EECS16A DIS 8B

email: moseswon@berkeley.edu

OH: W 10AM-12PM PT (HWP)
→ Discord
→ on queue

Logistical bits

1. Circuit Review sessions
2. Piazza posts
3. Scope: Norton/Thevenin
4. Karinna! Ask her questions too!

Topics/Learning objectives

1. Applying superposition (how to turn off sources, labeling nuances)
2. Resistor equivalence round 2
3. If time: example of a source dissipating energy/power

Playlist:
Superorganism
Everybody wants to be famous (Lucy Yang)
Waves (Tame impala remix)
Shura - the stage
suggestions @ bit.ly/16ajukebox

EECS 16A Designing Information Devices and Systems I
Fall 2020 Discussion 8B

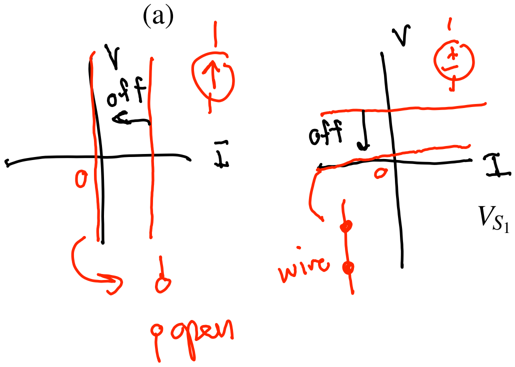
1. Superposition

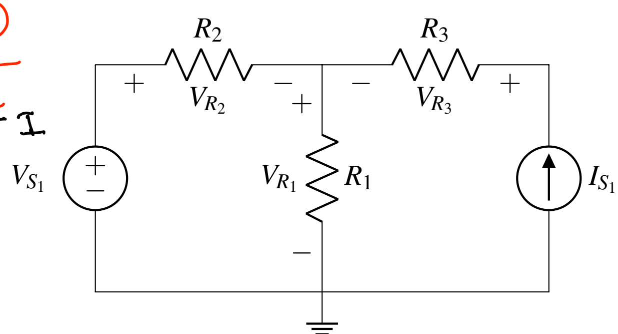
For the following circuits:

i. Use the superposition theorem to solve for the voltages across the resistors.

ii. For parts (b) and (c) only, find the power dissipated/generated by all components. Is power conserved?

(a)





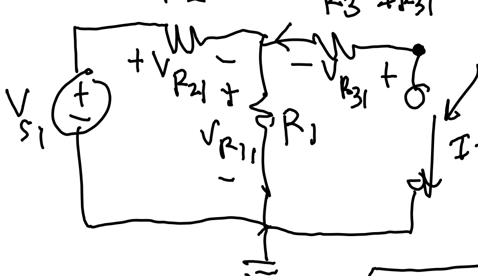
(circuit)

① Redraw ckt. w/ only one source on (for all sources) compute values

② Sum values to calculate

(subckt 1)

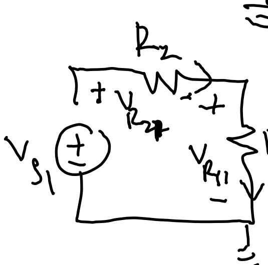
Vs1 on, Is1 off



$I_{R_{31}} = 0$

$V_{R_{31}} = R_3 I_{R_{31}}$

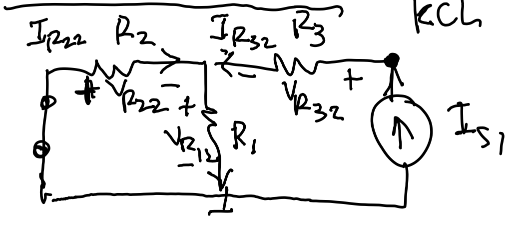
$I = 0$ $\boxed{V_{R_{31}} = 0}$



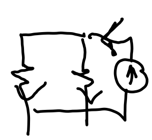
$$\boxed{\begin{aligned} V_{R_{11}} &= \frac{R_1}{R_1+R_2} V_{S_1} \\ V_{R_{21}} &= \frac{R_2}{R_1+R_2} V_{S_1} \end{aligned}}$$

$V_{R_{32}} = I_{R_{32}} \cdot R_3 = \boxed{R_3 I_{S_1}}$

Is1 on, Vs1 off



KCL $I_{3_2} = I_{S_1}$

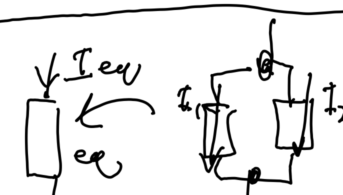


$I_{R_{22}} = -\frac{R_1}{R_1+R_2} I_{S_1}$

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

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

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



$I_{eq} = I_1 + I_2$

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

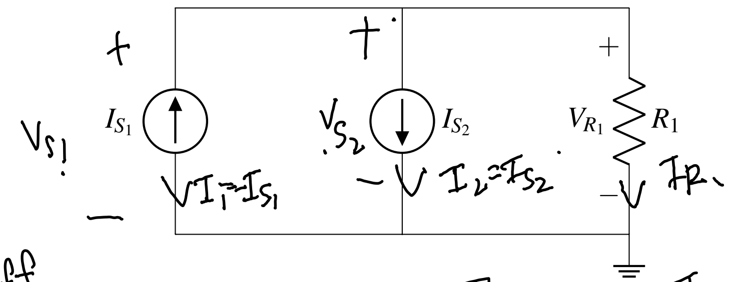
$V_{R_2} = V_{R_{21}} + V_{R_{22}} = \boxed{\frac{R_2}{R_1+R_2} V_{S_1} - \frac{R_1 R_2}{R_1+R_2} I_{S_1}}$

$V_{R_3} = V_{R_{31}} + V_{R_{32}} = 0 + \boxed{R_3 I_{S_1}}$

V_s off → wire
I_s off → open

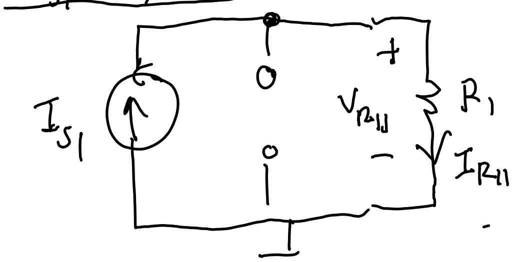
(b)

$V_{S_1} = V_{S_2} = V_{R_1}$ (parallel)



Don't calculate power in your subcircuits. POWER IS NOT LINEAR

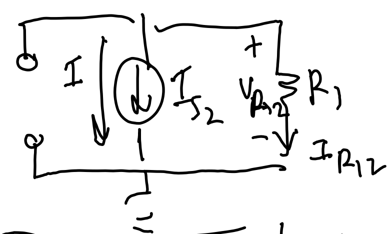
I_{S_1} on, I_{S_2} off



$\boxed{I_{R_{11}} = I_{S_1}}$? (KCL)

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

I_{S_2} on, I_{S_1} off



$\boxed{I_{R_{12}} = -I_{S_2}}$ (KCL @ top)

$\boxed{V_{R_{12}} = -R_2 \cdot I_{S_2}}$

By superposition:

$\rightarrow V_{R_1} = V_{R_{11}} + V_{R_{12}}$
$= \boxed{R_1 \cdot I_{S_1} - R_1 I_{S_2}}$

$\boxed{I_{R_1} = I_{S_1} - I_{S_2}}$

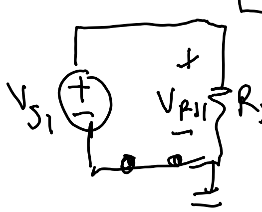
Power

$P_{R_1} = V_{R_1} \cdot I_{R_1} = R_1(I_{S_1} - I_{S_2})^2 > 0$ (dissipating)

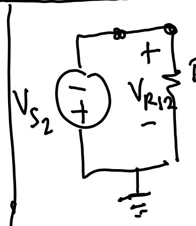
$P_{S_1} = R_1(I_{S_1} - I_{S_2})(-I_{S_1})$ ← can be positive or negative

$P_{S_2} = R_1(I_{S_1} - I_{S_2}) I_{S_2}$ ←

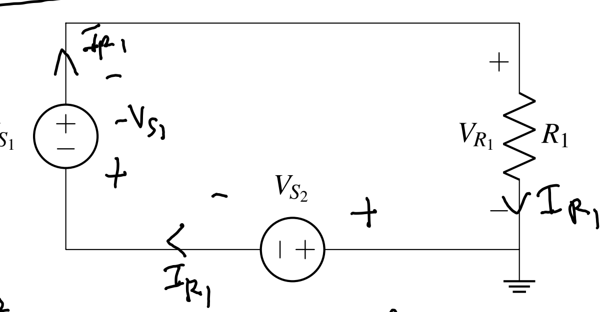
(c)



$V_{R_{11}} = V_{S_1}$



$V_{R_{12}} = -V_{S_2}$



$P = \frac{V^2}{R} > 0$

$P = I^2 R > 0$

Only for resistors! Resistors always dissipate! (also nonlinear)

$\boxed{V_{R_1} = V_{S_1} - V_{S_2}}$

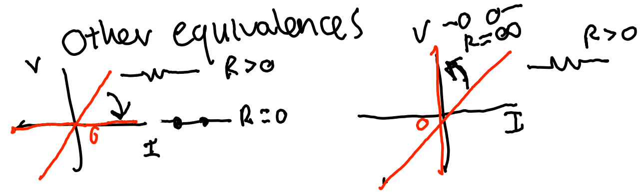
$I_{R_1} = \frac{V_{R_1}}{R_1} = \boxed{\frac{V_{S_1} - V_{S_2}}{R_1}}$

$P_{R_1} = \frac{(V_{S_1} - V_{S_2})^2}{R_1} > 0$

$P_{S_1} = -V_{S_1}\left(\frac{V_{S_1} - V_{S_2}}{R_1}\right)$ ← can be positive or negative

$P_{S_2} = V_{S_2}\left(\frac{V_{S_1} - V_{S_2}}{R_1}\right)$ ←

Other equivalences



2. (Practice) Series and Parallel Combinations

For the resistor network shown below, find an equivalent resistance between the terminals *x* and *y* using the resistor combination rules for series and parallel resistors.

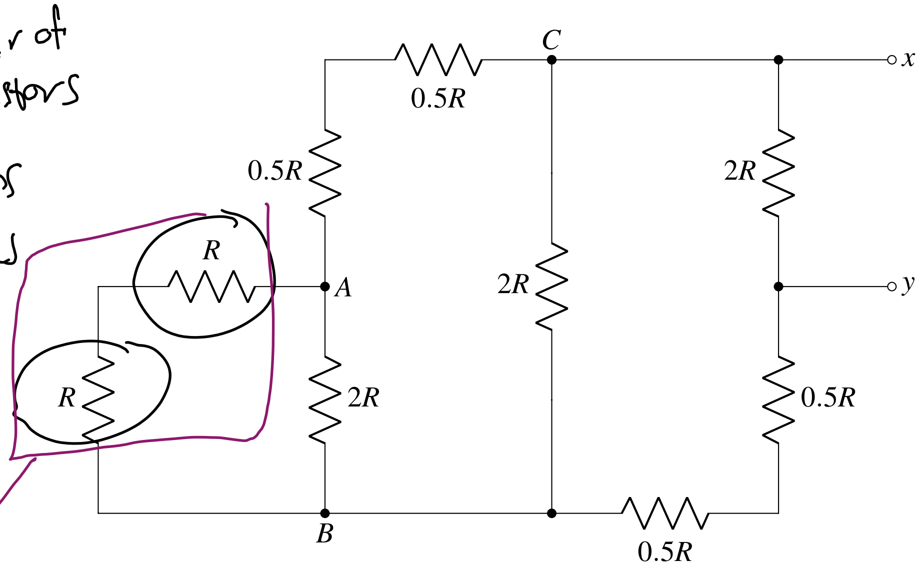
Practice

① Choose a pair of any two resistors

② Test definitions

Note: sometimes things are neither series + parallel

③ Redraw (simplifying) one at a time

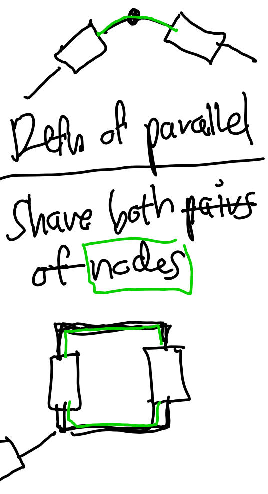


Defn of series

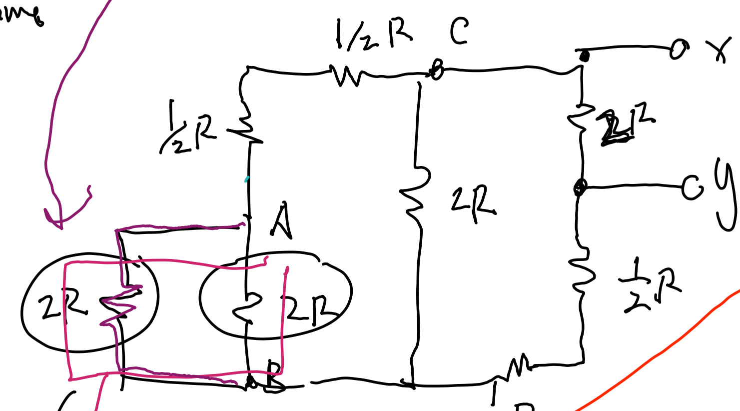
Share one node nothing else on it

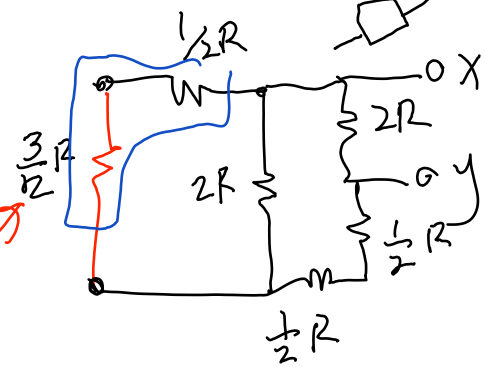
Defn of parallel

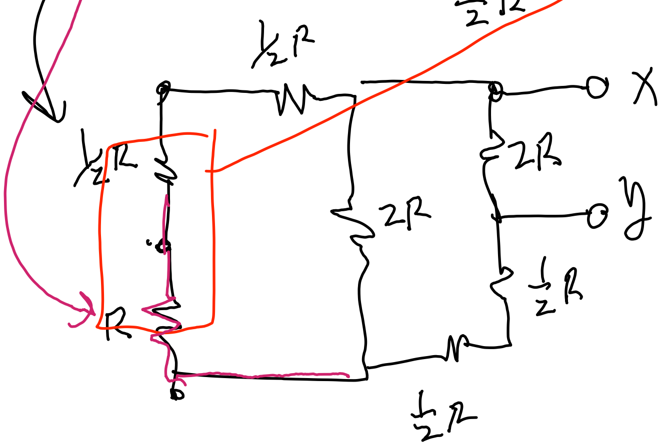
Share both ~~pairs~~ of nodes

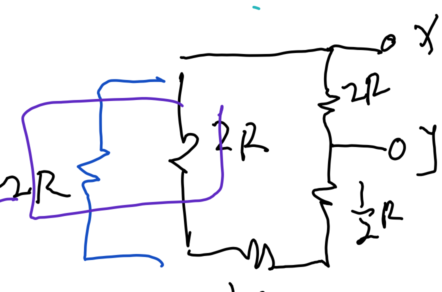


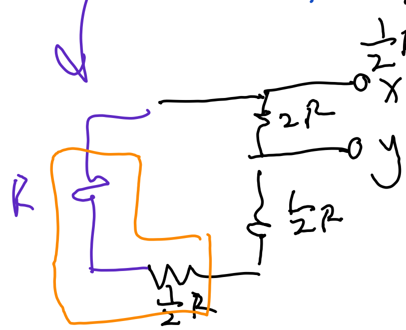
$R_{eq,\ series} = R_1 + R_2$

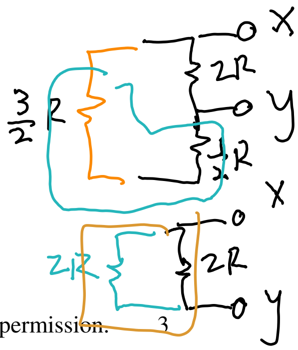












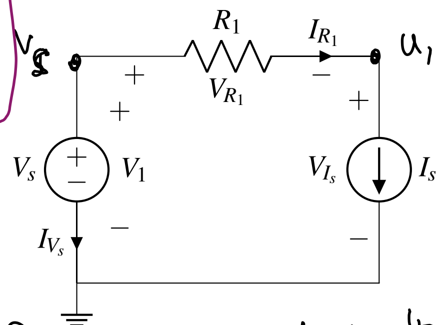
$R_1 \| R_2 = \frac{R_1 R_2}{R_1 + R_2} = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2}}$

$R_{xy} = R$

3. (Practice) Passive Sign Convention and Power v 2.0

Suppose we have the following circuit and label the currents as shown below. Calculate the power dissipated or supplied by every element in the circuit. Let $V_s = 5\,\mathrm{V}, I_s = 0.5\,\mathrm{A}$ and $R_1 = 5\,\Omega$.

$\boxed{\text{Voltages in parallel equal} \quad \text{Currents in series equal}}$



← (node voltages)

NVA

KCL @ u_1

$I_{R_1} = I_s$

$\frac{V_s - u_1}{R_1} = I_s$

$V_s - u_1 = R_1 I_s$

$\boxed{V_s - R_1 I_s = u_1}$

Compute currents + voltages using NVs

Voltage source

$V_1 = V_S$

$I_{V_S} = -I_{R_1}$ (KCL @ V_S node)

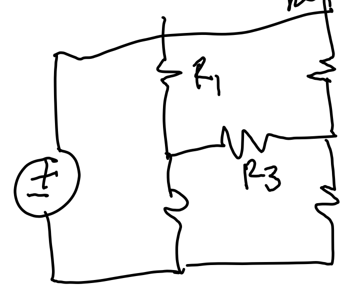
$I_{V_S} = -\frac{V_S - u_1}{R_1}$ (can use KCL)

$= -\frac{V_S - (V_S - R_1 I_S)}{R_1}$

$= -\frac{\cancel{R_1} I_S}{\cancel{R_1}} = I_S$

Examples of neither series nor parallel

R_1, R_2 not in parallel because of R_3



Current Source

$V_{I_S} = u_1 - 0$

$= V_S - R_1 I_S$

$I_S = I_S$

Resistor

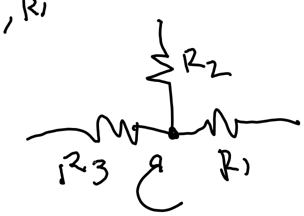
$V_{R_1} = V_S - u_1$

$= V_S - (V_S - R_1 I_S)$

$= R_1 I_S$ (when current by KCL, can use ohm's)

$I_{R_1} = \frac{V_{R_1}}{R_1} = I_S$

R_1, R_2
R_2, R_3
R_3, R_1 Not in series



R_2, R_3 are not in parallel
R_1, R_2 not in parallel

$P_{V_S} = V_1 I_{V_S} = V_S I_S > 0$ (always supplying)

$P_{I_S} = V_{I_S} \cdot I_S = (V_S - R_1 I_S) I_S$ (can be supplying or dissipating)
If I_S small enough dissipate
If I_S large enough supply

$P_R = V_{R_1} \cdot I_{R_1} = R_1 I_S \cdot I_S$
$= R_1 I_S^2 > 0$ (always dissipating)

power calculation