EECS16A DIS 8A

Learning Objectives

① Modeling 2-D touch screen designs (translating physical system to circuit)

ⓐ Review of what was in lecture/note 14

ⓑ New alternative design

② Resistor equivalence practice

ⓐ Identifying series

ⓑ Identifying parallel

ⓒ Voltages and currents in series and parallel

Today's playlist

① Alone - Miso

② Hi High - LOONA

③ Any Song - ZICO

Suggest @ bit.ly/16ajukebox

Other announcements

① Review sessions

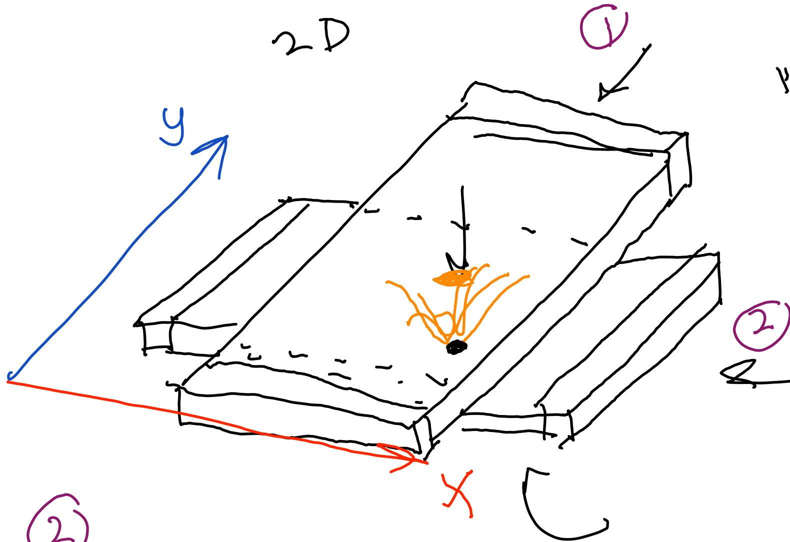
② Welcome, Ashwin + Dahlia's students

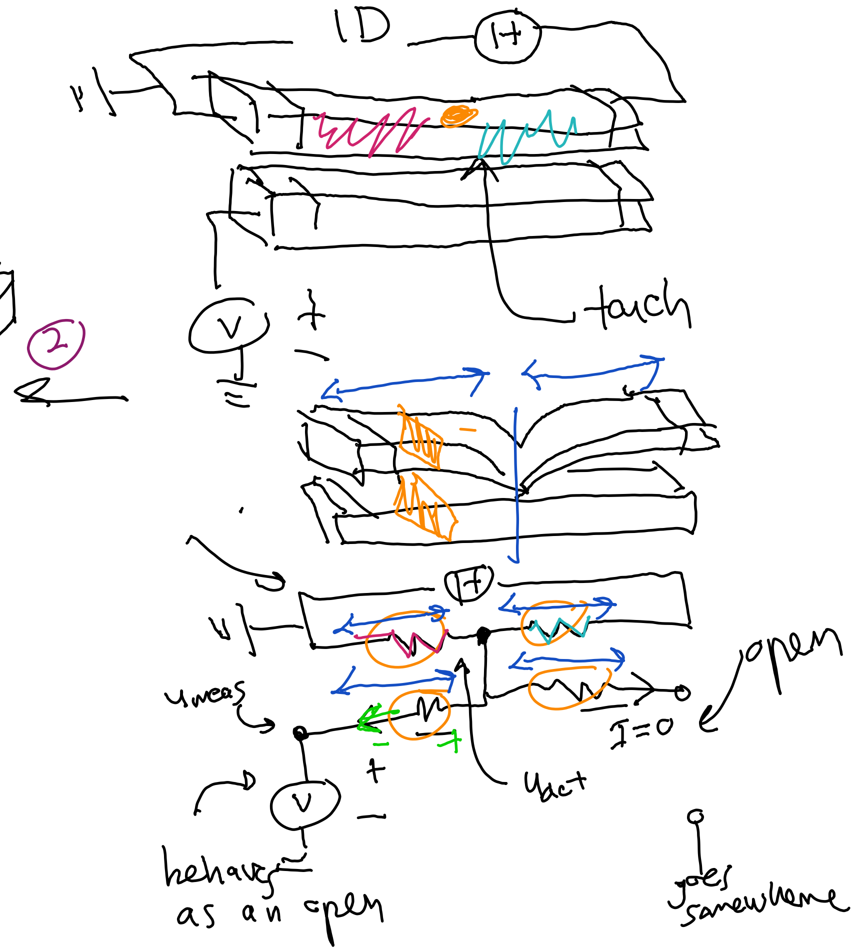
③ Korinna (ASE) will be helping out

email: moseswan@

Wednesday

HWP: 10AM-12PM PST

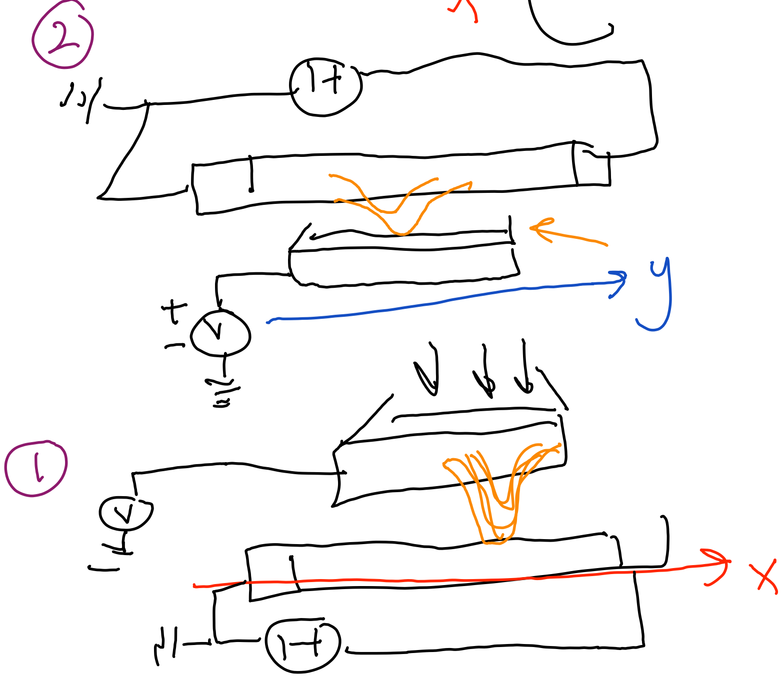


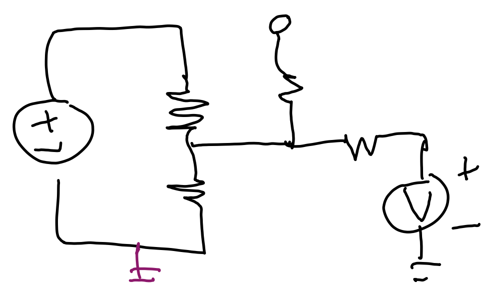


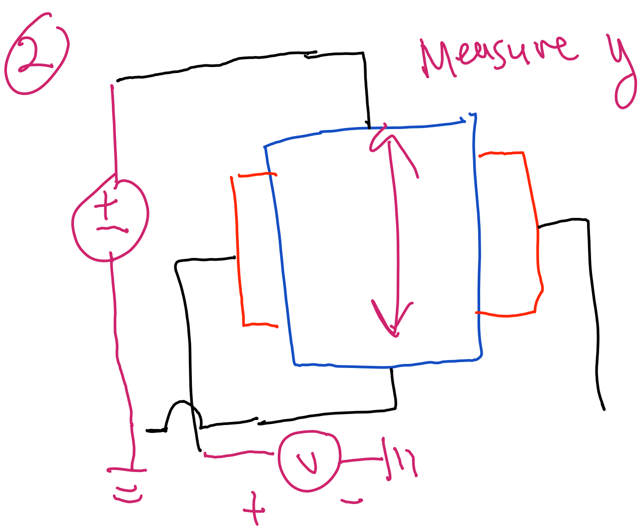
$U_{act} - U_{meas} = IR$

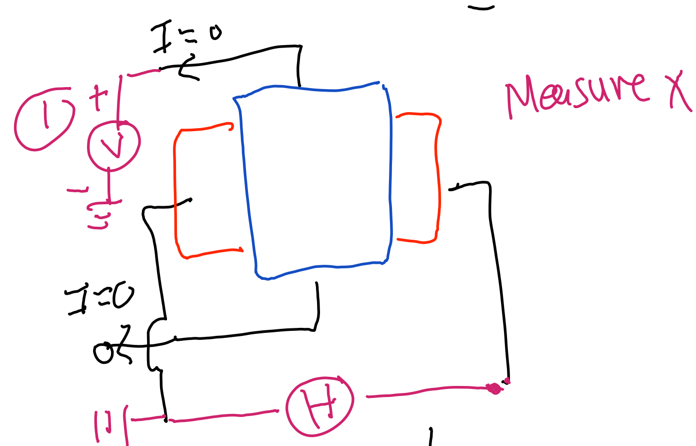
$= 0 \quad (I = 0$

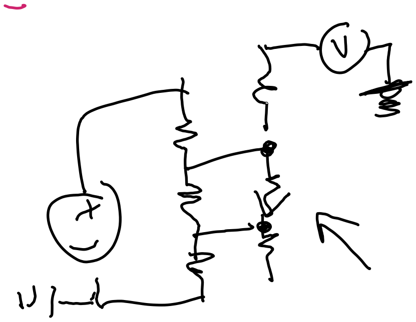
$U_{act} = U_{meas}$

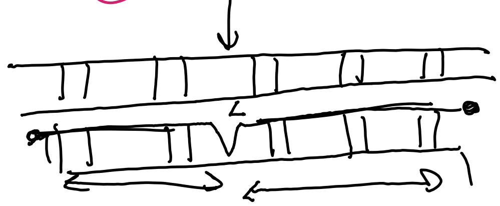


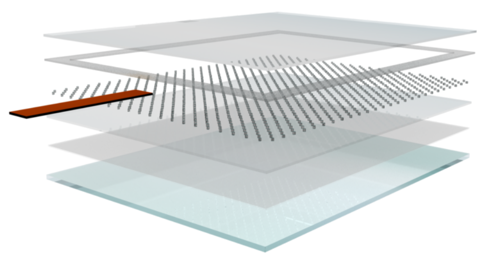








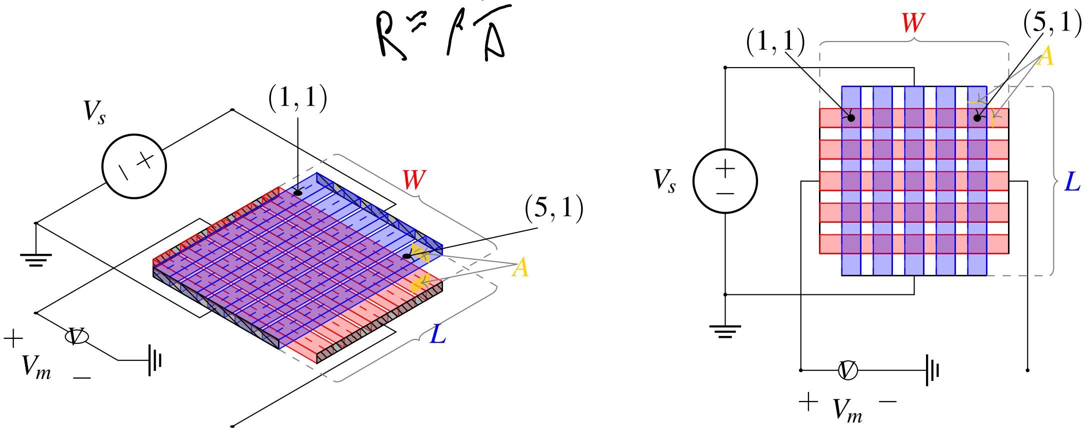



Polyester Top Circuit
Inner Adhesive Gasket
Space Dots
Polyester Bottom Circuit
Tail
Optical Adhesive
Glass

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

1. Resist the Touch

$R = \rho \frac{L}{A}$



(a) 5×5 2-D Resistive Touch Screen Oblique View (b) 5×5 2-D Resistive Touch Screen Top View

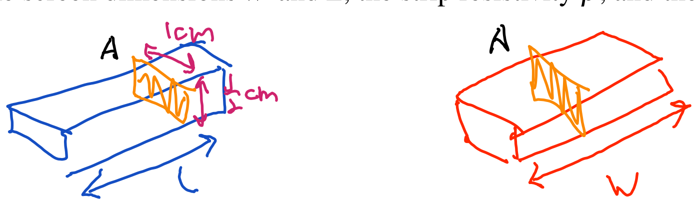
Figure 1: $N \times N$ Resistive Touch Screen, $N = 5$

In this question we will be re-examining the 2-dimensional resistive touchscreen. This touchscreen, is slightly different to the one shown in lecture and more like the one we will be examining in lab.

The touchscreen has length L and width W and is composed of a rigid bottom-layer and a flexible top-layer. Instead of a having a two continuous resistive sheets on the top and bottom layers, this is a simpler implementation with N vertical strips of conductive material in the top layer and N horizontal strips of conductive material in the bottom layer. The strips of a single layer are all connected by an ideal conducting plate on each side. All strips have resistivity, ρ, and cross-sectional area, A.

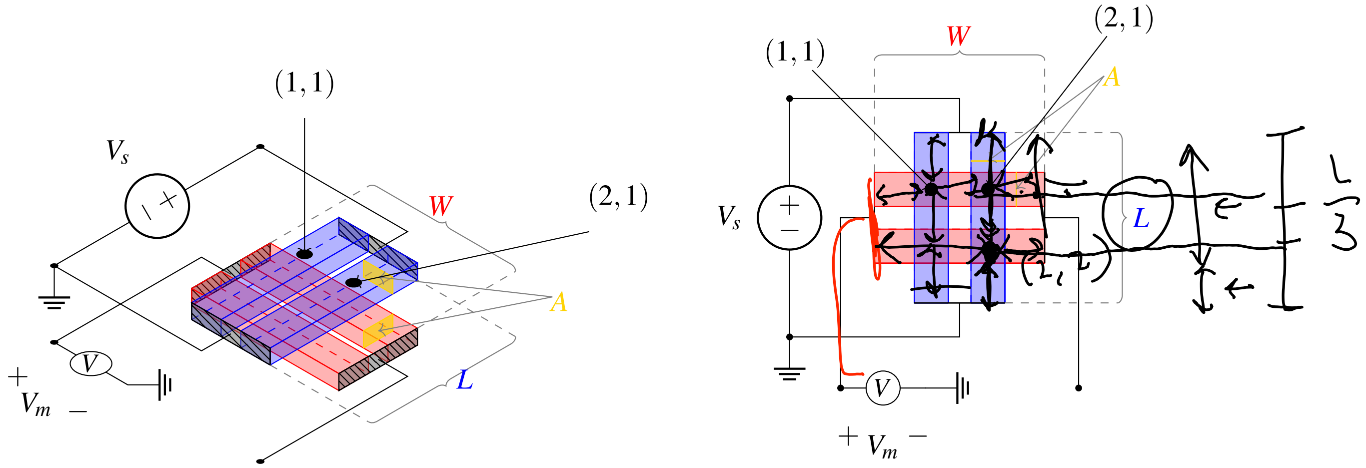
Assume that all top layer resistive strips and bottom layer resistive strips are spaced apart equally, and that the upper left touch point in Figure 1(b) is position $(1,1)$, and the upper right touch point is $(N,1)$. The spacing between the strips in the top layer is $\frac{W}{N+1}$, and the spacing between the strips in the bottom layer is $\frac{L}{N+1}$.

(a) Find the resistance R_y for a single vertical blue strip and R_x for a single horizontal red strip, as a function of the screen dimensions W and L, the strip resistivity ρ, and the cross-sectional area A.



$R_y = \rho \frac{L}{A}$ $R_x = \rho \frac{W}{A}$

$A = 1\text{cm} \cdot \frac{1}{2}\text{cm} = \frac{1}{2}\text{cm}^2$



(a) 2×2 2-D Resistive Touch Screen Oblique View

(b) 2×2 2-D Resistive Touch Screen Top View

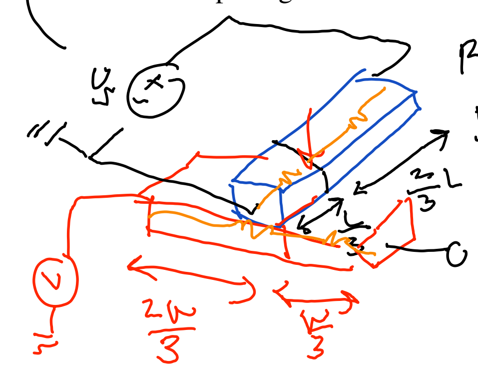
Figure 2: 2 × 2 Resistive Touch Screen

(b) Consider a 2×2 example for the touchscreen circuit, shown in Figure 2.

Assume that we connect a voltage source V_s, between the top and bottom terminals of the blue strips, and a voltmeter V_m to one of the left or right terminals as depicted in the diagram.

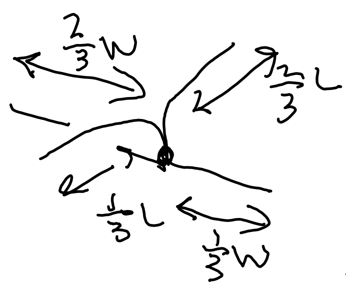
If $V_s = 3\,\text{V}$, $R_x = 2000\,\Omega$, and $R_y = 2000\,\Omega$, draw the equivalent circuit for when the point $(2,2)$ is pressed and solve for the measured voltage, V_m, with respect to ground.

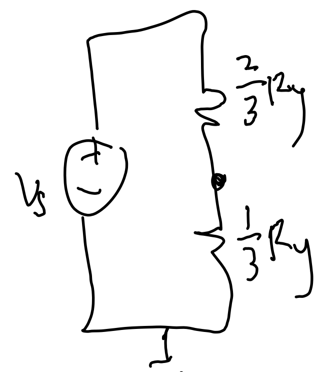
Reminder: all top layer resistive strips and bottom layer resistive strips are spaced apart equally, and that the upper left touch point is position $(1,1)$. The spacing between the strips in the top layer is $\frac{W}{N+1}$, and the spacing between the strips in the bottom layer is $\frac{L}{N+1}$.



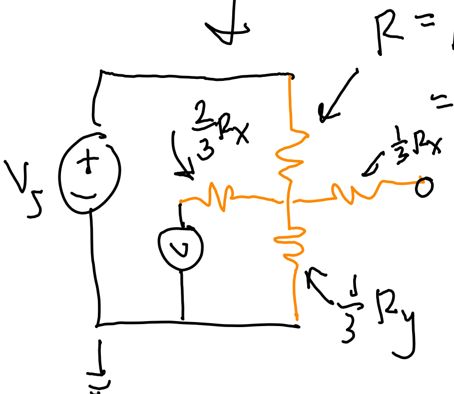
$R_y = 2k\Omega$

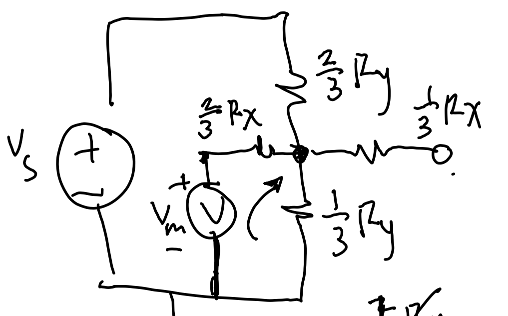
$R_x = 2k\Omega$





$R = \rho \frac{\frac{2}{3}L}{A} = \frac{2}{3}\left(\rho \frac{L}{A}\right) = \frac{2}{3} R_y$

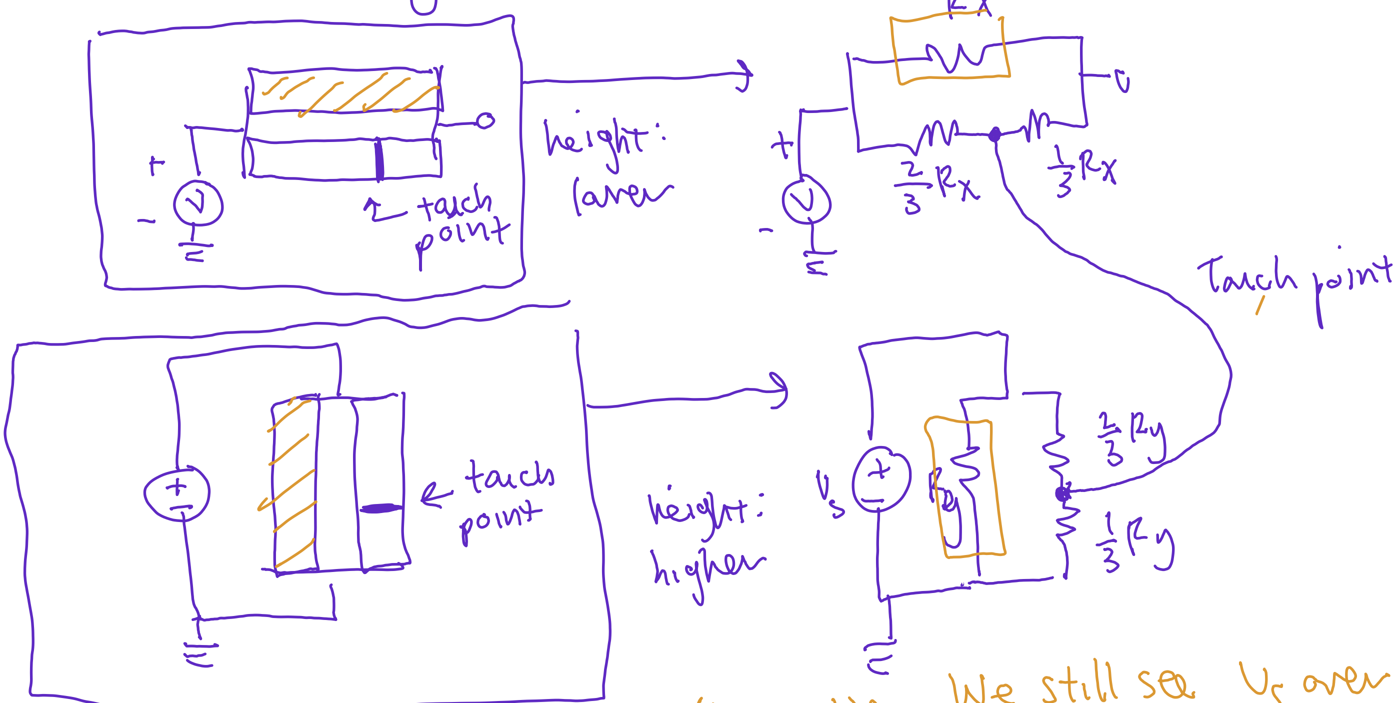




$V_m = \frac{\frac{1}{3}\cancel{R_y}}{\frac{1}{3}R_y + \frac{2}{3}R_y} V_s = \frac{\frac{1}{3}}{1} \cdot V_s = \frac{1}{3} V_s$

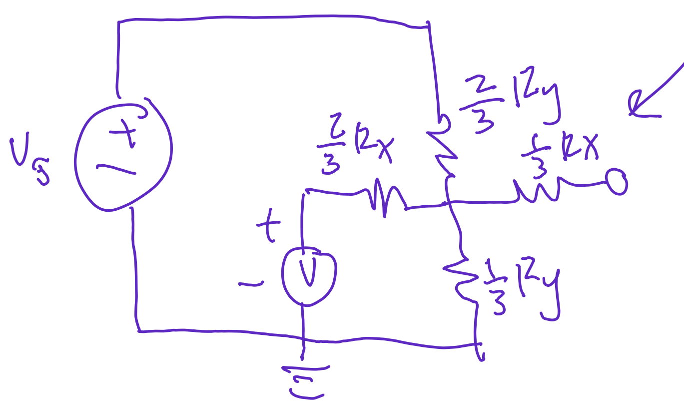
One thing that we didn't model above is the top left blue bar and the bottom top red bar.

This is the way it would appear in the diagram



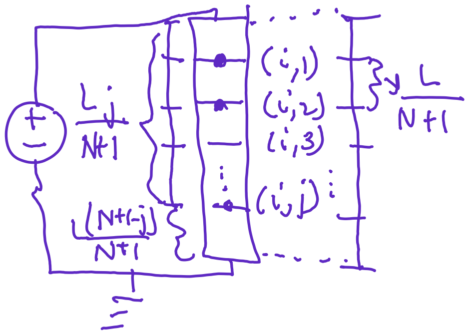
The added bars don't matter. We still see V_s over both R_y and the $\frac{2}{3}R_y + \frac{1}{3}R_y$, and no current goes through the R_x.

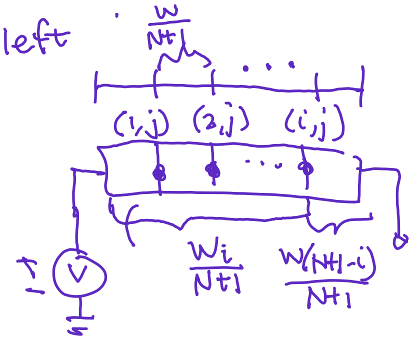
Also, note, our circuit is only setup to measure y right now. If we drop the R_x and R_y that isn't affecting us, we simply have what was shown on the previous page,



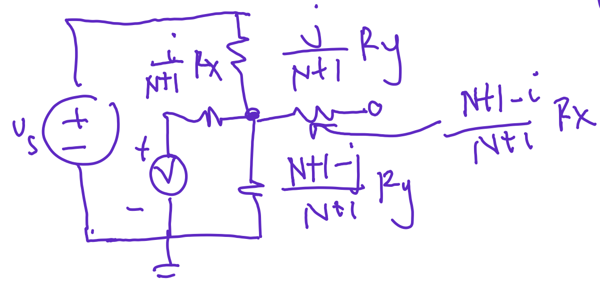
(c) Suppose a touch occurs at coordinates (i, j) for an arbitrary $N \times N$ touchscreen, and the voltage source and meter are connected as in the figures. A 5×5 example is shown in Figure 1(b). Find an expression for V_m as a function of V_s, N, i, and j. Again, the upper left corner is the coordinate $(1, 1)$ and the upper right coordinate is $(N, 1)$

i-th bar on top from left





j-th bar on bottom from top



$$V_m = \frac{\frac{N+1-j}{N+1}\cancel{R_y}}{\frac{N+1-j}{N+1}\cancel{R_y} + \frac{j}{N+1}\cancel{R_y}} V_s = \boxed{\frac{N+1-j}{N+1} V_s}$$

(only vertical dependence!)

(d) Optional / Fun: Experiment with the TinkerCad models below to validate the theoretical results you just derived.

TinkerCad model of 2 × 2 equivalent circuit: https://www.tinkercad.com/things/0wIXz3MkD7B

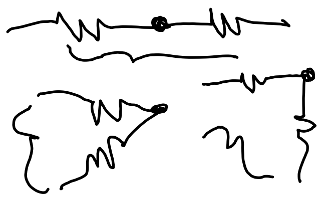
TinkerCad model of 3 × 2 equivalent circuit: https://www.tinkercad.com/things/k5oolj2tUEN

Falstad + Tinkercad are great!
They can help you verify your analysis!

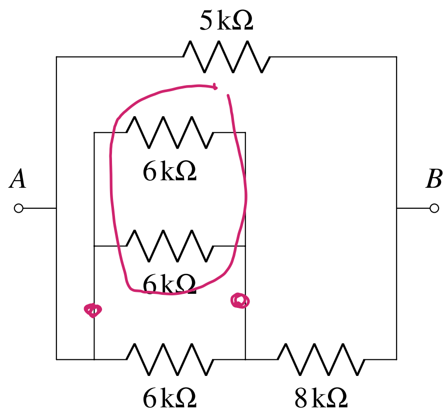
2. Practice: Series and Parallel Combinations

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

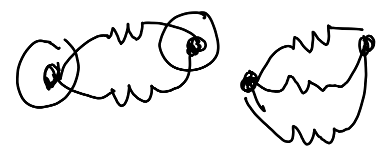
① series: two components share a single node, nothing else on it



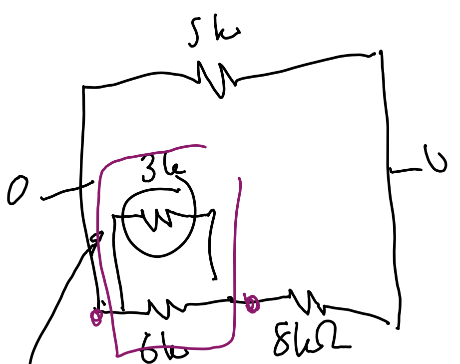
$R_{eq} = R_1 + R_2$



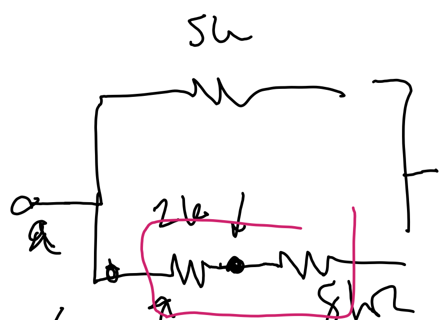
② Parallel: two resistors are in parallel if they share the same pair of nodes



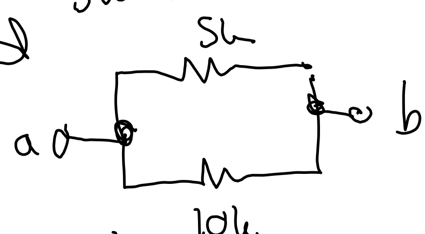
$R_1 || R_2 = \frac{R_1 R_2}{R_1 + R_2}$

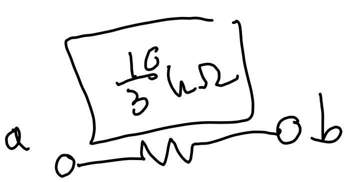


$\frac{6k \cdot 6k}{6k + 6k} = \frac{36k}{12} = 3k$



$\frac{3k \cdot 6k}{3k + 6k} = \frac{18k}{9} = 2k$





$\frac{5k \cdot 10k}{5k + 10k} = \frac{50}{15} k$

Example