Sensors, Actuators and Microcontrollers

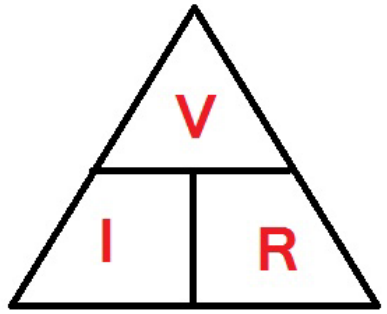
Sensors

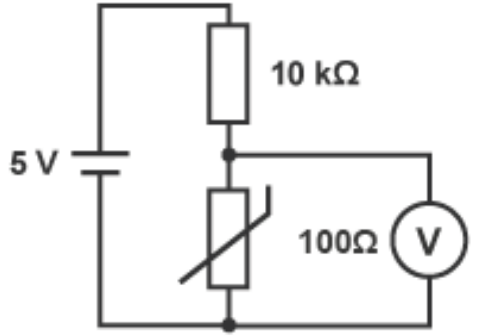
- Sensors detect aspects of an environment
- **Input:** Sensors can measure parameters such as temperature, pressure, humidity, motion, light, sound, chemical composition, or even biological properties.
- **Output**: The output of a sensor is usually an electrical signal that corresponds to the measured property. This signal is often processed and used by other systems or devices.

Voltage divider circuit

- To measure sensors which are resistance based a potential divider is often used

- A potential divider converts resistance change into a measurable voltage change, which is easier for most microcontrollers or measuring devices to process.

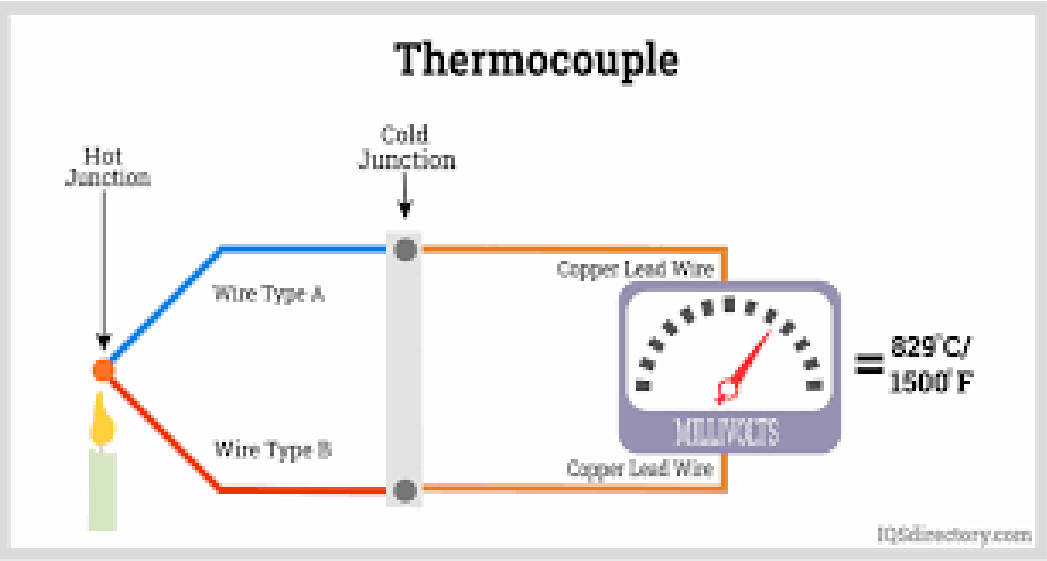




[Voltage dividers - Current, potential difference, power and resistance - Higher Physics Revision - BBC Bitesize]

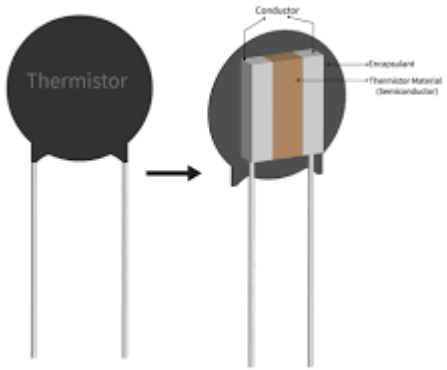
Temperature Sensors

- Measures the temperature of the environment
- Example: Thermocouples & Thermistors



Thermocouple – output voltage

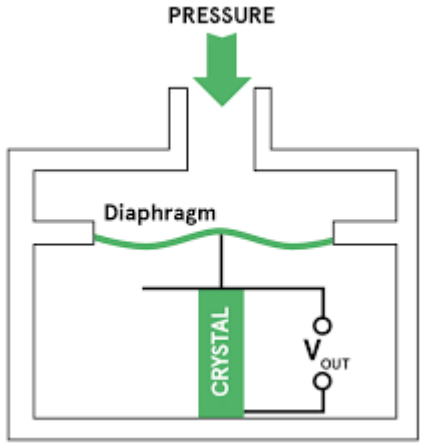
Thermistor Circuit Symbol



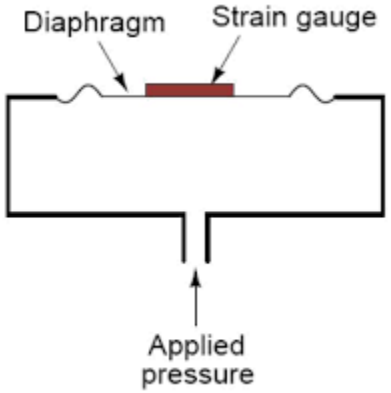
Thermistor – outputs resistance

Pressure Sensors

- Measures the pressure of gasses and liquids
- Example: Strain gauge & Piezoelectric



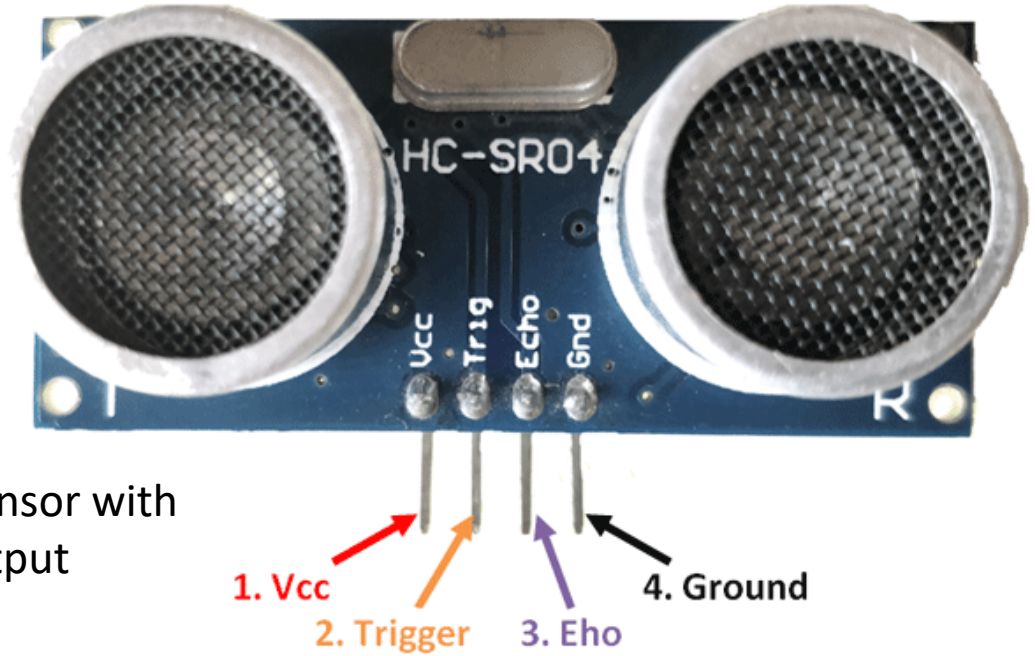
Piezoelectric pressure sensor – output voltage



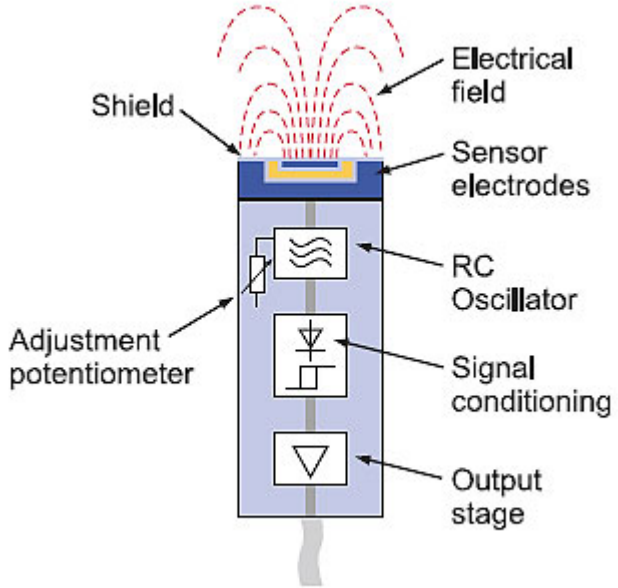
Strain Gauge – output voltage

Proximity Sensors

- Measures how far away something is without physical contact
- Example: Ultrasonic, Capacitive Proximity Sensor



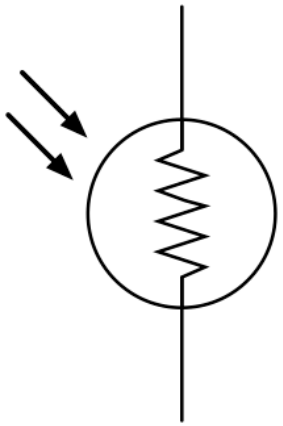
Ultrasonic sensor with pinouts – output voltage



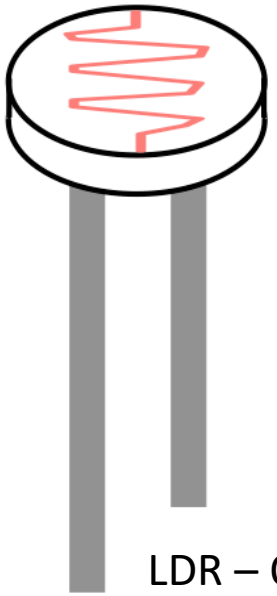
Capacitive proximity sensor – output voltage

Light Sensors

- Measures light intensity
- Example: LDR and Photodiodes



LDR circuit symbol



LDR – Output resistance

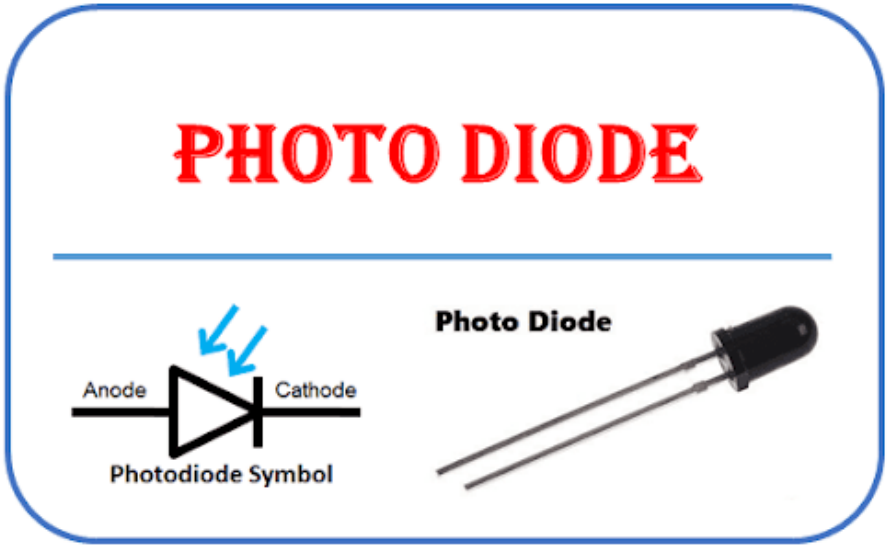
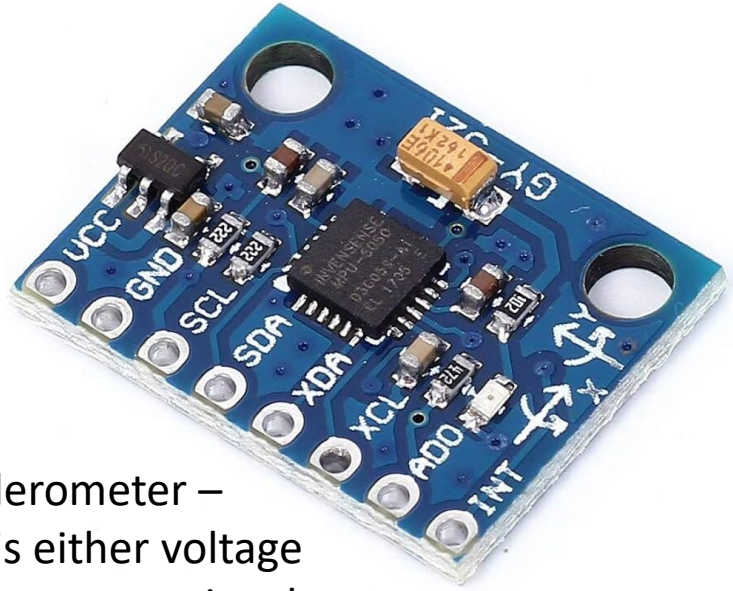


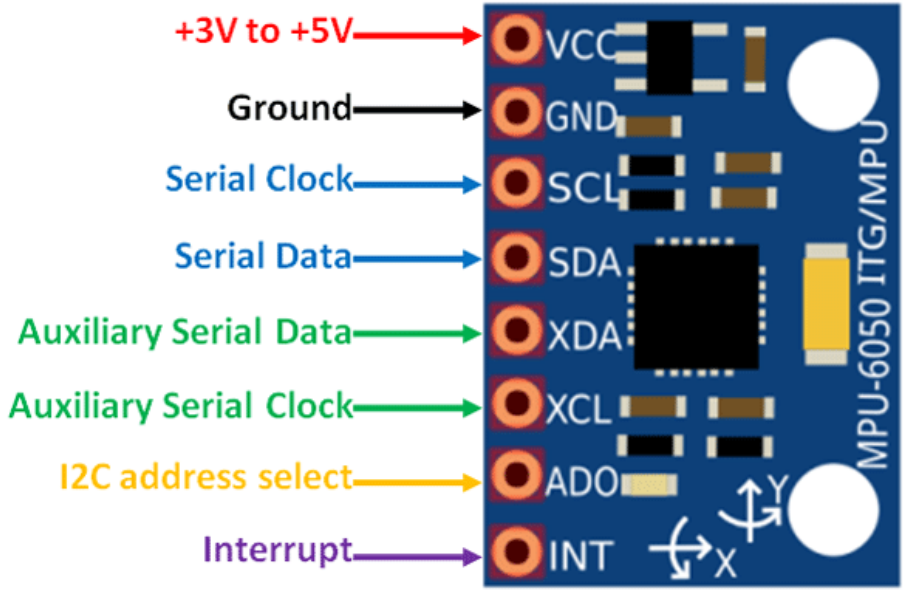
Photo Diode – Output voltage

Motion Sensors

- Detects movement
- Example: accelerometers and gyroscopes



An accelerometer – Output is either voltage for analogue or a signal for digital



Actuators

- Actuators allow for a circuit to interact with the environment by converting energy (often electrical, hydraulic, or pneumatic) into mechanical motion

- **Input:**
  - **Energy Source:** Provides the power needed for motion (e.g., electricity, compressed air, or hydraulic fluid).
  - **Control signal:** Determines the actuator's operation, often coming from a control system (e.g., microcontroller, PLC).

- **Output**: Actuators give a mechanical output which is the motion generated by the actuator, such as linear or rotational movement.

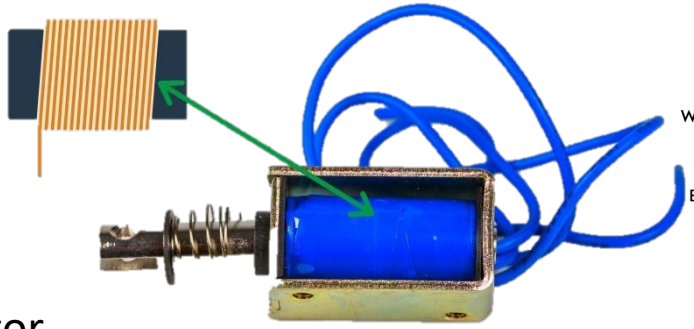
Actuators Outputs

- **Linear Actuators**: Produce straight-line motion (e.g., hydraulic pistons, lead screw actuators).
- **Rotary Actuators**: Produce rotational motion (e.g., motors, rotary solenoids).
- **Combination Actuators**: Use mechanisms like cams or gears to combine motions.

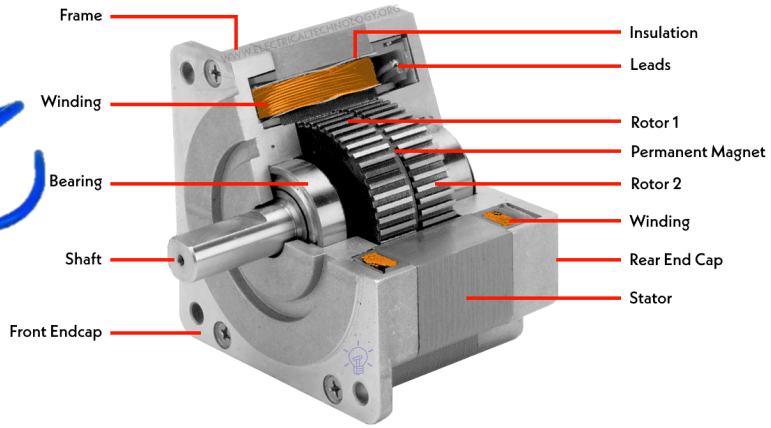
Electric Actuators

- Motion: Linear or rotary.
- Examples: Motors, solenoids, stepper motors, and servos.

An electric motor
Output – Rotary
Input – Power

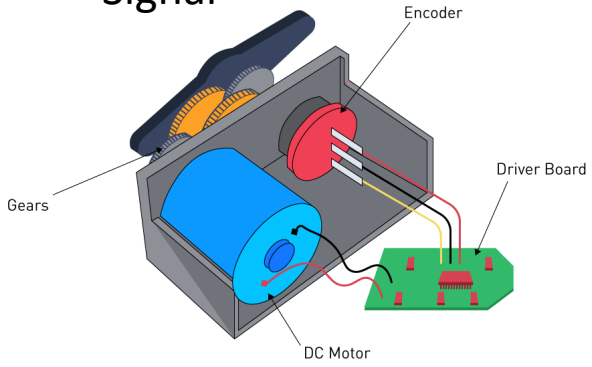


An electric solenoid
Output – Linear
Input – Power



A stepper motor
Output – Rotary
Input – Power & Control Signal

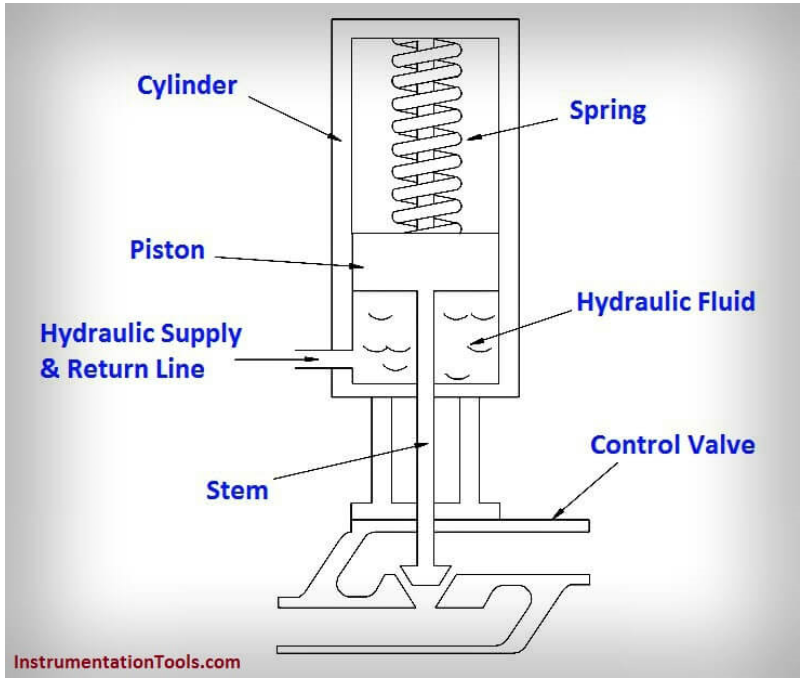
A servo
Output – Rotary
Input – Power & Control Signal



[How does an Electric Motor work? (DC Motor)]

Hydraulic Actuators

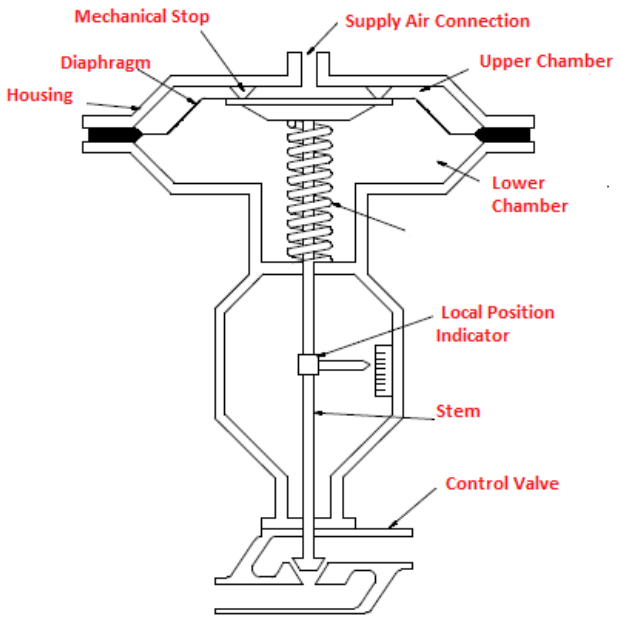
- Motion: Usually Linear.
- Working Principle: Uses pressurized hydraulic fluid to create motion.



How hydraulic actuators work

Pneumatic Actuators

- Motion: Linear or rotary.
- Working Principle: Uses compressed air to create motion.



Characteristics to Consider

- Speed: How fast the actuator can move.
- Force/Power: The amount of force it can apply or torque it can produce.
- Precision: The accuracy of its movements.
- Durability: How it withstands wear, environmental conditions, and continuous use.
- Energy Efficiency: How effectively it converts energy into motion.

Controllers

- Programmable Logic Controllers (PLCs) and microcontrollers are both used for automation and control, but they differ significantly in design, application, and functionality.

- They connect both sensors and actuators allowing for:
  - Better control of actuators movements
  - Processing of sensor input

PLCs

- A Programmable Logic Controller (PLC) is an industrial computer designed for controlling machinery and processes in manufacturing and other automation systems. It is built for reliability in harsh environments and can operate continuously.
- **Key Features**:
  - **Rugged Design**: Tolerates vibration, temperature extremes, and electrical noise.
  - **Inputs/Outputs (I/O)**: Large numbers of digital and analog I/O for connecting sensors and actuators.
  - **Ladder Logic Programming**: Often programmed using a graphical, logic-based language like ladder diagrams.
  - **Real-Time Operation**: Processes inputs and updates outputs continuously with minimal delay.

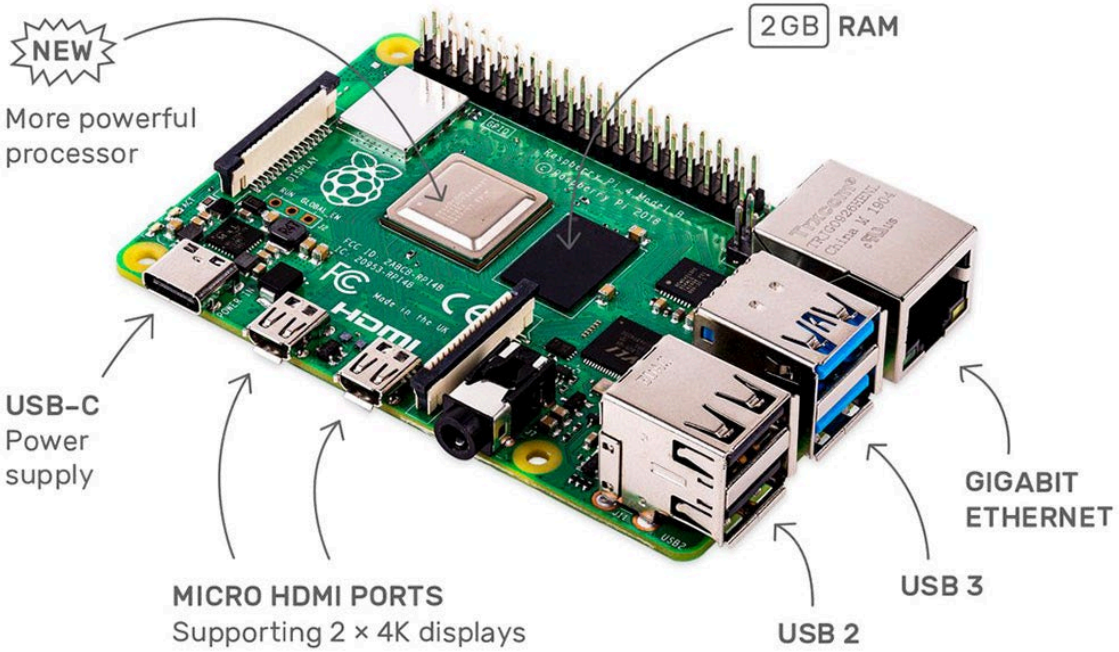
Microcontrollers

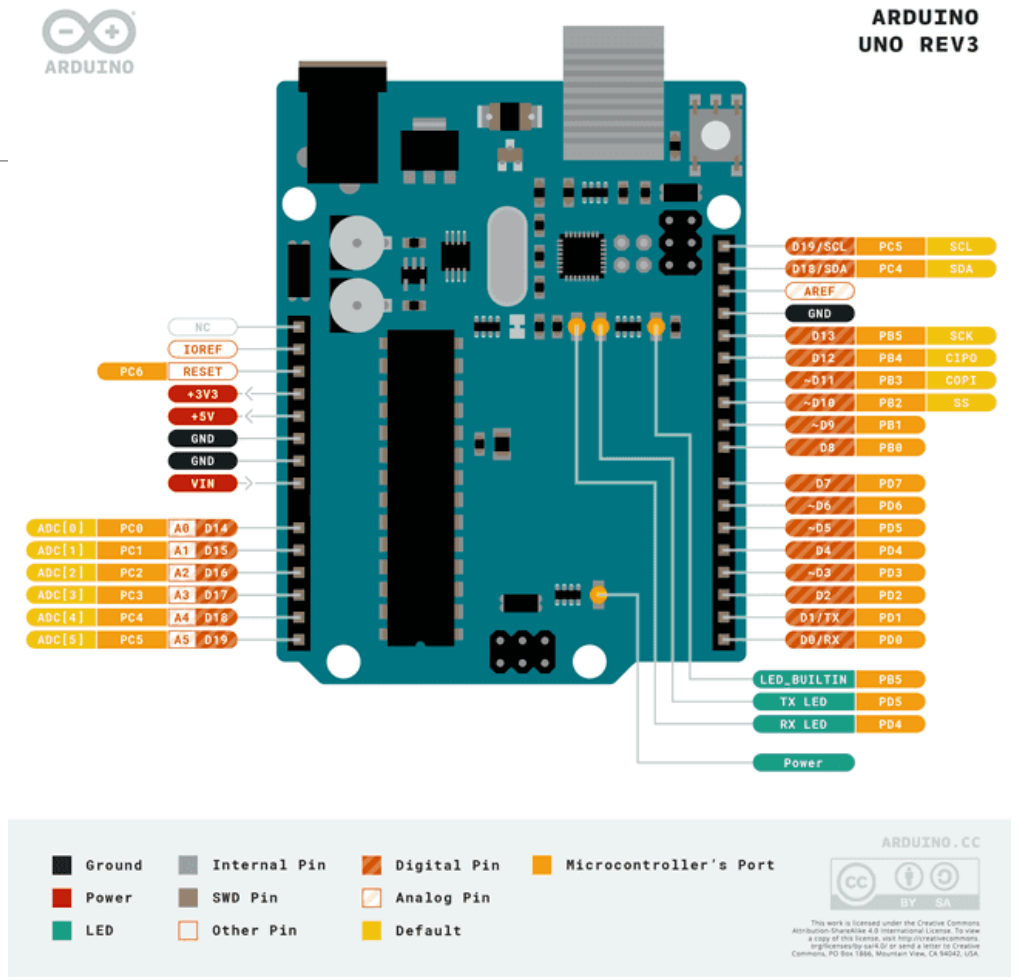
- A microcontroller is a compact integrated circuit that contains a processor, memory, and I/O peripherals, often used in embedded systems for controlling specific tasks.
- **Key Features**:
  - **Small and Lightweight**: Designed for single-purpose tasks or specific applications.
  - **Integrated Components**: Includes CPU, RAM, ROM, and I/O ports on a single chip.
  - **Programming Languages**: Typically programmed using C/C++, Python, or assembly language.
  - **Power Efficiency**: Suitable for battery-operated devices.

Microprocessor

- A microprocessor is the central processing unit (CPU) of a computer or embedded system, responsible for executing instructions, performing calculations, and controlling other components. It is essentially the "brain" of most electronic devices, allowing them to process data and make decisions.
- **Microcontroller vs Microprocessor**
  - Microprocessor: Focuses on computing and data processing tasks. It requires external memory and peripheral components (e.g., RAM, storage, I/O interfaces) to function.
  - Microcontroller: A complete, integrated system that includes a microprocessor, memory, and I/O components on a single chip, often used in embedded applications.

Arduino & Raspberry Pi





Group task

- Get into pairs or groups of 3
- Your job is to design systems to solve the scenarios in the document

- Think about what sensors, actuators, microcontroller and/or microprocessor will solve the task
- Look up components (sensors, actuators, MC/MPU) and select ones that fit the scenario
- Show how you would connect the components (if you don’t know how google it or ask me)