PHYSICAL SENSORS FOR ENVIRONMENTAL SIGNALS

Irene Nutini

Master Degree in Artificial Intelligence for Science and Technology (AI4ST)

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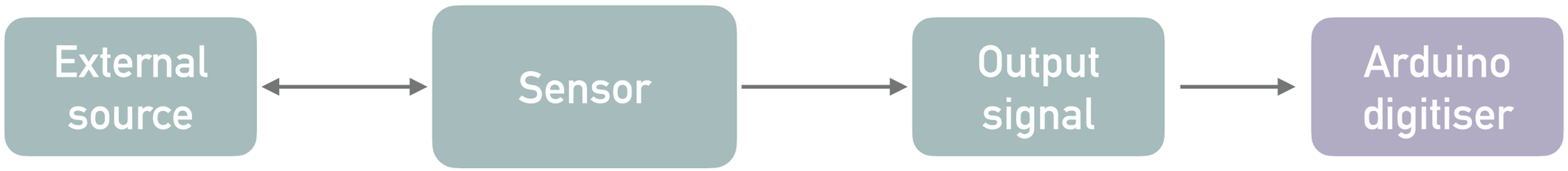
OUTLINE OF THE COURSE

- Lecture 1: Introduction to environmental signals and physical sensors
- Lab 1: Introduction to instruments for measurements
- Lecture 2: Vibrations: sources and detection
- Lab 2: Characterisation of an acoustic system
- Lecture 3: Distance, position and speed measurement
- Lab 3: Measuring distance with ultrasounds and speed with an accelerometer
- Lecture 4: Electromagnetic radiation: sources and detection
- Lab 4: Detecting and generating light

SENSING THE ENVIRONMENT

EXAMPLE: LIGHT DETECTION WITH A PHOTOSENSOR



- Source: Ambient light / LED
- Sensor: Phototransistor
- Read the signal output: Arduino digitiser

Lab.4 (today)

DETECTING LIGHT

- Source: Ambient light / LED
- Sensor: Phototransistor
- Read the signal output: Arduino digitiser

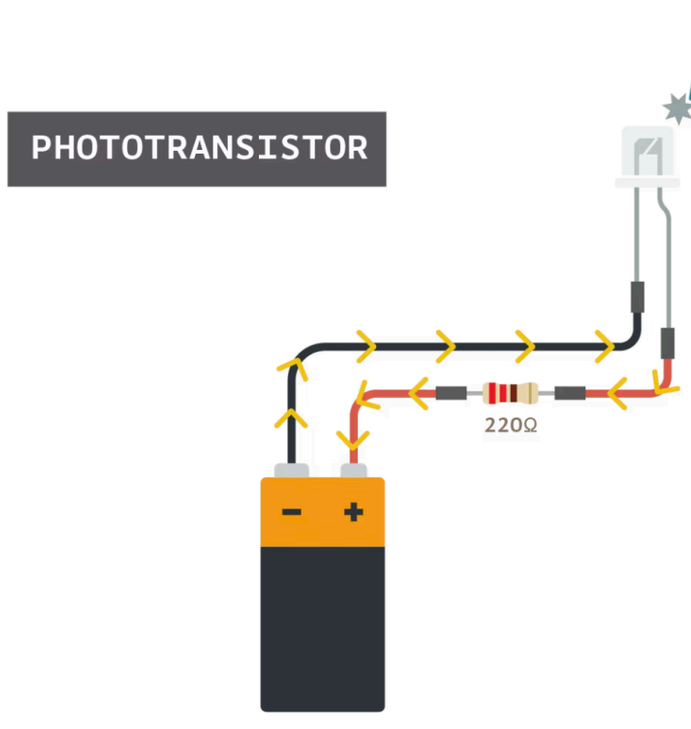
We'll use the Arduino board and a phototransistor to investigate electromagnetic waves – specifically visible light. We'll explore some of the applications of detecting and measuring light such as communication.

Reference: *https://studentkit.arduino.cc/studentkit/module/student-kit/lesson/light-wave-radar*

DETECTING LIGHT

- Phototransistor

A **phototransistor** is an electronic component that converts light energy into electrical energy.



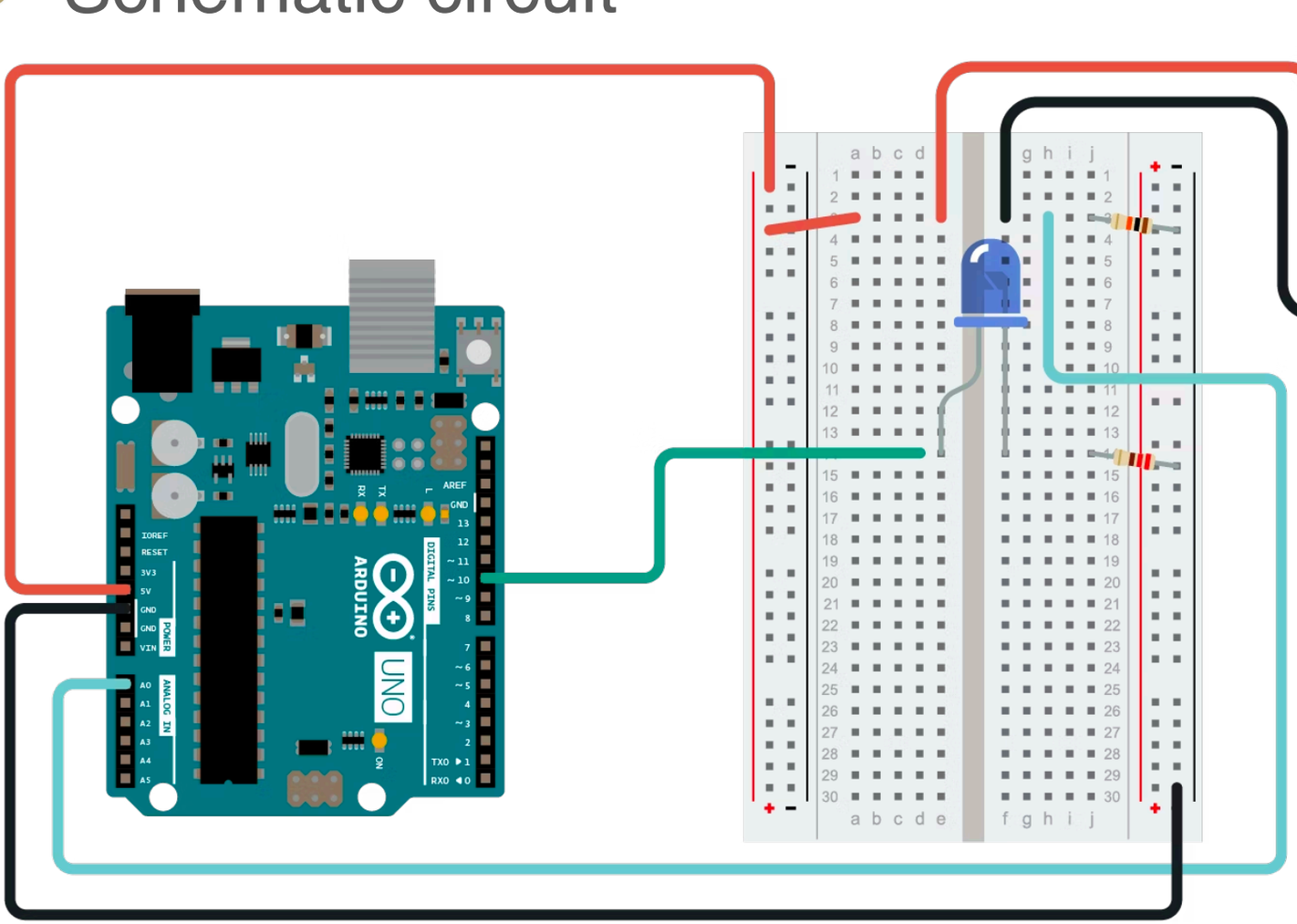
In Lab:

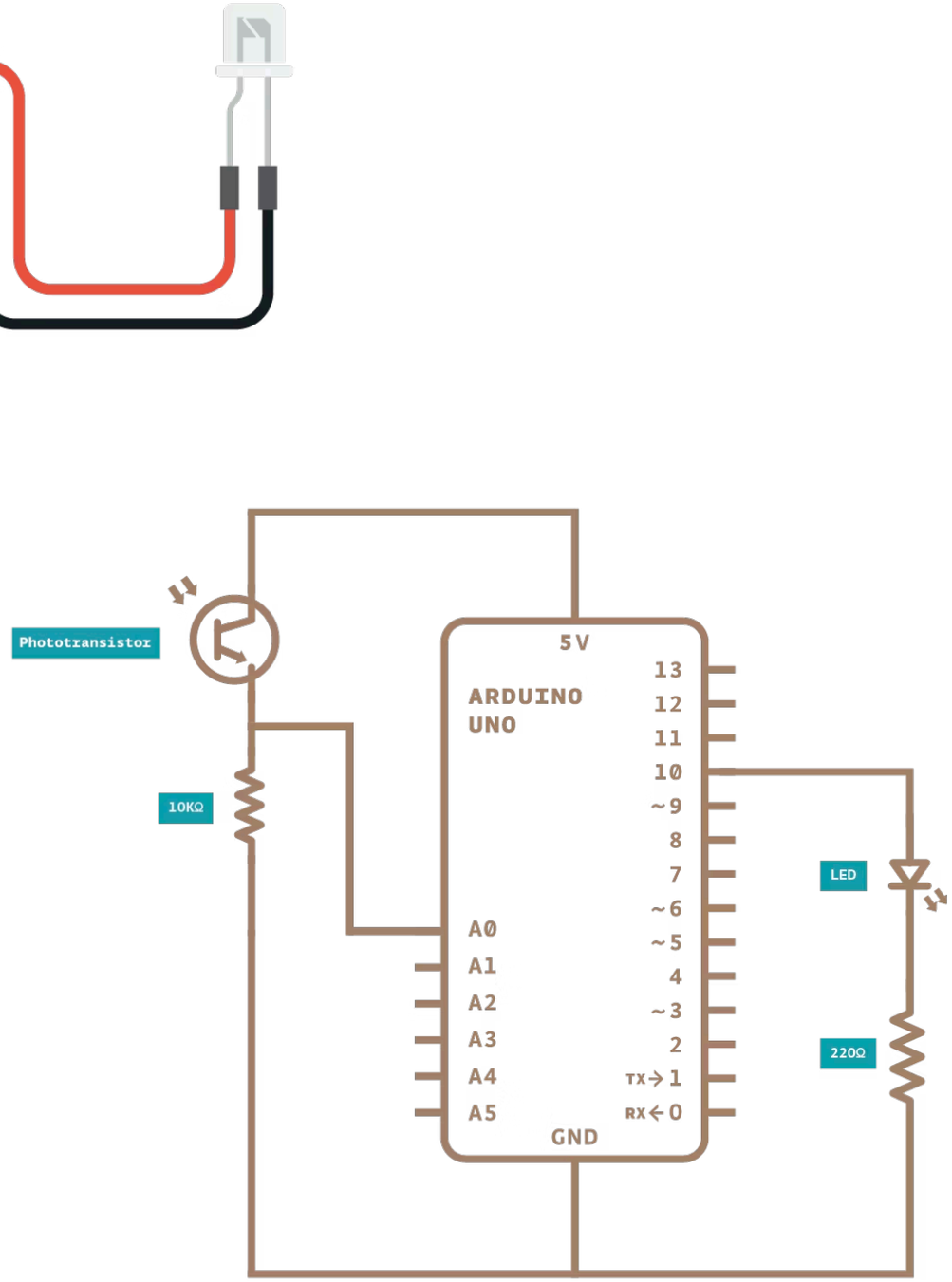
BPW40 Silicon NPN Epitaxial Planar Phototransistor

http://www-9.unipv.it/lde/strumentazione_comp_extra/datasheet/BPW40.pdf

DETECTING LIGHT

- Schematic circuit

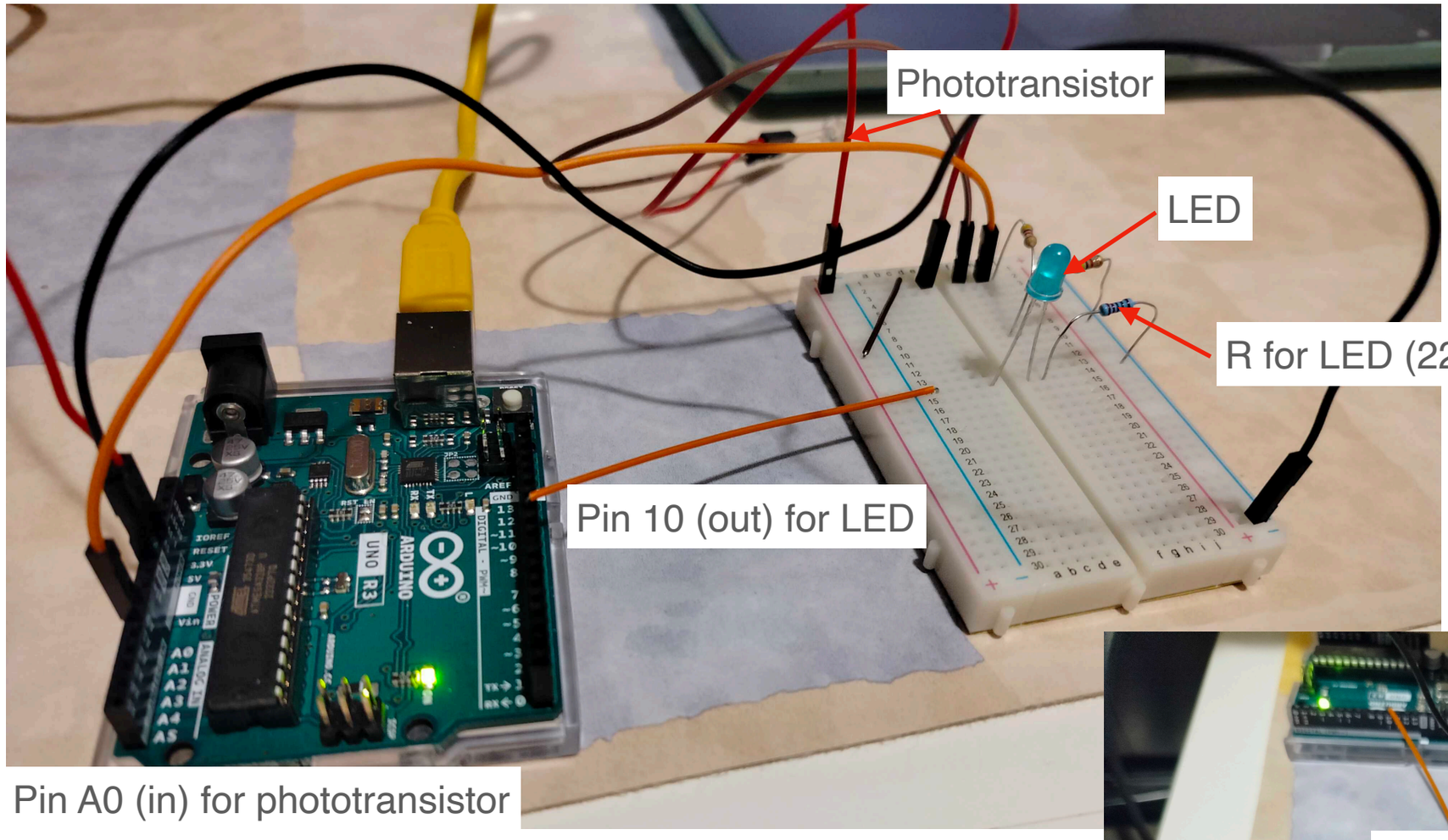


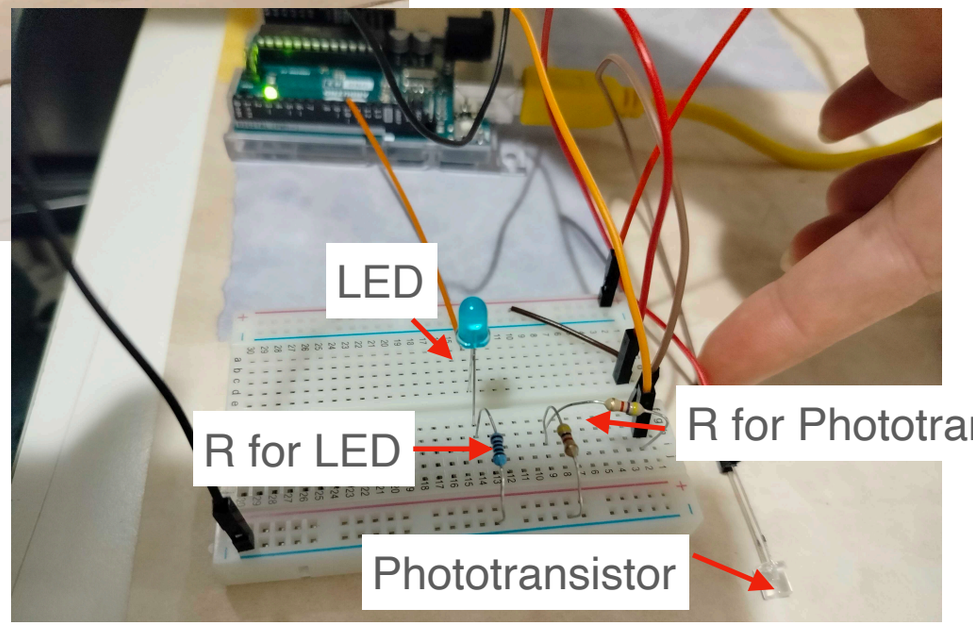


Note: in Lab, red LED

DETECTING LIGHT

- Real circuit





DETECTING LIGHT

- Reading the phototransistor signal with Arduino serial output

1. The first sketch enables to use the phototransistor as a light sensor to detect the brightness, or intensity, of the light in the room.

2. Move the light sensor around and observe the measurement on the serial monitor. Cover the light sensor with your hand. Point the light sensor at a light in the room.

Photodetector.ino

```
1   // name Arduino board pins used by the circuit
2   const int sensorPin = A0;
3
4   // declare variables
5   int lightAmount = 0;
6
7   void setup() {
8     // put your setup code here, to run once:
9     // start the serial monitor
10    Serial.begin(9600);
11
12  }
13
14  void loop() {
15    // put your main code here, to run repeatedly:
16    lightAmount = analogRead(sensorPin);
17
18    // output info to the serial monitor
19    Serial.print("Light Intensity: ");
20    Serial.println(lightAmount);
21
22    delay(1000);
23  }
24
```

DETECTING LIGHT

- Reading the phototransistor signal with Arduino serial output

1. In this activity, we use an LED and light sensor to simulate sending information through light waves (eg. Optical fiber transmission of information).
2. Modify the previous sketch to cause the blue LED to blink and act as a light source. As the light sensor is oriented at the LED, we observe how the light sensor reacts to the blinking light.

Photodetector_LED.ino

```
// name Arduino board pins used by the circuit
const int sensorPin = A0;
const int LEDPin = 10;

// declare variables
int lightAmount = 0;
long timerLED = 0;
long timerSensor = 0;
int toggleLED = 0;

void setup() {
  // put your setup code here, to run once:
  pinMode(LEDPin, OUTPUT);
  // start the serial monitor
  Serial.begin(9600);

}

void loop() {
  // put your main code here, to run repeatedly:
  //In the void loop() part of the sketch, you will have two tasks.
  //The first task is to create a transmitter that flashes the light.
  //The second task is to create a receiver that detects the light

  transmitter();
  receiver();

  //delay(1000);
}

void transmitter(){
  // code for transmitting a signal in 4-second intervals
  if (millis() >= timerLED + 2000) {
    toggleLED = !toggleLED;
    digitalWrite(LEDPin, toggleLED);
    timerLED = millis();
  }
}

void receiver(){
  // code for receiving signals every 100 milliseconds
  if (millis() >= timerSensor + 100) {
    // read the light sensor and store the measurement in a variable
    lightAmount = analogRead(sensorPin);

    // output info to the serial monitor
    Serial.print("Light Intensity: ");
    Serial.println(lightAmount);

    timerSensor = millis();
  }
}
```

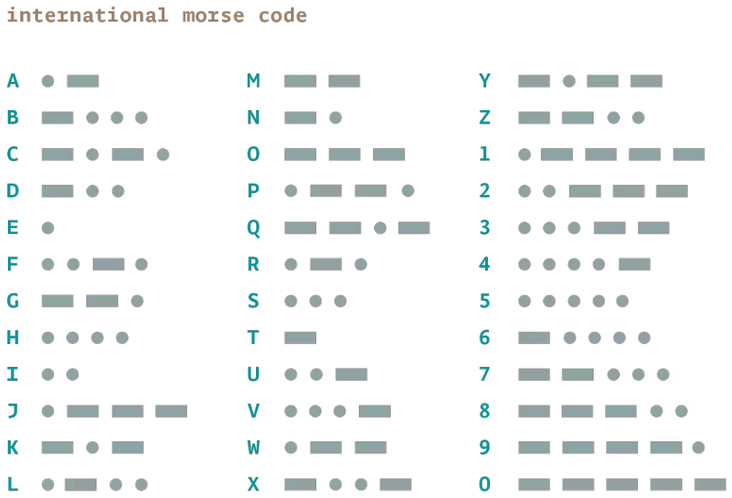
DETECTING LIGHT

- Generating light signal (with morse code) giving serial input to Arduino

1. In this activity, we'll see that the serial monitor can be used to input information and tell the Arduino UNO R3 board what to do.

2. You can turn on and off the LED of the circuit (pin 10) by inputting commands into the serial monitor. On the input line of the serial monitor: H - turns the LED on, L - turns the LED off

3. Send an SOS signal in morse code with LED blinking light by serial input




```
/*
  Physical Pixel - SOS
  From: https://www.arduino.cc/en/Tutorial/BuiltInExamples/PhysicalPixel
*/

const int ledPin = 10;// the pin that the LED is attached to
int incomingByte;       // a variable to read incoming serial data into

void setup() {
  // initialize serial communication:
  Serial.begin(9600);
  // initialize the LED pin as an output:
  pinMode(ledPin, OUTPUT);
}

void loop() {
  // see if there's incoming serial data:
  if (Serial.available() > 0) {
    // read the oldest byte in the serial buffer:
    incomingByte = Serial.read();
    // if it's a capital H (ASCII 72), turn on the LED:
    if (incomingByte == 'H') {
      digitalWrite(ledPin, HIGH);
      delay(300);
    }
    // if it's an L (ASCII 76) turn off the LED:
    if (incomingByte == 'L') {
      digitalWrite(ledPin, LOW);
      delay(300);
    }
  }
  // SOS
  // HL HL HL HHL HHL HHL HL HL HL
}
```