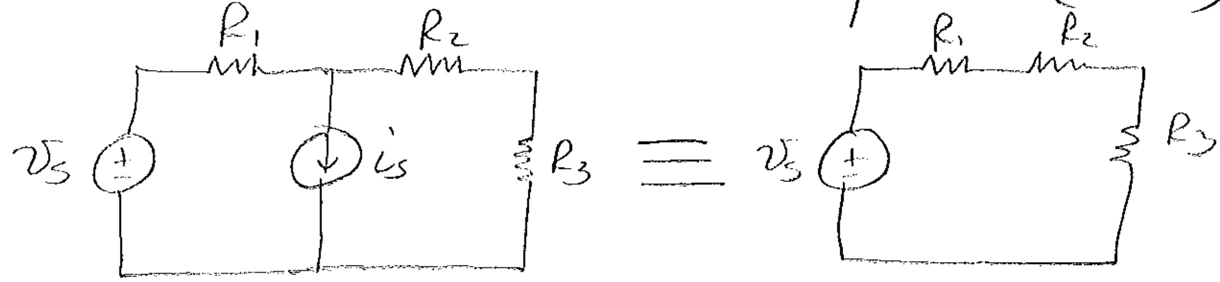
① Identify meshes (closed loops)
② Keep all mesh currents clockwise!
③ KVL each mesh
④ Solve

1: $-v_S + i_1 R_1 + (i_1 - i_2) R_2 = 0$

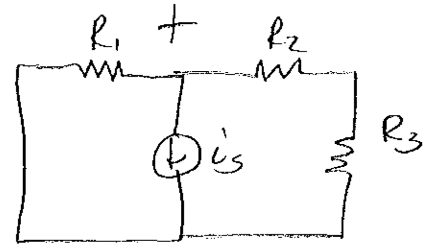
2: $(i_2 - i_1) R_2 + i_2 R_3 + i_2 R_4 = 0$

Superposition, linear circuits: each source can be evaluated individually

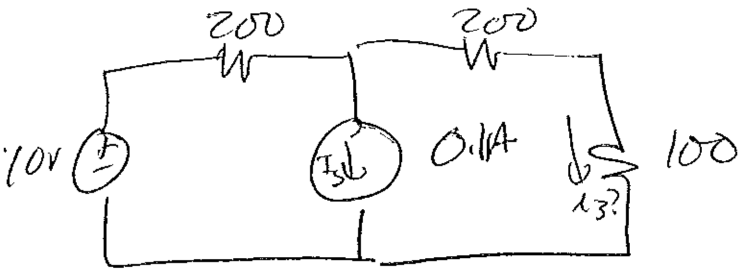
Voltage source → short ckt ($\Delta V = 0$)
Current " → open ckt ($i = 0$)
why



Linear system → sum solutions!



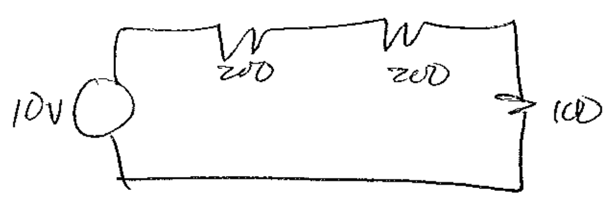
So, example: Superposition:



superposition: find i_3

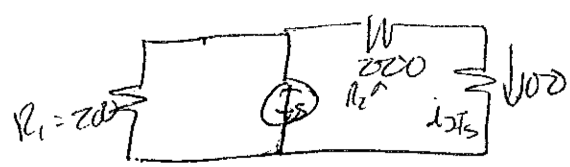
i_{3Vs}:

zero current: (open ckt)



$$i_{3Vs} = \frac{10V}{500} = 0.02A$$

i_{3Is}: zero Vs → short ckt



current division:

$$i_{3Is} = (-I_s)\frac{R_1}{\underbrace{R_1+R_2+R_3}_{\text{series combo}}}$$

$$= (-0.1A)\left(\frac{200}{500}\right)$$

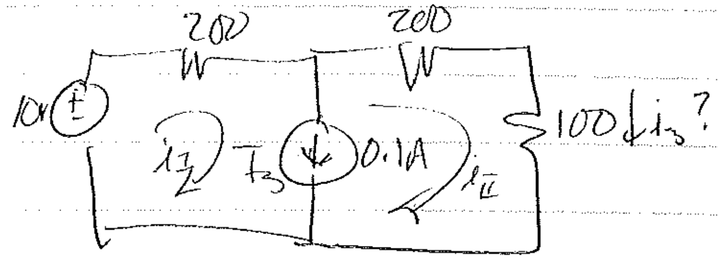
$$= -.04A$$

$$\boxed{i_3 = i_{3Vs} + i_{3Is} = 0.02 - 0.04 = -0.02A}$$

Could Also do mesh currents!

To here

mesh current example. from class example.



$i_3 = i_{II}$!

"Supermesh" (skip the current source)

$$-10 + i_I 200 + i_{II} 200 + i_{II} 100 = \phi$$

$I_s = i_I - i_{II}$ $\qquad$ $i_I = I_s + i_{II}$

$$-10 + (I_s + i_{II}) 200 + 300 i_{II} = 0$$

$$-10 + 200 I_s + 500 i_{II} = 0$$

$$i_{II} = \frac{10 - 200 I_s}{500} = \frac{10 - 20}{500} = \frac{-10}{500} = -.02A$$

Need formal lecture on mesh currents +
Thevenin / Norton Equivalent ckts!

Post some practice problems ← KCL
KVL

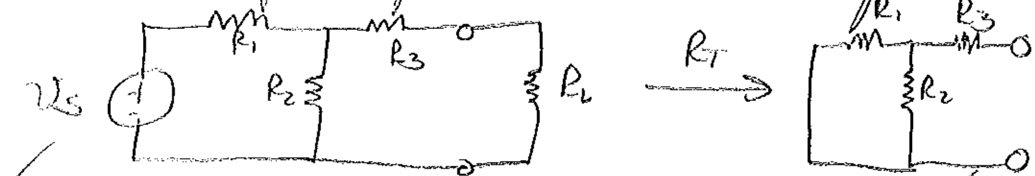
Equivalent Circuits

* Simplify analysis w/ different loads

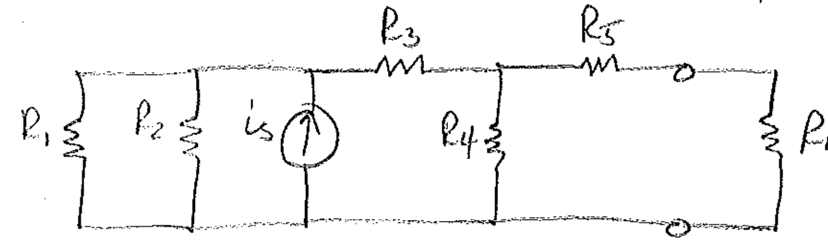
* Source transformations to further simplify problems

Thevenin → ideal voltage source (v_T) + equiv. resistance (R_T)

1. Remove load
2. Eliminate all independent (V) + (I) sources
3. Compute equiv. resistance as seen from load terminals

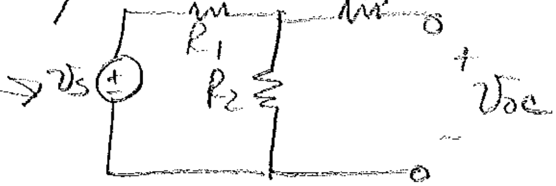


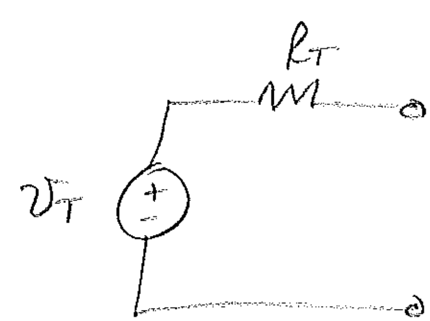
$$R_T = R_3 + (R_1 \| R_2)$$



$$R_T = \left(\left[(R_1 \| R_2) + R_3 \right] \| R_4 \right) + R_5$$

Keep all sources + solve for v_{oc}:



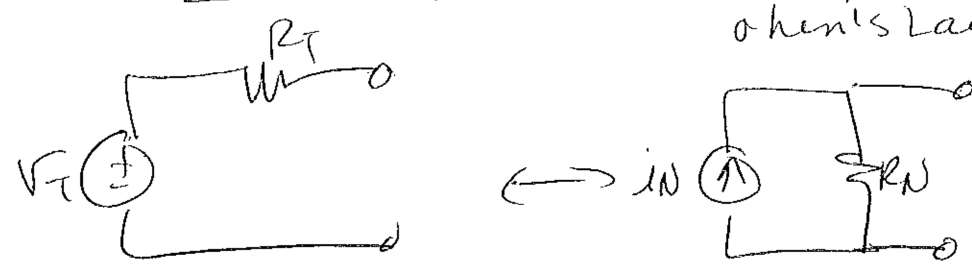


$v_T = v_{oc}$

Norton equivalent circuit:

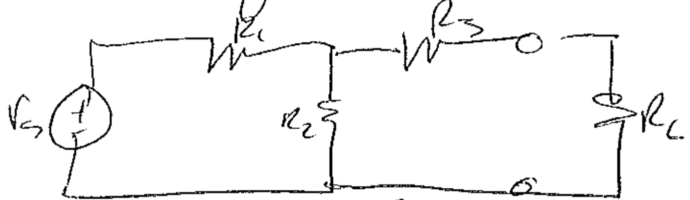
~~could also solve~~

$R_T = R_N$, instead of v_{oc},
ohm's Law: $i_{sc} = i_N = \frac{v_{oc}}{R_T}$

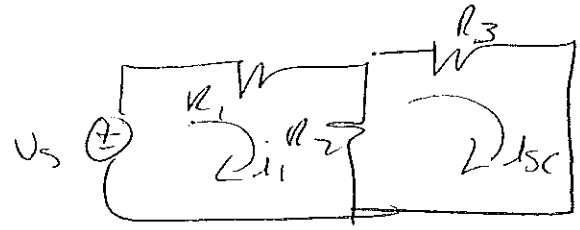


$v_T = i_N R_T$

or, solve for i_N using i_{sc}:



$R_N \leftarrow$ same as R_T
i_{sc} : short ckt the load & solve for i_{sc}

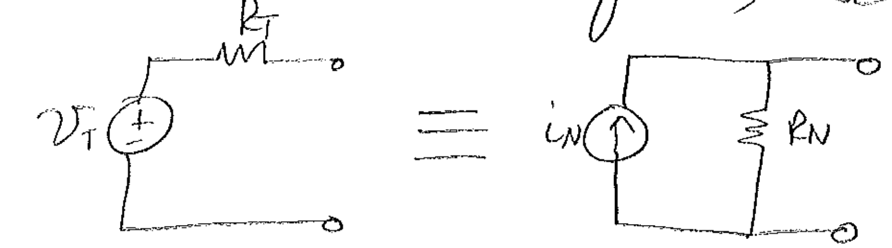


$-v_s + i_1 R_1 + (i_1 - i_{sc}) R_2 = 0$

$(i_{sc} - i_1) R_2 + i_{sc} R_3 = 0$ ...
solve for $i_{sc} = i_N$

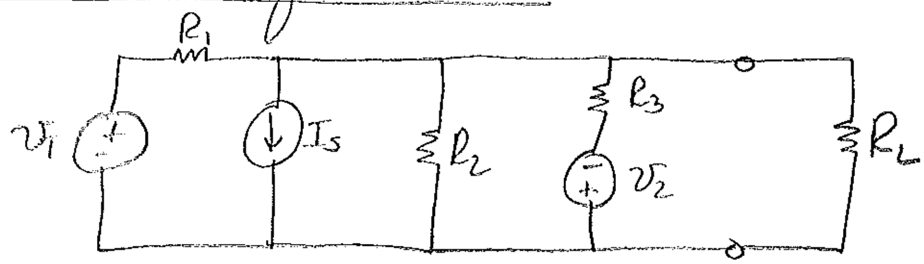
Norton Equiv.

$R_T = R_N$ Instead of v_{oc}, $i_{sc} = i_N$

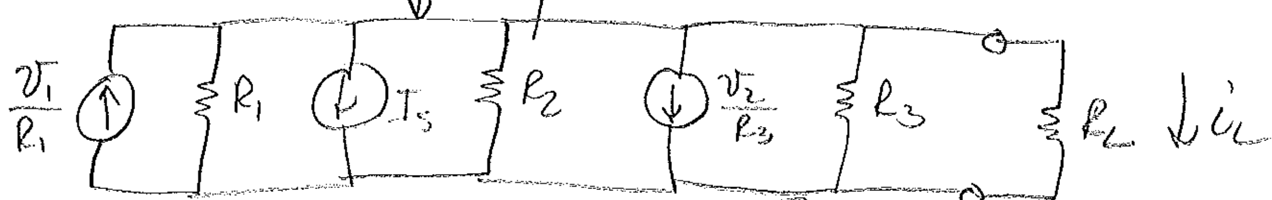


$v_T = i_N R_T$

Source Transformations



"simple" current divider



$$i_L = \left(\frac{v_1}{R_1} - I_S - \frac{v_2}{R_3}\right)\left[\frac{\frac{1}{R_L}}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_L}}\right]$$