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ROBOSTEM IO2 – Studying the kinematics and Dynamics of Simple Harmonic Oscillator with the use of a Microcontroller-based System

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Title

Studying the kinematics and Dynamics of Simple Harmonic Oscillator with the use of a Microcontroller-based System

Required elements

- 1x Arduino Uno
- 1x Breadboard
- 1x LCD Display
- 1x Accelerometer
- HC-SR04 Ultrasonic Sensor
- Springs
- Brass Weights
- Stand
- Computer
- Microsoft office 365 (for excel Microsoft Streaming Data)

Assembly steps

Step 1 Setting up the hardware

The hardware is quite simple to set up. The ultrasonic sensor will be used to measure the distance to the weights which will be attached to the spring. Figure 1 depicts the wiring configuration that will be used.

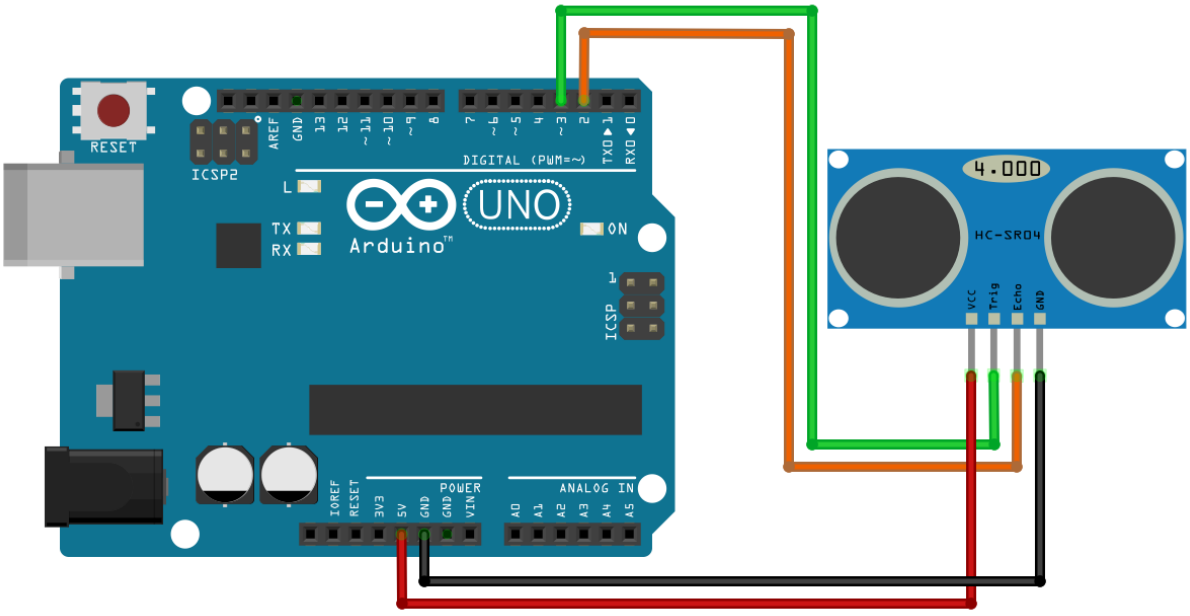

Figure 1 - Ultrasonic Sensor Wiring configuration

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First what is needed is to define the inputs/outputs of the ultrasonic sensor. For this, we state that the echo pin is of pin D2 & trigger pin to D3 of the Arduino.

```
#define echoPin 2 // attach pin D2 Arduino to pin Echo of HC-SR04
#define trigPin 3 //attach pin D3 Arduino to pin Trig of HC-SR04

int i;

// defines variables
float duration; // variable for the duration of sound wave travel
float distance; // variable for the distance measurement

void setup() {
  pinMode(trigPin, OUTPUT); // Sets the trigPin as an OUTPUT
  pinMode(echoPin, INPUT); // Sets the echoPin as an INPUT
  Serial.begin(9600); // // Serial Communication is starting with 9600 of baudrate speed
}
```

The code below depicts the workings of an ultrasonic sensor. Since it is using sound to measure, we use the speed of sound to calculate the time it will take for the ultrasonic sensor to measure the speed.

This is done by triggering a High Output and a low output from the sensor to know when it outputted a signal and for how long it will take for the sensor to get feedback from it. This value is then divided by 2 and multiplied by the speed of sound. This is then sent via the USB connection to the computer with the “Serial.println” command. The code is depicted below with the comments inside it for better understanding.

```
void loop() {
  // Clears the trigPin condition
  digitalWrite(trigPin, LOW);
  delayMicroseconds(2);
  // Sets the trigPin HIGH (ACTIVE) for 10 microseconds
  digitalWrite(trigPin, HIGH);
  delayMicroseconds(10);
  digitalWrite(trigPin, LOW);
  // Reads the echoPin, returns the sound wave travel time in microseconds

  duration= (0.01*pulseIn(echoPin, HIGH))+(0.99*duration);
  //filteredValue = x * rawValue + (1-x)*lastFilteredValue
  //Moving Average

  distance = duration * 0.034 / 2; // Speed of sound wave divided by 2 (go and back)
  // Displays the distance on the Serial Monitor
  //Serial.print("Distance: ");
  Serial.println(distance);
  //Serial.println(" cm");
}
```

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Step 2 Enabling the Data Streamer

Data Streamer is a tool used by Microsoft excel to collect data from microcontrollers. To enable this tool, first you need to access it and enable it (Note: Not all versions have this so check what is supported by your system).

1. Open Excel
2. Go to File > Options > Add-Ins.
3. Make sure COM Add-ins is selected in the Manage box and click Go.
4. In the COM add-Ins dialog box, make sure to select the box next to Microsoft Data Streamer for Excel add-in, then click OK.

Link: https://support.microsoft.com/en-us/office/enable-the-data-streamer-add-in-70052b28-3b00-41e7-8ab6-8a9f142dffeb

Supposedly, you should see a new tab at the top of the Excel window with “Data Streamer”. This will let you start recording data from your microcontroller (which is at this point sending data to your computer. The data will be saved in real time to it. Since its quite a complex software to use, it is best to see the following link and see step by step on how to set it up.

Link: https://support.microsoft.com/en-us/office/start-streaming-real-time-data-with-the-data-streamer-add-in-b6fac0bb-a495-423b-99eb-60c1f1e338d4

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Step 3: Analysis

Once you have everything set up, the data will be displayed onto the excel file where it is then recorded. This data can easily be plotted upon an excel file to achieve this. The picture is showing the sensor set up measuring the bottom of the weights. Since the weights are moving in an oscillatory movement, we are receiving a similar signal upon the Data streamer.

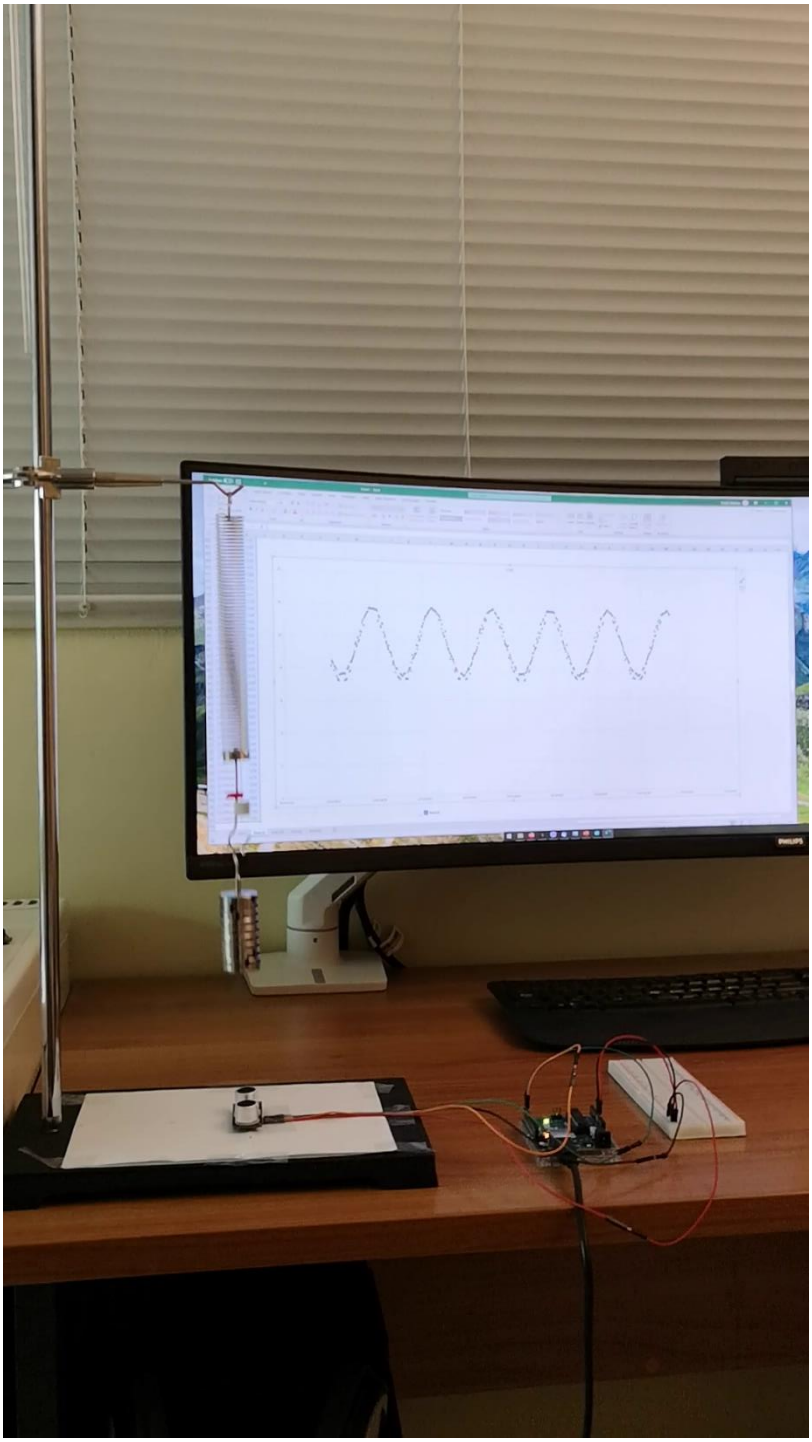

Figure 2 - Final Set up

This is a good experiment to set up in the classroom since it makes it easy to analyse behaviours depicted by a spring. (Note: See video attached “Case Study 2” for a better presentation).

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Useful Links

Microsoft Excel Data Streamer

https://support.microsoft.com/en-us/office/what-is-data-streamer-1d52ffce-261c-4d7b-8017-89e8ee2b806f#:~:text=Data%20Streamer%20is%20a%20two,to%20a%20Windows%2010%20PC

Ultrasonic Sensor

https://www.tutorialspoint.com/arduino/arduino_ultrasonic_sensor.htm

Hooke's Law

https://phys.org/news/2015-02-law.html#:~:text=Hooke's%20Law%20is%20a%20principle,is%20proportional%20to%20that%20distance.

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