SASTA OLIPHANT SCIENCE AWARDS

SOUTH AUSTRALIAN SCIENCE TEACHERS ASSOCIATION

Prize Winner

Computer Programming, Apps & Robotics

Year 3-4

Jackson Burford

St John's Grammar School - Junior School

Government of South Australia
Department for Education

SASTA South Australian Science Teachers Association

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Doppler Shift Simulator – Report

By Jackson Burford - Oliphant Science Awards 2020

My Project is A Doppler Shift Simulator that will measure light waves. The way it will do that is by using a Ultrasonic Sensor so that when my project goes near an observer all the LEDs will go blue and if it's heading away from the observer the LED's will go red but if my project is not moving all the LED's will white.

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Aim, Purpose, Application and How It is Scientific

My aim is to make a Doppler Shift Simulator using hidden waves. When my project goes toward an observer all the LEDs will go blue and if it is heading away from the observer the LED's will go red but if my project is not moving all the LED's will white. The purpose I am doing this is to get more understanding of waves, but the odd thing is that I am using hidden waves to show Doppler Shift for light waves (light waves aren't actually hidden waves). This will be used to show the science of Doppler Shift.

Supplies

- Ultrasonic sensor
- Arduino
- LEDs
- Battery Pack
- Computer
- Wires
- Google documents
- Keyboard
- Drill
- Hot Glue Gun
- Arduino case
- Wires

How to Use the Doppler Shift Simulator

1. Turn on the Doppler Shift Simulator.
2. Pick the simulator up and keep it still and now the LEDs should be white
3. Move the simulator to the observer fast but not too fast and now the LEDs should be blue.
4. Now move it away from the observer fast but not too fast and now the LEDs should be red.

*The Doppler Shift Simulator works best on flat surfaces.

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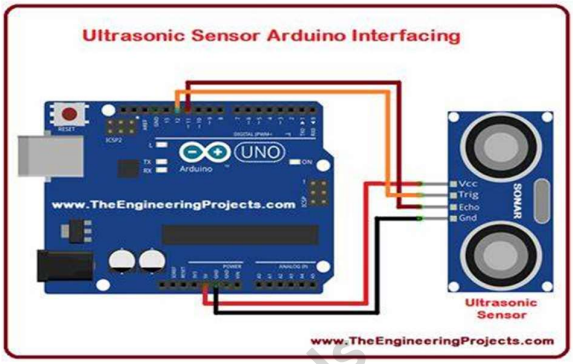
Building the Doppler Shift Simulator

First, I had to watch lots of videos of how the Doppler Effect works and what is the Doppler Effect. Once I knew that my task was to figure out how gravitational, sound, and light waves work. After that I had to start working on my essay for Hidden Waves. While going through my essay I had some tough questions that I had to search up on the internet. When I finished that task, I started to work on my simulator because I got more interested in Doppler Shift. For that I had to work out how to set up the Arduino, LEDs and Ultrasonic Sensor by looking at sites and videos. I have pasted codes into my code then redo the code in my own way. After I have got all my codes into one sketch, I was testing my codes then what I did not see coming is as much debugging as I did. When the code started to work, I plugged out the cord from my computer then plugged my battery pack into the simulator.

Dad helped with drilling and some gluing into the case.

Learning the Code

Recently after I came second in OSA last year I found this book called Python For Kids so I read through it and I found quite a few projects that we can do that is using python so I started doing all of the projects then after a few months I completed the book then I started on a new course. Before I was able to complete the course, I knew that OSA was coming soon so I started to learn a lot more about programing with Arduino after I knew what project I wanted do.



My Arduino Doppler Shift Code

The code below is the code that I used to make the Doppler Shift simulator. I have all the codes commented at the end so that you can understand you will also see the code I made by myself and didn't make by myself by looking at the headings. Also in blue.

```
// SETTING UP ARDUINO HARDWARE
int LED = 9;
long duration; // variable for the duration of sound wave travel
int distance; // variable for the distance measurement
int DistanceValue = 0; // THE DistanceValue IS 0 /BY Jackson
int prev = 0;// THE PREVIOUS DISTANCE IS 0  // BY Jackson

// defining variables
#include <Adafruit_NeoPixel.h>
#define PIN 13
#define N_LEDS 40
#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
Adafruit_NeoPixel strip = Adafruit_NeoPixel(N_LEDS, PIN, NEO_GRB + NEO_KHZ800);

// SETTING UP CODE
void setup() {
 //************
 Serial.begin(9600);
 strip.begin();
 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 baud rate speed
}
```

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```
//**************LED FUNCTIONS*****************************//
//**************BY Jackson*******************************//
void WhiteLED(){
   for (int i = 0; i < 40; i++){ //TELLING ALL LEDS TO LIGHT UP
     strip.setPixelColor(i, 255, 255, 255 ); //TELLING THE LED'S TO LIGHT UP WHITE
    }
   strip.setBrightness(5);
   strip.show();
}
void BlueLED(){
   for (int i = 0; i < 40; i++){ //TELLING ALL LEDS TO LIGHT UP
   strip.setPixelColor(i, 0, 0, 255); //TELLING THE LED'S TO LIGHT UP BLUE
   }
   strip.setBrightness(5);
   strip.show();
}

void RedLED(){
   for (int i = 0; i < 40; i++){ //TELLING ALL LEDS TO LIGHT UP
   strip.setPixelColor(i, 255, 0, 0); //TELLING THE LED'S TO LIGHT UP RED
   }
   strip.setBrightness(5);
   strip.show(); // telling all the other LEDs to be left blaNK
//****************ARDUINO MAIN CODE***************//
void loop (){

//***********LED DISTANCE USING IF ELSEIF ELSE LOOP*****************************
  DistanceValue = distance;// DEFINE DistanceValue AS distance

//**********ULTRASONIC MEASURE**********************
    // 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 = pulseIn(echoPin, HIGH);
  // Calculating the distance
  distance = duration * 0.034 / 2; // Speed of sound wave divided by 2 (go and back)

//****** IF ELSEIF ELSE LOOP**************************
//******BY Jackson************************************
    if (DistanceValue > (prev+5)) {//PREVIOUS CODE + 5
       Serial.println("RED");// WRITE THE WORD RED IN Serial Monitor
       RedLED();//LIGHT UP THE RED LED
    } else if (DistanceValue < (prev-5)) {PREVIOUS CODE - 5
       Serial.println("BLUE");// WRITE THE WORD BLUE IN Serial Monitor
       BlueLED();//LIGHT UP THE BLUE LED
    } else {
```

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```
    Serial.println("WHITE");// WRITE THE WORD WHITE IN Serial Monitor
    WhiteLED();//LIGHT UP THE WHITE LED
  }
  prev = DistanceValue;
  Serial.println(DistanceValue);//PRINT THE DistanceValue ON Serial Monitor
  delay(100);// CHECK THE DistanceValue EVERY 100 MILLISECONDS
}
```

YouTube Video Link

If there is a problem with the in-person presentation, his video can be found at:

https://youtu.be/ds1qXxgTECA

Note Re Input from Father (Brett Burford)

Each year I take time to detail what input I have had into Jackson's project. This year, I am pleased to say that my role has very much been a more background/support role than in previous years.

Jackson's curiosity into Doppler Shift was quickly evident when he was presented with challenges in his essay. He quickly decided to focus his coding project on this, despite the initial title being 'Hidden Waves' when he was considering radio communication as a topic.

The first area was in finding the correct sketch codes to get the LEDs and sensor working correctly. As the items were sourced from Jaycar, I provided him with the PDF manuals which had the sample code to get them working. This code remains BLACK in the code above to differentiate between that and Jackson's code. He did require some inspiration to write his LED functions, in particular the `for (int i = 0; i < 40; i++)` use in a loop. After we together found a suitable resource to provide some ideas to experiment with, he was able to get this working. He took some time to grasp the more mathematical nature of this coding approach.

Secondly, there were occasional debugging issues where I helped by finding a mistyped character or similar.

Lastly, he mostly had a challenge with manipulating the DistanceValue to compare it to the older value for the purpose of distance over time measurement. We had to discuss and work together (with Jackson leading and typing) to find the solution of implementing a second distance variable (prev), and then adjust the sensitivity with (+/-5).

Jackson had some frustrating times when experimenting with his code, and researching online for solutions, but did well to get a working model completed. You will still see his code to output to the serial monitor for testing.

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Acknowledgment and References

Thankyou Dad for helping me get the supplies I needed and finding the documents for my project and sometimes you even helped me do some debugging so thanks a lot.

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