Speed of Sound Lab

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Procedure

To calculate the speed of sound we used an arduino apparatus with an ultrasonic sensor and measured the time it took for the ultrasonic signal to go out to and then bounce back off a wooden block. By measuring various distances to the "bouncing point", a wood block, and time of the signal response we can determine how fast this signal is moving and thus the speed of sound using the equation `Velocity = Distance/Time`.

Arduino Set-up

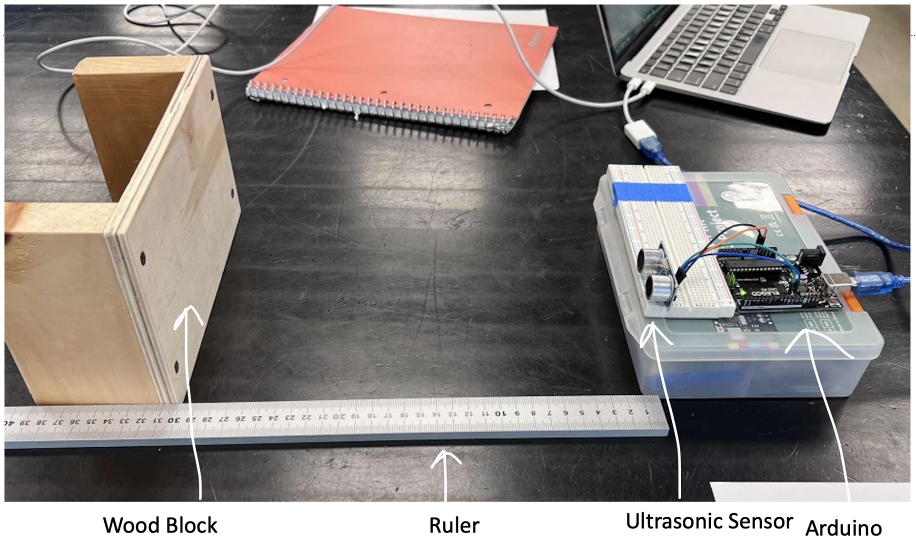

Figure 1. Arduino set up with ultrasonic sensor, a wood block to reflect signal, ruler for positioning block and computer to read signal.

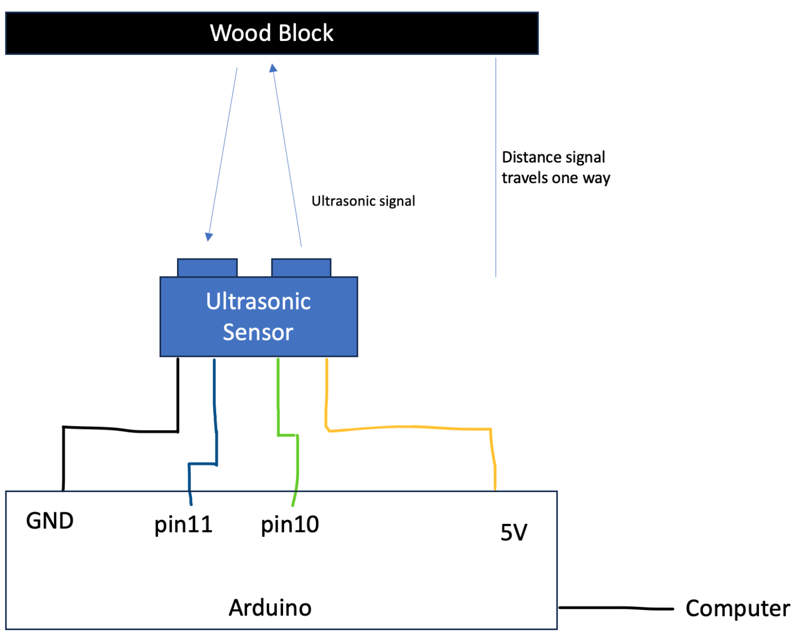

Figure 2. Wire diagram of ultrasonic sensor on Arduino board with wood block.

The ultrasonic sensor was wired to ground on one end as seen in figures 1 & 2 with the black wire and 5 volts on the other in yellow wire. The ultrasonic trig was connected to pin 10 on the Arduino board as seen in green in figures 1 & 2 while the ultrasonic echo was connected to pin 11 in blue. The Arduino itself was also connected to a laptop running the program below.

Code Set-up

```
unsigned long pingTime; // time as an unsigned long to measure microseconds
int trigpin = 10; // outpin to the trig of Ultrasonic Sensor
int echopin = 11; // input pin to the echo of Ultrasonic Sensor
float distance; // Distance in Meters that signal is being sent
float avg; // Avergage time in microseconds to travel distance and back
int sum; // variable for counting microseconds for avg

void setup() {
  pinMode(trigpin, OUTPUT); // initialize trig pin
  pinMode(echopin, INPUT); // initialize echo pin
  Serial.begin(9600); // initialize serial monitor for printing and UI
}
void loop() {

  sum = 0; // initialize sum of microseconds to 0
  Serial.println("How far away is the object?"); // get distance in meters

  while(Serial.available() < 1){} // wait for user input of distance
  distance = Serial.parseFloat(); // read in distance as float to include decimals

  for(int i = 0; i < 10; i++){ // get 10 measurements of time from Ultrasonic sensor
    digitalWrite(trigpin, HIGH); // begins the pulse to the trig pin
    delayMicroseconds(10); // the pulse needs to be high for 10 microseconds
    digitalWrite(trigpin, LOW); // then the pulse can go low

    pingTime = pulseIn(echopin, HIGH); // read in time it takes for signal to come back
    sum += pingTime; // add it on to sum for avg after loop finishes
    Serial.read();
  }
  avg = sum/10; // calculate avg time for 10 tests at this distance
  Serial.println(avg); // print avg

  delay(5000); // delay for 5 seconds before prompting for new distance
}
```

The code we wrote initializes the serial monitor for user input and ultrasonic sensor for measurements. First we prompted the user for the distance from our ultrasonic sensor to the block of wood in meters (ie 30 cm would be input as .3 m). We then sent a high pulse for 10 microseconds on the ultrasonic sensor and measured the time it took for the signal to come back off of the barrier. This was repeated 10 times via a for-loop and the average time in microseconds it takes for the signal to respond is printed to the user interface (serial monitor) to be recorded for analysis.

Collecting and Analyzing Data

Once Arduino board and code set-ups were completed they were run with the wood block positioned 10 cm from the ultrasonic sensor and when prompted for the distance, 0.1 was entered. The code then prints the average time in microseconds it took the signal to go out 10 cm hit the barrier and travel 10 cm back which was recorded by hand. This process was repeated up to 80 cm in increments of 10 (for a total of 8 average times).

To calculate the speed of sound from our data the distance traveled by the signal was plotted against the time (converted to seconds) for the signal to return to the ultrasonic sensor. The distance traveled traveled by the signal is twice the distance the wood block is from the ultrasonic sensor. For example if the block is 10 cm from the sensor we measured the time it takes the signal to travel 10 cm out and another 10 cm back for a total of 20 cm. Thus the time we measured is the time it took the sound wave to travel 20 cm. By plotting our 8 data points with the *total* distance traveled in meters on the y-axis and time in seconds on the x-axis we fit an linear equation where the coefficients is the speed of sound in meters per second.

Using our experimental speed of sound we then calculated our expected speed of sound at room temperature of 20 C. We then calculated the percent difference of our experimental speed to the expected using the formulas below.

```
Vsound = 331m/s + (0.6m/Sc)T
T = 20
Vsound = 343m/s


Percent Difference = |difference/average| x 100%
```