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Through a microbiologist's eyes: optimal time to add honey to tea

Measuring temperature with Arduino

This optional method can be used instead of a standard thermometer in Activity 3. An Arduino Uno and a DS18B20 digital temperature sensor record the water temperature automatically at regular intervals.

Safety note: Take care when handling freshly boiled water. Wear safety goggles and heat-resistant gloves, keep electrical components dry and place the Arduino and computer away from the cup.

Materials and equipment

For each group:

- Arduino Uno
- DS18B20 digital temperature sensor
- 4.7 kΩ resistor
- Breadboard
- Jumper wires
- USB cable
- Computer with Arduino IDE installed
- Laboratory stand and clamp
- 250 ml ceramic cup
- 200 ml freshly boiled water
- Measuring cylinder
- Heat-resistant gloves
- Safety goggles
  Equipment for boiling water, e.g. a kettle or a hot plate with a heatproof beaker.
- Worksheet 3

Connecting the DS18B20 sensor

1. Connect the sensor's power wire to the Arduino 5 V pin (figure 1).
2. Connect the ground wire to the Arduino GND pin.
3. Connect the data wire to digital pin 13.
4. Connect a 4.7 kΩ resistor between the data wire and the 5 V connection.
5. Check all connections before powering the Arduino.

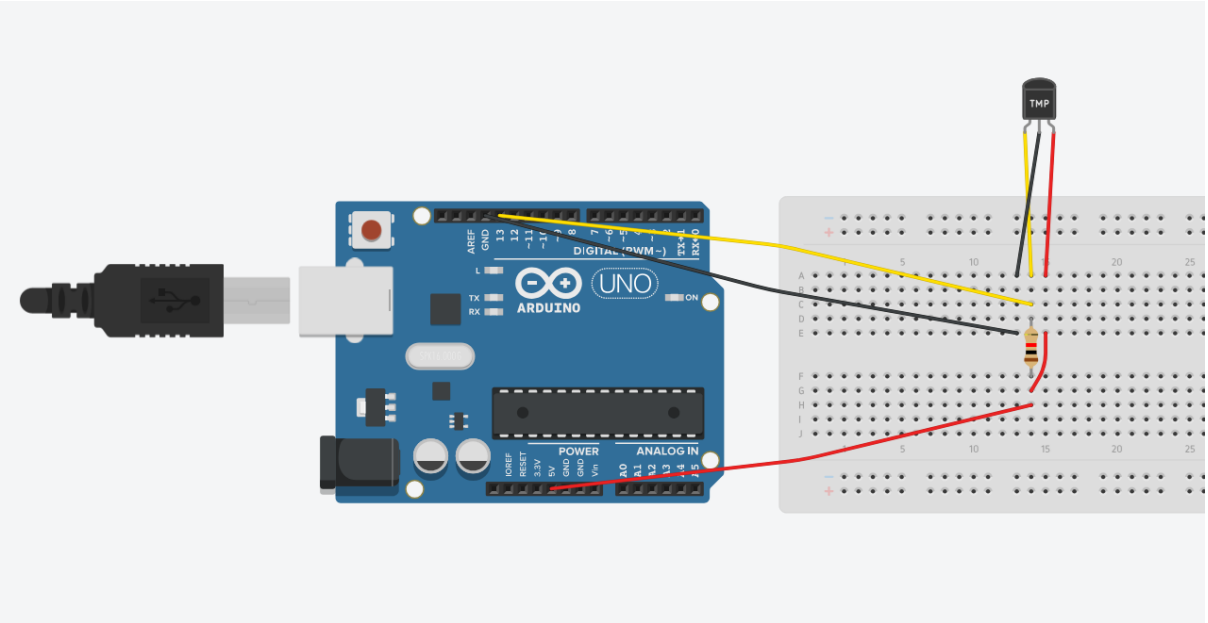


Figure 1: Connecting the DS18B20 temperature sensor to the Arduino
Image courtesy of the author, created using Tinkercad

Software preparation

1. Open the Arduino IDE.
2. Install the OneWire and DallasTemperature libraries.
3. Connect the Arduino Uno to the computer using a USB cable.
4. In the Arduino IDE, select Tools → Board → Arduino Uno.
5. Select the correct connection under Tools → Port.
6. Copy the code below into the Arduino IDE.
7. Click Upload to transfer the code to the Arduino.

The sensor should be connected according to its manufacturer's wiring information, as wire colours may differ between models.

Arduino code

```
#include <OneWire.h>
#include <DallasTemperature.h>
const int SENSOR_PIN = 13;
OneWire oneWire(SENSOR_PIN);
DallasTemperature tempSensor(&oneWire);
float tempCelsius;
void setup() {
  Serial.begin(9600);
  tempSensor.begin();
}
void loop() {
```

```
  tempSensor.requestTemperatures();
  tempCelsius = tempSensor.getTempCByIndex(0);
  unsigned long currentMillis = millis();
  unsigned long seconds = currentMillis / 1000;
  unsigned long minutes = seconds / 60;
  seconds = seconds % 60;
  Serial.print("Time: ");
  Serial.print(minutes);
  Serial.print(" min ");
  Serial.print(seconds);
  Serial.print(" sec | Temperature: ");
  Serial.print(tempCelsius);
  Serial.println(" °C");
  delay(1000);
}
```

This code records the temperature once every second and displays the elapsed time and temperature in the Arduino IDE Serial Monitor

Note: This activity can also be carried out in collaboration with an IT teacher. The IT teacher can work together with students to prepare, adapt, and test the Arduino code before the experiment.

Procedure

1. Secure the DS18B20 sensor to a laboratory stand so that it remains in the centre of the cup.
2. Ensure that the sensor does not touch the bottom or sides of the cup.
3. Measure 200 ml of freshly boiled water and pour it carefully into a 250 ml ceramic cup.
4. Connect the Arduino Uno to the computer using the USB cable.
5. In the Arduino IDE, confirm that Arduino Uno is selected under Tools → Board and that the correct connection is selected under Tools → Port.
6. Upload the code by clicking Upload.
7. Open the separate data-output window by selecting Tools → Serial Monitor or by clicking the Serial Monitor icon in the upper-right corner of the Arduino IDE.
8. Set the baud rate in the Serial Monitor to 9600, matching 'Serial.begin(9600)' in the code.
9. Place the sensor in the water. Temperature and elapsed-time readings should now appear continuously in the Serial Monitor (figure 2)
10. Begin recording from the first displayed value and continue until the water reaches the target temperature identified in Activity 2.
11. Record the time required to reach this temperature in Worksheet 3.

12. Repeat the measurement at least three times under the same conditions.
13. Calculate the mean cooling time and plot temperature against time.

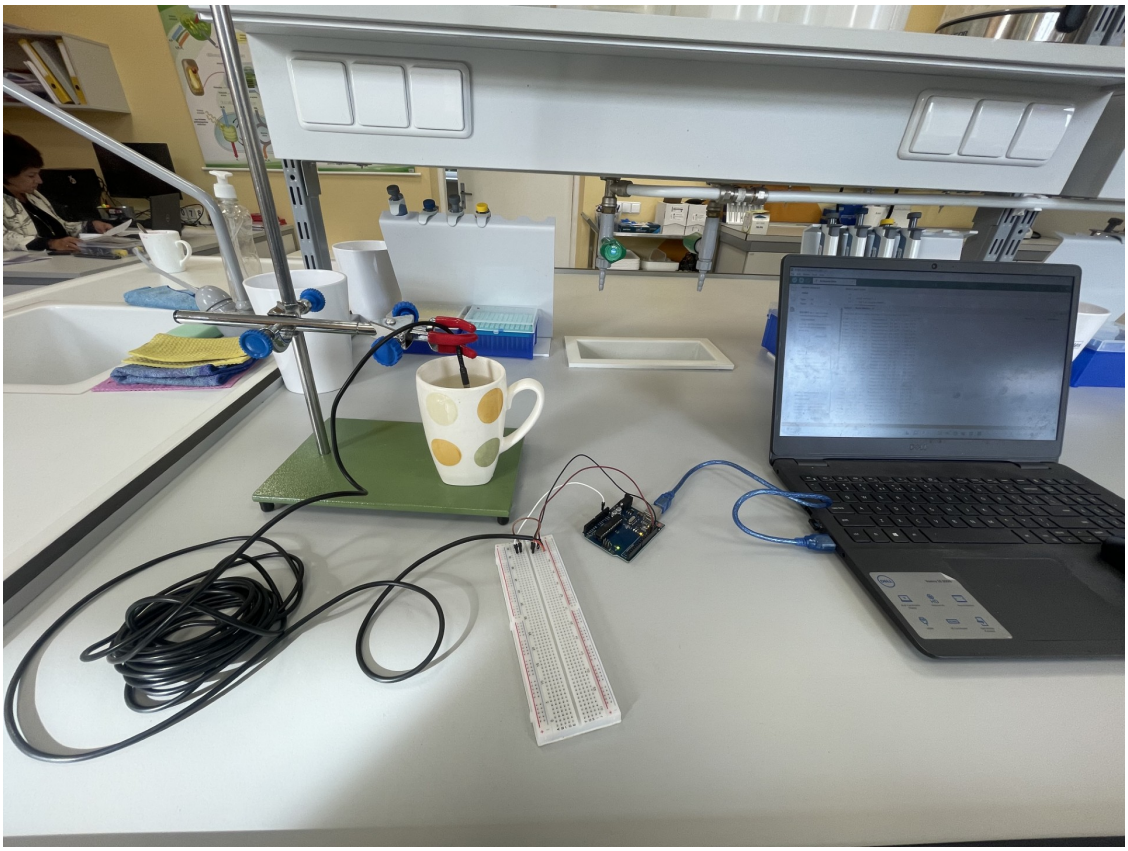


Figure 2: Measuring temperature with DS18B20 sensor and Arduino
Image courtesy of the author

Resources

Tutorial on how to connect the DS18B20 temperature sensor to the Arduino microcontroller: https://www.circuits-diy.com/ds18b20-temperature-sensor-arduino-tutorial/