ENGI 128

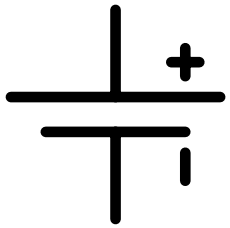
INTRODUCTION TO ENGINEERING SYSTEMS

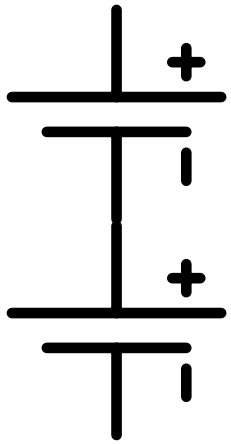
Lecture 5:
Voltage Dividers and
Non-Linear Elements: LEDs

"Understand Your Technical World"

Schematics

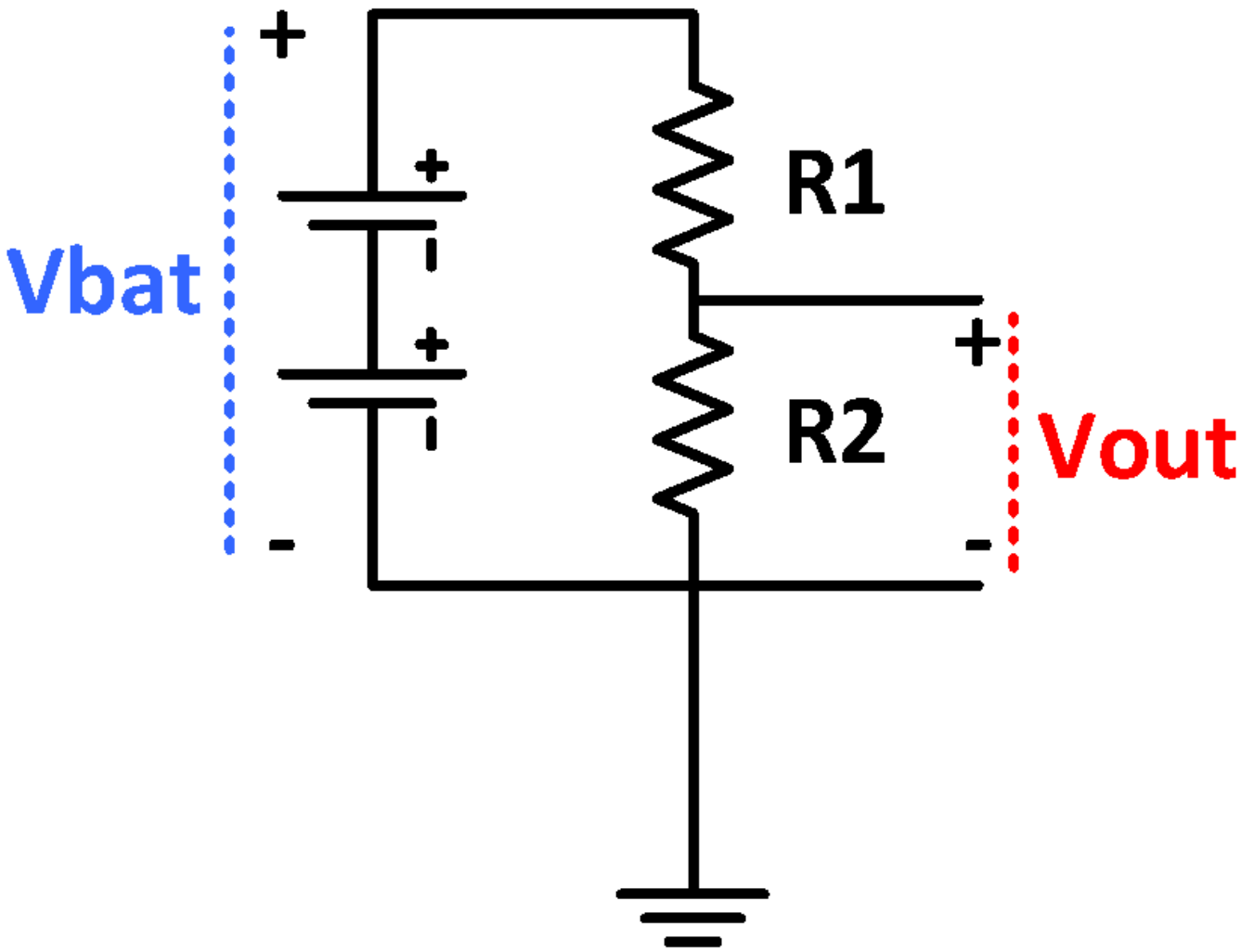
Schematic Symbols





A Schematic Diagram: The Voltage Divider

Single most useful circuit on the planet:



The Voltage Divider

Voltage Divider Math

Ohm's Law

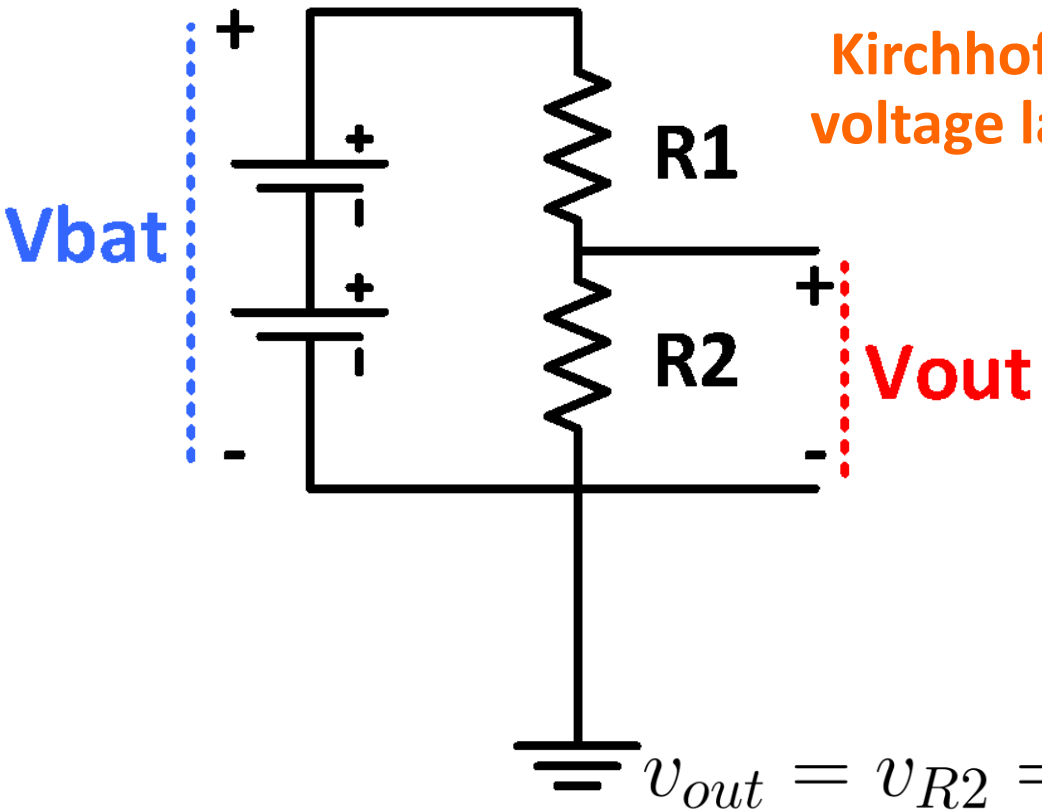
$$v = ir$$
$$v_{R1} = i_{R1} \cdot R1$$
$$v_{R2} = i_{R2} \cdot R2$$

Conservation of current

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

Kirchhoff's voltage law

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



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

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

Non-Linear Elements

Non-What?

What does “non-linear” mean?

Why does it make our lives difficult?

The Humble LED

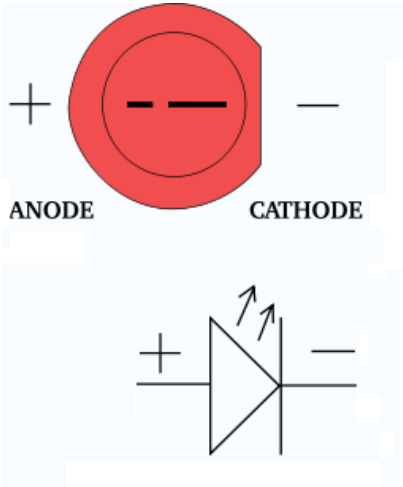
LED = Light-Emitting Diode

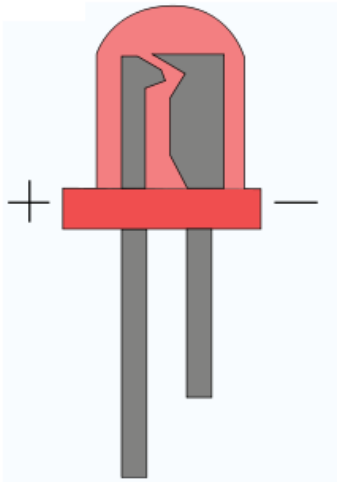
- They are used everywhere, in almost everything.

Wait, what's a Diode?

The Diode

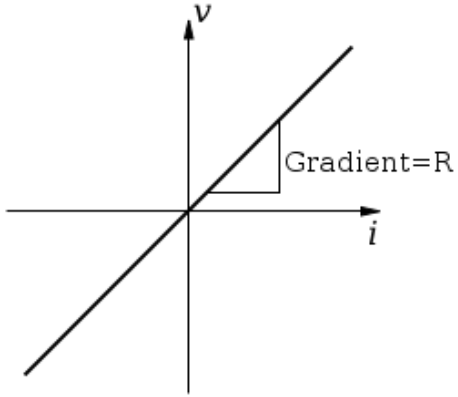
A diode only lets current flow in one direction





Ok, so what makes a LED non-linear?

$$i = \frac{v}{r}$$

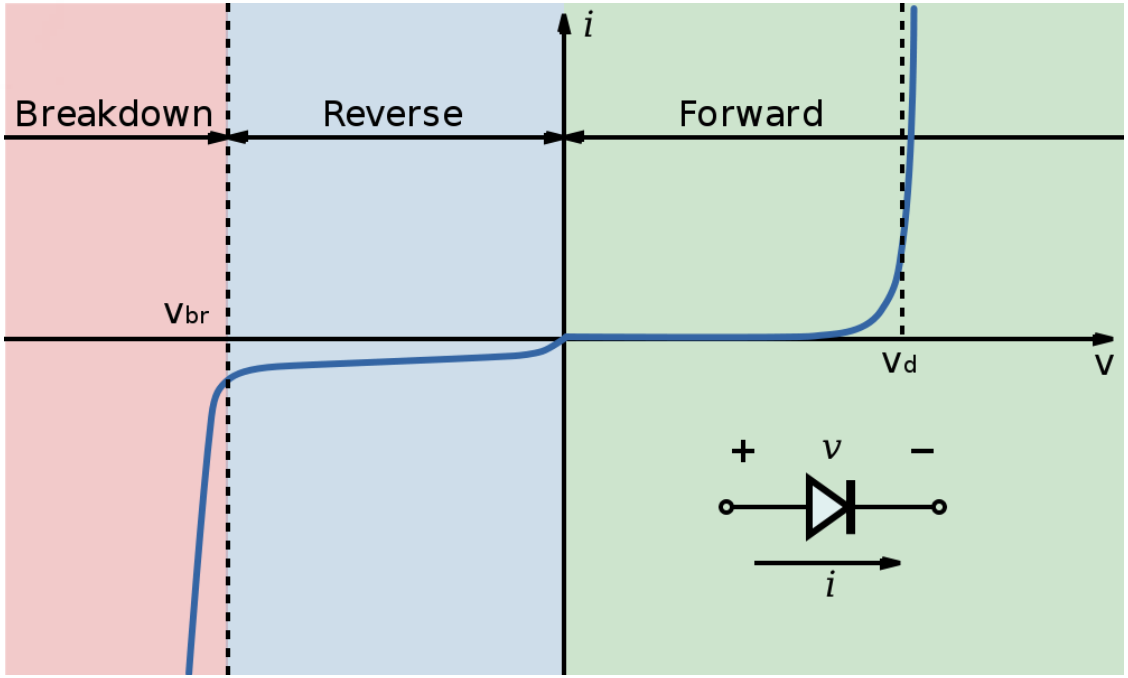


$$i = i_s(e^{V_D/(nV_T)} - 1), V_T = \frac{kT}{q}$$

oh…

The Diode Equation

$$i = i_s(e^{V_D/(nV_T)} - 1), V_T = \frac{kT}{q}$$



If Vd = 0.8v, how much current flows for a voltage of 3.3v?

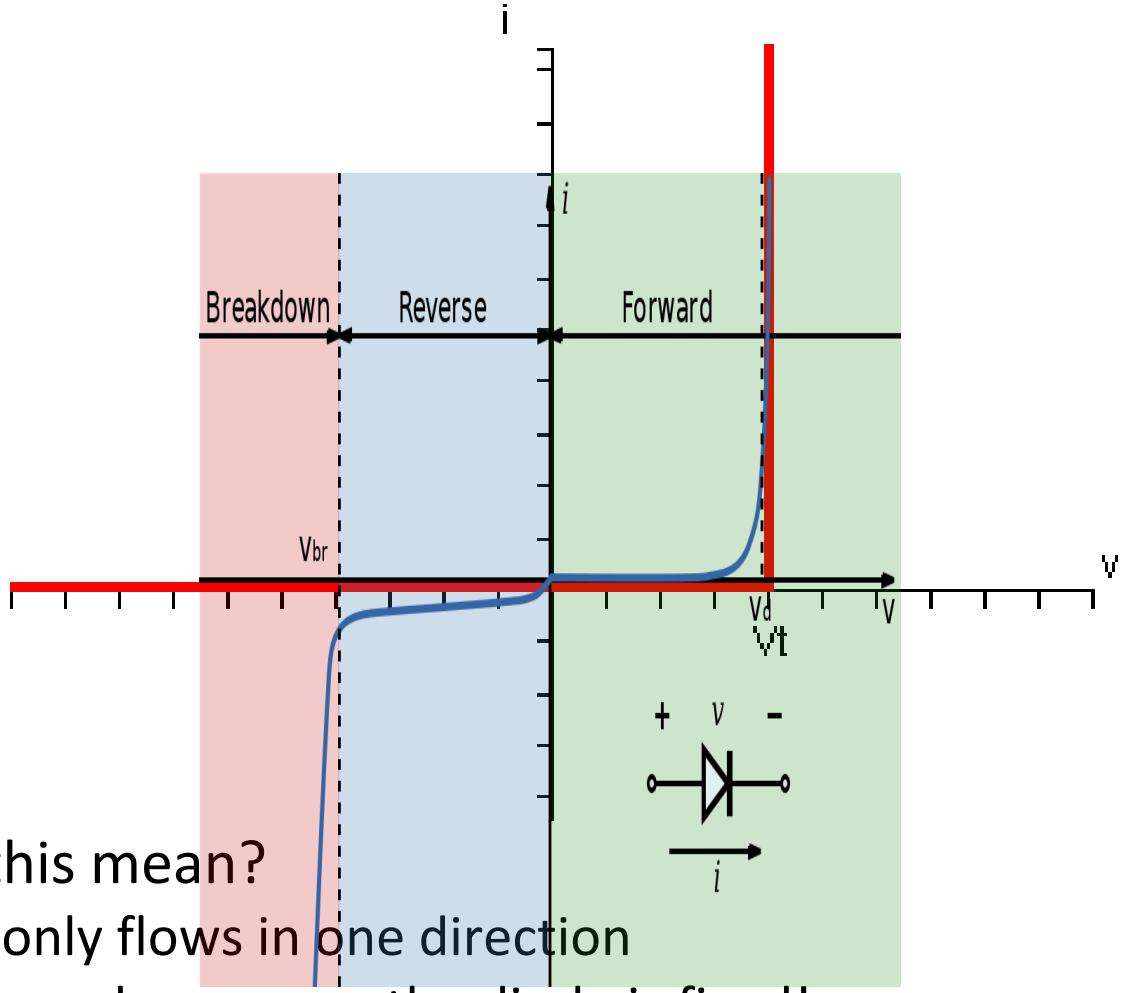
This looks complicated…

Working with Non-Linear Elements, Part I

How can we get a grip on this equation in a circuit?

- Simplify the non-linearity:

The Simplified Diode Model



What does this mean?

- Current only flows in one direction
- The voltage drop across the diode is fixed!
- We lose Vt volts across the diode, no matter how much current flows

If Vt = 0.8v, how much current flows for a voltage of 1.0v or 3.3v?

Working with Non-Linear Elements, Part II

How can we get a grip on this equation in a circuit?

- Simplify the non-linearity
- We will use the fixed voltage drop

Use a linear element to cope with this non-linear element

- A resistor can be a current limiter?

[whiteboard]

Now, how much current flows for a voltage of 3.3v?

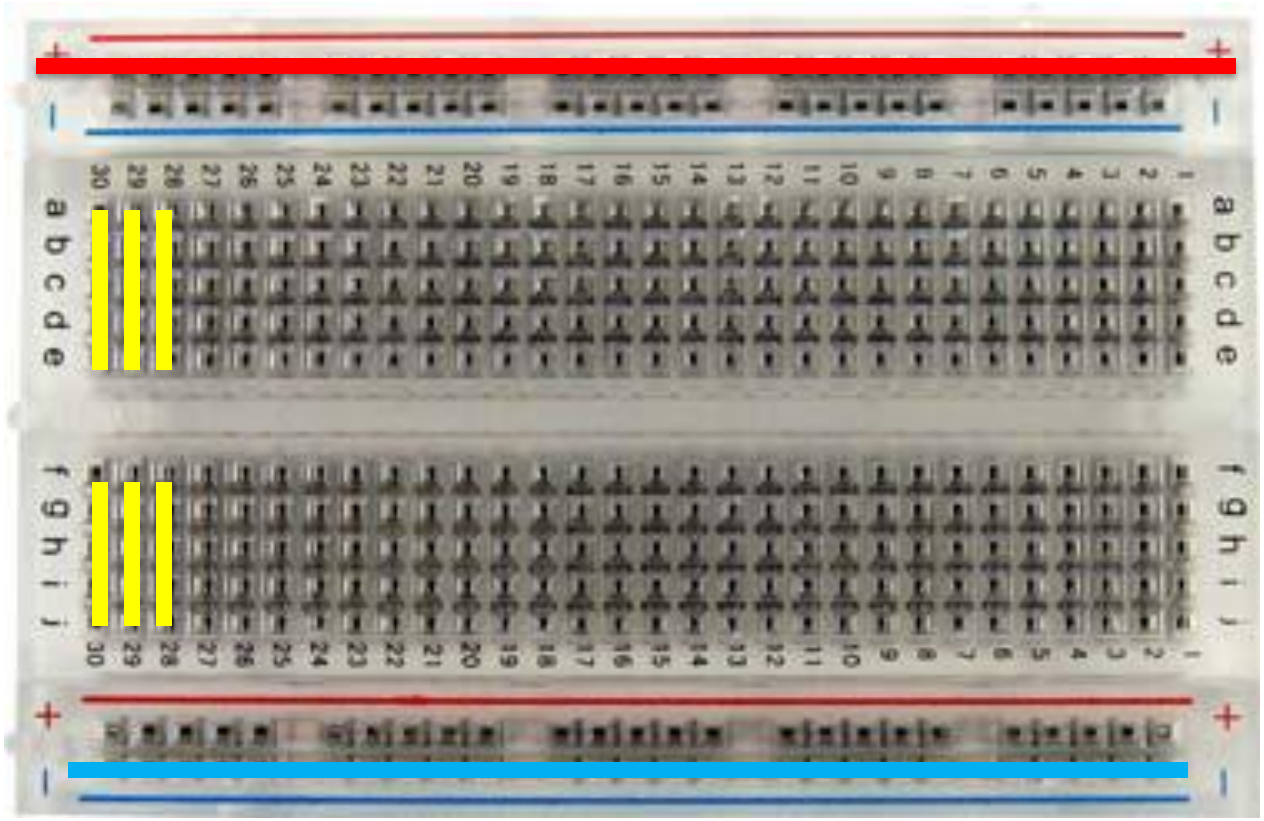
Ta-da! Sanity.

Lab 02: Building Circuits on Breadboards

Solderless Breadboard

This lets you build circuits quickly

- The long rows are connected horizontally
- The short columns are connected vertically

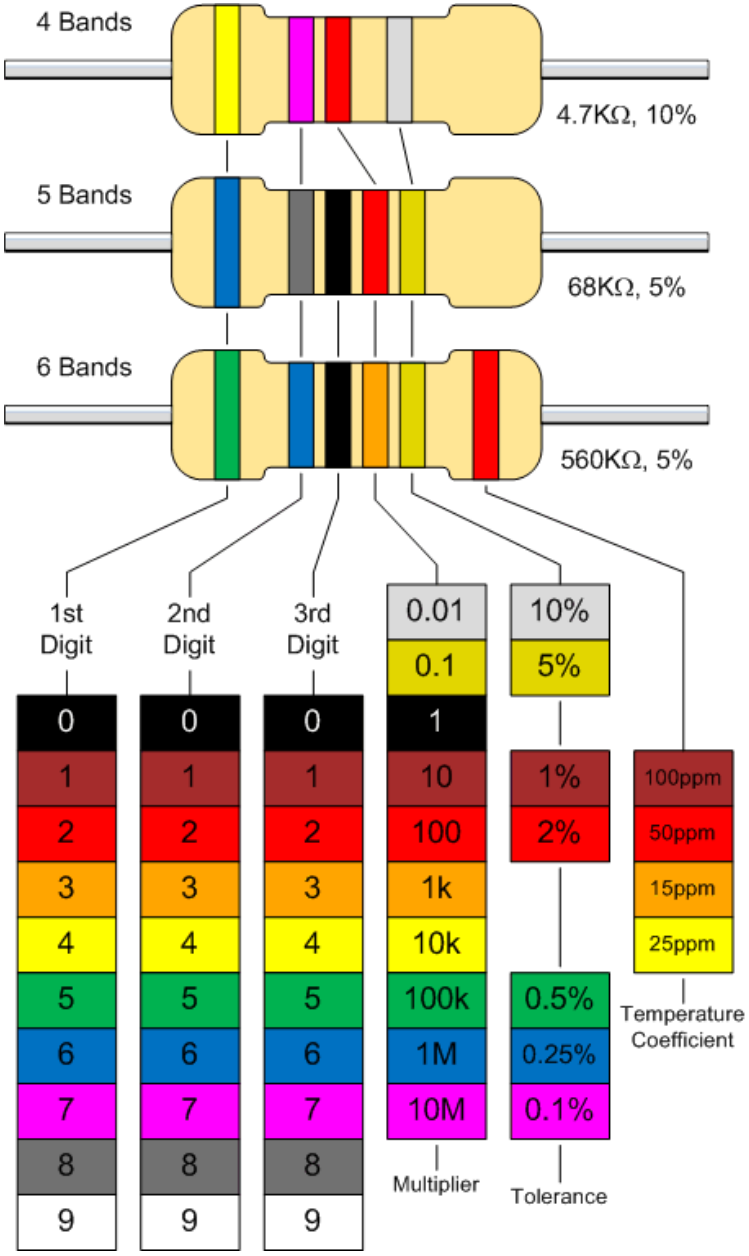


The Multimeter

OK, all together now:

- Measuring voltage
- Measuring resistance

reading resistors: color codes



Books

Getting Started in Electronics

Make Magazine

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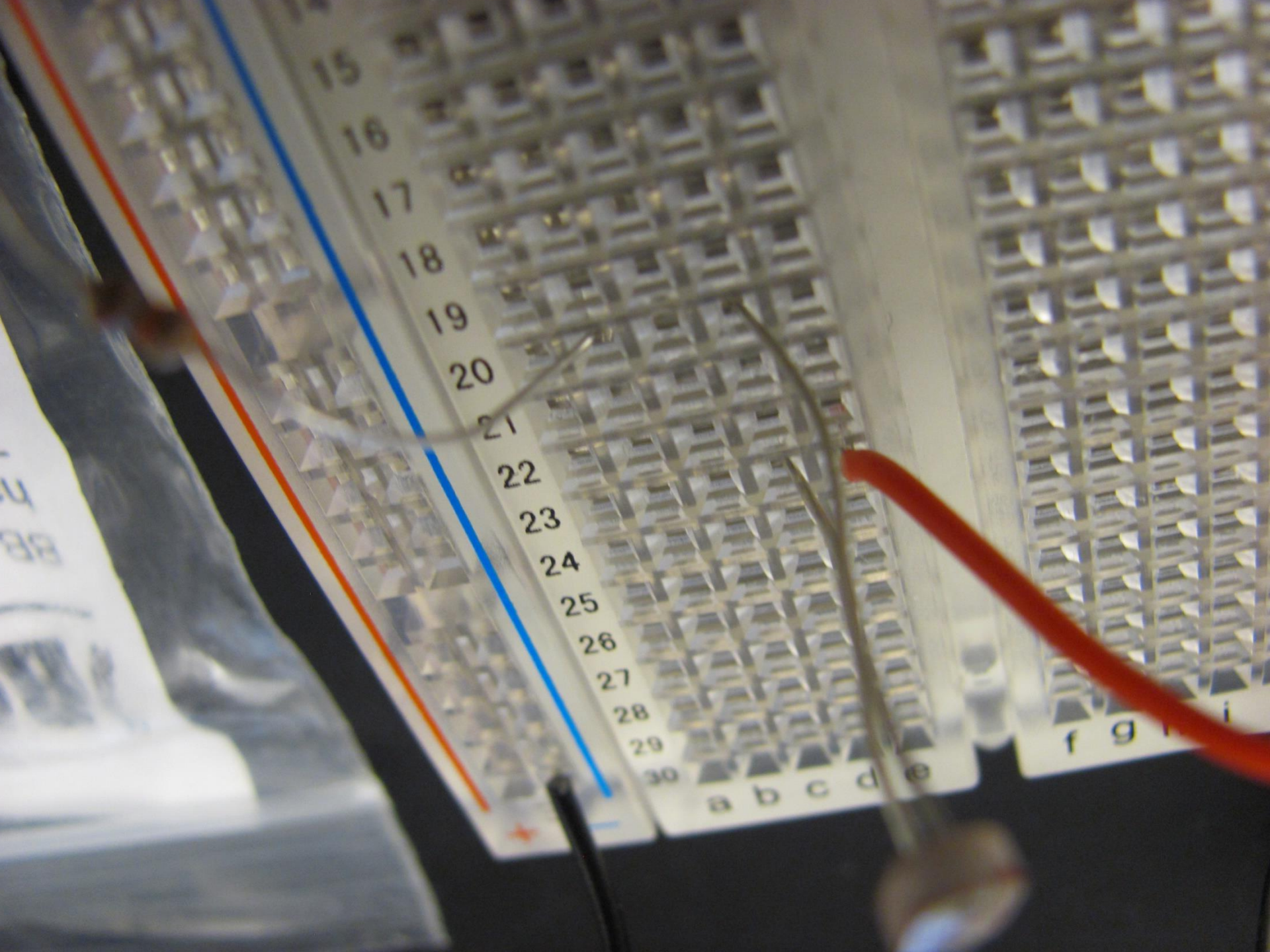
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