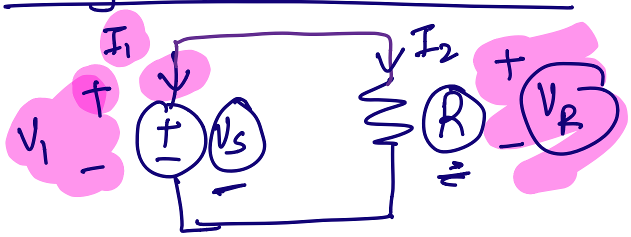
EECS 16A Module 2, Lecture 2

Logistics :
- Introduction to Research (Today) 5pm.
- Trivia Game Night (Saturday) 7pm
- Shoot HW 6 tonight
- Midterm redo – due Monday.

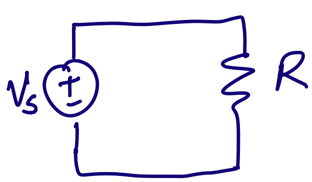
Module 2: ① Node Voltage Analysis

Analyse / Solve a circuit.



→ Convert it into a system of equations

$V_s = 5V$ $R = 1\,\Omega$



No names

$V_s = 5V$ $R = 1\Omega$

Two main parts of analysing a circuit

① Picture → System of linear equations.

Giving labels

② KVL, KCL, Ohm's Law

③ Solve. ✓

Node Voltage Analysis Example

V_s, R_1, R_2 are known.

Challenge: No labels.

Solve: Systematic labeling.

① Select your reference ⏚

② What are the nodes? Which node voltages do we know?

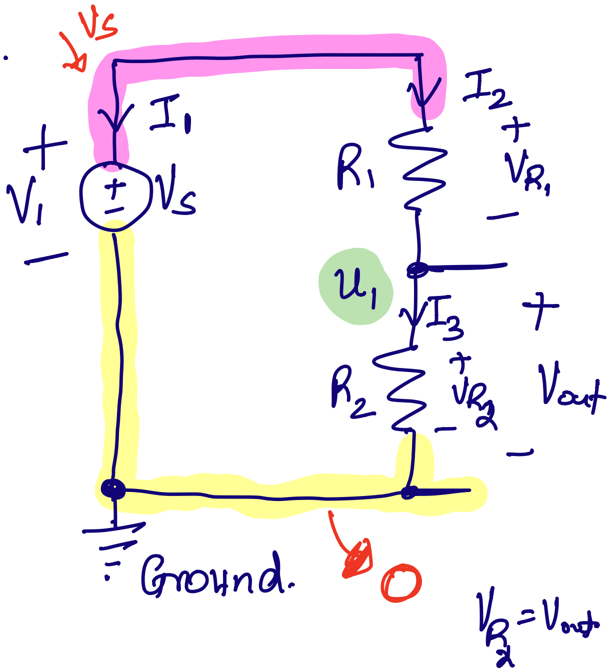
Label node voltages that you know

③ Mark the unknown nodes. ← Label unknown voltages.

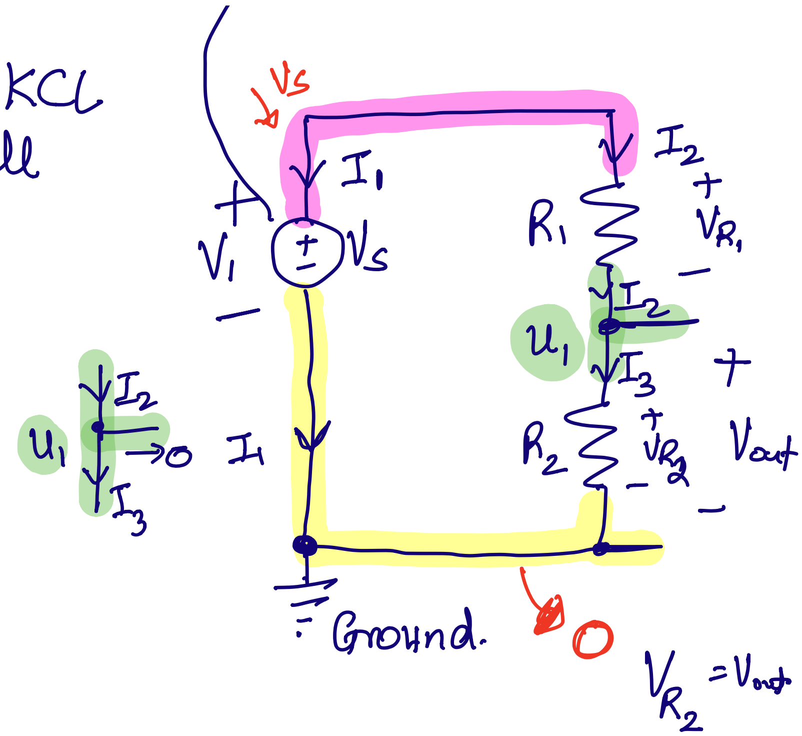
④ Mark element currents

- Passive sign convention to mark element voltages.

→ voltage source: —(±)—



⑤ Write out the KCL equations for all nodes with an unknown voltage.



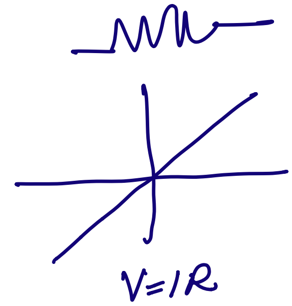
$$I_2 = I_3$$

$$I_2 - I_3 = 0$$

⑥ Use Ohm's law (other component eq^n) to express currents in terms of voltages.

$$V_{R_1} = I_2 \cdot R_1 \Rightarrow I_2 = \frac{V_{R_1}}{R_1}$$

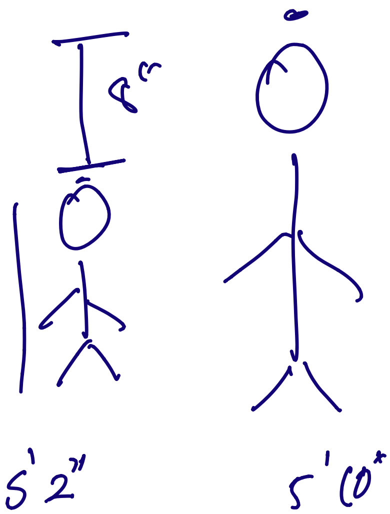
$$V_{R_2} = I_3 \cdot R_2 \Rightarrow I_3 = \frac{V_{R_2}}{R_2}$$

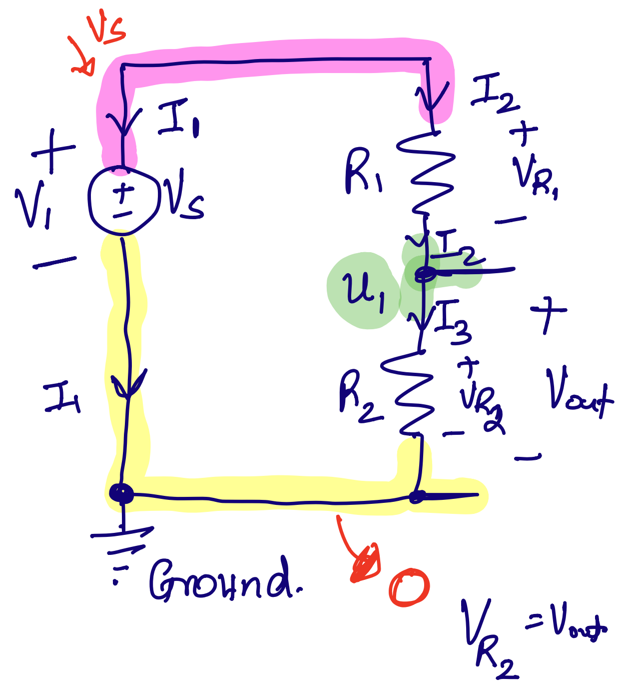


⑦ Replace element voltages with node voltages V_{R_1}, V_{R_2} with known things and u_1

$$V_{R_1} = V_s - u_1$$

$V_{R_2} = u_1 - 0$





$$\begin{cases} I_2 = \dfrac{V_{R_1}}{R_1} = \dfrac{V_s - u_1}{R_1} \\ I_3 = \dfrac{V_{R_2}}{R_2} = \dfrac{u_1 - 0}{R_2} = \dfrac{u_1}{R_2} \end{cases}$$

⑧ Substitute into KCL ⑤

$$\frac{V_s - u_1}{R_1} = \frac{u_1}{R_2}$$

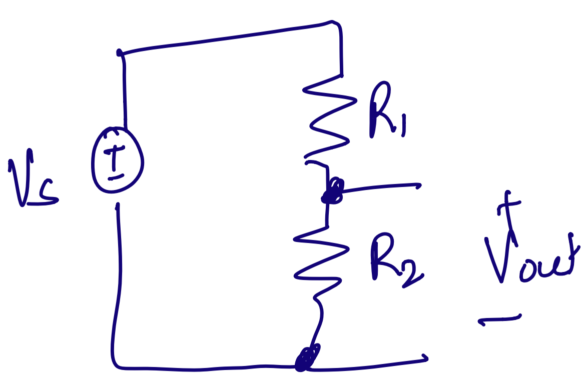
using KCL from step ⑤

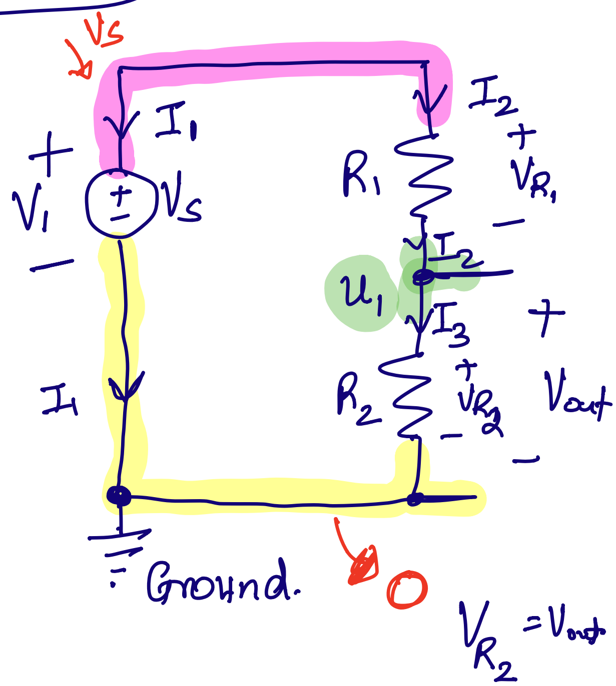
$$\frac{V_S}{R_1} = u_1\left(\frac{1}{R_1} + \frac{1}{R_2}\right) = u_1\left(\frac{R_1+R_2}{R_1 R_2}\right)$$

(9) $$u_1 = \frac{V_S}{R_1}\left(\frac{R_1 R_2}{R_1+R_2}\right)$$

$$\boxed{u_1 = V_S \cdot \frac{R_2}{R_1+R_2}}$$

Voltage Divider



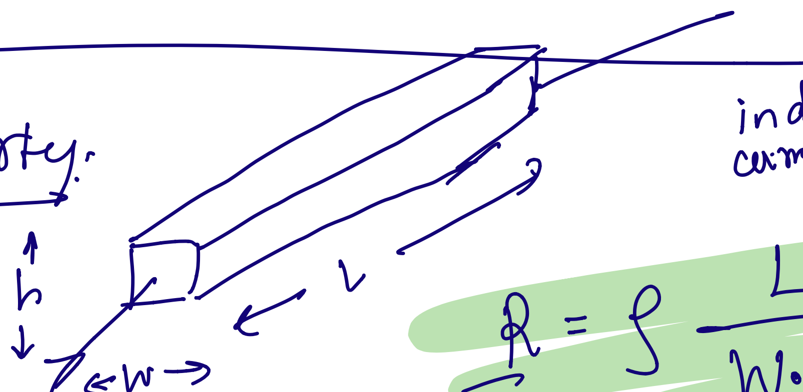


Thinking like an engineer.

Say I told you, V_{out}, V_s, $R_1 + R_2$.

$$R_2 = \frac{U_1 \, (R_1 + R_2)}{V_s}$$

Property:



$$R = \rho \frac{L}{W \cdot h}$$

in direction of current — length

height

width

resistivity.

ρ: resistivity

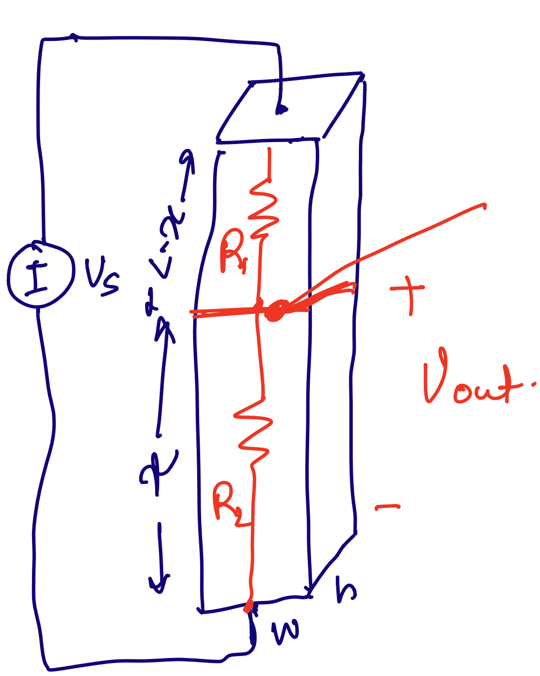
"rho"

Units: [Ωm]

Resistance is resistivity × $\frac{L}{W \cdot h}$

Resistor length: L.

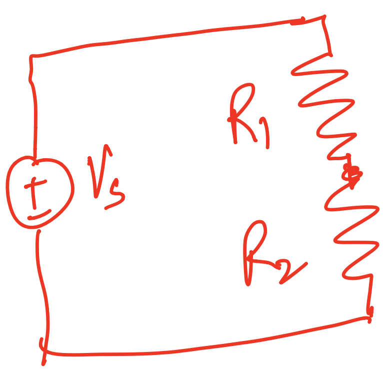
Break @ length x



$$V_{out} = V_s\left(\frac{R_2}{R_1+R_2}\right)$$

$$R_2 = \rho \cdot \frac{x}{w \cdot h}$$

$$R_1 = \rho \cdot \frac{(L-x)}{w \cdot h}$$



$$V_{out} = V_s \cdot \frac{\dfrac{\rho \cdot x}{w \cdot h}}{\rho \cdot \dfrac{L-x}{(w \cdot h)} + \rho \dfrac{x}{w \cdot h}}$$

$$V_{out} = V_s \cdot \frac{x}{L}$$

Solve for x:

$$x = \frac{L \cdot V_{out}}{V_s}.$$

x is the distance of the point at which I touch!

1D touchscreen.

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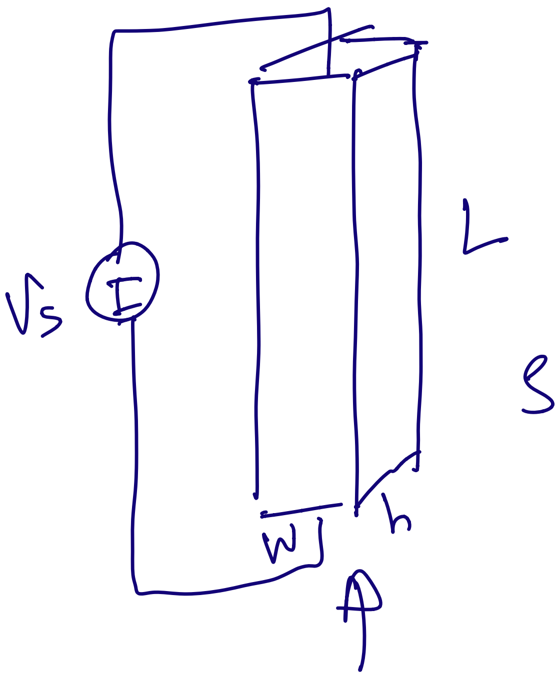
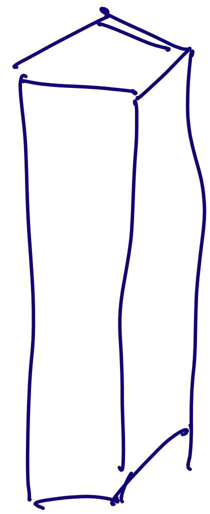
(1) Voltage V_{out} is proportional to the resistance R_2.

(2) Resistance R_2 is proportional to the length of the resistor. (x)



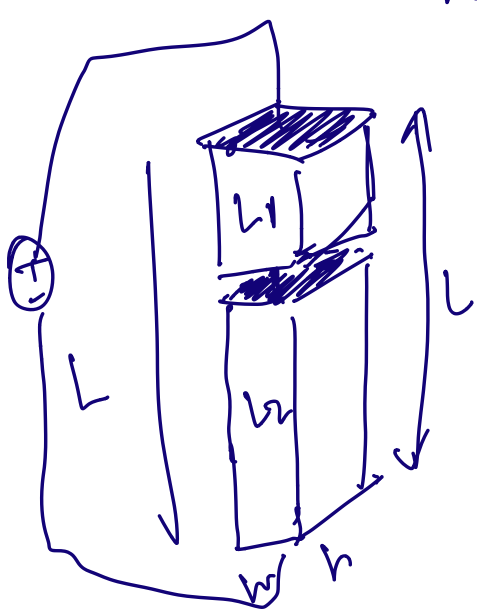


Resistance of block?

$$R = \rho \cdot \frac{L}{W \cdot h}$$

Block 1: resistivity ρ

Block 2: re… ρ

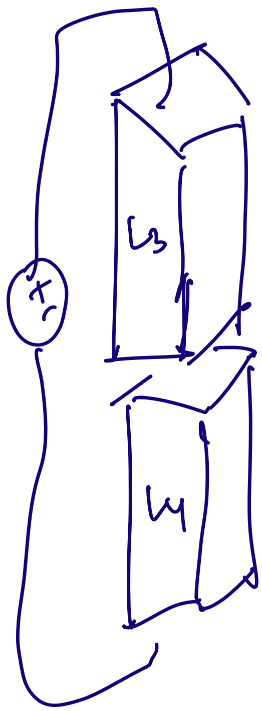


$$R = \rho \cdot \frac{L}{W \cdot h}$$

R_1 (top block)

$$= \frac{\rho \cdot L_1}{W \cdot h}$$

$$R_2 = \frac{\rho \cdot L_2}{W \cdot h}$$



$L_3 + L_4 = L$