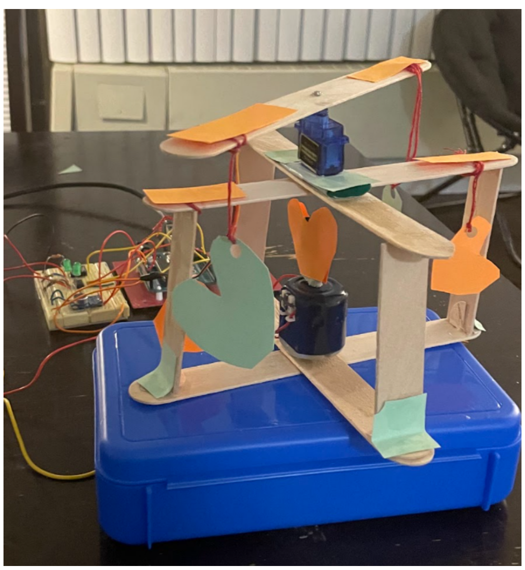
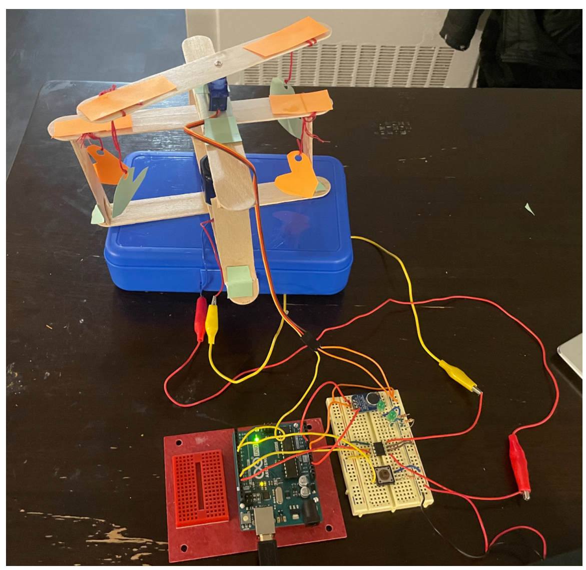
MAE 3780 Individual Project Plan, Fall 2021

The Audio-Powered Baby Mobile

Overview

The Audio-Powered Baby Mobile (APBM) is an entertainment system for young children that operates based on the input from a crying child and can be controlled by a parent. Once the APBM is turned on, two green LEDs signal that a microphone sensor is measuring sound levels in a room because the power source is on. If a child cries in the vicinity of the APBM, the microphone on the breadboard detects a difference in the frequency of noise in the room, triggering two main outputs. The DC motor output will spin heart-shaped stimuli at the base of the APBM frame. At the same time, a servo motor output will also continuously rotate a tongue depressor from the top of the APBM's wooden frame, causing the attached stimuli to rotate. The rotation of this top tongue depressor and its attached paper objects creates a soothing, spinning mobile effect that children can view from any angle. The APBM breadboard also has a button sensor that allows the parent to temporarily stop the motor for safety if a child gets too close, by pressing down for just a few seconds. The overall mechanical structure of the APBM consists of two bisecting rectangular tongue depressor frames with hanging paper objects, which will support the motor and servo elements.

Final Device Images

Design Considerations

If I were to do this project again with the same constraints, I would have chosen to use a purchased gear system with my DC motor to change the rotation rate of the attached heart stimuli. Even using less power, the DC motor still spins incredibly fast with the stimuli friction fitted around the motor's driving shaft. If I used gears, I could better control the rotation rate to slow the motor's rotation of the stimuli and create a better visual effect for children. I would have also chosen to incorporate purchased wire in place of string since I had enough room in my budget to accommodate this. The wire would've better supported the heart stimuli on the top tongue depressor, and made assembly easier because less glue would have been required. The current string suspension had to be wrapped and glued many times to create enough tension to suspend the hearts. A wire would've had more tension and rigidity to hold the hearts.

If I had more time and money, I would have 3-D printed the tongue depressor frame with a 20-30% infill. This would make the structure a lot more stable, so motor movement and servo rotation would not cause tongue depressors to buckle or vibrate. In addition, the assembly would be much more streamlined since not as much glue or wait time would be required. The APBM frame 3-D print could also be printed feasibly for 8-10 dollars since this is not a full-scale prototype. In addition to this change, I would buy a quieter motor for about $5-10. This would have allowed me to filter the sound better with the microphone so that I could better identify the frequency of baby noise once the motor and servo began their operations so that once the baby stopped crying I could more easily detect the sound change with less ambient motor noise. With more time, I could have also learned more about signal processing to increase the precision of my sound filtering and identification technique in the code. Right now, my method is fairly rudimentary using only a few frequency filtering techniques, but signal processing could increase the accuracy of the sound detections.

Assembly Instructions

1. Tap two small holes in the middle of two tongue depressors using a small screwdriver, and then glue them in an x formation so that the holes overlap (See Figure 1 & 2a/b in Appendix C). The angle of x formation is not consequential.
2. Cut the ends off of two tongue depressors, and proceed to cut the rectangular sections in half. You should have four rectangular pieces now (See Figure 3 in Appendix C for Dimensions of Pieces in mm).
3. Glue each of the rectangular pieces onto one of the four corners of the original tongue depressor cross from step 1. Reinforce glue joints with cardstock and leftover scraps from tongue depressors (Figure 4 in Appendix C).

4. Create another tongue depressor cross just like in step one and glue the four corners of the cross to the upright rectangular pieces. Your final product should look like Figure 5 in Appendix C.
5. Cut six paper hearts (roughly 4 cm x 4 cm dimensions) out of the cardstock, then punch holes in the corner of four of them. Cut four pieces of string, and tie the strings to four of the hearts. Then tie two of the attached two string-heart suspensions to the ends of one of the top-most tongue depressors (See Figures 6a/b in Appendix C).
6. Obtain a new tongue depressor and tap a hole into the top just like in step one. From there, use a servo screw (provided with servo) to attach the tongue depressor to a servo with a screw. Then proceed to tie the remaining two string-heart suspensions to the ends of this new tongue depressor. (See Figure 7 in Appendix C)
7. Attach the servo and its tongue depressor to the top of the main APBM wooden frame with a piece of inside-out tape. (See Figure 8 in Appendix C for Placement).
8. Then slide a small piece of inside-out tape over the motor's driveshaft (with the non-sticky side touching the shaft so that no damage is done). Then place the two remaining hearts on either side of the piece of tape. (See Figure 9 in Appendix C for this).
9. Place the motor's untouched, shorter shaft end into the bottom hole of the wooden frame. The motor should rest evenly on the tongue depressor. (See Figure 9 & 10 in Appendix C).
10. Place the whole Wooden Assembly on top of a cheap pencil box for height and stability (See Figure 11 in Appendix C).
11. Note: To use the purchased microphone sensor with the breadboard, one must solder the pins provided with the sensor kit to the three connection points (OUT, GND, VCC) so the sensor can be inserted into the breadboard. Soldering was conducted with the permission of course staff. (See Figure 12 in Appendix C)

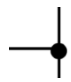
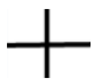
Operation Instructions

Once the device is fully assembled, connect the computer and Arduino using USB Cable A to B After verifying and uploading the code, open the serial monitor within Arduino IDE and turn on the 6V battery pack. Two LEDs should light up, indicating the power source is connected to the board. The serial monitor display should also show numbers less than 4, indicating it is quiet. Make a baby noise or create a high-pitched noise, and the DC motor and servo motor will automatically start spinning on the device. The serial monitor will display values greater than 4, to indicate sound is being detected and the motor and servo should be operational. To stop the motor temporarily, press the button sensor on the board. The motor will resume spinning shortly after stopping, as the sound is detected. If you wish to turn off the operations entirely, turn off the battery pack and unplug the computer-Arduino connection.

Appendix A: Bill of Materials

Part Name	Vendor/Source	Part Number	Quantity	Price Per Unit in USD ($)	Subtotal in USD ($)
MAX4466 Microphone Pre-Amp Audio Evaluation Board	Digikey	1528-1013-ND	1	6.95	6.95
Tounge Depressors	Scavaged (From Past Projects)	N/A	6	0.03	0.18
8.5" x 11" 22Pt Cardstock (Green & Orange)	Scavenged (From Past Projects)	N/A	2	0.15	0.3
Plastic Pencil Box	Scavenged (From School Supplies I Had)	N/A	1	1	1
Embroidery String	Scavenged (From Past Projects)	N/A	1	0.75	0.75
Modge Podge glue	Scavenged (From Past Projects)	N/A	1	1.99	1.99
Green Masking Tape	Scavenged (From Past Projects)	N/A	1	3.99	3.99
100 Ohm Resistor, 5%, 1/4 W Axial	Digikey (Lab Kit)	100QBK-ND	3	0.01	0.03
Tactile Switch Push Button	Jameco (Lab Kit)	155380	1	0.35	0.35
Green LEDs	Jameco(Lab Kit)	334086	2	0.08	0.16
4-AA Battery Holder	Jameco(Lab Kit)	216187	1	1.75	1.75
AA Batteries	McMaster-Carr (Lab Kit)	71455K58	4	0.4	1.6
USB Cable A to B	monoprice (Lab kit)	39918	1	1.09	1.09
Alligator Clip Lead	Sparkfun (Lab Kit)	PRT-12978	2	0.33	0.66
Wire Kit	Amazon (Lab Kit)	ASIN : B07PQKNQ22	1	2.17	2.17
Arduino Board	Digikey(Lab Kit)	1050-1024-ND	1	20.9	20.9
Bread Board	Newark (Lab Kit)	79X3922	1	2.71	2.71
Micro Servo continuous rotation	DFR Robot (Lab Kit)	SER-0043	1	3.9	3.9
Mini DC motor 1.5-12VDC 1350 Rpm	Jameco (Lab Kit)	2209094	1	1.25	1.25
Motor Driver IC: L9110H	Digikey(Lab Kit)	1528-4489-ND	1	1.42	1.42
Mini Breadboard	Newark (Lab Kit)	98AC7296	1	1.05	1.05
Small Screwdriver	QLP (Lab Kit)	Custom Imprint	1	-	
USB Cable A to MicroB	monoprice (Lab kit)	4867	1	0.89	0.89
Total Price of Purchased Scavenged + Purchased Materials	15.16	(US Dollars)			
Total Price of All Materials	55.09	(US Dollars)			

Appendix B: Circuit Diagram

	Means wires are connected
	Means wires are not connected

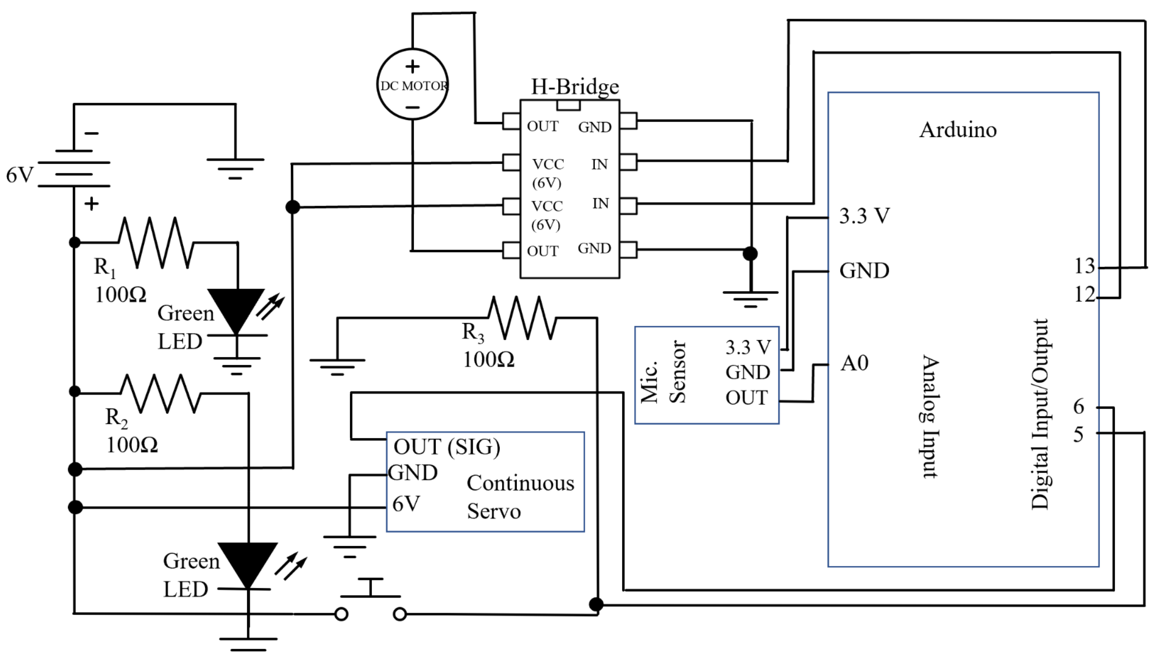


Figure 1: Circuit Diagram Made in PowerPoint

Appendix C: CAD & Drawings

Manual Assembly Images

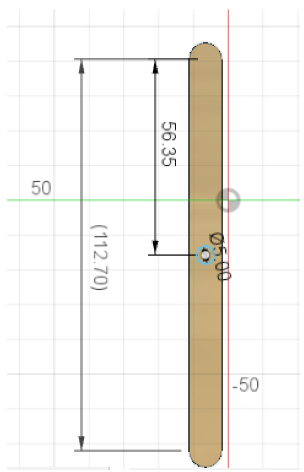
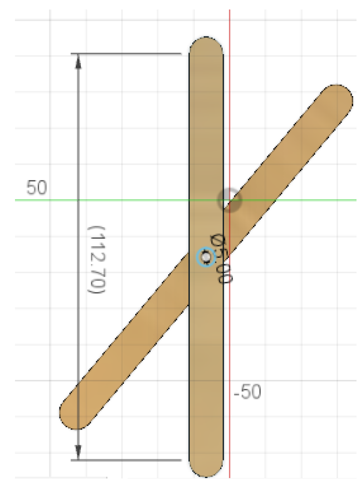
	

Figure 1: Hole tapped in the middle of the tongue depressor. The diameter of the hole is approximately 5mm but does not need to be exact, as it depends on the screwdriver used to tap and just needs to be large enough to insert the motor shaft.	Figure 2a: Two tapped depressors glued in a cross formation. The angle of X formation does not matter. Dimensions are shown here in mm for reference.

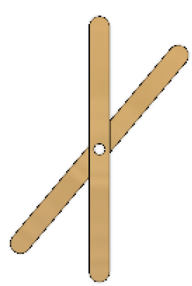
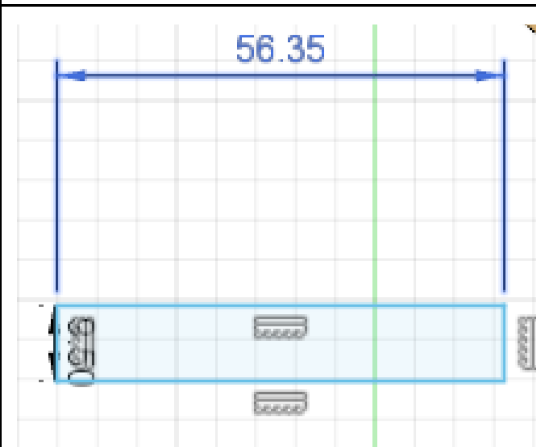

	

Figure 2b: Two tapped depressors glued in a cross formation.	Figure 3: One of the four rectangular sections after cutting, shown in drawing form to show dimensions (9.5 mm by 56.35 mm).

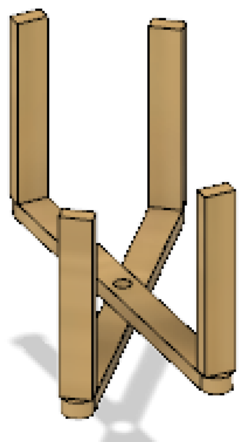


Figure 4: The structure with the rectangular pieces glued onto. The height of rectangular pieces is approximately 56.35 mm

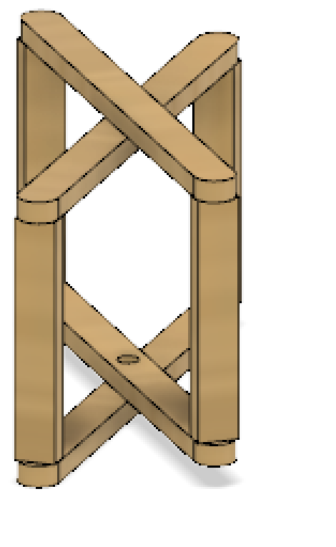


Figure 5: Finished APBM wooden base. with the additional cross placed on top.

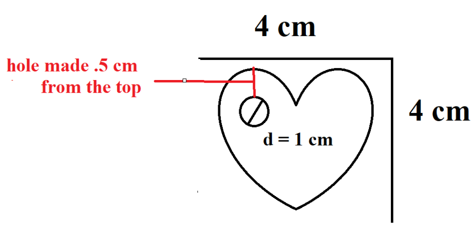


Figure 6a: The paper heart dimensions for cardstock cutting. Dimensions are approximate and can be modified based on user preference.

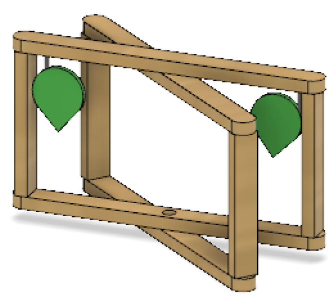


Figure 6b: Placement of string stimuli on the frame. Stimuli placement does not need to be exact, it depends on the aesthetic preference of the builder.

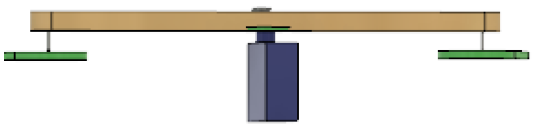
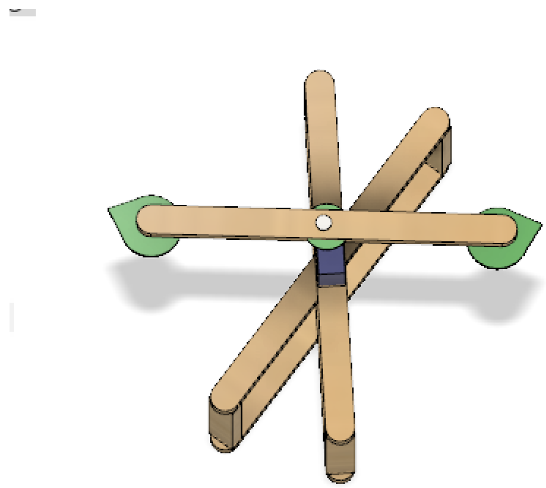
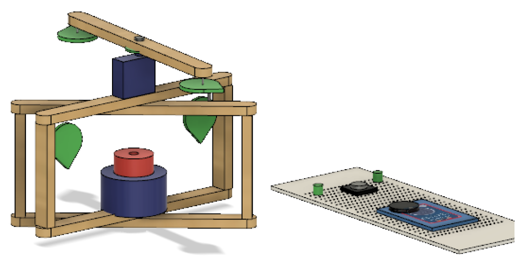
	

Figure 7: Servo with the attached tongue depressor, and string-stimuli suspensions. The screw from the kit was used to attach the servo to the tongue depressor. Stimuli placement does not need to be precise as long is it near the ends of the stick.	Figure 8: Placement of the servo on the APBM Mainframe. The servo should roughly be 56.35 mm away from the top rectangular edge of the top tongue depressor (dimension shown in Figure 1 in Appendix C).
	
Figure 9: Motor with the stimuli attached, with the motor sitting evenly on the bottom cross. The motor shaft is inserted into the bottom hole from figure 6b.	Figure 10: Motor placement on the frame. The bottom shaft gets inserted in the hole in the middle of the x section.

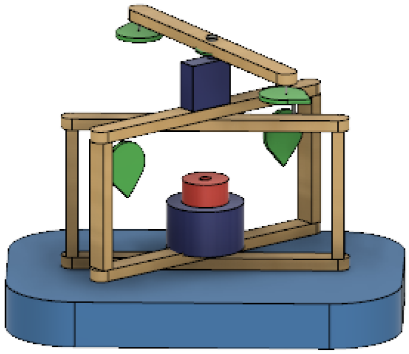
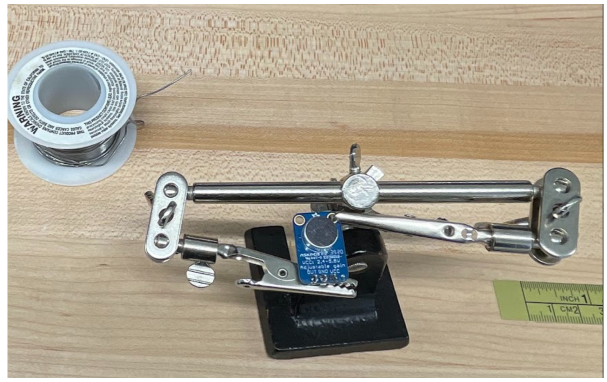
	

Figure 11: Finished assembly with the box supporting the whole frame. Box can be any size or dimension as long as it supports the whole frame, which is 112.7 mm long. The box used in the design is 212 mm by 143 mm by 63.5 mm. The frame can be placed anywhere on the box also long it supports the whole frame.	Figure 12: Soldered microphone sensor, with pins now attached so that it can fit into the breadboard.

Final CAD Images

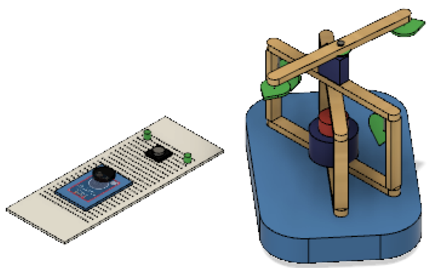
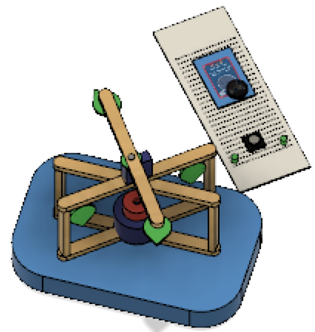
	

Figure 13: Final CAD Assembly of the Design	Figure 14: Final CAD Assembly of the Design

Appendix D: Commented Arduino Code

Code

// GOAL of the CODE
//1) LEDs light up as soon as simulation starts showing the board has power!
//2) Microphone Starts taking measurements
//3) IF the difference measured mic values and threshold value meets the standard for sound detection then
 //motor spins & servo rotates back and forth
// (Meets standard if measured mic values are different from threshold by +/- 4 Hz to indicate baby crying)
//4)If the button is held down while the motor is spinning, the motor temporarily stops moving
// Motor stop is only temporary until the if statement is re-entered within the void loop
//5) IF Measured Microphone Values Does NOT meet the above criteria for triggering, only output is LED light
 	
#include <Servo.h>
Servo myservo;
int angle;
int dt = 10;
int sensorValue = 0;// microphone sensor value
int diff1 = 0; //for sound filtering
int threshold = 334; // sound level threshold for quiet times
int standard = 4; // standard differnce between quiet and measurement to detect a baby sound
 	
void setup() {
  // set up
   Serial.begin(9600);// for serial monitor
   pinMode(13, OUTPUT);//motor set to output
   pinMode(12, OUTPUT); //motor set to ouput
   pinMode(5, INPUT); //button set to input
   myservo.attach(6); ////Servo set to Output
}
 	
void loop() {
  //Code loops Repeatedly
 	
    sensorValue = analogRead(A0); //checks the microphone value
    diff1 = abs(sensorValue- threshold); // takes the difference between measured value and the quiet time threshold

```
   Serial.println(diff1); //prints the difference to the serial monitor

  //will not trigger the motor and sensor inputs if there is not an appropriate sound
  // enter IF  sensor measurement is different than quiet frequencies by the standard
+/-4 Hz
   // this effectively filters out microphone measurements which are variations in quiet
time or not meeting noise threshold

  if(diff1 > standard){ // sound detected under this condition

     // motor spins
     analogWrite(12,128); // get motor spining
     digitalWrite(13, LOW);

     // continuous servo spins
     //taken from Lab on motors and servo operations

     while(angle<180){  // rotate forward in 1 degree increments
      angle++;        // increment angle
      myservo.write(angle); // move to new angle
      delay(dt);
      }//while 1 end
     while(angle>0){ // rotate backward in 1 degree increments
     angle--;        // decrement angle
     myservo.write(angle); //move to new angle
     delay(dt);
      }//while 2 end

    //button press detection occurs here

    if(digitalRead(5) == HIGH){ //if button is pressed then motor stops spinning
temporarily
     //motor stops spinning at values between 0 and 120
     analogWrite(12,100); // get motor to momentarily stop spinning
     digitalWrite(13, LOW);
     delay(2000); // delay so viewer can visably see the motor stop moving and motor
does not change stop too rapidly

    }// button push end

  }//overall sound detection if statement end
}//void loop end
```