Lecture 14 -- Post
Tuesday, July 11, 2023 4:59 PM

Lecture 5A: (7/17/23)

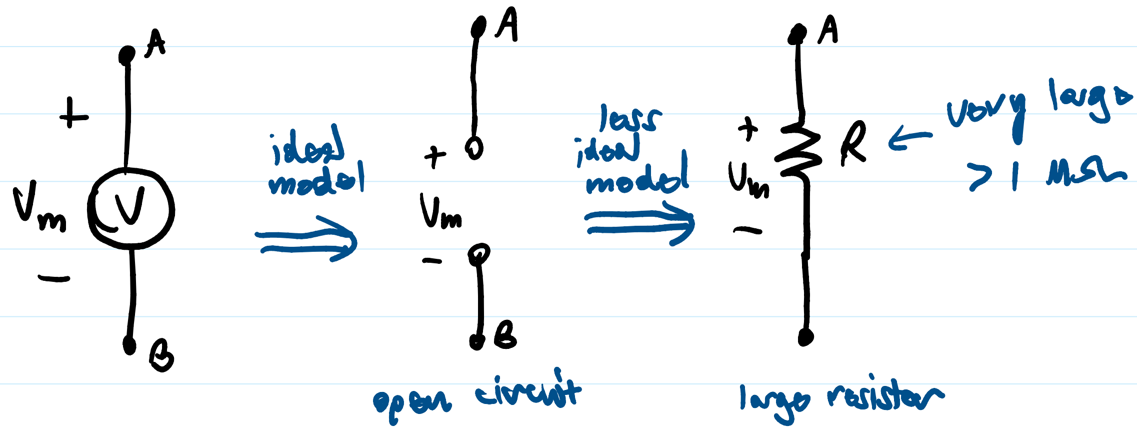
Announcements:

- Quest: grades are released. Mean: 82.1% Median: 87.3%
  - You have until Wednesday at midnight to request a regrade
- Midterm: Next Monday from 5-7pm, Dwinelle 145
- Lab - Touch 1 (Tues) and Touch 2 (Thurs)
  - Please consider moving sections
- Office Hours - Mon/Wed 1-2pm in Cory 144MA
  HW Party - Friday 10am-noon
- Today's Topics:
  - Voltage/Current Measurement (Note 13)
  - 1D Resistive Touchscreen (Note 13)
  - 2D Resistive Touchscreen (Note 14)
  - Superposition (Note 15)

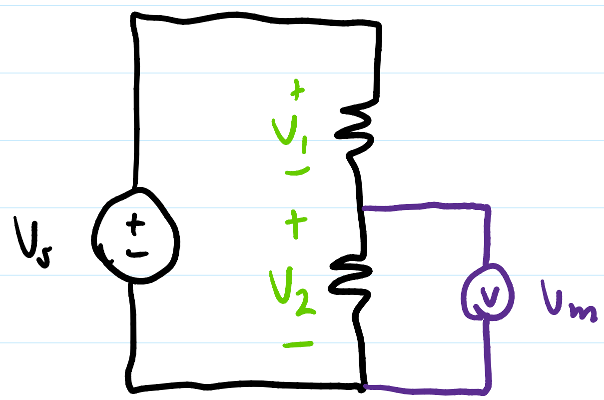
Measuring Voltage and Current

Voltmeter: device which measures voltage across it

Voltmeter: device which measures voltage <u>across</u> it



Ex).

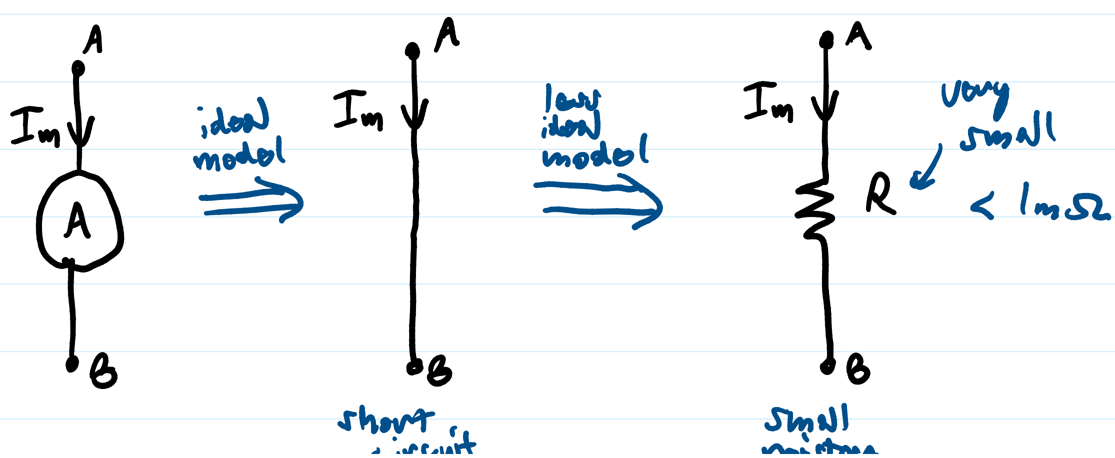


$V_m = V_2$

If voltmeter is open circuit then

$p = v \cdot \underbrace{i}_{=0} = 0$ ← no energy loss

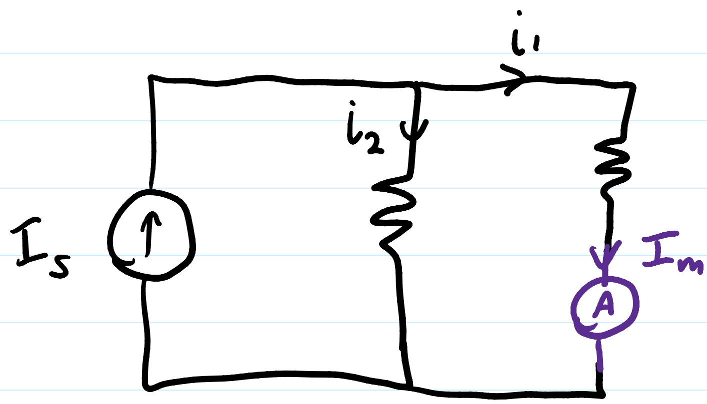
ammeter: device which measures current (amps) <u>through</u> it



• B   • B   • B

short circuit   small resistor

Ex).



$I_m = i_1$

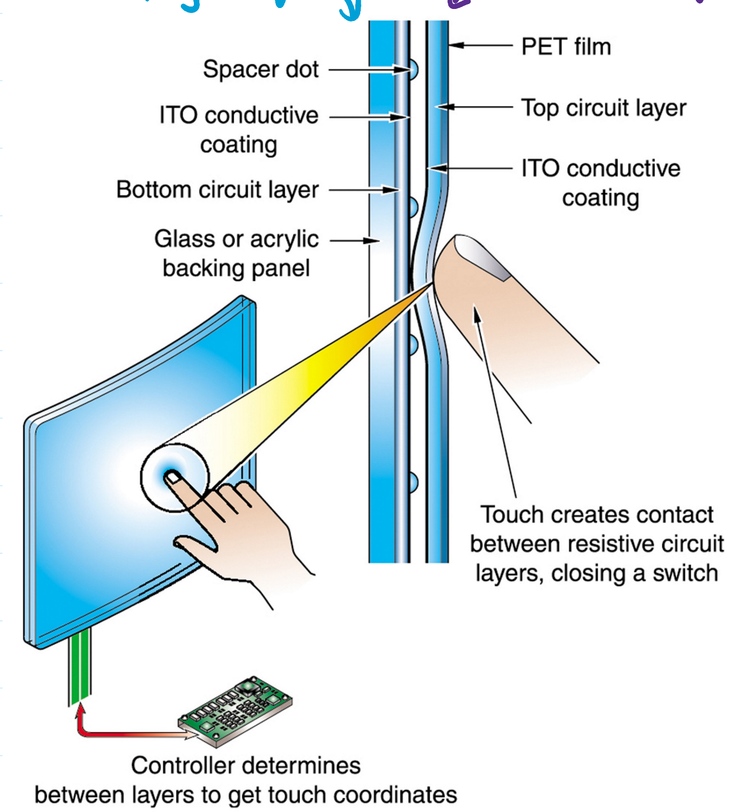
If ammeter is short circuit, then

$p = v \cdot i = 0$ ← no energy loss

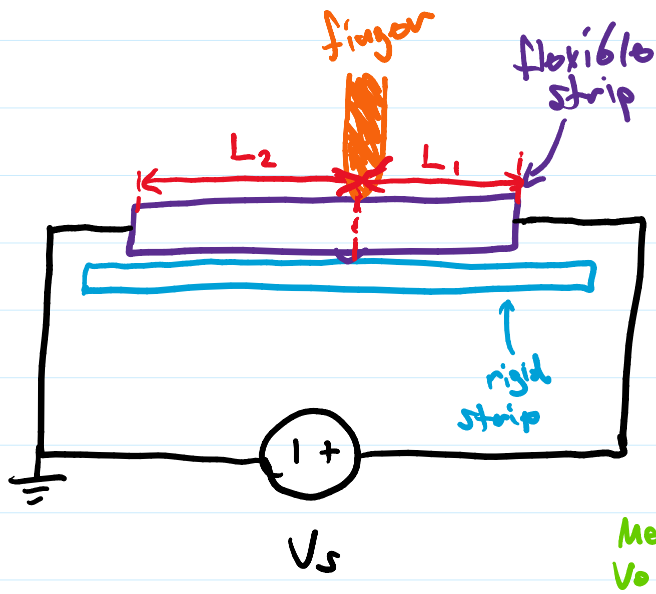
$v = 0$

1D Resistive Touch

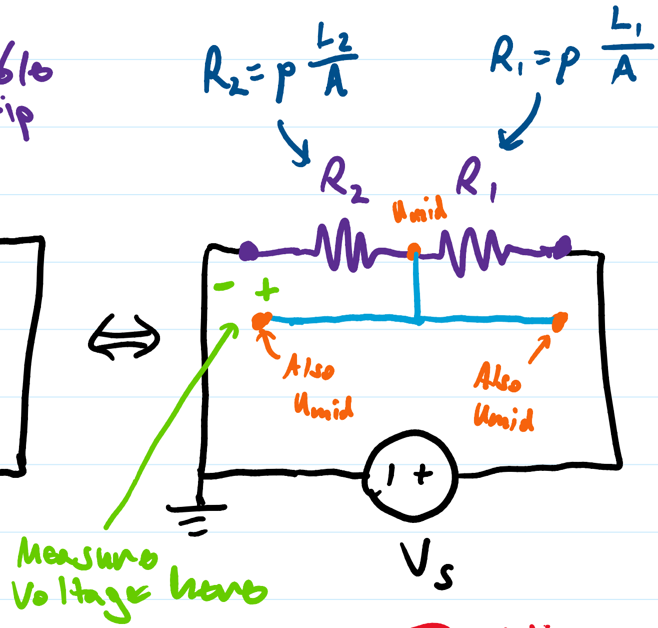
rigid layer   flexible layer



Both layers are resistive!



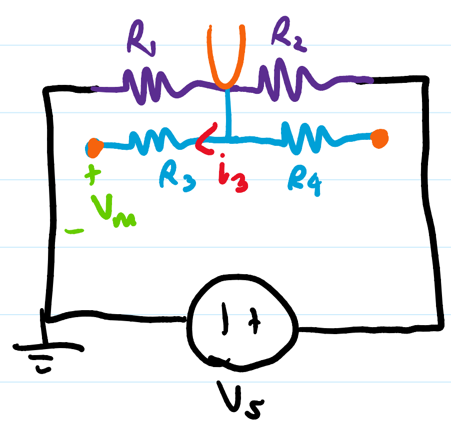
$\Leftrightarrow$



$$u_{mid} = \frac{R_2}{R_1+R_2} V_s = \frac{\left(\rho \frac{L_2}{A}\right)}{\left(\rho\frac{L_1}{A}\right)+\left(\rho\frac{L_2}{A}\right)} V_s = \frac{L_2}{L_1+L_2} V_s = \underbrace{\frac{L_2}{L_{total}}}_{\text{relative position}} V_s$$

How can we actually measure u_{mid}?

Use rigid layer ← Doesn't this have resistance too? :(



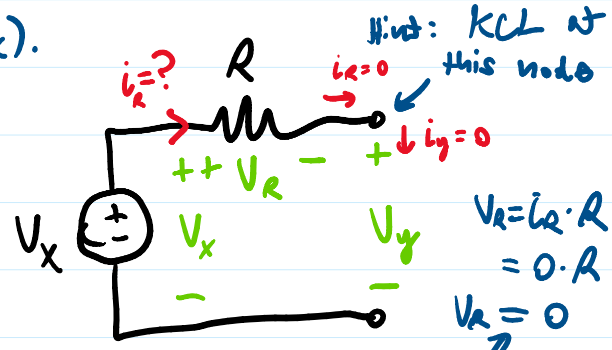
Does measured V_m change because of R_3 and R_4?

How much current flows through R_3? $i_3 = 0$!

$$\boxed{\text{Current flow requires closed loops}}$$

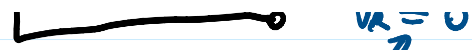
The resistance of the rigid layer is inconsequential

Ex).



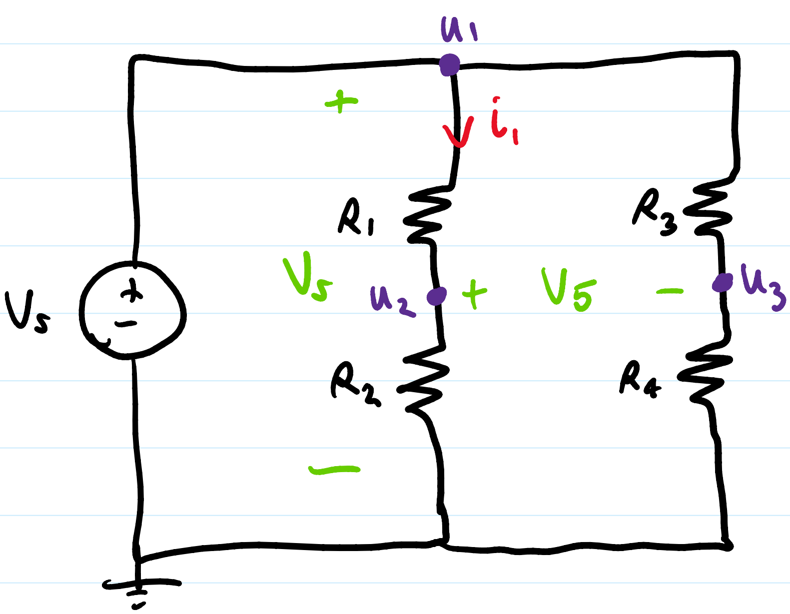
$V_R = i_R \cdot R$
$= 0 \cdot R$
$V_R = 0$
no voltage drop!

rigid layer is inconsequential



no voltage drop!

Interesting Circuit:



What is u_2?

$$u_2 = \frac{R_2}{R_1+R_2} V_s$$

Add second branch:

What is u_3?

$$u_3 = \frac{R_4}{R_3+R_4} V_s$$

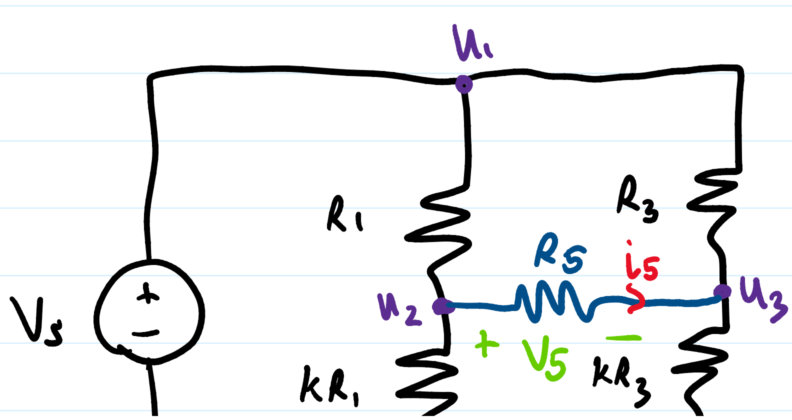
Does u_2 change?
(Does i_1 change?)

No

$$i_1 = \frac{V_s}{R_1+R_2} \qquad u_2 = i_1 \cdot R_2 = \frac{R_2}{R_1+R_2} V_s$$

If you add (or subtract) to the circuit, the circuit voltages and currents likely change. ← Need to check

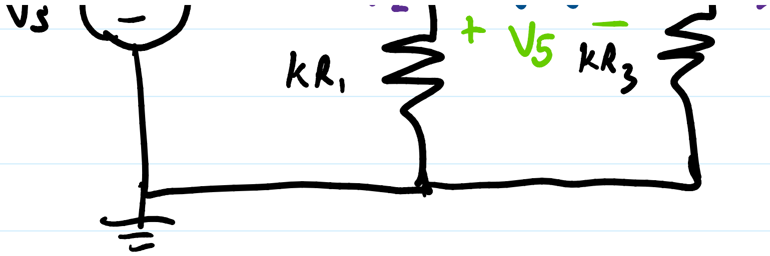
What if $R_2 = k \cdot R_1$ and $R_4 = k \cdot R_3$?



$$u_2 = \frac{kR_1}{R_1+kR_1} V_s = \boxed{\frac{k}{1+k} V_s}$$

$$u_3 = \frac{kR_3}{R_3+kR_3} V_s = \boxed{\frac{k}{1+k} V_s}$$

The same!



The same!

$$\boxed{u_2 = u_3}$$

$$i_5 = \frac{V_5}{R_5} = \frac{(u_2 - u_3)}{R_5} = 0$$

Let's add a resistor R_5 between u_2 and u_3.

What's the current through this resistor?

Foolproof way $\Rightarrow$ Perform full NVA

Sneaky way $\Rightarrow$ Do u_2 and u_3 change?

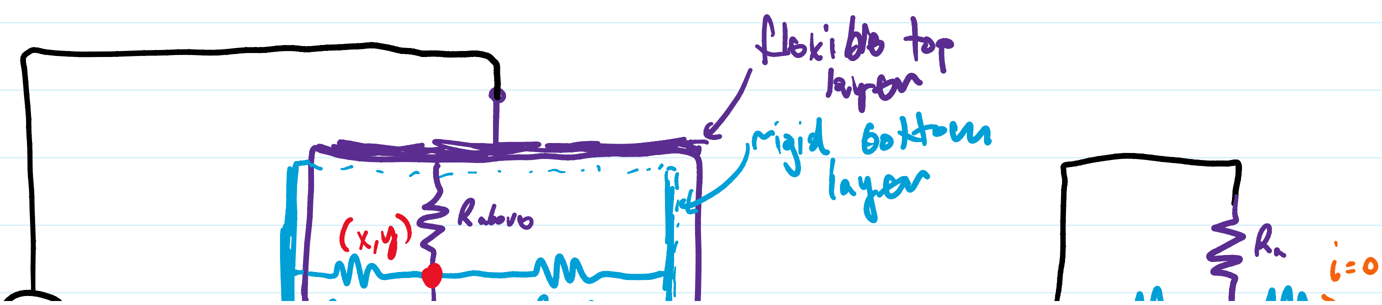
Before: $V_5 = u_2 - u_3 = 0$

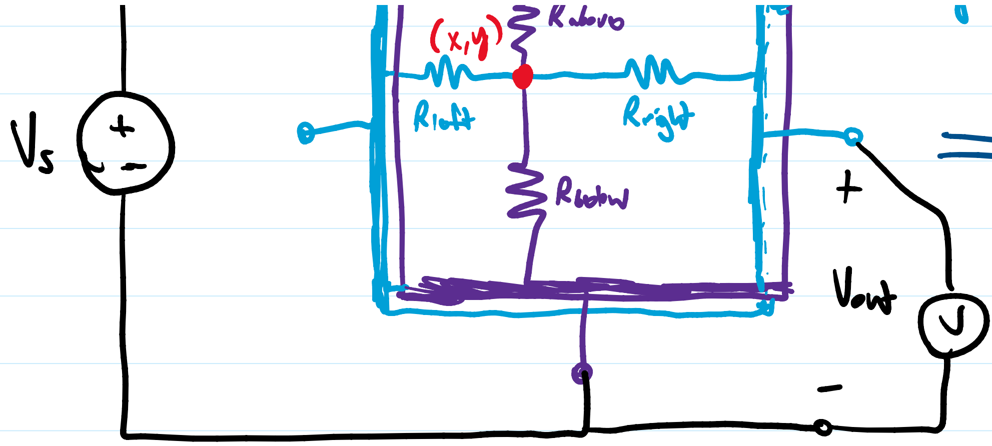
After: $V_5 = u_2 - u_3 = 0$

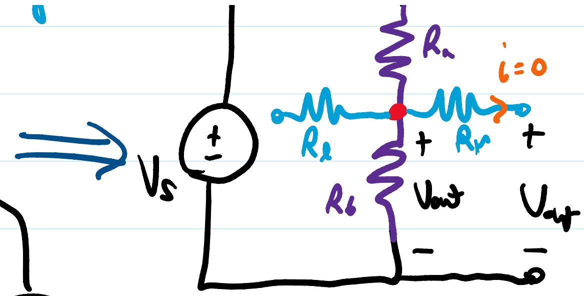
Trick: If you connect a resistor between two nodes with the same voltage, then it does not change the circuit $\leftarrow$ "virtual open circuit"

since $\underbrace{i=0}_{\text{I-V characteristic of open circuit}}$ ALWAYS

2D Resistive Touch





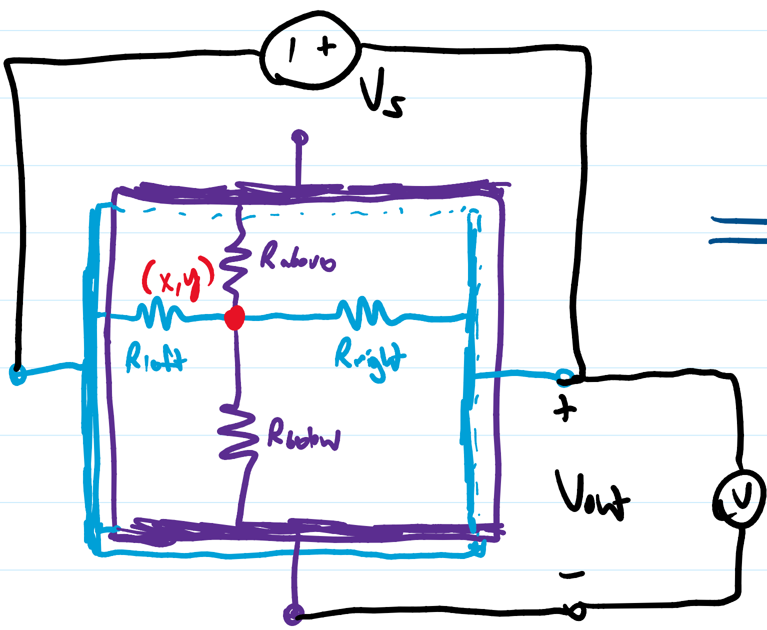


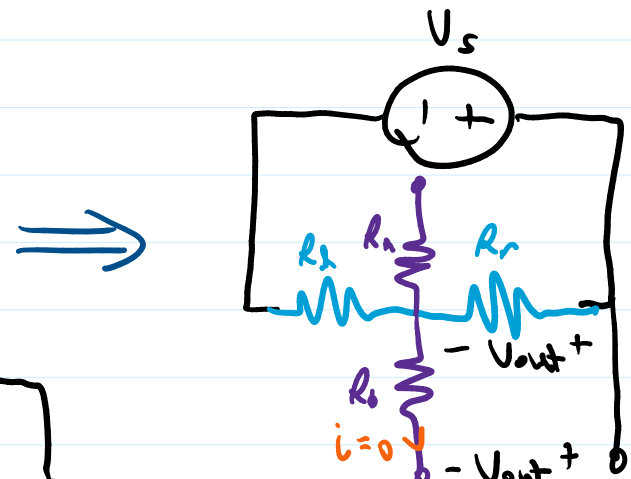
$$V_{out} = \frac{R_b}{R_a + R_b} \cdot V_s$$

known — can determine y value — known

This circuit measures vertical position.

How can we measure horizontal position?
- Connect voltage source to bottom layer.





$$V_{out} = \frac{R_r}{R_l + R_r} \cdot V_s$$

This circuit measures horizontal position

Switch between two circuits to get both x and y.