Féidearthachtaí as Cuimse
Infinite Possibilities

Week 1
Module introduction & basic electronics

Fundamentals of IoT
Dr. Eoin Rogers (eoin.rogers@tudublin.ie)

OLLSCOIL TEICNEOLAÍOCHTA BHAILE ÁTHA CLIATH
TU DUBLIN
TECHNOLOGICAL UNIVERSITY DUBLIN

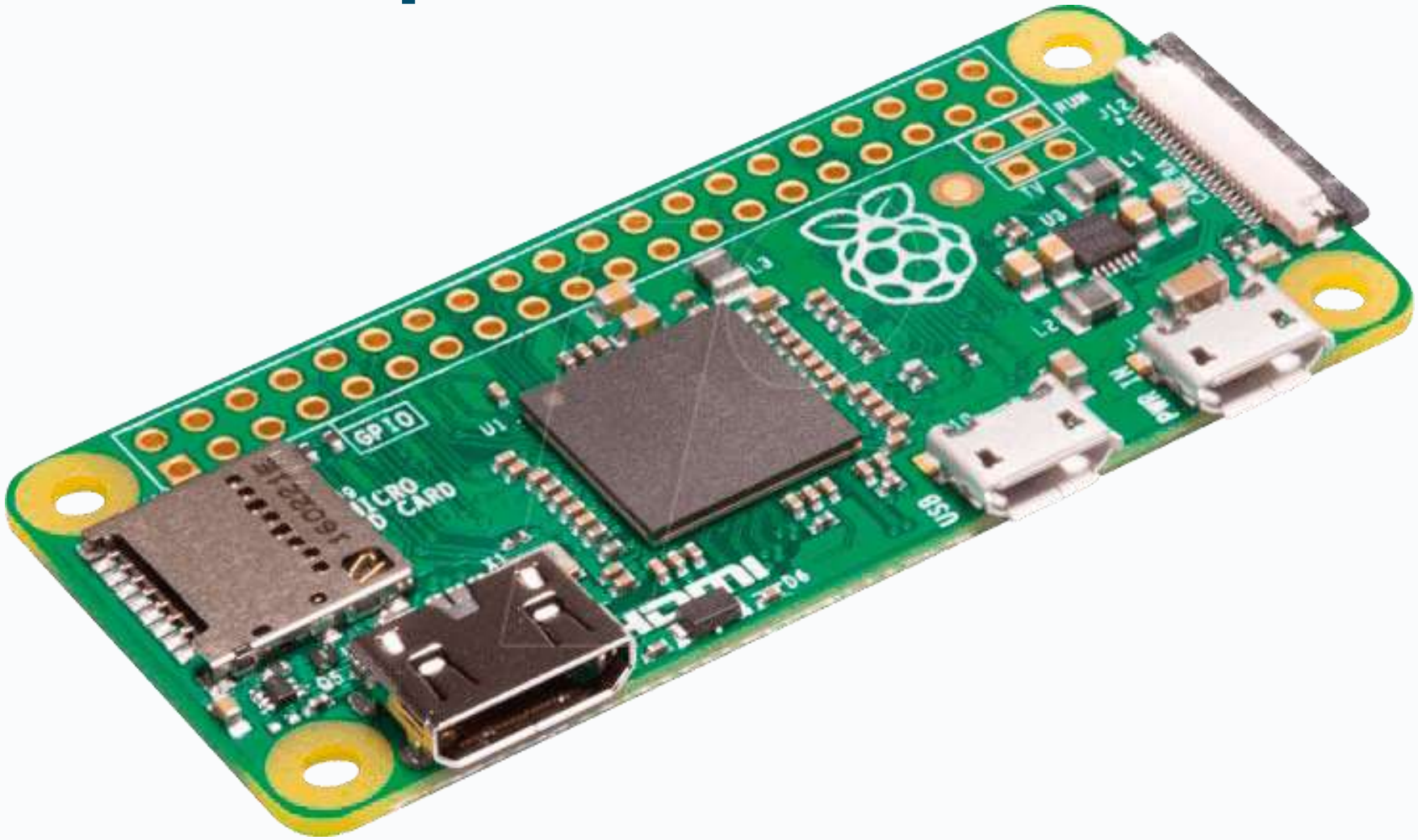
Lesson Outline

- Basic introduction to what we will be covering in the class
- How the module will be assessed
- A (very basic!) introduction to electronics
- Overview of this week’s lab (if there’s time)

Course intro

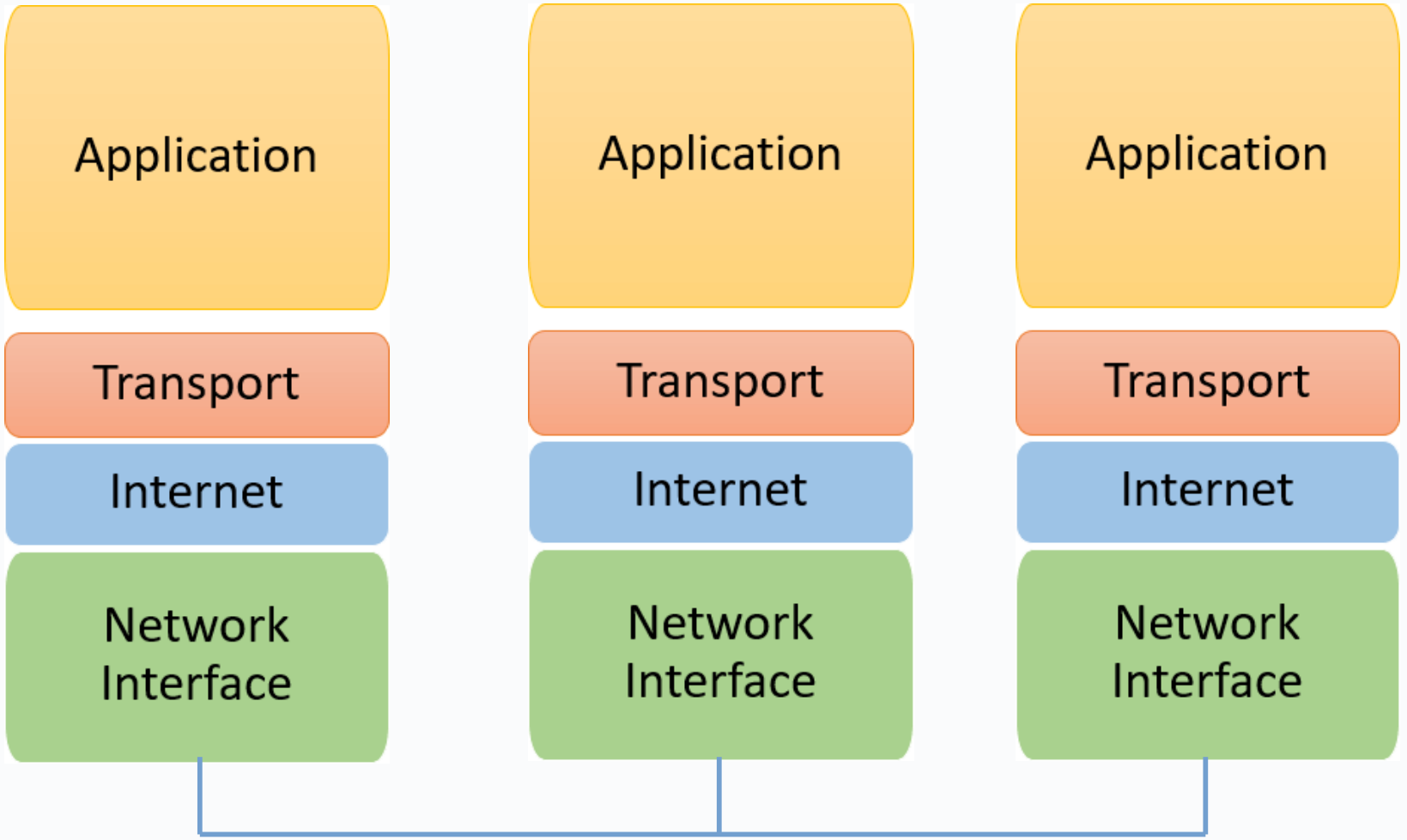
What will we be covering during this course?

Modern computer hardware is cheap!

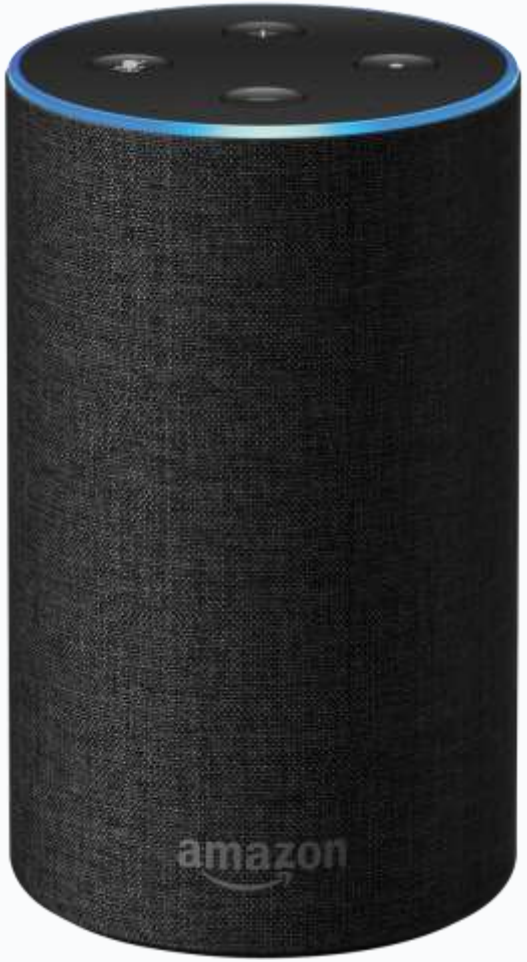


Almost everything contains one...

These can be connected together



Some useful applications



Smartspeakers
(e.g. Amazon Echo)

Some useful applications

Smart lighting

Some useful applications

Electronic road signs

Some useful applications

Agriculture(!)
See [farm.bot]

What will the course cover?

- Low end, cheap hardware platforms
  - Raspberry Pi
  - Arduino
- How to program these platforms and interface with other hardware
- How to offload compute-intensive tasks to external services (i.e. datacentres)
- Data visualisation

But we’ll also cover the bad things!

- Security
- Privacy
- Frgmentation and vendor lock-in
- Cost
- Environmental concerns

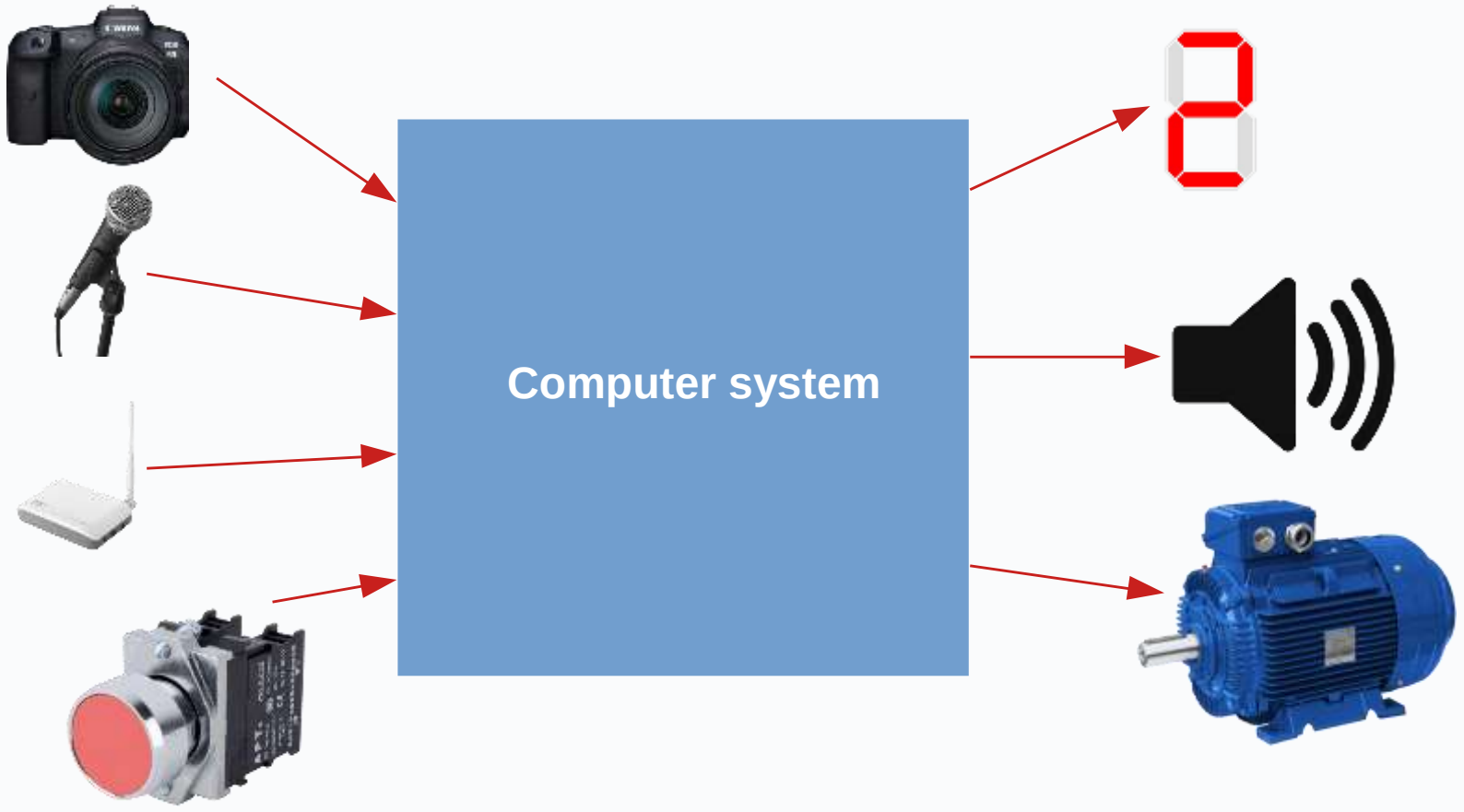
Some fundamentals

How is this different from normal computer science?

How is this different from what you've seen so far?

- Limited computer resources
- Closer to the metal (not always bare metal, but often much closer to it!)
- Unusual types of input and output (can you think of any examples?)

But fundamentally, this is just computer science!



Assessment

How is the module marked?

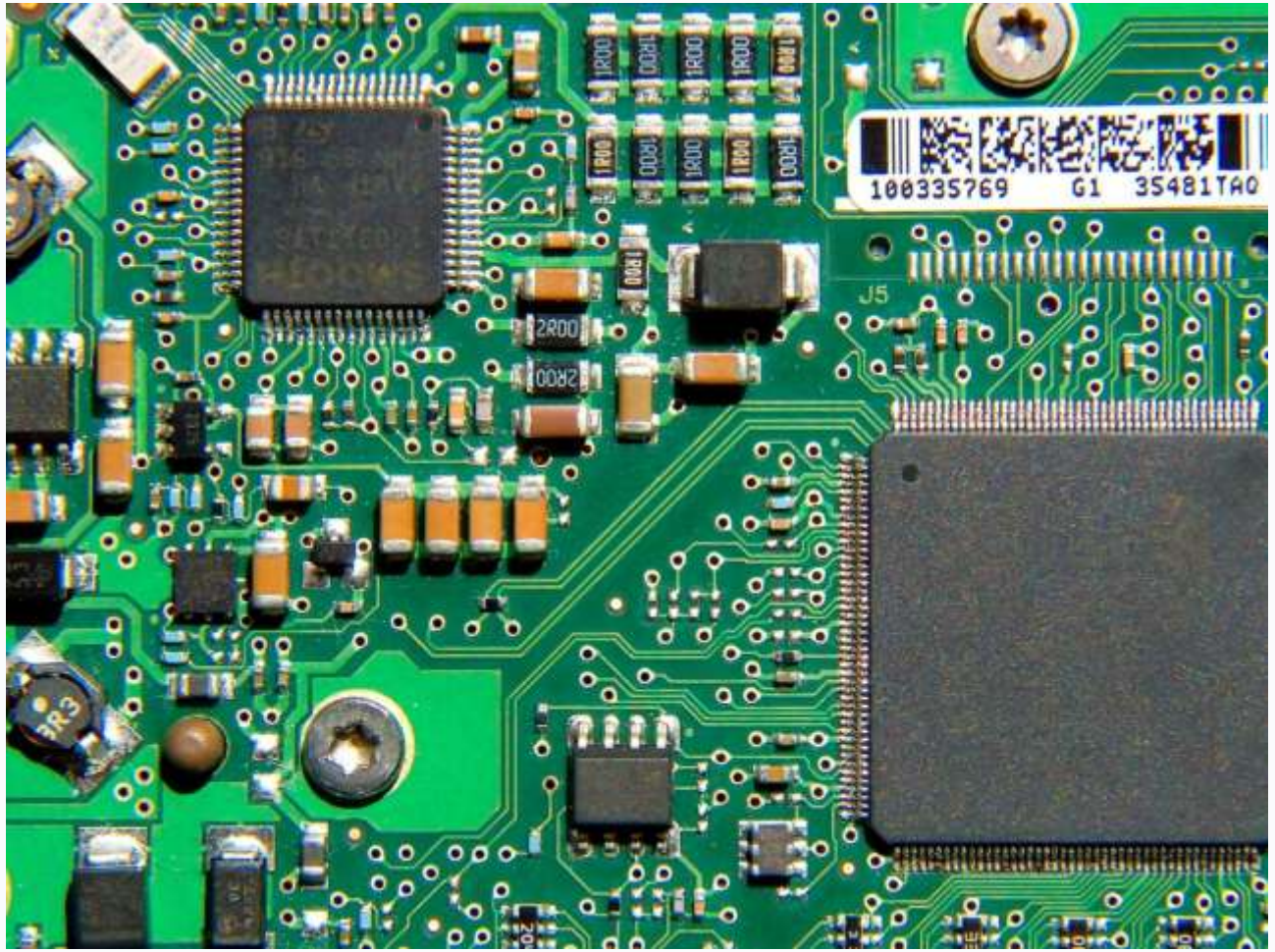
Assessment

- **60%** written exam in January
- **40%** continuous assessment
  - **5** marked labs, each worth **8** marks
  - Limitations on bringing the hardware off-campus means we can’t do a traditional assignment

Basic electronics

This course is not an electronics course, but knowing some basic electronics terminology can be very helpful!

Electronic circuits



A bunch of **wires** connecting **electronic components** together

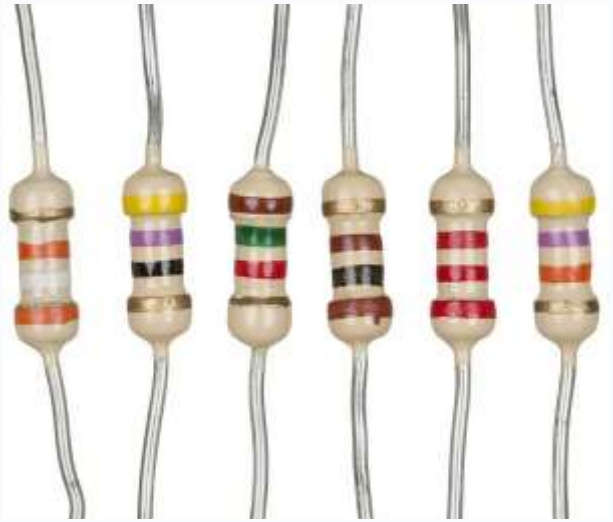
Electronic circuits

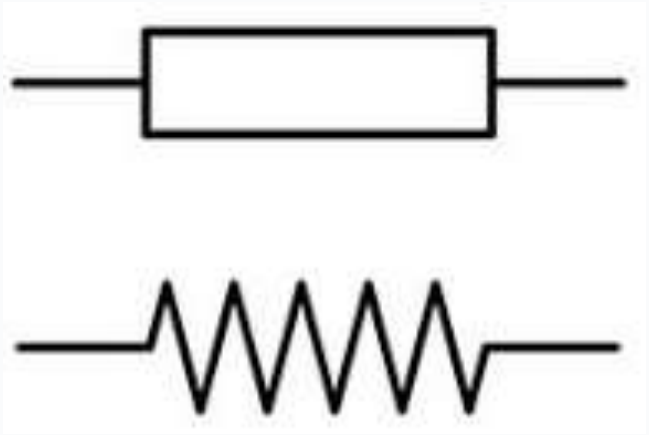
- At each point/wire, we care about **two** quantities:
  - **Voltage** (**V**), pressure in the hydraulic analogy
    - Measured in **volts** (**V**)
  - **Current** (**I**), speed in the hydraulic analogy
    - Measured in **amperes** (**A**)

Common electronic components

You might recognise some of these!

Resistors





Sort of like an electronic speed bump: reduces the voltage and current of the power flowing through it.

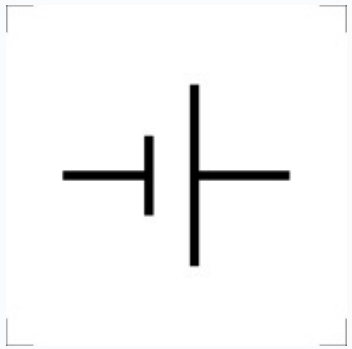
The degree of **resistance** (**R**) is measured in **ohms** (**Ω**).

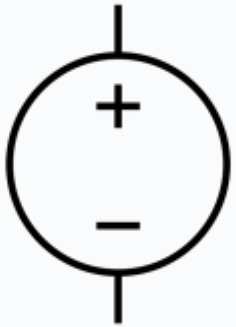
Resistors are exremely common in real electronic circuits.

Batteries/voltage sources

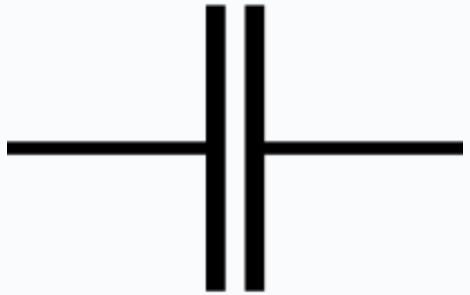
Generate electricity with a fixed voltage V.

I think everyone is familier with batteries!





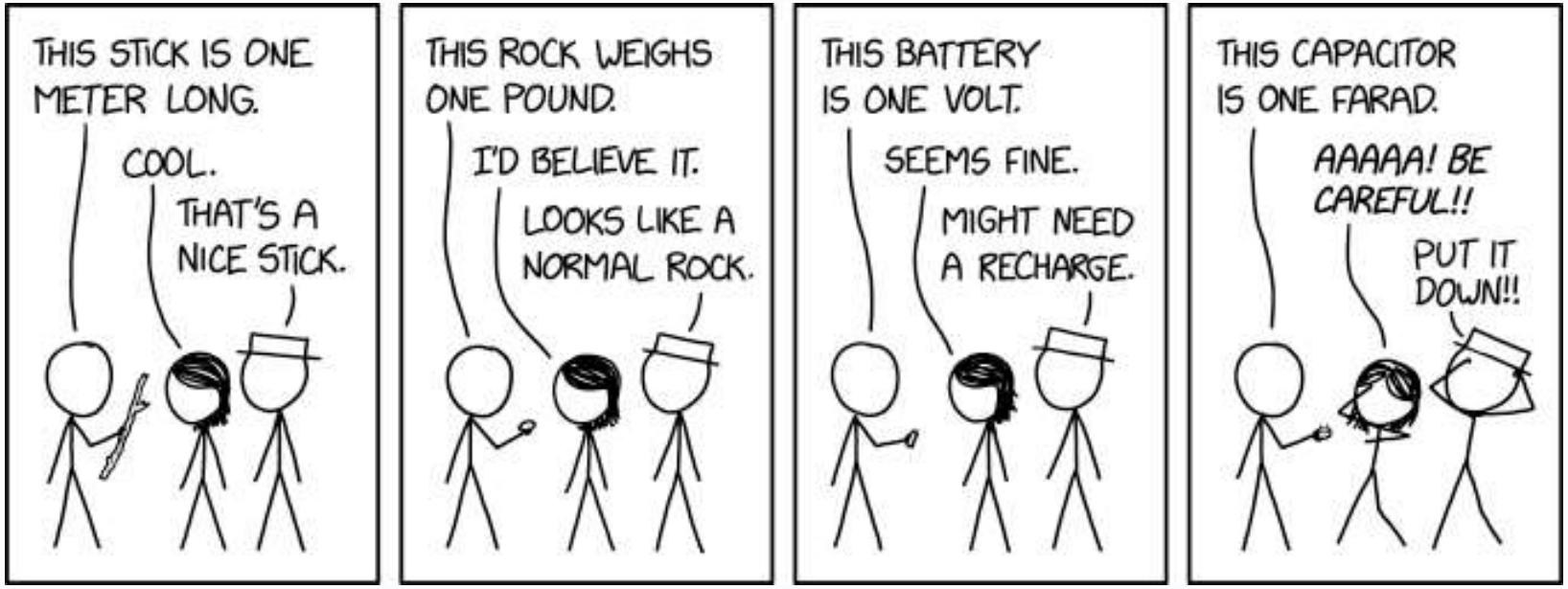
Capacitor



Sort of like a tiny rechargeable battery: stores a small amount of electricity for a period of time. Capacitors use an **electric field** to store power.

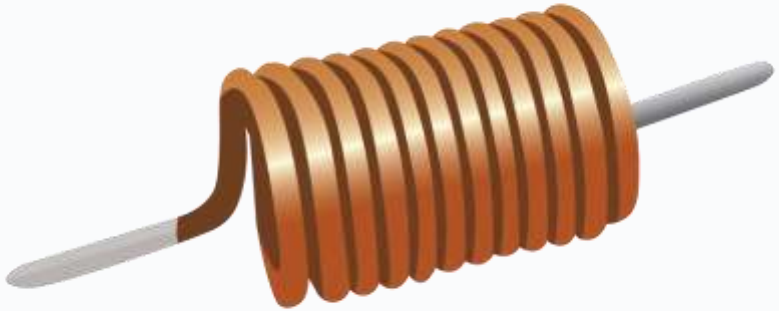
The amount it can store is called the **capacitance** (**C**), and is measured in **Farads** (**F**).

There's an XKCD for everything...



1 Farad is very large: most capacitors you'd be dealing with have a capacitance measured in milli- or microfarads.

Inductor



Similar to a capacitor, but stores energy in a magnetic field rather than an electric field.

Unlike capacitors, they don’t stop the flow of electricity when fully charged.

The **inductance** of an inductor (**L**) is measured in **Henries** (**H**).

Diode

Only allows electricy to flow in one direction.

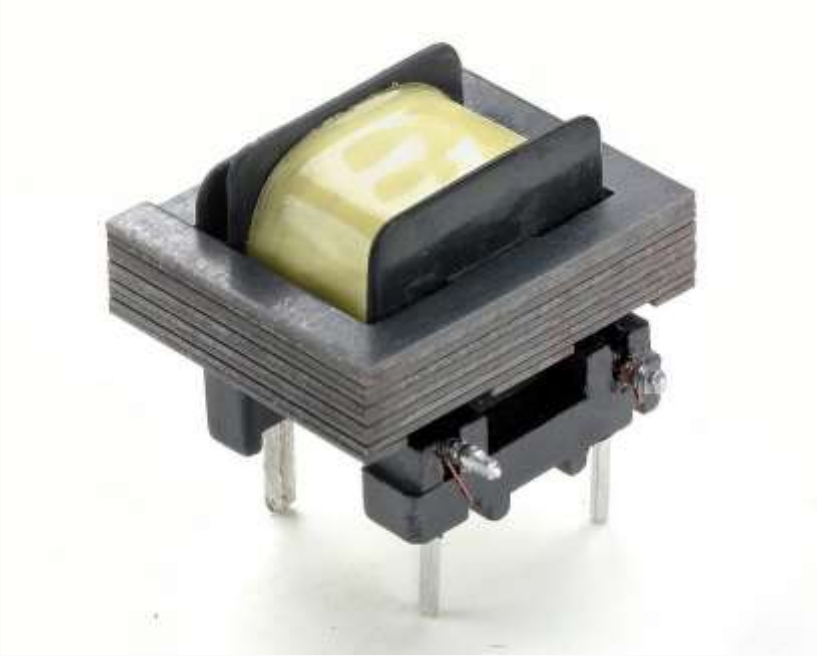
Diodes aren’t all that interesting, but **light-emitting diodes** (**LEDs**) are obviously common in modern electronics!

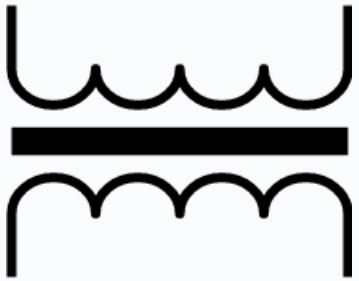
Current source

Like a battery, but generates a **fixed current** instead of a fixed voltage.

They are infrequently used in real electronics, but are very important in electronics theory.

Transformer





Used to **change the voltage** of electricity.

A transformer is basically two or more inductors wrapped around a **core** (usually made from something like iron).

That’s all we need to know for now

- We’ll talk more about electronics as we go along, but you’ll notice that new components/devices that we introduce will mostly be a **variant** or **aggregation** of the components we’ve seen already
  - For example, a **transistor** is actually two diodes stuck together!
- If this interests you, I give a list of suggested readings in the lab, but none of them are mandatory!

Electronics intuition

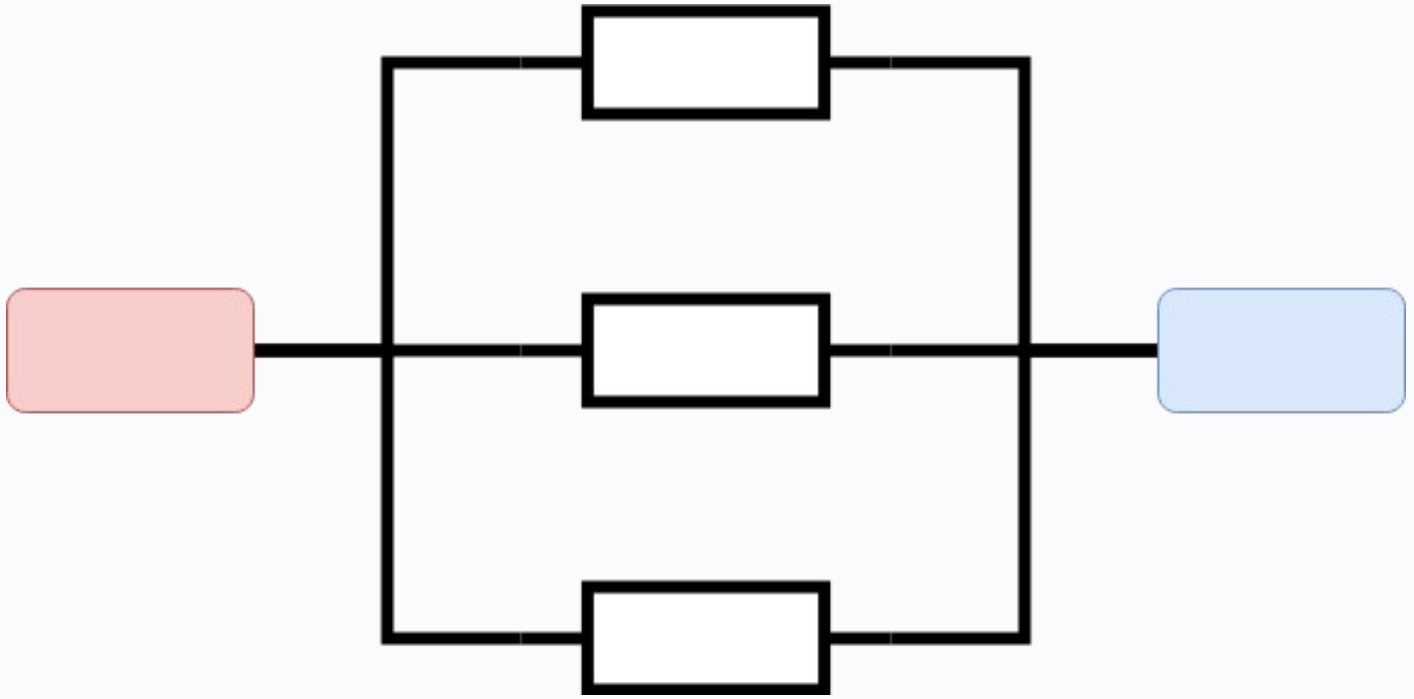
Building intuition about how components behave can be useful, but don’t worry if you don’t fully understand what follows

Resistors in series

$$R = R_1 + R_2 + R_3$$

The resistance of **several resistors in series** is equal to the **sum of the resistance** of the individual resistors

Resistors in parallel



By contrast, the resistance of **several resistors in parallel** is much more complicated!

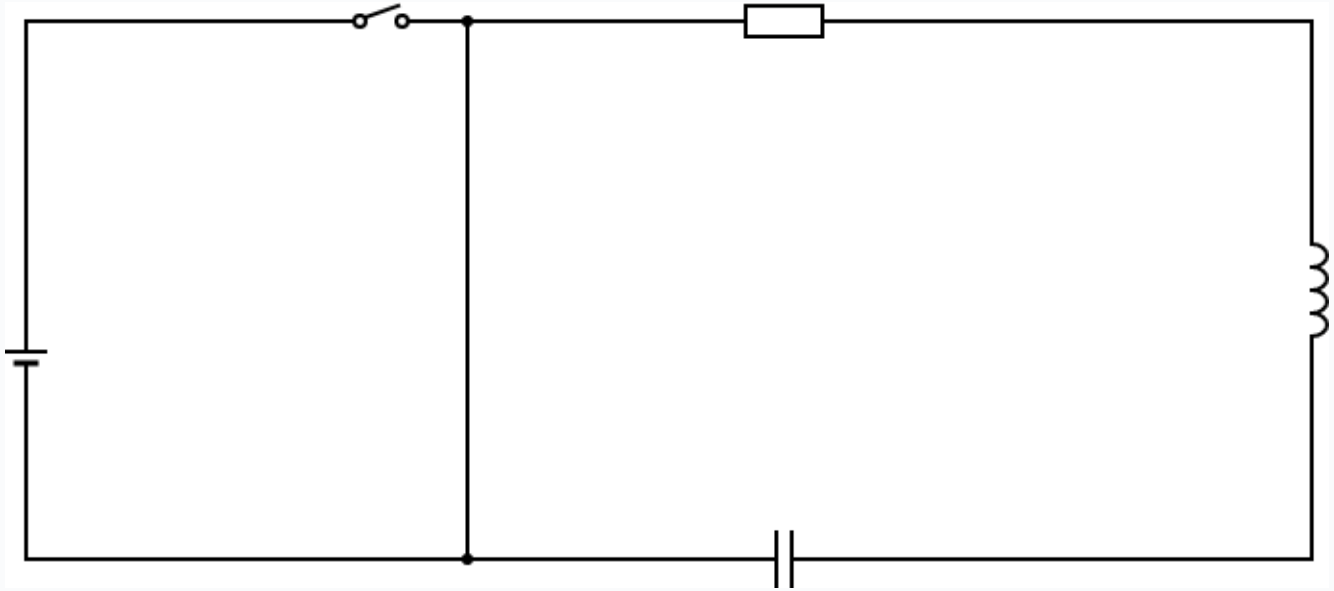
$$\frac{1}{R} = \frac{1}{R_1} \times \frac{1}{R_2} \times \frac{1}{R_3}$$

Capacitors in parallel and series

- Capacitors work the other way around: the capacitance of multiple capacitors in parallel is the sum of the individual capacitances
- The capacitance of multiple capacitors in series is:

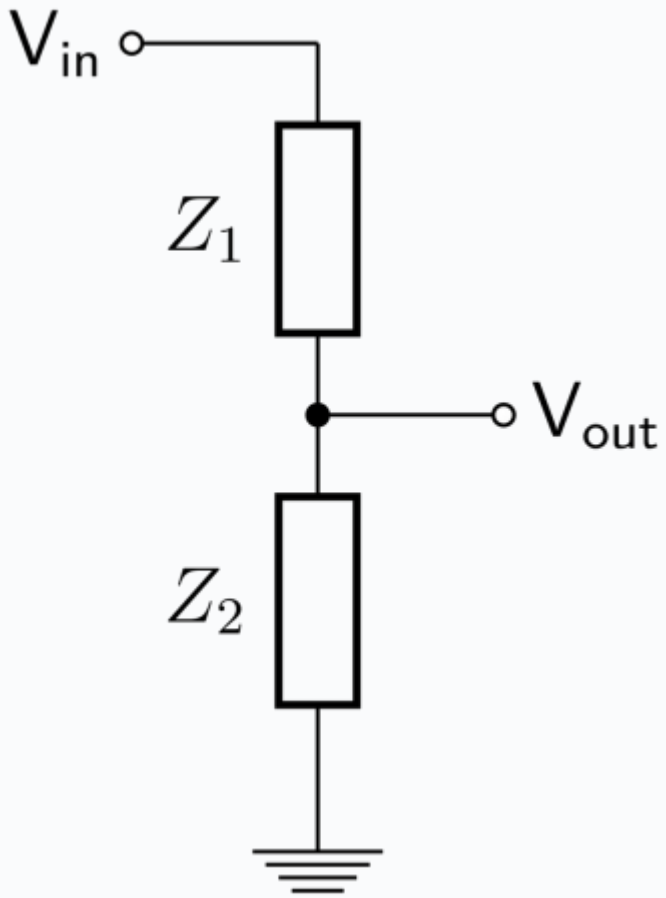
$$\frac{1}{C} = \frac{1}{C_1} \times \frac{1}{C_2} \times \frac{1}{C_3}$$

Example: RLC circuit



$$f = \frac{1}{2\pi\sqrt{LC}}$$

Example: Voltage divider



$$V_{out} = \frac{Z_2}{Z_1 + Z_2} \times V_{in}$$

Summary

- Computers are small and ubiquitous, and internet connections are fast and cheap
- Putting a cheap computer into everyday electronic devices and connecting them to the internet allows us to create stuff that is cool and/or useful
- This basic concept is called the Internet of Things (IoT)

Summary

- We covered some basic electronic components:
  - Resistors, capacitors, inductors and diodes are very important
- We covered two basic types of circuit:
  - RLC circuits
  - Voltage dividers

That’s all for this week

Thanks for your attention!