Introduction to Scientific Computing

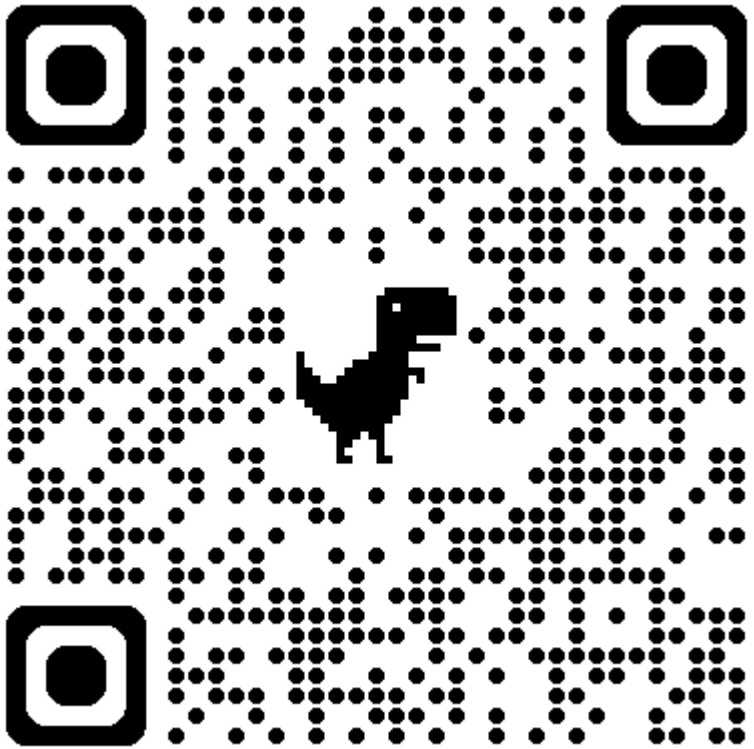
ENGR1050 – Lecture 6

Fall 2025

Nat Trask

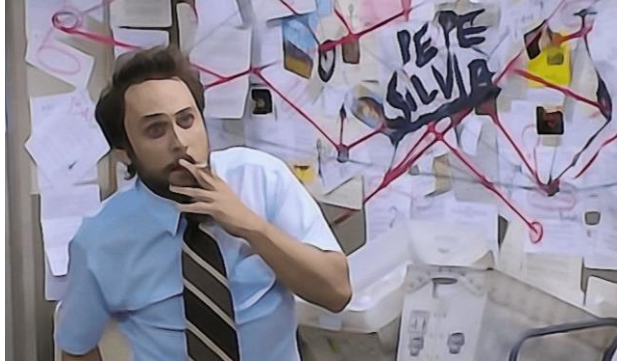
Guest Lecture by Ben Shaffer

University of Pennsylvania



Introduction to Microcontrollers

Hello world on the Raspberry Pi Pico



Real Python Programs

Installing Thonny

In-class exercise

Submit a picture showing you installed Thonny and can run a python script outside colab

Note
Depending on your background, it may range from trivial to painful to install Thonny. Today is a nice slow day to get Thonny set up on everyone's computer.

Introduction to Microcontrollers

To drive a circuit, we can't use Colab – it lives in the cloud and can't touch a circuit in real life!

Today we will install Thonny, which is a tool to run Python on your laptop that we can use to drive circuits and make robots

Today you only have one job: get Thonny installed and working on your computer

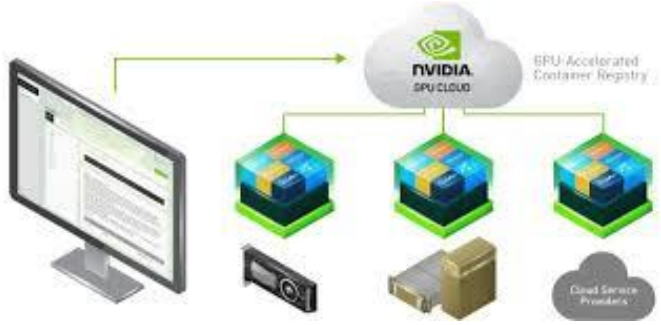
Real Python Programs

First we will see a demo running a python program using Thonny

Then we'll see a demo of how easy it is to use python to drive a microcontroller
(don't worry – you won't need to do this yourself for another week or two)

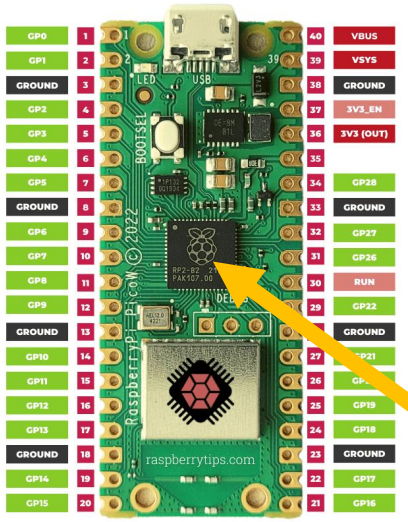
Finally, we will install Thonny on all of your computers. For directions go to the course github and check the notes for todays lecture

Three places so far for you to run code – understand what they mean



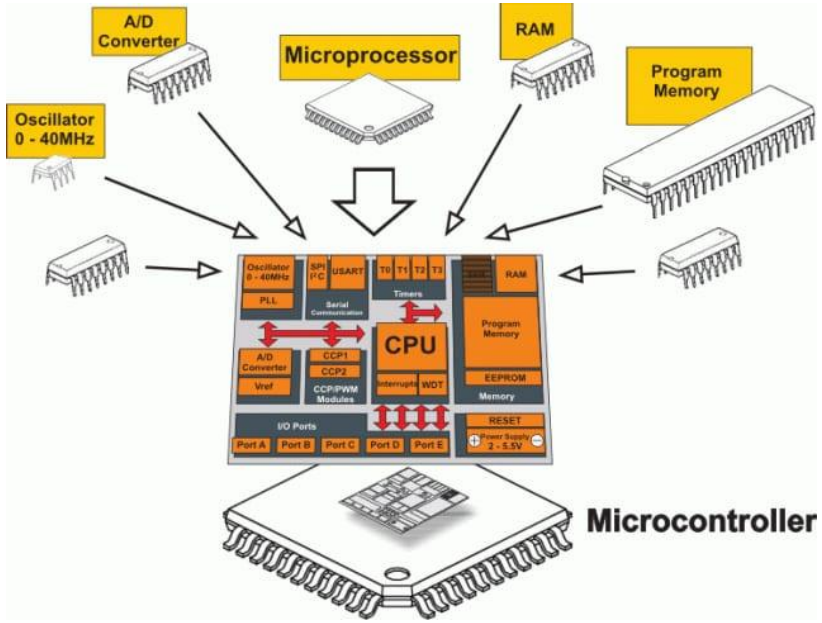
Runs in the cloud
You connect through the internet to see program output, but its running on some GPU in Google's basement

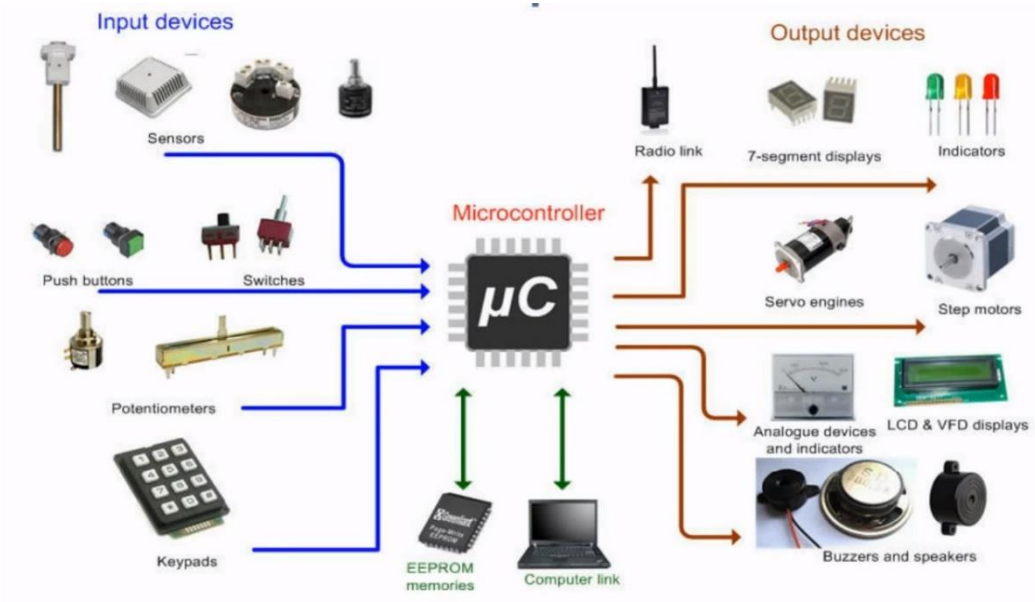
Run on your laptop
Today we'll use Thonny to run directly on your laptop

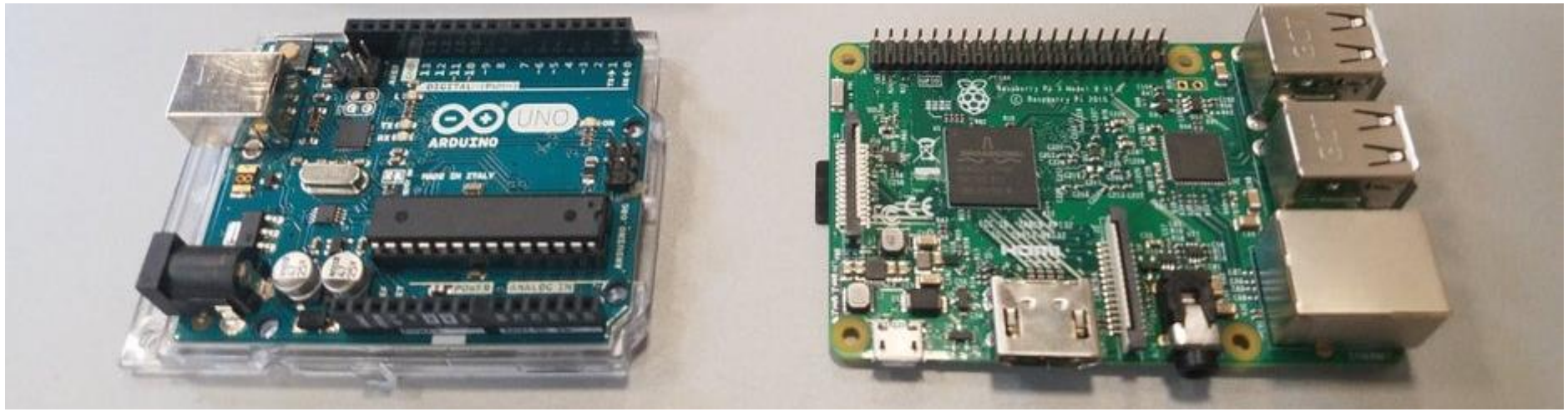


Run on a microcontroller
We'll show how to run a program on this little black chip
This is good for steering robots, drones, and other little mechatronic systems

What is a microcontroller?





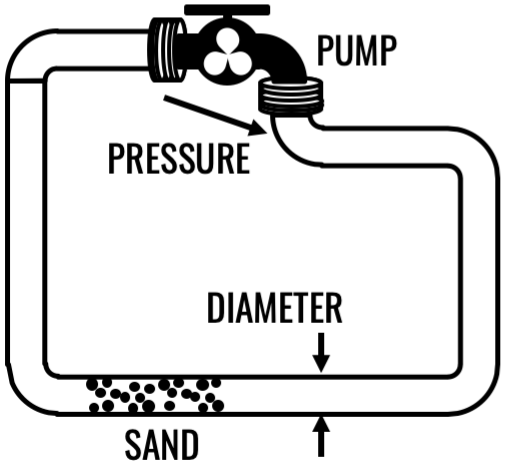


What is a circuit?

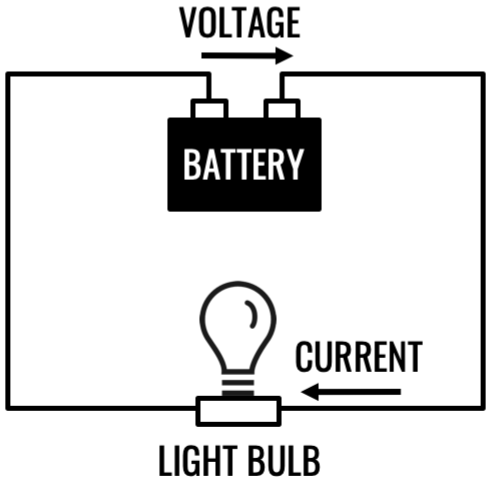
Voltage = Current x Resistance

(V = I x R)

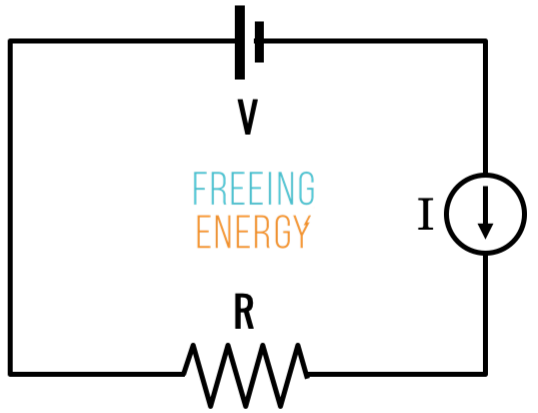
Water



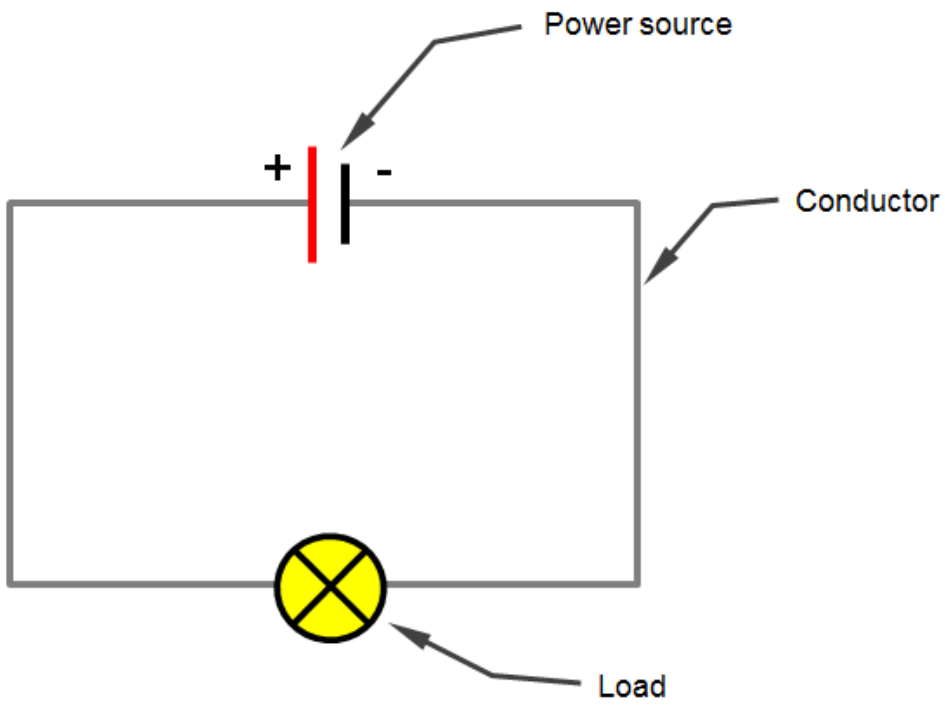
Electricity

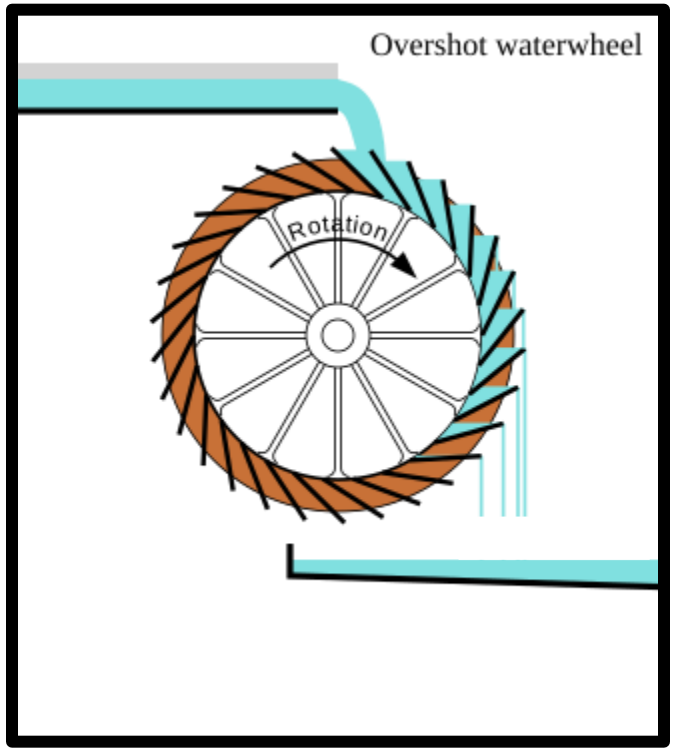


Circuit Diagram



How does electricity drive a circuit element? A hydraulic analogy





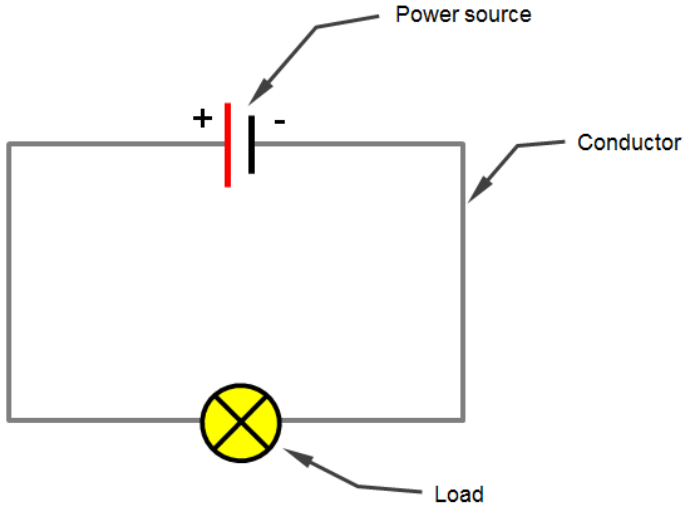
Change in potential energy

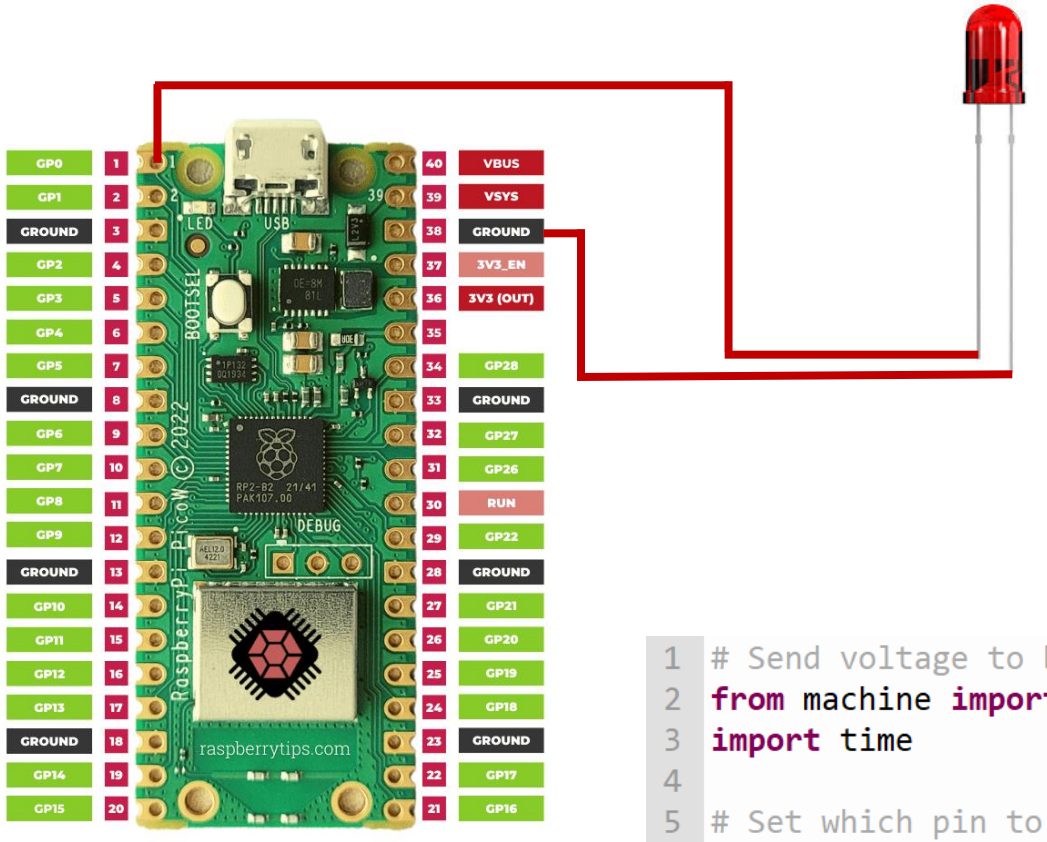
Change in <u>potential energy</u> drives a <u>current</u>

Potential energy: Voltage difference between two points on circuit
Current: flow of electrons through wire

Potential energy: Difference in elevation storing gravitational energy
Current: flow of water through pipe

We will write a program that sets a voltage at one “pin” to switch lights off/on



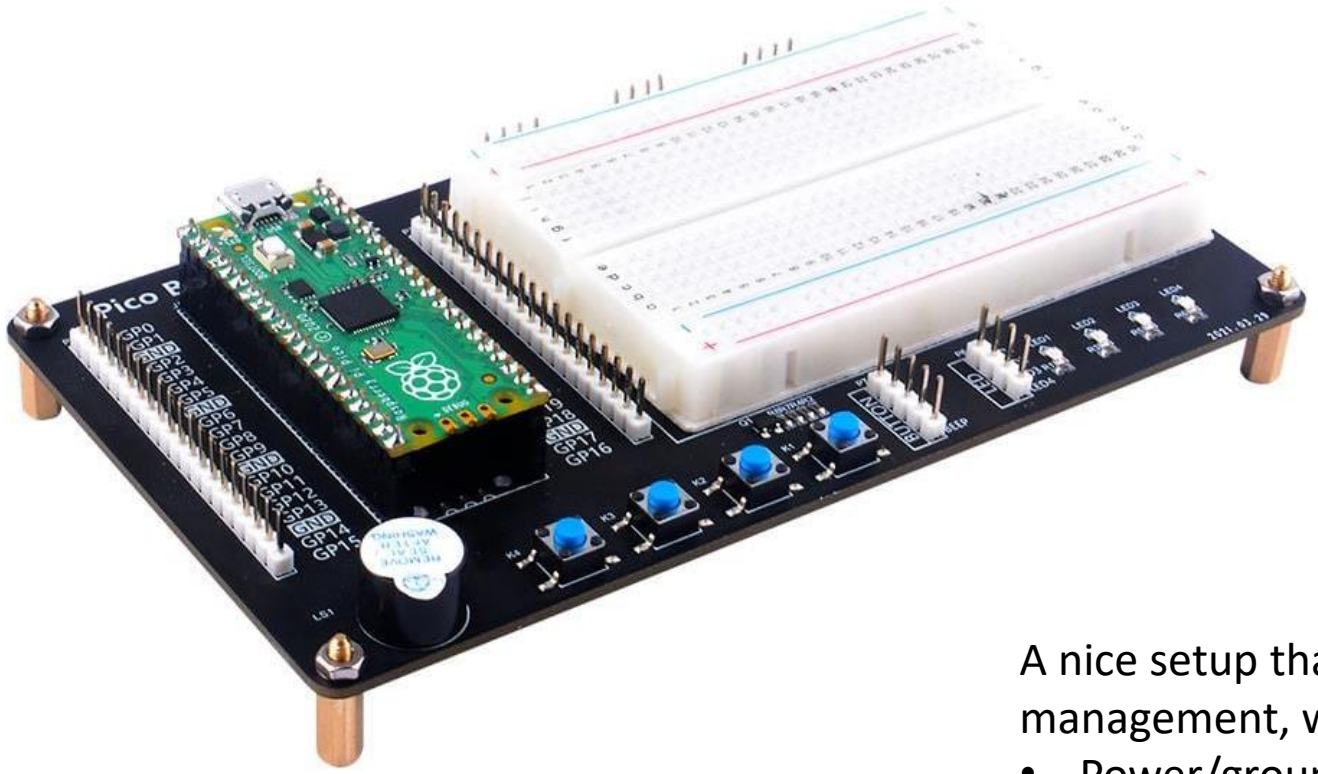



```python
# Send voltage to blink an LED
from machine import Pin
import time

# Set which pin to send voltage to
led = Pin('GP0', Pin.OUT)


while True:
    led.toggle()      # set voltage off/on
    time.sleep(0.5)   # wait a half second
```

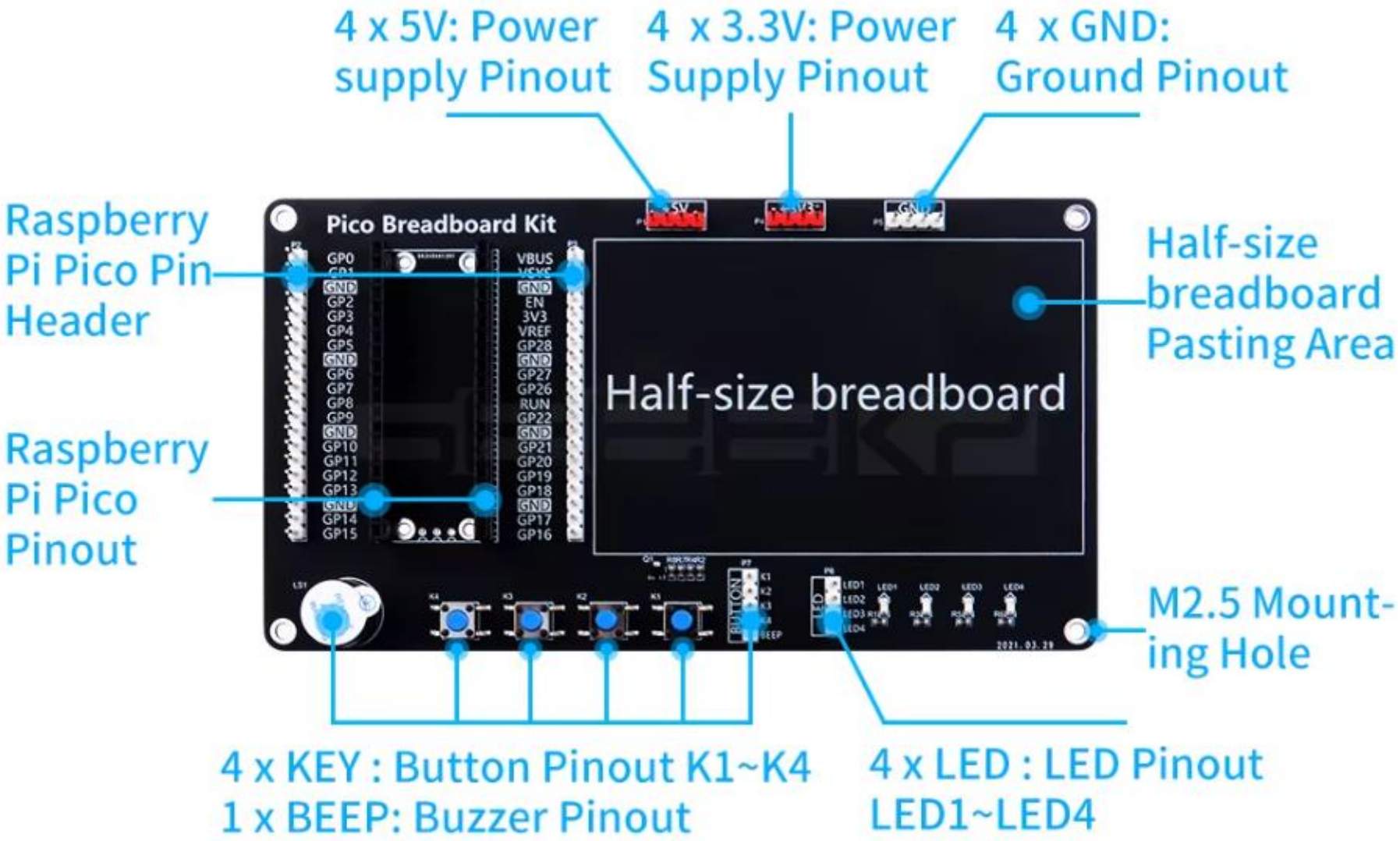
This is your Raspberry Pi Pico – a microcontroller with some basic functionality



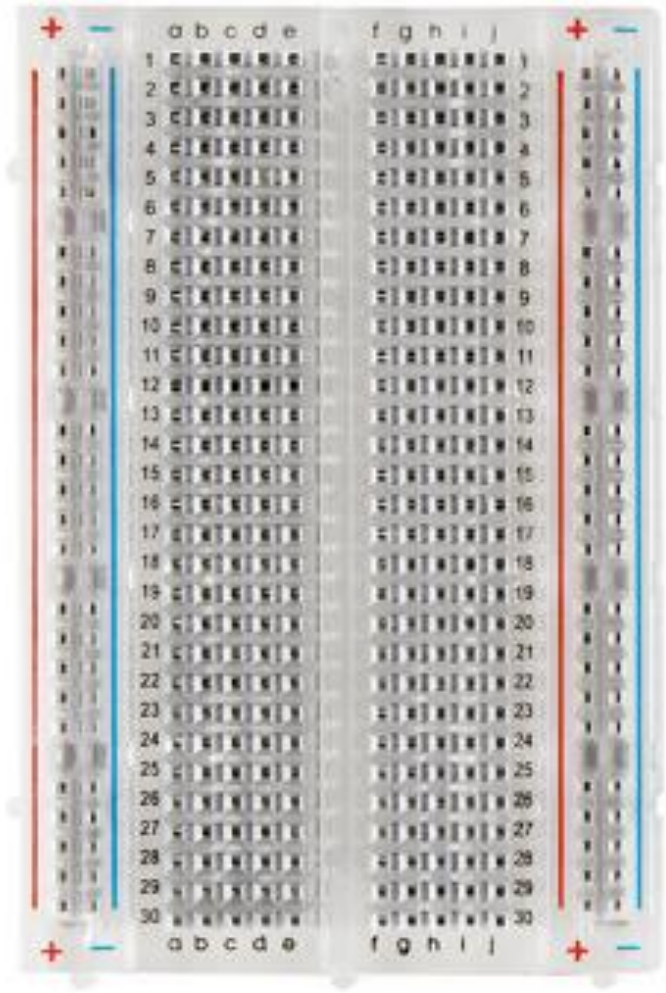
A nice setup that minimizes wire management, with built in:

- Power/ground lines
- Buttons
- LEDs
- Speakers
- Compact breadboard

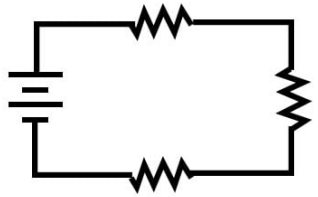
This is a mounting board that your Pico is attached to, with lights and convenient pins for connecting wires



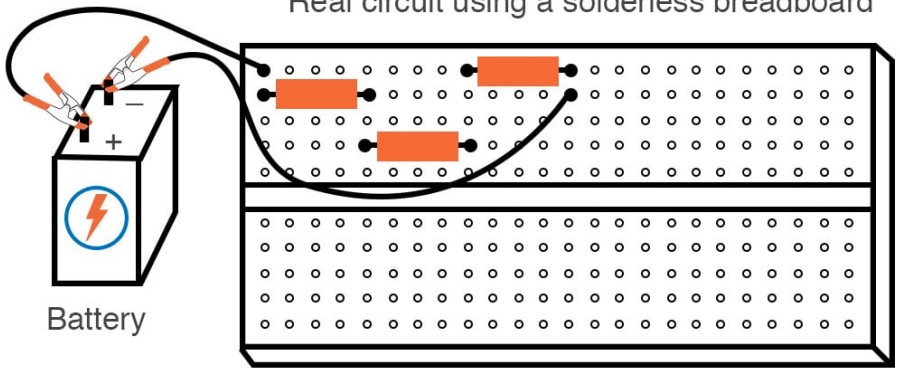
This is a breadboard – it lets you build circuits without needing to solder wires



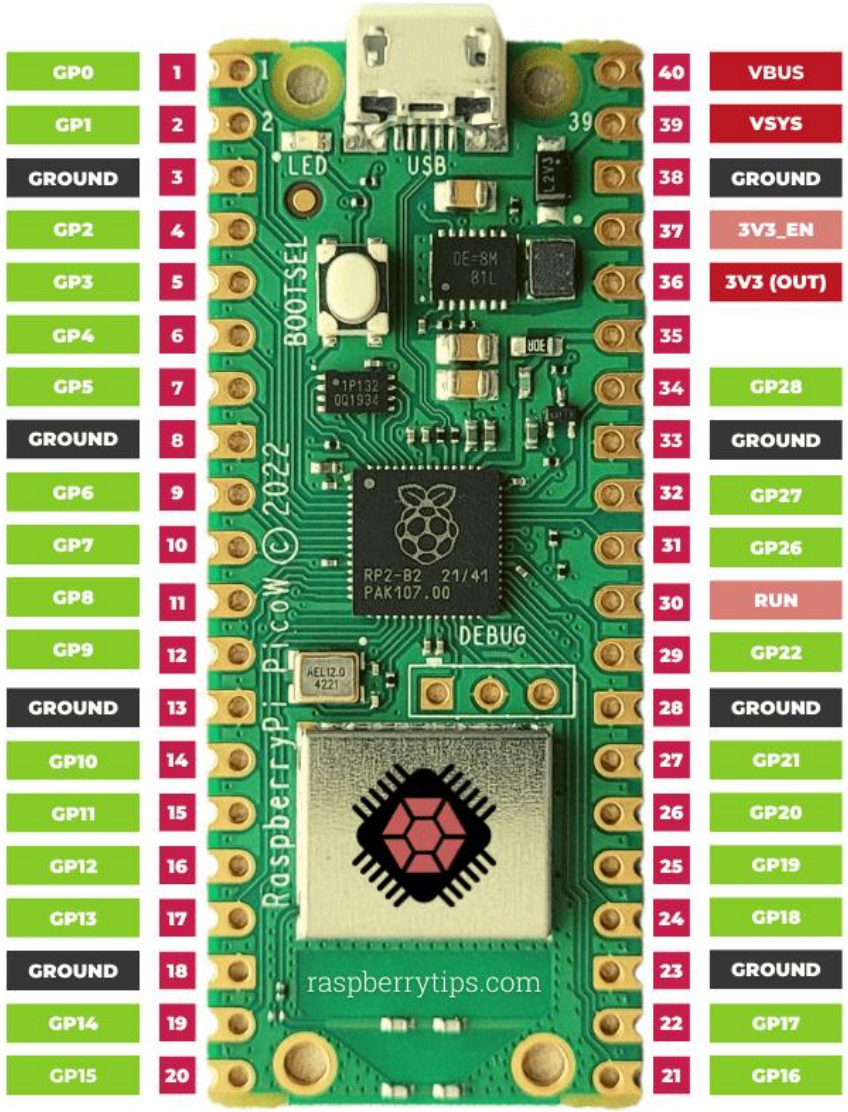
Schematic diagram



Real circuit using a solderless breadboard



This is the actual Pico – we can use python to feed juice to pins



LED – built in LED on the pico can be lit without wiring for diagnostics

GPX – general purpose input output (GPIO), which the microcontroller can set to high or low voltage in output mode. Rated for 3.3V and 20mA.

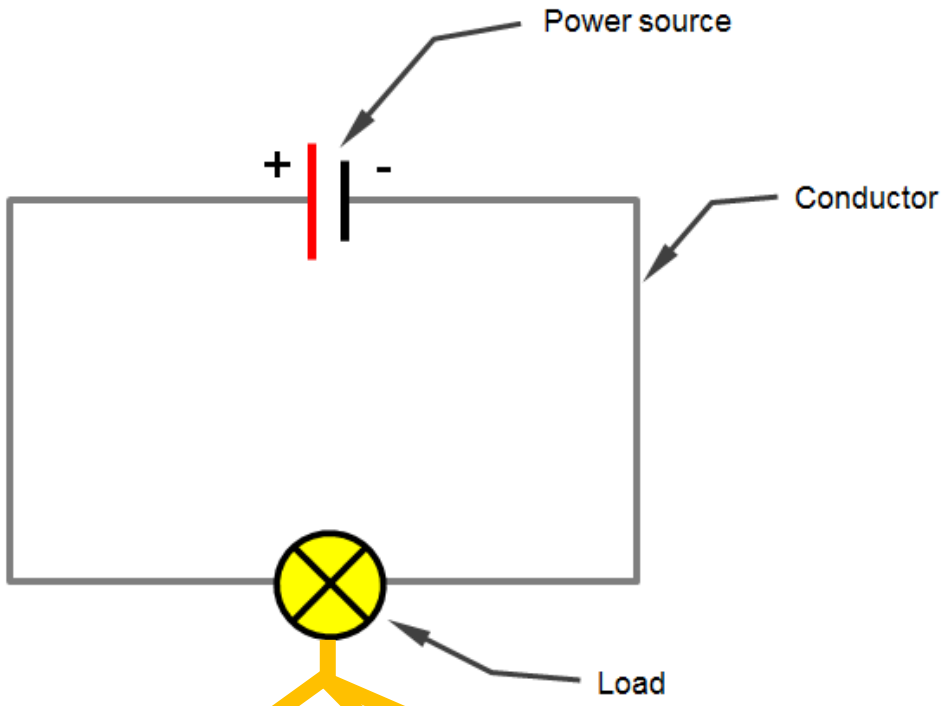
3V3 – A power source pin, which always outputs 3.3V and can draw up to 1A.

Ground – Where to close the circuit

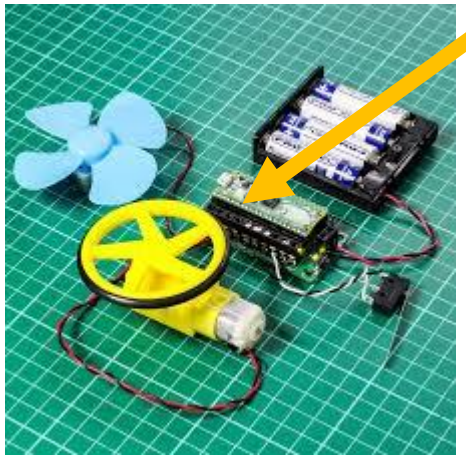
1.ADC pins – Only some pins can convert analog to digital. **Raspberry Pi Pico (RP2040)**:

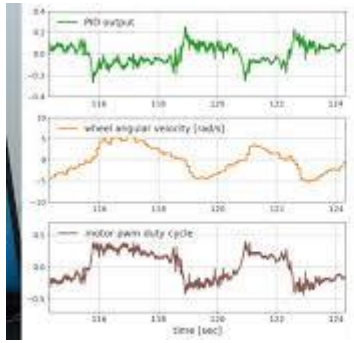
1. ADC0: GPIO26
2. ADC1: GPIO27
3. ADC2: GPIO28

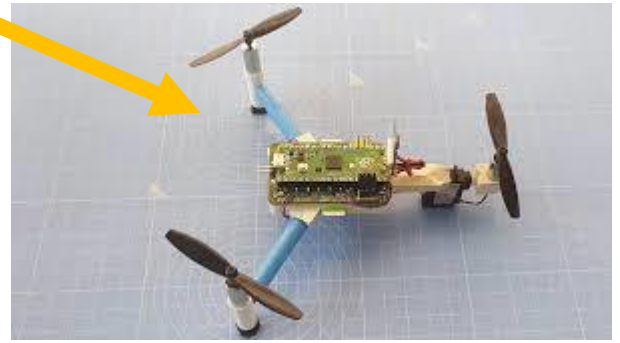
Ready for labs



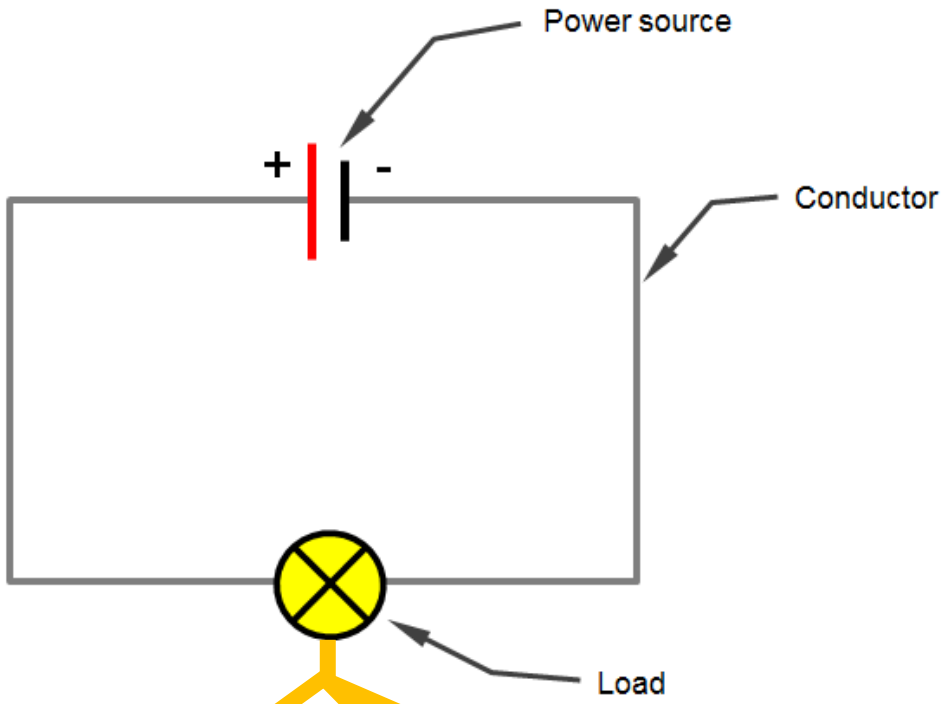
We now know enough python to write programs to drive loads and build some basic robots. Every couple weeks we'll break to play with robots in the GM lab.







Ready for labs



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