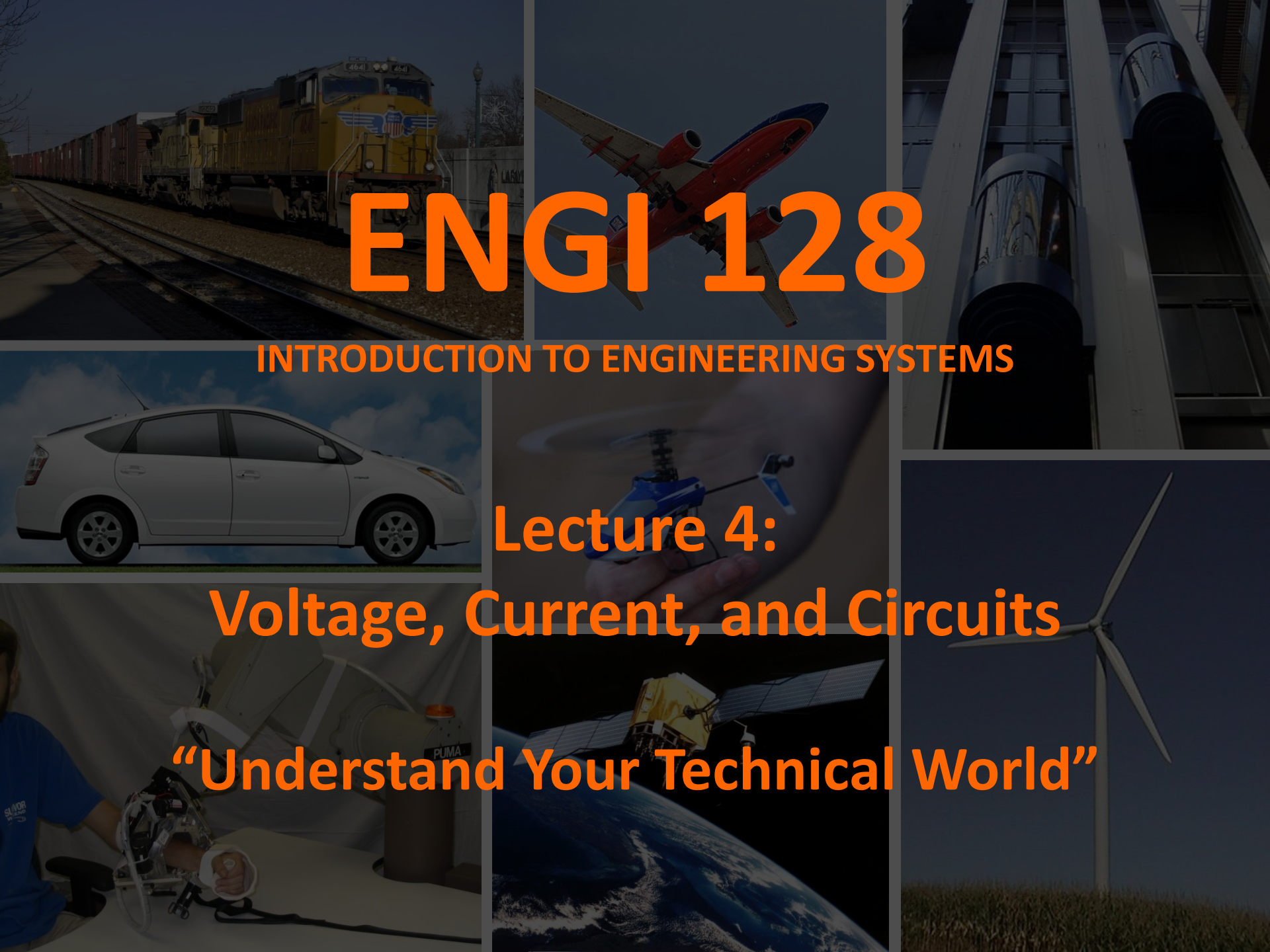


ENGI 128

INTRODUCTION TO ENGINEERING SYSTEMS

Lecture 4:
Voltage, Current, and Circuits

“Understand Your Technical World”

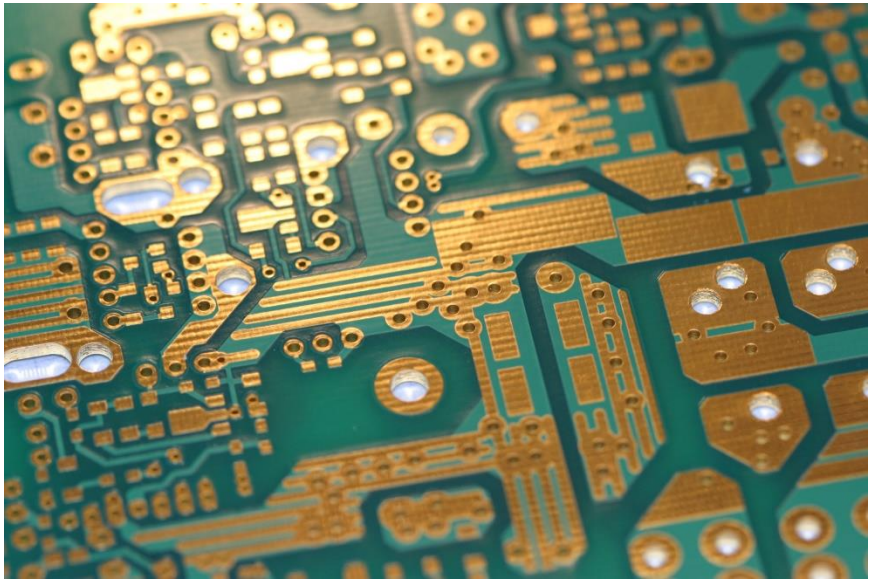
Welcome to Electrical Engineering!

We will start our study of electrical engineering with its two most basic concepts: voltage and current.

We'll introduce the most popular element in electricity, the resistor

We'll then move to the simplest possible circuit, the voltage divider.

Finally, we'll go over some measurement techniques that you will need next week.



Voltage & Current

Well, what are they?

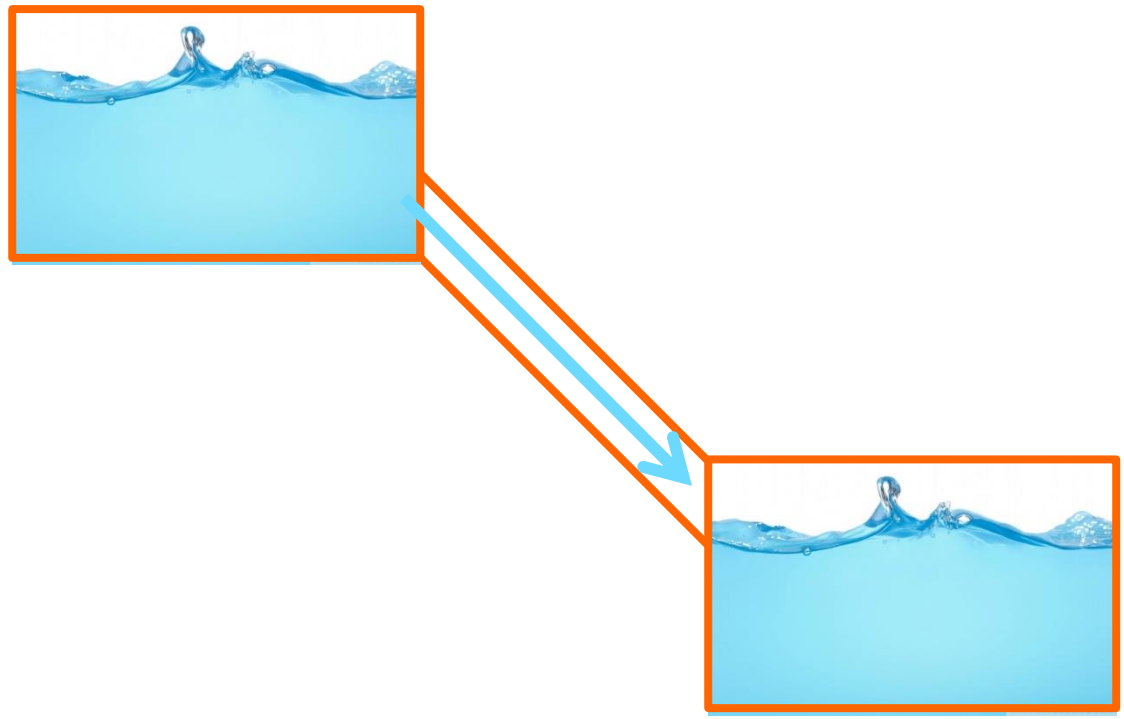
Voltage = Electrical potential energy (the ability to do work)

Current = Flow of electricity (work being done)

Voltage fun facts:

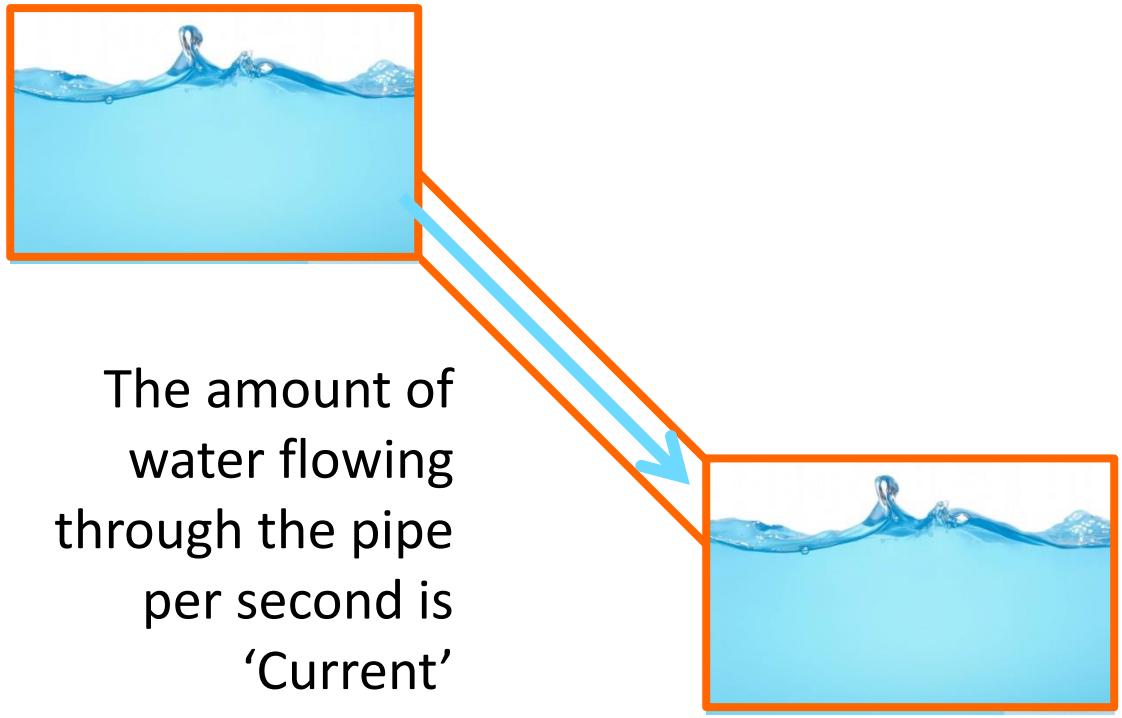
- Voltage is the *difference* in electrical potential energy
- Therefore, voltage must be measured between two points
- Every system has some reference voltage that we define as 0. This is also called *ground.*
- In this class, voltages are all measured relative to ground

The difference between these two containers is the 'Voltage' of the water



Current fun facts:

- Current is the flow of electrons
- Current only flows from high voltage to low voltage
- Current requires a voltage, but not the other way around
- Current cannot leave a circuit, it must be *conserved*
- Current is *pulled* not *pushed*



The amount of water flowing through the pipe per second is 'Current'

[current and voltage demo]

How do you get the electrons off of the ground?

Current can't flow without a way to get back home

- You have to add energy to the electrons to increase their voltage

This creates a *circuit*

- All the electricity we will look at and talk about is in a circuit
- A circuit is a closed system of electrons:

This means that we never lose any electrons

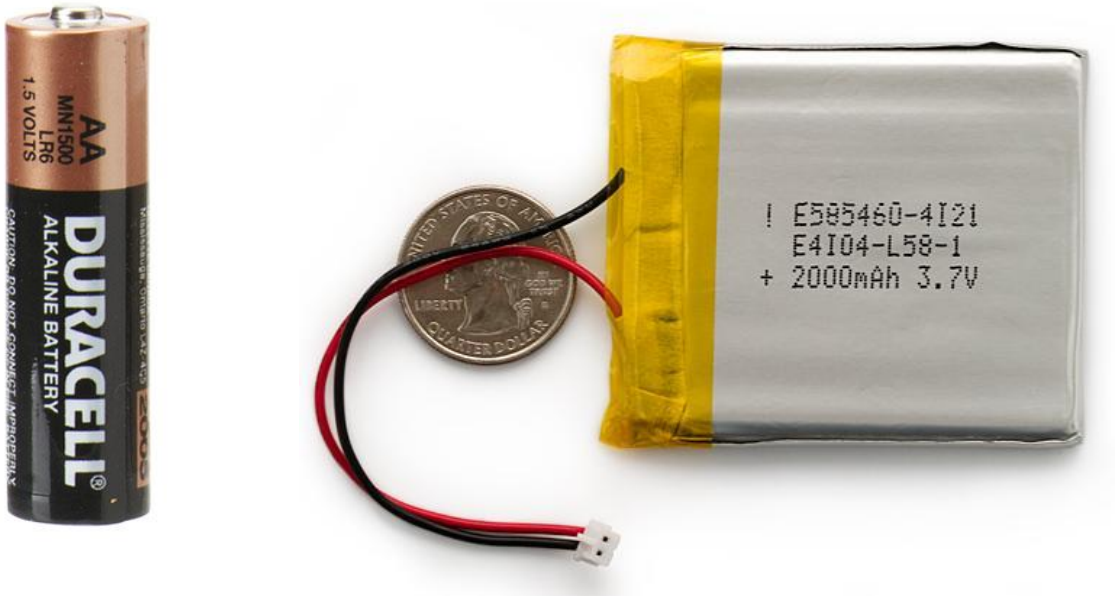
- This means that you can't push electrons down a open-ended wire
- There needs to be a path to get back to home
- If you want the circuit to run more than once, you need to get voltage back into the electrons

Power Supplies

Where do we get voltage and current from?

Batteries

What else?



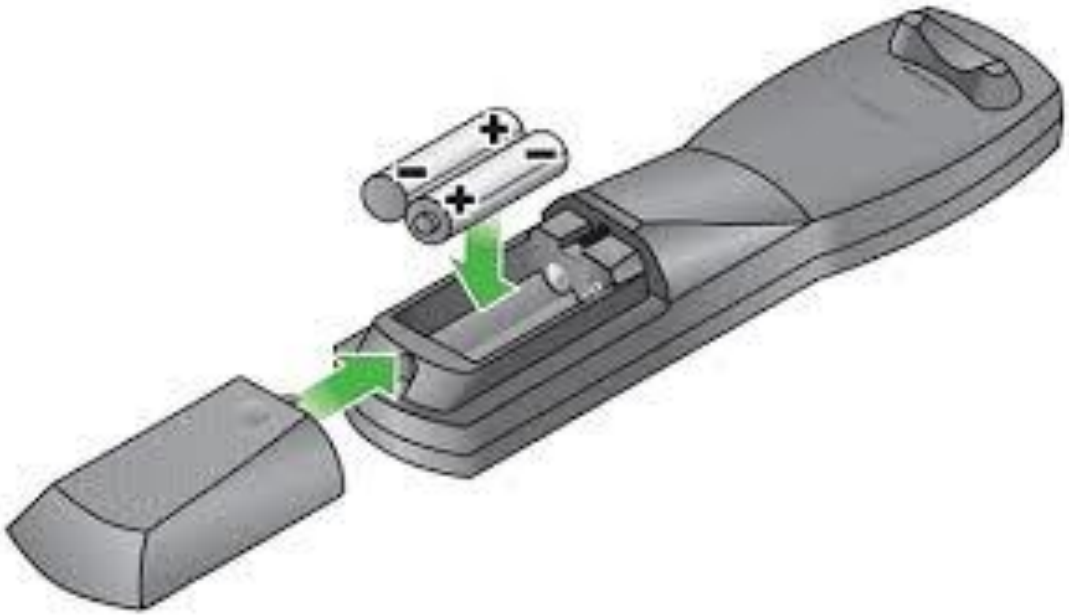
Why all the batteries?

But why does everything use more than one battery?

a. To have more energy

b. To have more voltage

c. To have more current



Adding Voltage: Multiple batteries

Putting batteries in *series:*

Putting batteries in *parallel*:

Resistors

Resistors

Resistors impede the flow of current

So why in the world would you ever use them?

- Because as current flows through them, it creates a *voltage drop* across the resistor
- This change in voltage can be useful.

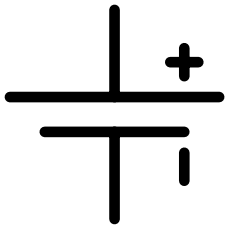
And this brings us to our only equation in this module, Ohm's law:

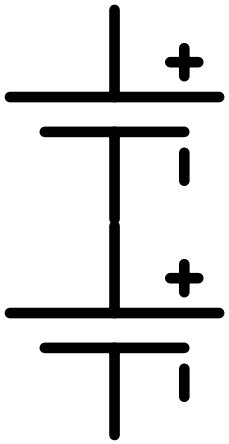
- voltage = current · resistance
- V = I R

Schematics

Schematic Symbols

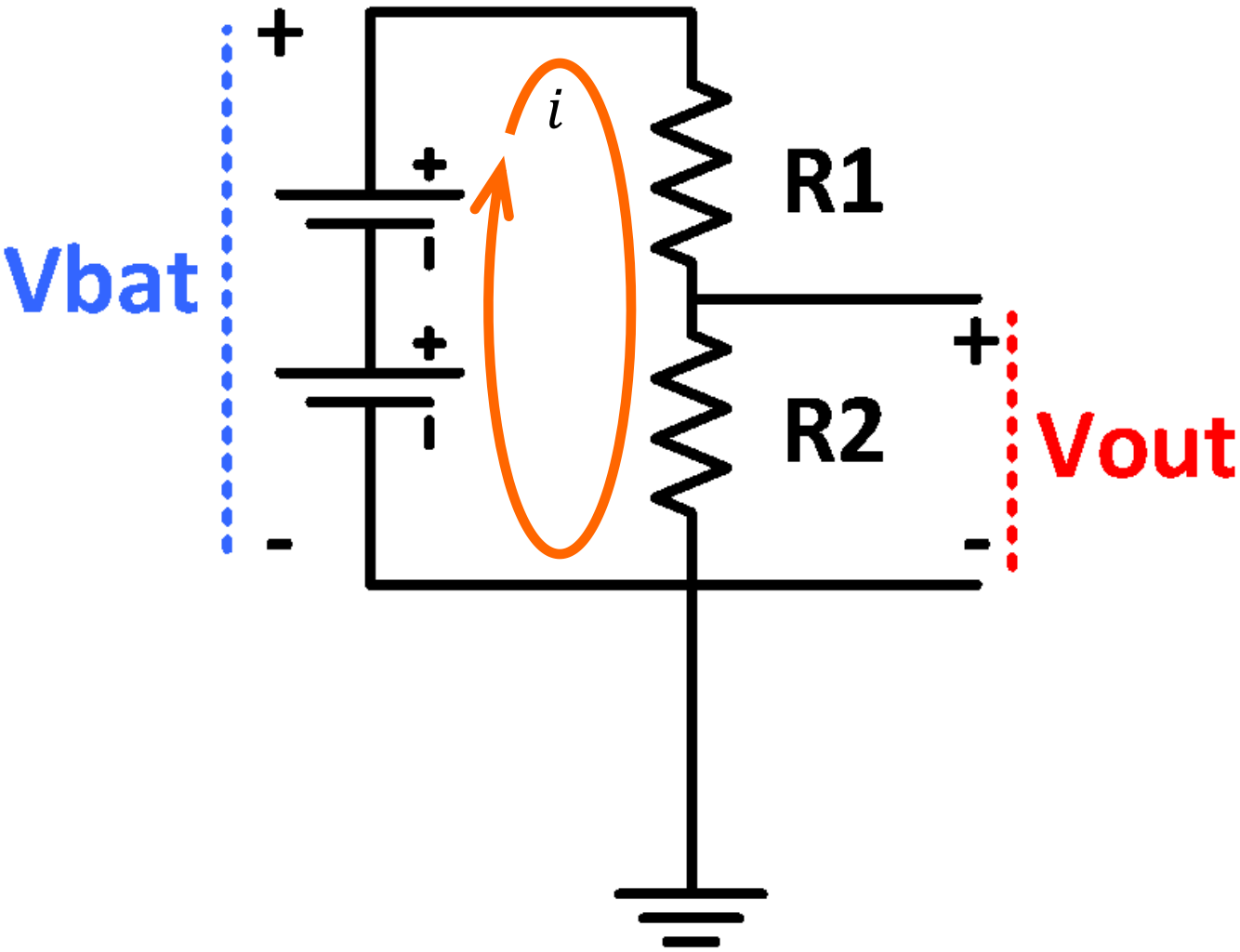
Drawing is hard





A Schematic Diagram: The Voltage Divider

Single most useful circuit on the planet:



The Voltage Divider

[show r-one schematics
resistors & voltage dividers]

Voltage Divider Math

Ohm's Law

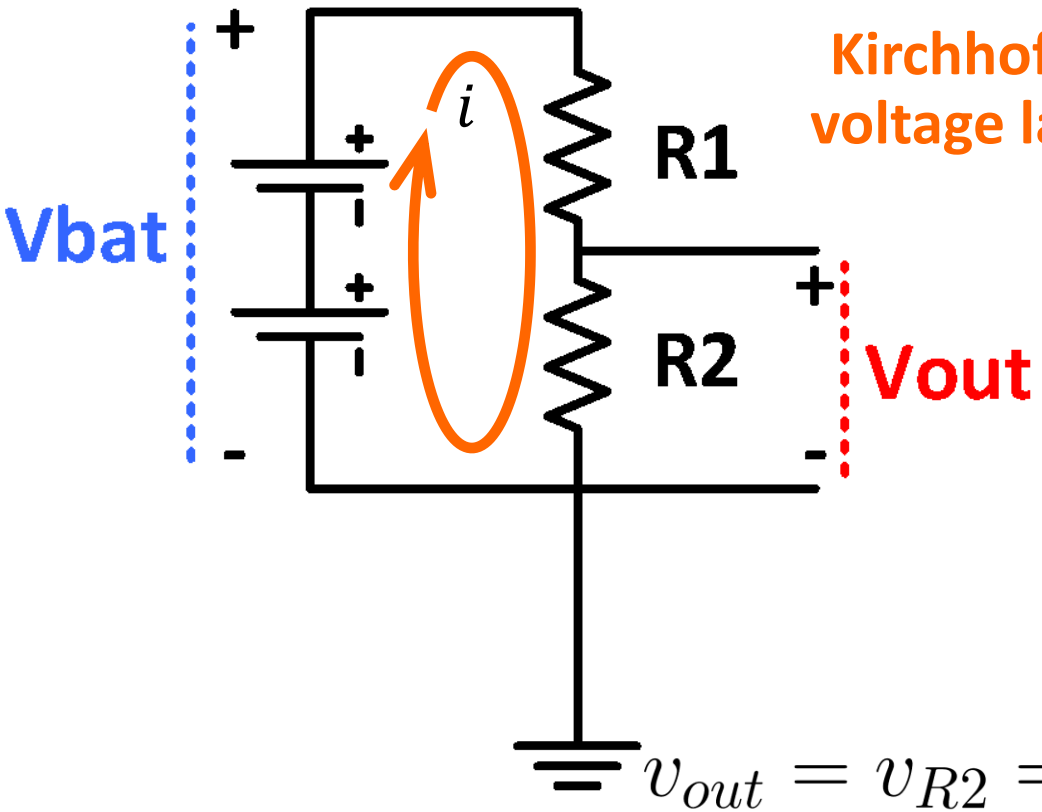
$$v = ir$$
$$v_{R1} = i_{R1} \cdot R1$$
$$v_{R2} = i_{R2} \cdot R2$$

Conservation of current

$$i_{R1} = i_{R2} = i_{bat} = i$$

Kirchhoff's voltage law

$$v_{out} = v_{R2}$$
$$v_{bat} = v_{R1} + v_{R2}$$



$$v_{bat} = i \cdot R1 + i \cdot R2$$
$$v_{bat} = i(R1 + R2)$$
$$i = \frac{v_{bat}}{R1 + R2}$$

$$v_{out} = v_{R2} = i \cdot R2 = \boxed{v_{bat} \frac{R2}{R1 + R2}}$$

[show r-one schematics and highlight voltage dividers]

Taking Electrical Measurements

The Multimeter

OK, all together now:

- Measuring voltage
- Measuring resistance

[multimeter examples]