CAPUEE 25-26

Communications

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Agenda

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1. Introduction
2. ESP32 -> Laptop (receive data from sensors)
3. Laptop -> ESP32 (send commands to actuators)

Why connect Python and Arduino?

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Arduino/ESP32:

- Reads sensors and control actuators
- Real time interaction with the physical world
- **But low computing power**

Laptop (Python):

- Handles heavy computation (i.e. data processing, ML algorithms, visualizations…)
- Easy access to APIs, databases, …
- Faster to code and more user friendly compared to C/C++

Objectives

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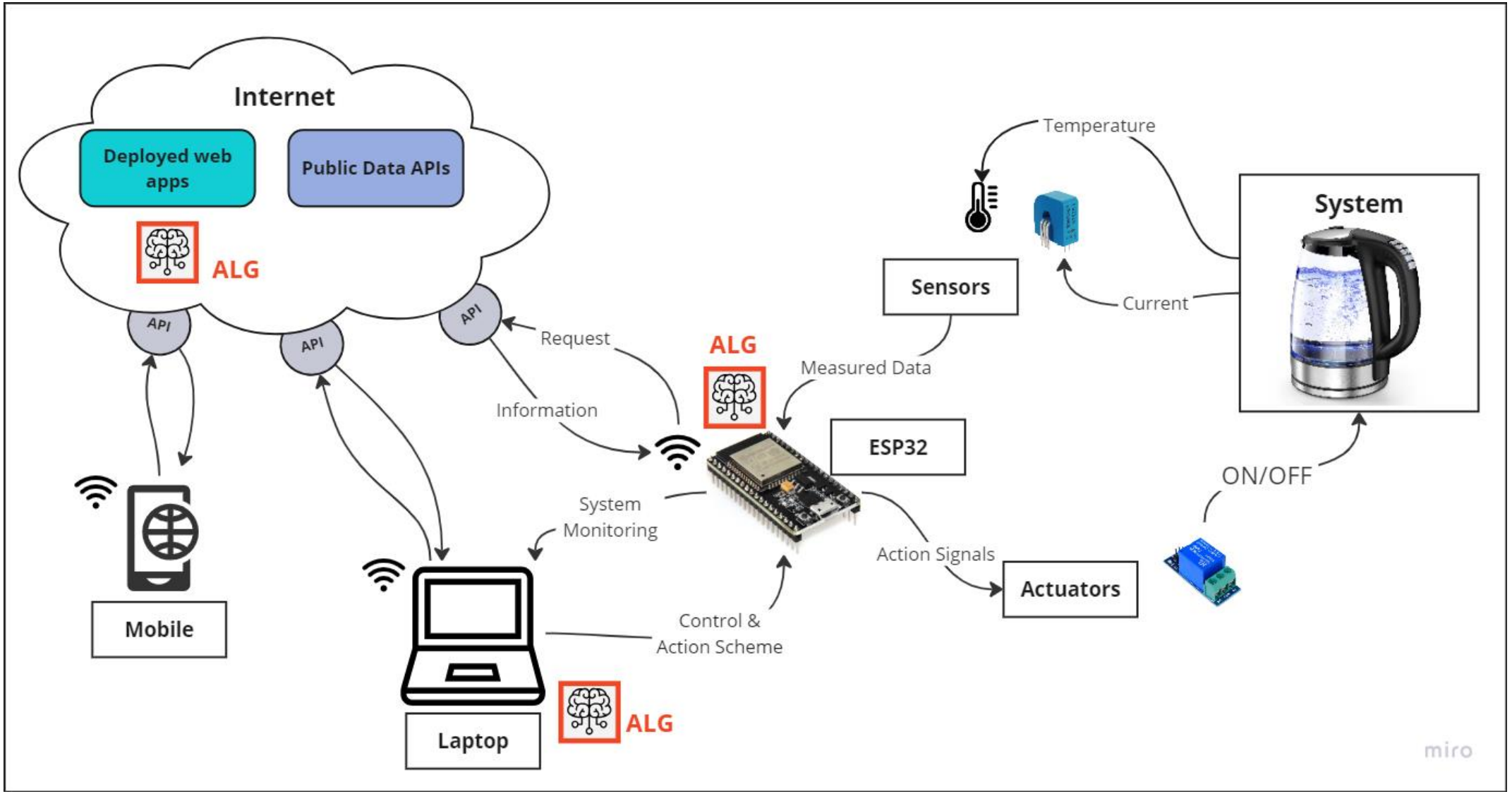
ESP32 -> Laptop

- Verify hardware and sensors connections
- Install pyserial library
- Establish serial communication and send data to laptop
- Store in .csv and visualize measured data

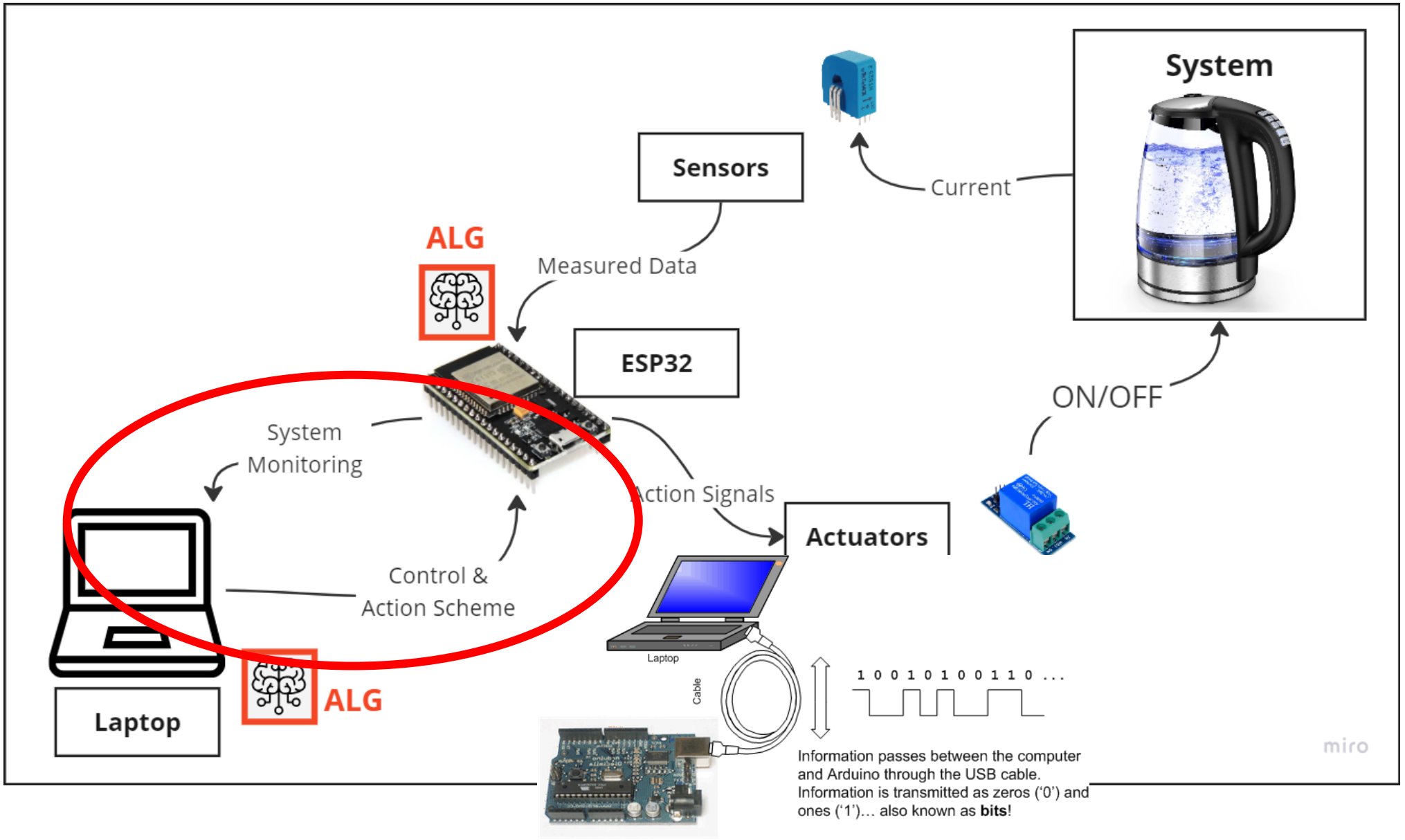
Laptop -> ESP32

- Define action signals (When do we turn ON/OFF?)
- Implement relay actuation

Communications & data flows



Communications & data flows



Serial communication

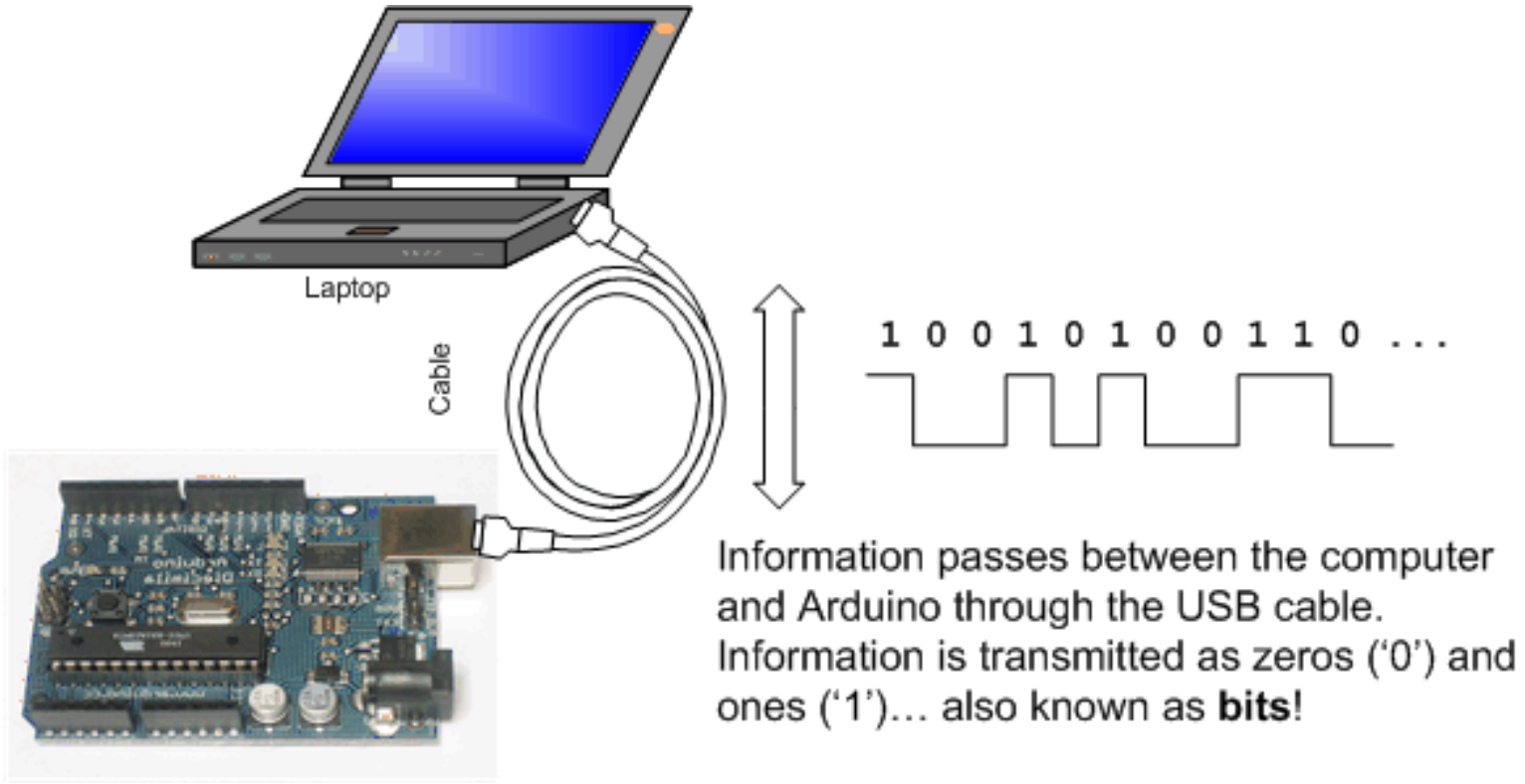
Serial port: information is transferred (Input or Output) sequentially one bit at a time

PROS:

- Easy to code and to set up

CONS:

- Requires cable
- Low data transfer capabilities (ok for sensors but not for audio)
- Needs to define how to parse the message

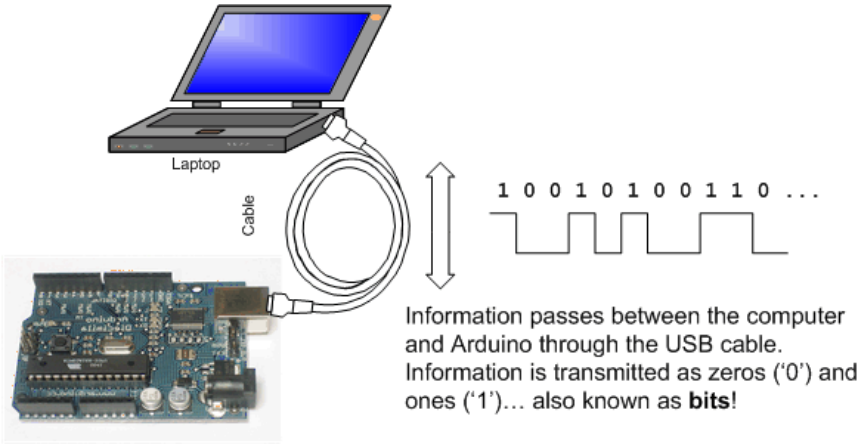


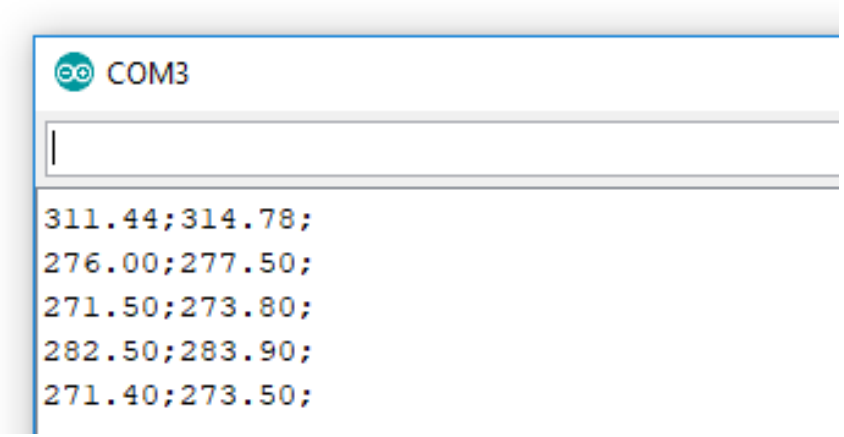
1. Send data from ESP32 to PC

Send data from ESP32 to PC with pyserial

1. Install **Pyserial;**
2. Connect ESP32 (Windows: “**COM3**”, “COM4”…; macOS: ***/dev/ttyUSB0***, /dev/ttyACM0, or similar);
3. (Arduino IDE): print desired variables;
4. (python): initialize serial object, read data lines and decode in desired data structure – i.e. pandas dataframe.

OBS 2: useful to separate values with “;”.





Install pySerial

Install with package manager of choice

```
pip install pyserial
```

When we use the code then we import the module it with:

```
import serial
```

Somewhat uncommon (but not impossible) for a **module** to have a different name from the **package** that installs it. (in most cases, the package name and module name are the same to avoid confusion)isn’t

pySerial how to use

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- Same baud rate on Arduino and Python side
- Make sure the serial monitor is closed (exclusive control over serial port taken by pyserial);
- Wait after opening port
- Use **println()** on the Arduino side and read line by line in Python using **.ser** command

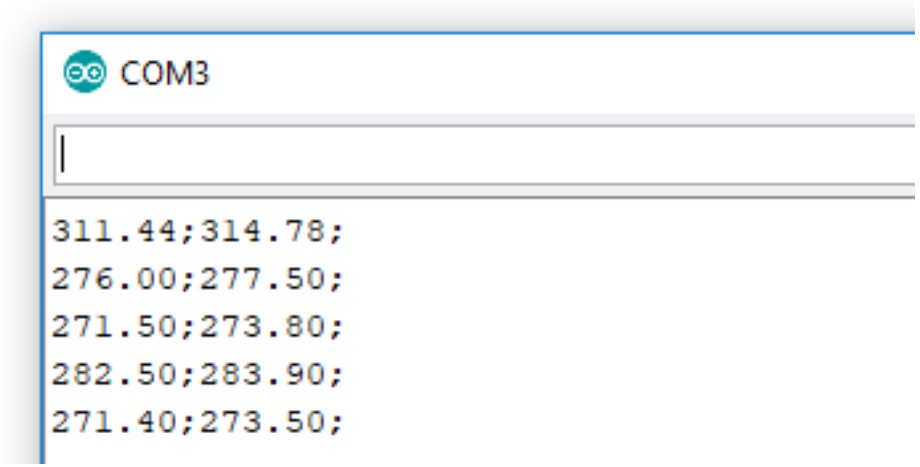
```
line = ser.readline().decode().strip()
```

- Read the line passed from the serial port, decode it and strip it of blanks

Aduino code: print() & println()

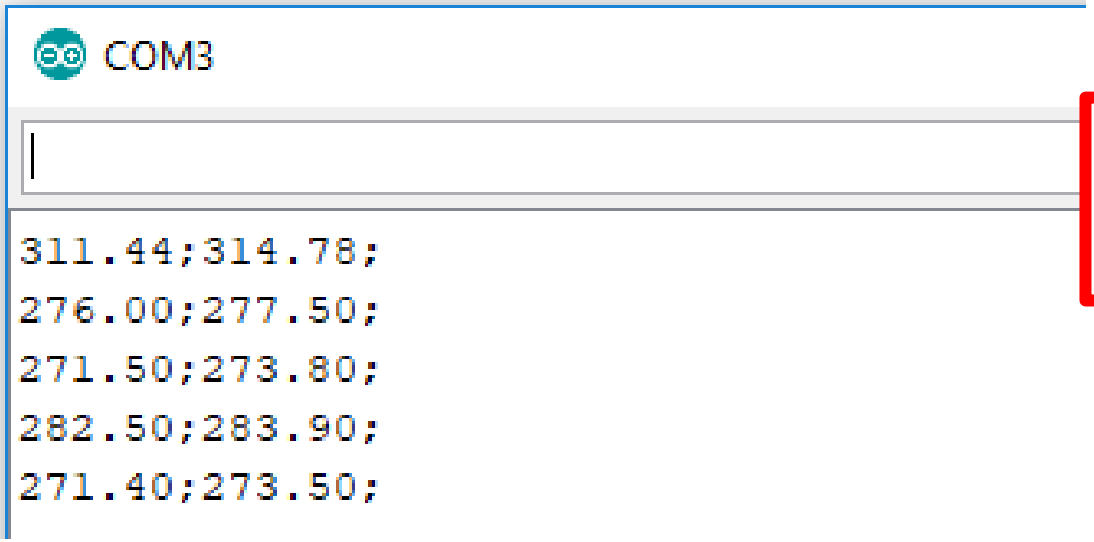
- **print():** print to serial monitor (or **serial output**);
- **println():** print to serial monitor and create new line afterwards.

```
const int sensor1Pin = A0;
const int sensor2Pin = A1;

void setup() {
  Serial.begin(9600);
}

void loop() {
  int sensor1Value = analogRead(sensor1Pin);
  int sensor2Value = analogRead(sensor2Pin);

  // Print the sensor values on the same line, separated by ";"
  Serial.print(sensor1Value);
  Serial.print(";");
  Serial.print(sensor2Value);  // Send sensor 2 value and a newline
  Serial.println(";");

  delay(1000);  // Wait 1 second before the next reading
}
```



Parsing data

parsing: take a raw string and extract useful meaningful values



Understand the format

float + “;” + float + “;” + newline

Parsing with Python functions

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```python
import serial

ser = serial.Serial("COM3", 115200)

while True:
    line = ser.readline().decode().strip()  # read a full line
    if not line:
        continue

    parts = line.split(";")  # split at semicolon
    parts = [p for p in parts if p]  # remove empty elements

    # convert to floats
    values = [float(p) for p in parts]

    print(values)
```

Or with regex

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```python
import serial
import time
import re

# Set up the serial port
ser = serial.Serial('COM3', 9600, timeout=1)
time.sleep(2)  # Wait for Arduino to initialize

try:
    while True:
        if ser.in_waiting > 0:
            line = ser.readline().decode().strip()  # Read a line and decode

            # Use regex to find all numbers in the received line
            numbers = re.findall( pattern: r"[-+]?\d*\.\d+|[-+]?\d+", line)

            # Print the extracted sensor values
            print(f"Extracted values: {numbers}")
```

Parsing data: REGEX

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To find and extract specific text from a string

```python
import re

data = "Price: 42, Discount: 5.5%"
numbers = re.findall( pattern: r"[-+]?\d*\.\d+|[-+]?\d+", string=data)
print(numbers)  # Output: ['42', '5.5']

data2 = "32; 32.44; 375.67"
numbers2 = re.findall(pattern=r"[-+]?\d*\.\d+|[-+]?\d+", string=data2)
print(numbers2) # Output: ['32', '32.44', '375.67']
```

Floating-Point Numbers: [-+]?\d*\.\d+: **[-+]?** optional + or – sign, **\d*** zero or more digits before the decimal point, **\.** decimal point, **\d+** one or more digits after the decimal (e.g., 3.14, -982.22).

Integers: [-+]?\d+: **[-+]?,** optional + or -, **\d+** one or more digits (e.g., 42, -15).

2. Send data from PC to ESP32

Send data from PC to ESP32 (example)

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1. Send command from python using pyserial
2. Receive command with Arduino IDE
3. Action signals based on command (i.e. turn ON/OFF)

Python code

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```
try:
    while True:
        current_time = datetime.now()

        # Determine if the current second is even or odd to toggle the relay
        if current_time.second % 30 < 15:
            command = 'H'  # Send HIGH
        else:
            command = 'L'  # Send LOW

        ser.write(command.encode())  # Send the command to Arduino
        print(f"Sent command: {command} at {current_time.strftime('%H:%M:%S')}")

        time.sleep(1)  # Adjust the sleep time as necessary

except KeyboardInterrupt:
    print("Stopped by user")

finally:
    ser.close()  # Close the serial connection when done
```

Arduino code

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```ino
const int relayPin = 13;  // Pin connected to the relay or LED

void setup() {
  Serial.begin(9600);  // Start serial communication at 9600 baud
  pinMode(relayPin, OUTPUT);  // Set the relay pin as an output
}

void loop() {
  if (Serial.available() > 0) {  // Check if data is available to read
    char command = Serial.read();  // Read the incoming command

    if (command == 'H') {
      digitalWrite(relayPin, HIGH);  // Turn on the relay or LED
      Serial.println("Relay/LED ON");
    } else if (command == 'L') {
      digitalWrite(relayPin, LOW);  // Turn off the relay or LED
      Serial.println("Relay/LED OFF");
    }
  }
}
```

Exercise

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1) Write an Arduino code to send a line to python (sensor data, “hello world”, ...) and read it with python

2) Do the opposite. Write a python code that writes piece of information (I,e, “HIGH” or “LOW”) and send it to Arduino

THANK YOU
FOR YOUR ATTENTION

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