Date - January 4th, 2020

Course - TD3MR

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Instructor - Mr. Rattray

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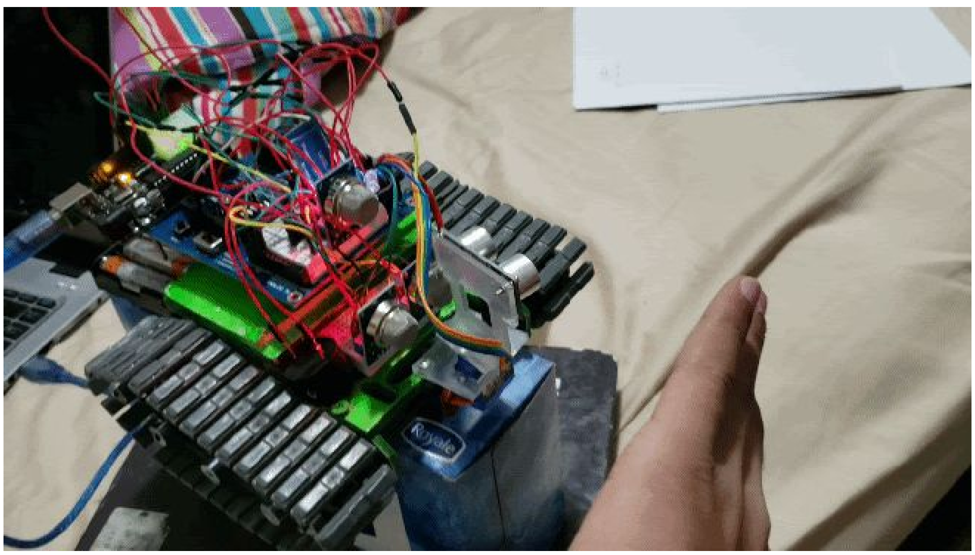
Smart Bot



Version 1.0.0

Executive Summary:

Designers of the Toronto Fire Department have told us to create an autonomous robot which will detect various types of harmful gases inside confined spaces which are inaccessible to firefighters. This robot is powered by a microcontroller which is an open-source hardware and software made by Arduino. Robot will operate on 2 powerful 5 volt continuous rotation servos. The technical aspects of the robot will operate based on Ultrasonic Sensors (Ping Sensors) which will send ultrasonic signals to objects further away from the robot and based on the input signal back from the signal, distance will be calculated. This ultrasonic sensor will be rotated using a turrent made by micro servos. The robot will work in all conditions are the rubber vex tracks provided exceptional friction and a strong structure is given from 6 tooth gear sprockets.

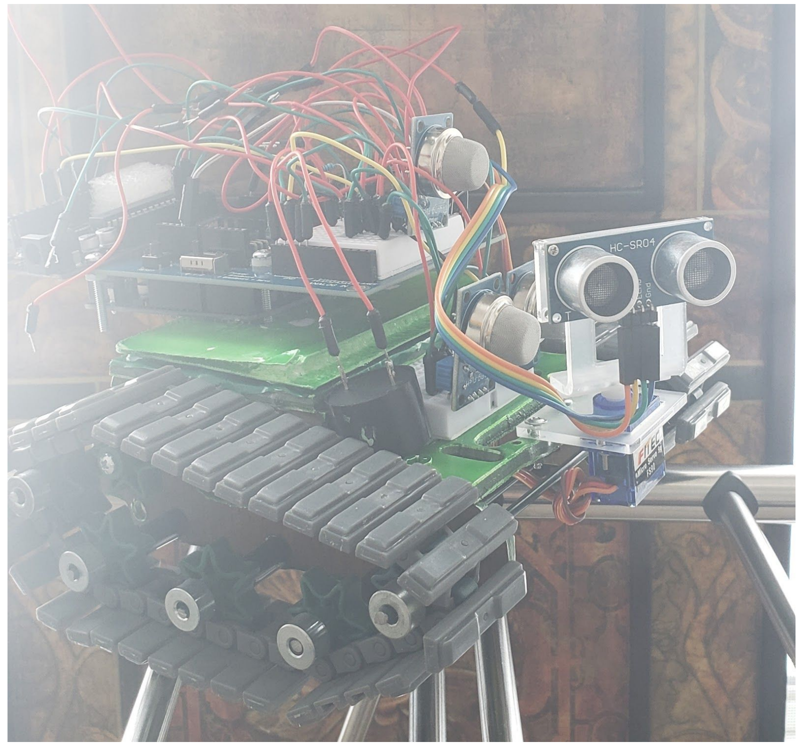


Figure 1.0: From SmartBot Photoshoot

The decision was to create the robot itself and as well as a well structurally integrate box which is airtight. Instead of making the robot from a premade built BOE Robot, it was decided that a custom cassis will be made as it would further enhance the custom capabilities of the robot. The robot is very efficient as it will use its power to good use as there will be a lot of sensing and movement of motors. The space size of the robot is very minimal and that can be seen as every component of cassis is being utilized.

The box component of the project contains a rotational string method to raise and close the doors. This was designed while taking into considerations of the airtight requirements. The doors have been sealed off using silicon, magnets and rubber bands. The rubber bands as a mechanical fixture which use its elasticity to close the doors.

Results have shown the effectiveness of the robot and how anthropometrics have been used to set average thresholds of the gas levels to a great extent. The robot has proven its capabilities in every single situation no matter was its environment is and what is in front of the robot. But there have been situations where the blindspots of the robot have interfered with its performance. This is due to the 180 degrees of rotational freedom of the micro servo. An app for this as also been made to display the ppm outputs from serial print.

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Design problem and objectives:

As mentioned in the summary, “Designers of the Toronto Fire Department have told us to create an autonomous robot which will detect various types of harmful gases inside confined spaces which are inaccessible to firefighters.” (Line 1-5) The objective of the robot is to determine safe paths and determine gases inside different situations. In the line of fire, it is difficult to make way for firefighters to get inside areas and detect gases. Our design is supposed to include a minimal sized robot which can get inside these hard to reach areas.

Background information:

According to NFPA, the risk of fire fighting injuries have only increased in the past few decades. These fatalities include overexertion, crashes, **lost inside, exposure** and etc.

Cause of Injury	Fatalities	Percentage
Overexertion/stress/medical	28	44%
Crashes	12	19%
Structural collapse	6	9%
Rapid fire progress	5	8%
Struck by vehicle	3	5%
Struck by object	3	5%
Fell	2	3%
Exposure	2	3%
Lost inside	1	2%
Caught under water	1	2%
Assault	1	2%
Total	64	100%

The exposure of unexpected gases can cause this to happen. Firefighter may also lose their way while going inside. The robot can help guide and find a way for the firefighters to get out of the facility where the fire is occuring. Firefighters can be ready to face unexpected fire with the use of the MQ sensors which are sensitive to different gases and the voltage drop caused by the air will help the code take the input into a serial print.

Materials: Aluminum composite, Boe Shield, electronic sensors and other parts.
Time: Friday November 1st 2019 - Monday January 20th 2020
Gases to be detected: Hydrogen gas, Natural Gas, and CO_2
Budget: $0 - No material will be purchased
IRL Budget: $100 plus. This is due to the cost of the sensors, bluetooth module, BOE shield and other mechanical aspects.
Size: It should be as minimal as possible. Therefore the robot should also be able to fit inside the designed sealed box to show demonstration.

Figure 2.0: Previous examples where used in order to gain more knowledge about the actual robots and its function. The tracks were also a big take-away from this example. The size of the robot shown above is not ideal for this scenario, but it provided a great example about the structural design and the design details that must be taken in detail.

Detailed design documentation:

After looking at the design constraints and the objective, my partner and I created various sketches, brainstorms, and prototypes. Using the ENGINEERING DESIGN PROCESS we both started researching different basis of the gas detection robot. We decided on making a sealed box which would provide a confined space to show the actual physical robot working in a confined space. Then we decided to make sure that the robot was small and minimal. I worked on making various codes and learning about the parallax BOE shield as it was my first time. We made assumptions that the robot would work best with wheels. But after looking at various designs on existing robots and also the robot that Mr.Rattray gave an example of, I was certain that the tracks would provide a better pivot point, have more friction with the ground, and also go over obstacles more effectively than a robot with circular wheels.

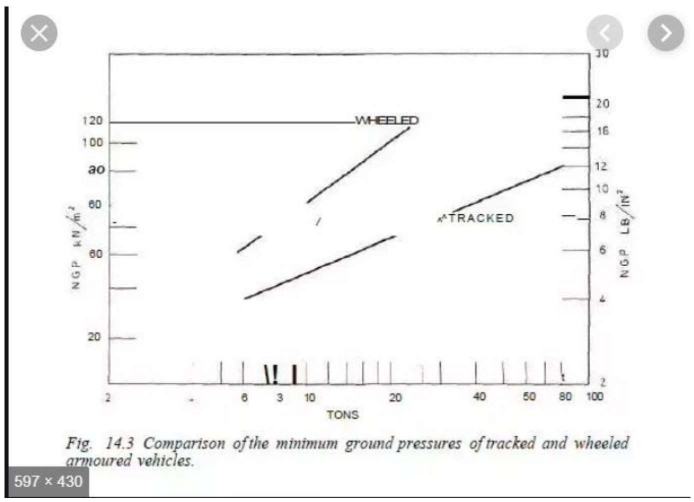

Figure 3.0: Difference between wheels and tracks and the relationship of pressure. As you can tracks create the least pressure therefore being the most efficient.

After getting a good idea of the problem, we started the brainstorm. It is part of the EDP. (Engineering Design Process) Brainstorm included a lot of thinking and just putting our ideas on paper. The box motor was a work in process as we worked on the design of the box. But on paper, we had back-up ideas and we also did a lot of background research. I was able to use my time efficiently while waiting for the box to done and put the box motor in it. We were able to get a rough estimate on how much the materials would cost, what machinery we need and what specifications are required for the targeted audience. This process allowed us to go back and forth and do a lot of iteration in our processes.

I also used the parallax BOE shield manual inorder to gain more knowledge about about the robot. I did research online and took notes on how the circuits are made and how I can implement my ideologies to them. [Click Here to access pdf]

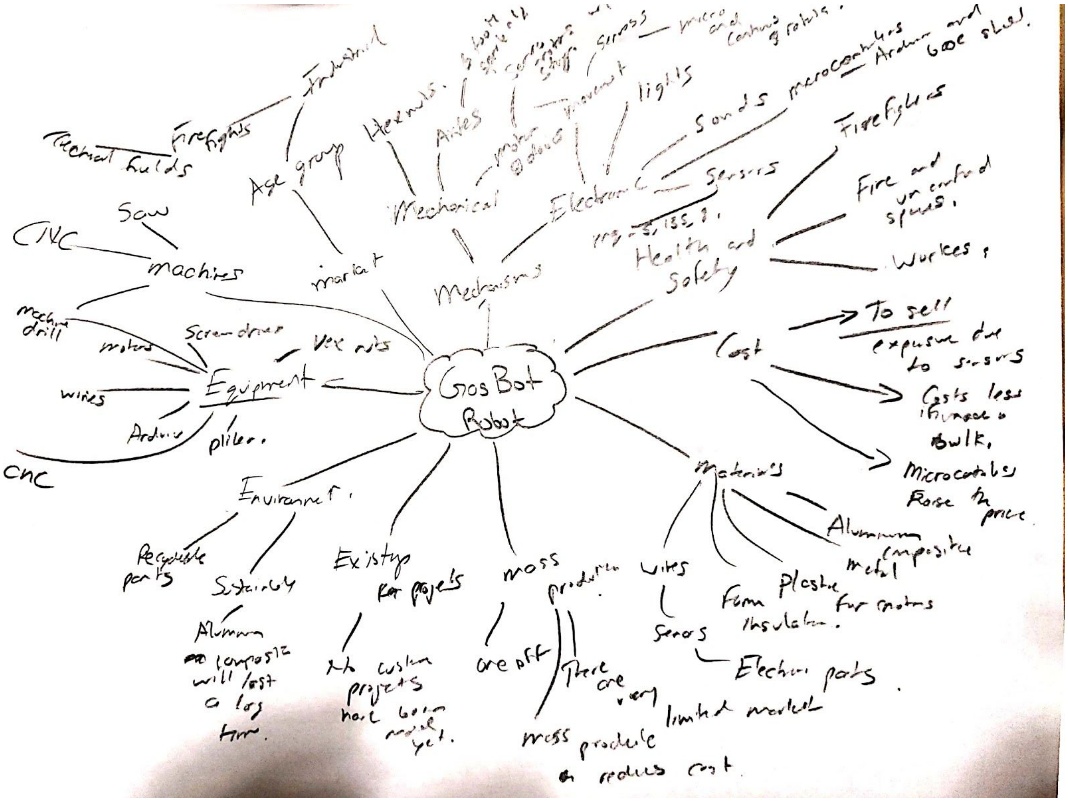

Figure 4.0: Brainstorm for the Robot

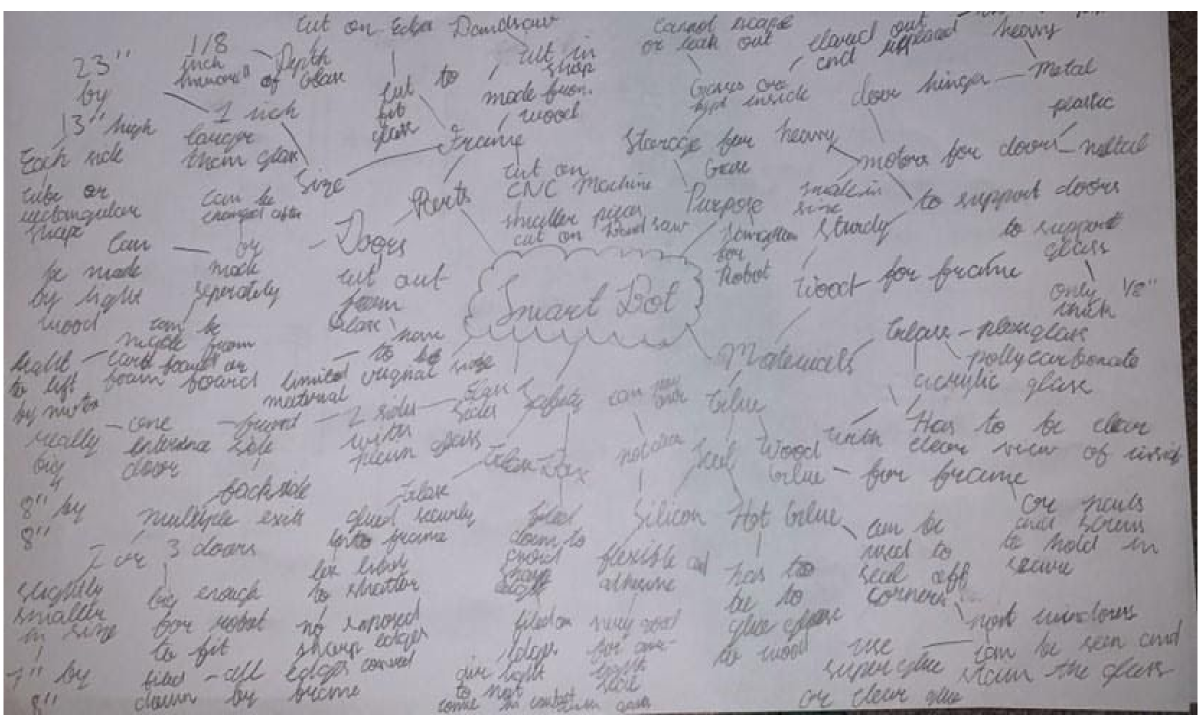

Figure 4.1: Brainstorm for Gas Box

Sketches made: I made sketches for the robot so I can have a visual representation of the robot and see what dimensions I need to know. The visual idea representation of where each component was going made sure no pieces were interfering with each other. I did a lot of **Iteration** as well as **synthesis.**

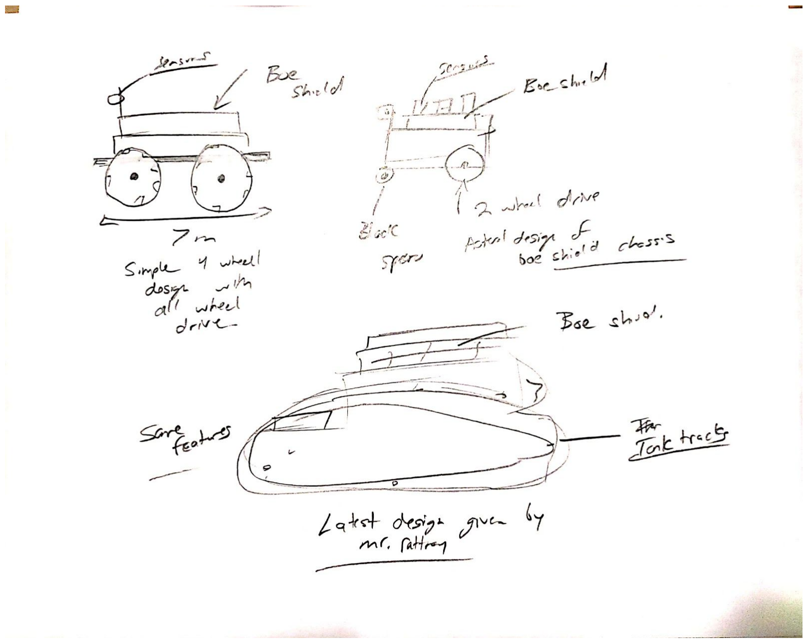

Figure 4.2: Rough sketch of Ideas for Robot. I went and did **Iteration** to make the BOE Default Robot work as the high performance that was needed.

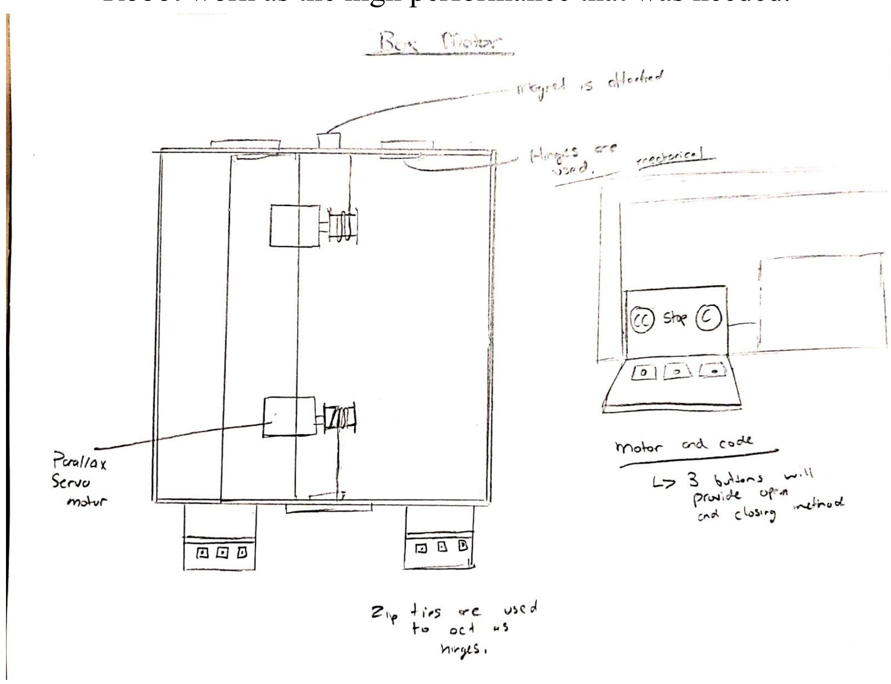

Figure 4.3 : Box motor fully planned out in order to lift the air tight doors.

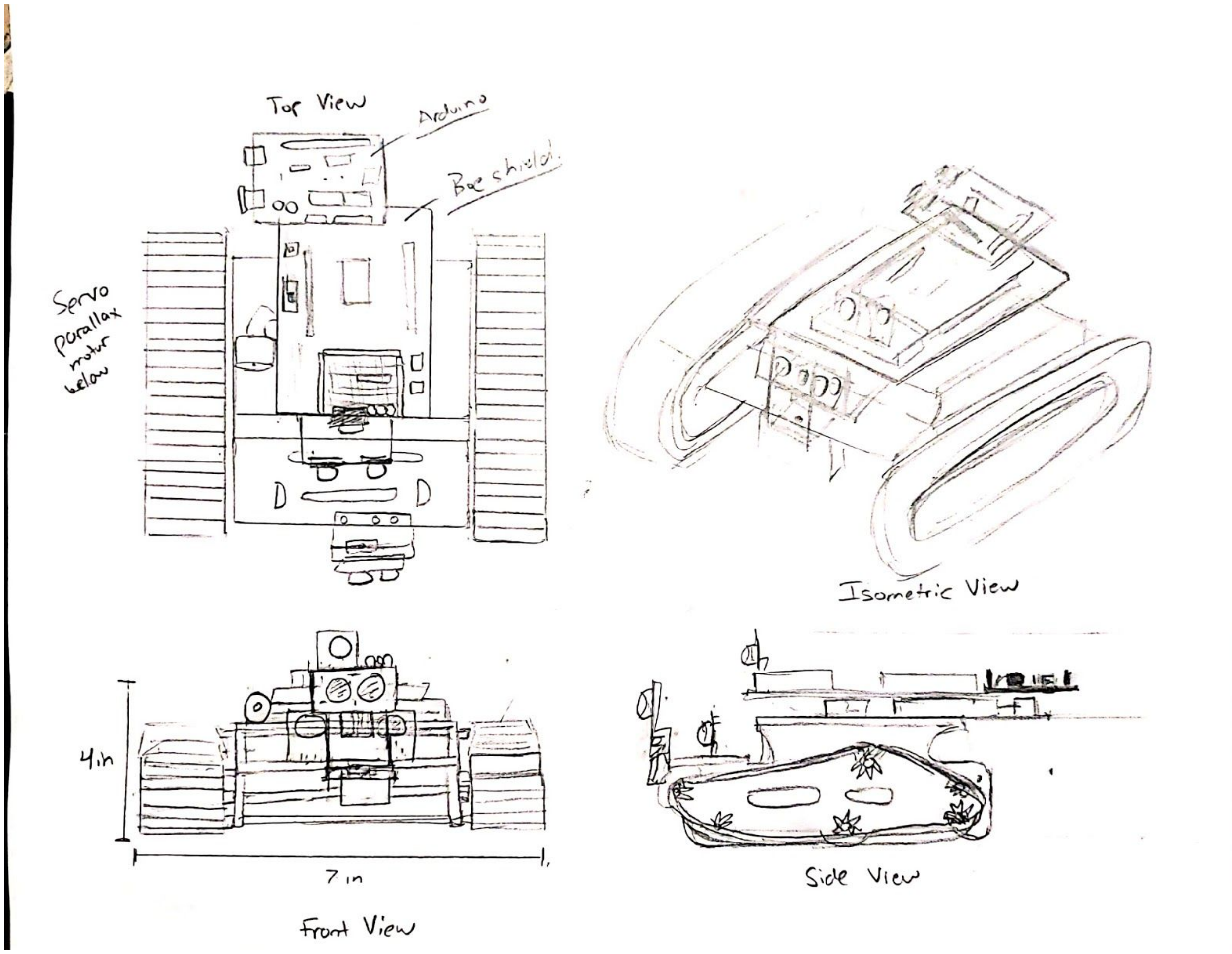

Figure 4.4: New Sketches were made to show the technical differences between the default BOE shield and the new custom design. This custom design allowed me to be more creative and add more aspects which would have been limited in the default BOE Shield.

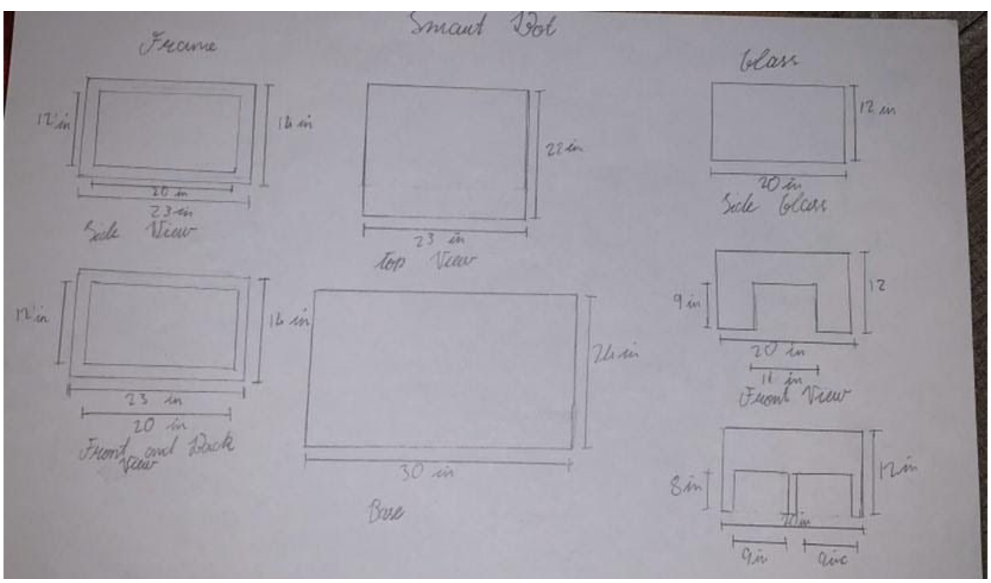

Figure 4.5: Design and dimensions of the Box

Functional and Cost Analysis:
The design of the robot and box design is to make sure that gas is detected and as well as sealed.

We developed a BOE Shield bot with the default chassis and the default design. This was used as the prototype. The prototype as developed and was tested with the sensors. It was able to take the gas quality in with the sensor and as the voltage drop occurred. The output signal on the serial monitor was given an a PPM amount. This is due to the code which included reading the input and doing a mathematical equation inorder to get the ppm output.

Figure 5.0: Prototype BOE Shield

The cost analysis is based on IRL (In Real Life) manufacturing. The cost of arduinos can range from \$30 a piece and attaching the BOE shield will further increase the cost of the robot. Then the gas sensors cost up to \$5 dollars per piece if not bought in a pack which is way cheaper overall. Cost aluminum composite is not that expensive because it is aluminium. Aluminum is very cheap due to the axxesibleity of it in the market.

Human Factors Engineering/Anthropometrics/Ergonomics: I did research on the average threshold of CO_2, Hydrogen and Natural gas safe in the environment.

Safe co2 levels in confined space

In the case of a **confined space** where **CO2** is generated as a byproduct of aerobic bacterial action, a **concentration** of 19.5% O2 (the hazardous condition threshold for oxygen deficiency in most jurisdictions) would be associated with an equivalent **concentration** of at least 1.4% (= 14,000 ppm) **CO2**.

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Carbon Dioxide A Real Hazard - Thermo Fisher Scientific

Figure 6.0: CO_2 thresholds

PPM of CO_2	Effects
370	Concentration in atmosphere
5,000	Long-term exposure limit (8 hours)
15,000	Short-term exposure limit (10 min)
30,000	Discomfort, breathing difficulties, headache, dizziness, etc.
100,000	Loss of consciousness, death
300,000	Quick death

Figure 6.1: Extension to the thresholds.

We have made the robot so that the threshold that the robot starts beeping after is minimum 3000 ppm because we have look at the outside conditions and in situations of fire and other events the area around the robot will most likely be open. Or at least connected to an opening.
Same goes with Hydrogen where its average threshold is around 75ppm. The sensors on our robot have been coded to send a negative signal if the ppm jumps over that. Especially natural gas which is normally where high in areas of gas leak fires. 50,000 ppm of natural gas is harmful and causes death, but I have set the code so that the robot beeps at a ppm of 1500. This way it is easily read in confined areas.

It was important that I looked into this as it would provide better results when used by the customer of this product. This project will not only provide **customer satisfaction** but also exceed expectations and create **excitement** in the market.

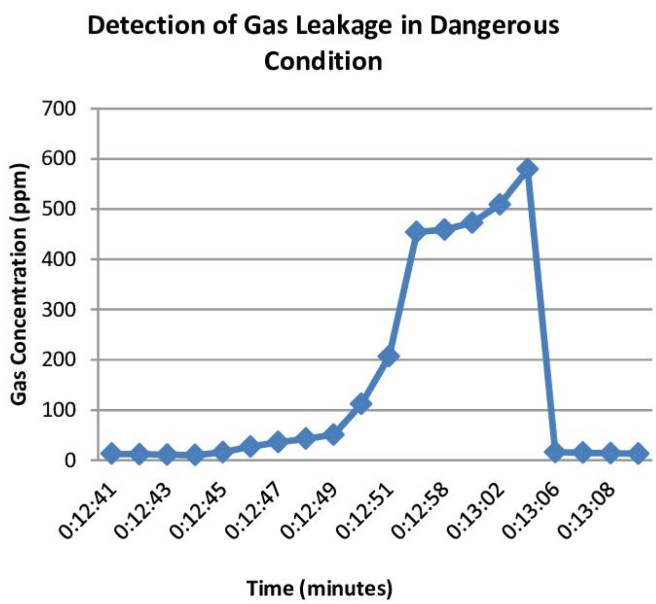
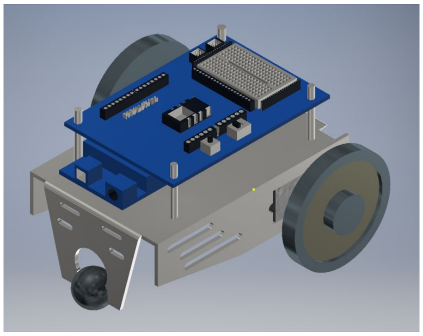


Figure 6.2: The average detection of Gas Leakage in Dangerous Conditions. I had to make sure that our robot was able to understand the relationship between gas concentrations and time.

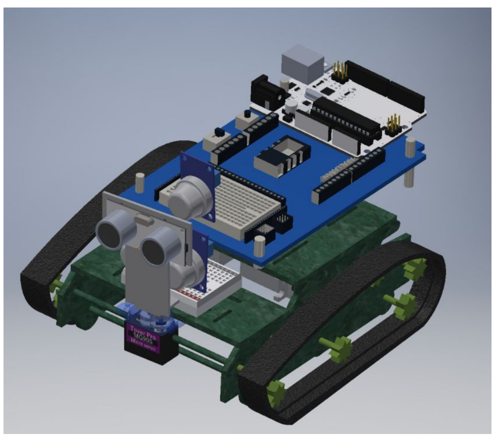
After using the brainstorm, sketches, I was able to decide on the design that I was told to do by the teacher. My partner and I worked with the new dimensions of the robot and made sure that each part was well cut so that the robot would be able to fit inside the box. I still used the default BOE shield to test my code and practice learning (Prototype). I went back and updated by design to make sure that I could improve whatever was needed. This was the process of **iteration** used once again. Then after carefully **analyzing** at my sketches and my notes I was able to make a CAD which included all of my improvements. I **systhenzised** all of my concepts about robot and took into considerations of the design constraints given by the box.

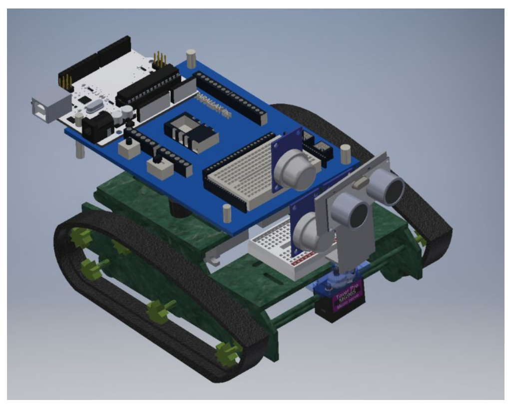
Prototype CAD for Robot:

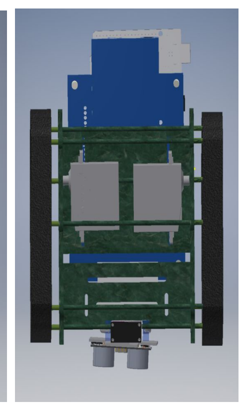


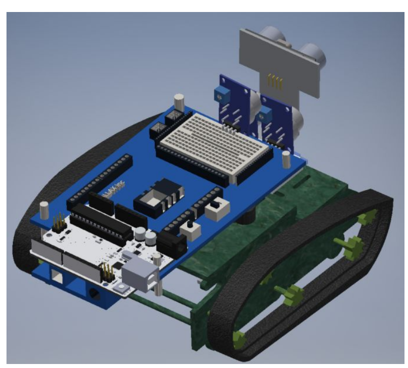
The prototype was declared way too “easy” by my teacher and therefore in order to give a harder challenge, I had to change up the design of the prototype and make my custom robot.

Final Cad:



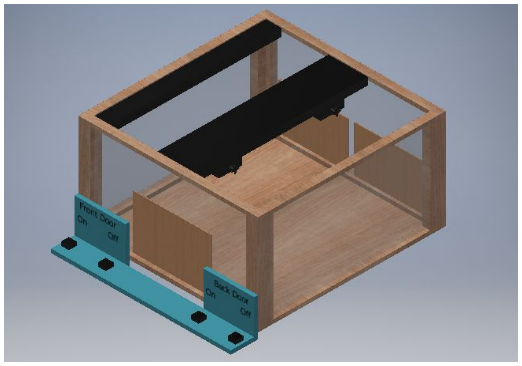






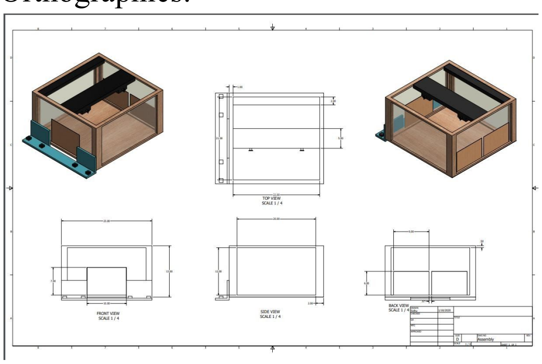
This design was not only a bit more challenging to make, but it provided me with more freedom to do more with my design. The track provided a big boost as my background research had shown before. Plus, the more sprockets that I added the more the tension between the tracks increased and that helped shape a really firm and solid structure. This type of robot is able to go over all types of terrains. I **synthesised** the BOE Shield part and the frame chassis from the default BOE shield

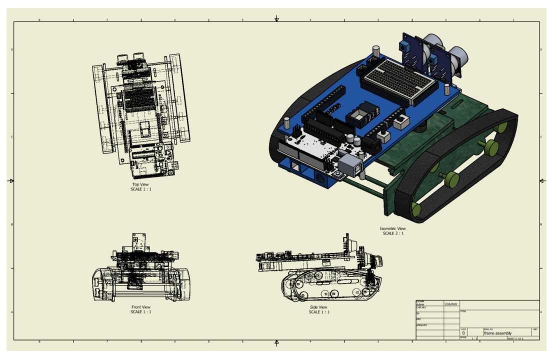
Cad for Box:



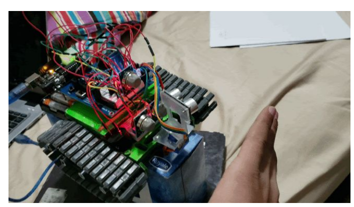
My design for the motor in the box had changed. But this was the most practical as it is 100% working everytime. My previous design had caused me to cut the roof at some point just to get the door to open up. This design works with a buttons and is manual to provide control to the user at all times.

Orthographics:



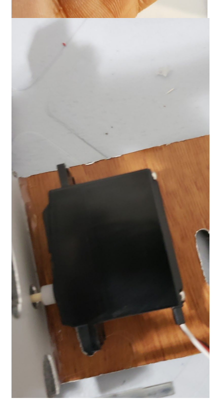


<u>Functional Design, wiring, code and etc. :</u>



Robot:

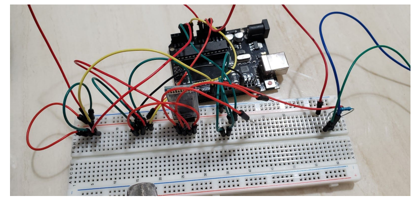
The robot works on a micro-controller called an Arduino and a BOE shield.



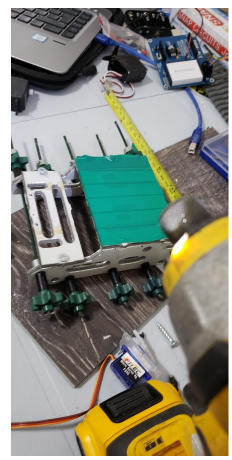
- Track mechanism: Included 6 tooth sprockets, metal rod axle, screws and hex nuts with screws. The track mechanisms include of vex components which were connected together using simple click mechanism. The power to the tracks mechanism was given through a gear which was attached to the servo using a double sided thread screw. It was connected to a spacer and then super glued inorder to give it a permanent bond. The tracks have rubber pieces on the end and that stops it from sliding and slipping.
- Servos: There were 2 types of servos attached, one was the continuous rotation and the other one was the micro servo. The micro servos only turned 180 degrees and that was ideal for the turret which was attached to the ultrasonic sensor. The ultrasonic

sensor needed to be moved in order to map the objects around it. There were 2 continuous rotation servos attached to the tracks. It display turns, one of the motors would increase its speed and the other would reduce its own speed and that would make it turn due to it rotating at 1 point. The micro servos was given a code to rotate only 180 on both sides.

- Sensors: There were 3 different sensors, (Mq-5, Mq-8 and Mq-135) and they all worked on voltage. As the concentration of gases would change, the voltage would change and that would provide an output to the arduino and then through mathematical questions, it would provide an accurate serial print. (Also on the app)



- The app was made so that there could be bluetooth connection between the robot and the people waiting for the results outside. The app was made using Mit App Maker and was connected to the HC-06. The HC-06 used the Tx and Rx pins to get the serial output and send it via bluetooth into the bluetooth receiver of the phone. Then the output was converted and extracted by the app and displayed as a continuous serial print.
- Frame: The frame was CNC'd and that provided very accurate cutting from the measurement given by the software. There was sanding that had to be done. The frame of aluminum composite was conductive and therefore the parts that included wiring had to be protected. Therefore I added a layer of electrical tape and also included a layer of foam to stop the conductivity.



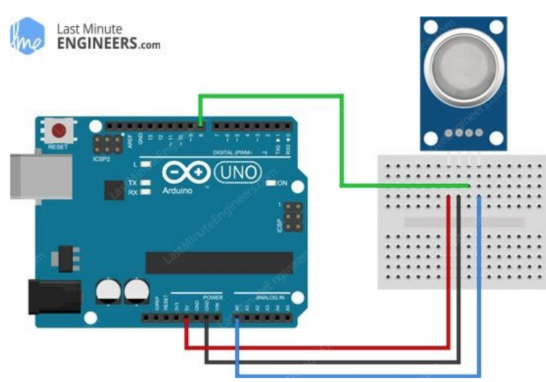
- There were 2 micro controllers doing the work. One of the arduino was outputting the signals using digital and analog pins. The other was giving it power. 2 arduinos had to be shared because there were a lot of conflicts between the sensors and servo motors. **Iteration** had to be done. Plus there was a lot of **Innovation.**

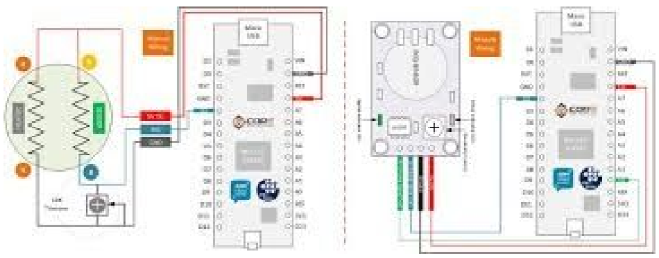
Exploded View

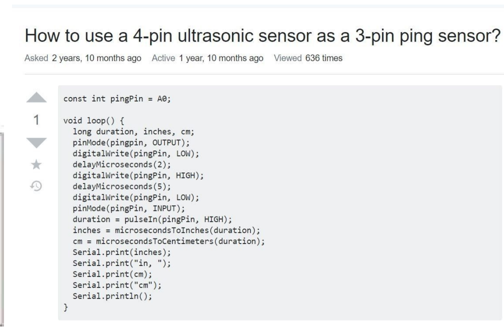
https://www.youtube.com/watch?v=fkgx9TAoZhk&feature=youtu.be

Wiring and coding:

```
 if(co2ppm>3000){                              //if co2 ppm > 1000
tone(piezoPin, 100, 50);
 digitalWrite (redLed, HIGH);
// turn on led
}
else{                                         //if not
    digitalWrite (redLed, LOW);                   //turn off led
}

  if(gas_value>1000){                              //if co2 ppm > 1000
 tone(piezoPin, 1000, 100);
 digitalWrite (blueLed, HIGH); //turn on led
}
else{                                         //if not
      digitalWrite (blueLed,LOW);                 //turn off led
}


        if(valueS>75){                              //if co2 ppm > 1000
      tone(piezoPin, 10000, 1000);
       digitalWrite (greenLed, HIGH); //turn on led
      }
      else{                                         //if not
             digitalWrite (greenLed, LOW);              //turn off led
      }
```





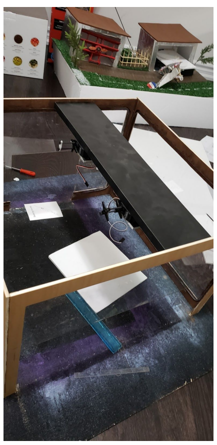


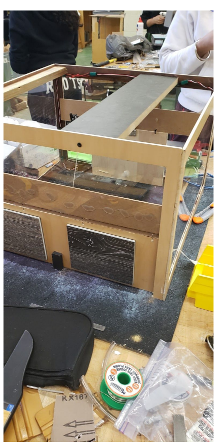
How to use a 4-pin ultrasonic sensor as a 3-pin ping sensor?

Asked 2 years, 10 months ago Active 1 year, 10 months ago Viewed 636 times

1

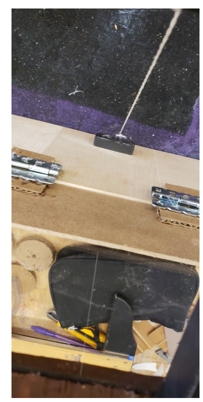
```
const int pingPin = A0;

void loop() {
  long duration, inches, cm;
  pinMode(pingpin, OUTPUT);
  digitalWrite(pingPin, LOW);
  delayMicroseconds(2);
  digitalWrite(pingPin, HIGH);
  delayMicroseconds(5);
  digitalWrite(pingPin, LOW);
  pinMode(pingPin, INPUT);
  duration = pulseIn(pingPin, HIGH);
  inches = microsecondsToInches(duration);
  cm = microsecondsToCentimeters(duration);
  Serial.print(inches);
  Serial.print("in, ");
  Serial.print(cm);
  Serial.print("cm");
  Serial.println();
}
```



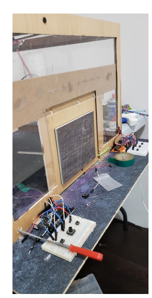


Box Motor:

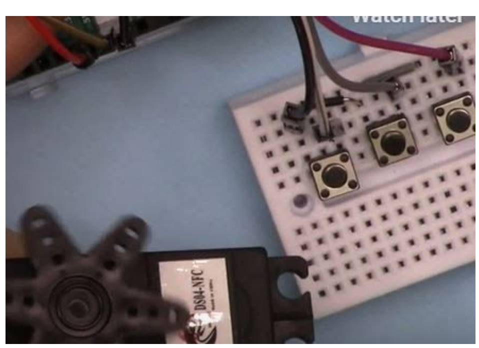
This was a mechanism which was needed to open and close the doors. The doors had to be air tight at the same time. Therefore continuous rotation servos were used to open and close the door. This a mechanism which included using string and a hook to open the door with the use of buttons. This part of the project included the most iterations as it was one of the more physically challenging parts. The pervious design included opening the door up and down using micro servos which only allowed 180 degrees of freedom.



- Frame: The 2 motors were rested upon the glass frame of the box. Then they were screwed against a 2 x 4 piece of wood. The motor frame was very firm has there was going to be a lot of torque coming from the load that is pulling itself down.
- Servos: The servos had 2 screws coming out of them to act as a platform for the string to tie up and get rotated around. This was tape to ensure the string did not rip. The servos were connected to 2 arduinos and those circuits included 3 buttons. Each button had a different role, each button made either made the servo go clockwise, counterclockwise and also stop.



- The circuit was very simple and straightforward and it included the buttons going into the digital pen along with the motor. But it was mainly a transfer of the GND and 5V throughout the circuit from one button to the other.
- Door mechanical aspects: The doors included hinges to allow the doors to close up and downwards. Inorder to make the front door air-tight, there is a rubber band used in order to lock up the door. The eslasity of the band allows this to occur. On the larger door, a magnet has been used to close the door and therefore providing it with an airtight seal.



Laboratory test plans and results

Test plans:

1. Let servos run for 10 seconds and then stop. (For Robot and Box Motor)
    - If servo keeps moving after 10 seconds then it needs to be calibrated.

` Result: Servo is calibrated.

2. Let fully assembly of robot without gas sensors run in open area.
    - If the robot exceeds to not crash then it is successful. If it fails then it need modifications in the code.

    Results: The ultrasonic Sensor is working and the motors are in sync with each other.

3. Make gas sensor circuit on 1 breadboard. Blow into gas sensor, and take it near the stove with the gas on, but no combustion.
    - If sensoring is working then it will show a raise in ppm very quickly. The results should be displayed on the serial monitor or app.

    Results: Sensor code will be working and it will be calibrated.

4. Attach Piezo and LED to gas sensor code.
    - If the code runs and gas is detected then the piezo will make a unique sound and there will be a certain light on the LED.

    Results: The code and calibration of piezo and LED is working.

5. Attach the whole circuit and servo motors. Give 2 sources of power and make sure everything is attached.
    - Place inside the box. Release gases and if the robot is detecting gas then the LED and Piezo will beep.

    Results: Everything is working and ready to go.

Written Record: My design performs perfectly against the specifications that are needed. It able to move in every direction, detect gases, and also not crash into anything in it's way due to the ultrasonic range finder sweeping mechanism.

Bill of materials:

Main suppliers: Amazon, ebay, abra electronics and Chinguacousy Secondary School

Mechanical Parts

Item Number	Item Name	Item Description	Qty
1	Tracks	2 inch	2 Sets of 35 pieces
2	Axle	Metal rod. 1/16”	6
3	Frame	Aluminum Composite: - Metal frame 3” x 3 1/4” - Metal Frame 3 ¼” x 1” - Side frame	1 each 2 for side frame
4	High Strength 6 tooth sprocket.	1” spokets - 6 tooth sprocket	12

Components

Item Number	Item Name	Item Description	Qty
1	Micro Servo Clamps	Clamps to Ultrasonic Sensor	1
2	Hexagon Socket Button Head Cap Screw	Inch 8 - 32 x 1/4	18
3	Drywall screws	1 inch. ⅛ width	6
4	Parallax Screws	Tread 2-56	10
5	Foam Board	Placed on metal to stop conductivity.	1

Electronic Components

Item Number	Item Name	Item Description	Qty
1	Servo	Parallax Continuous Rotation	4
2	Arduino $30 each	Arduino Uno	2
3	Shield	Parallax BOE shield	1
4	Wires	1. Male to Male 2. Male to female 3. Female to female	-----
5	Power Supply	AA Battery Pack Power supply cable	1
6	LED	LED Strip - Blue - White - Green	1
7	Gas Sensors $5 each	MQ-135 MQ-5 MQ-8	3
8	Resistors	100 - 300 Ohm	4
9	Ultrasonic Proximity Sensor	HC-SR04P	1
10	Micro Servo	Micro Servo	1
11	Piezo	Stable Piezo	1
12	Breadboard	Mini	3
13	Push Button	Mini and large	6
14	Bluetooth Module $16	HC-06	1

Tools

Item Number	Item Name	Item Description	Qty
1	Screw Driver	BOE shield Driver	1
2	Screws	½” Screws	2
3	Soldering Kit	-------------------------	1
4	Electrical Tape		1 roll
5	3/32” Allen Key	3/32” Allen Key	1
6	5/64” Allen Key	5/64” Allen Key	1

For the box:

Mechanical Parts

Item number	Item name	Item description	Quantity
1	Front Glass Wall	Polycarbonate sheet 18” x 12” with one door	1
2	Back Glass Wall	Polycarbonate sheet 18” x 12” with two doors	1
3	Side Glass Wall	Polycarbonate plain sheet 18” x 12”	2
4	Wooden Frame	Wooden frame 20” x 13” each side	4
5	Front Glass Door	Polycarbonate door 7”x10”	1
6	Back Glass Doors	Polycarbonate door 9”x6”	2
7	Glass Roof	Polycarbonate Sheet 22” x 21”	1

Components

Item number	Item name	Item description	Quantity
8	Nails	1” Gold Nails	8
9	Glue	Wood Glue	1 bottle
10	Switches	Wooden Plank with 4 switches	1

Gantt chart:
Responsibilities: Includes CAD and Sketches for each. Plus procedure pictures.
Ayush: Anthonomus BOE SHIELD Robot and motorized doors for the box. Plus code the whole thing.
Mahik: Make a sealed box with polycarbonate windows and enhance visual aspects.

Month of November

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
					1 Start working on the materials list	2
3	4 Discuss Ideas	5 Brainstorm	6 synthesize Final idea brainstorm	7 Make material list	8 Materials on list Bought	9
10	11 Began Sketches	12 Worked on sketches	13 Finished last sketch	14 Began CAD Ayush- robot Mak- the box	15 Worked on CAD PA day	16
17	18 Worked on Cad	19 Finish Cad	20 Begin to prototype build box- Mak and Ayush	21 Begin on robot- Ayush	22 Work on prototype box - Mak Work on robot- Ayush	23
24	25 Work on box - Mak Work on robot- Ayush	26 Refine the design with each other	27 Trial and error	28 Refine design of box and robot	29 Begin final box model - Mak Work on robot - Ayush	30

Month of December

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
1	2	3	4 Ayush is gone	5 Ayush is Gone	6 Ayush is gone	7
8	9 robot	10 Coding	11 Coding	12 Coding	13 Coding	14
15	16 Test and troubleshoot	17 Test and troubleshoot	18 Test and troubleshoot, Finish BOX!	19 Ayush is Gone	20 Ayush is Gone	21
22	23 Winter Break Starts	24	25	26	27	28
29	30	31				

Month of January

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
			1	2	3 Winter break ends	4
5	6 Test and troubleshoot	7 Polish and Decorate model Code/app start	8 Polish and Decorate model Work on Robot	9 Work on robot	10 Work on robot	11
12	13 Model Finishing touches Box motor	14 Box Motor Robot	15 Box Motor Robot	16 Box Motor Robot	17 Box Finish Robot	18 Make Presentation
19	20 Everything due	21	22	23	24	25
26	27	28	29	30	31	

TEAM 101	Defining the Problem	Intro & Strategy	Problem Analysis	Systems Design	Concept Generation	Concept Evaluation	Detailed Design	Discussion & Conclusions	CAD	TOTAL	Student SIGNATURES*
Mahik Sidhu	40	50	40	60	35	40	40	50	50	**405**	
Ayush Singh	60	50	60	40	65	60	60	50	50	**495**	Ayush
TOTAL	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**		

Ethical Consideration

There is a huge market for these types of products in the human resources/firefighters and etc. Nothing in the market has been made with this simplicity but also with the amount of detail into each phase of the product. There is a **need** for stuff like this in the market and the **excitement** level would also be driving this thing forward as this will be a fully autonomous robot. With the app this robot will be going above expectations and providing a more luxurious feeling for the price people will be paying. If this robot is to be mass produced then the cost of building and manufacturing will be very low. Arduino is very accessible and easy to operate and use. The software development cost will be cut down by a lot plus there are various companies who can manufacture the same parts for us.

Safety

The robot is reducing the jobs of many firefighters, gas detecting people, and etc. It is reducing the risk of any type of fatalities that can occur during these jobs. This robot can do the same jobs and even do it better as the computers are made by humans to be smarter than humans. This robot is reducing "the human to dangerous situations" physical contact. There are no sharp edges or any physical objects that hurt someone. All of the wiring has been done in an orderly manner and zip tied down so that no loose wire comes off. The gas sensors are also attached to the breadboard so that they do not fall off.

Conclusions

The robot is able to meet all of the design requirements while keeping the constraints in mind. The BOE Shield robot is able to use ultrasonic range sweeping mechanism inorder to find distance and not crash into anything. It is also able to use the high-end technology of gas sensors to detect different types of gases in hard to reach places. This robot has solved the design problem. The only mishap/unwanted result is that due to the 180 degree rotation of the micro servo, the robot has developed a blindspot which can cause it to bump into unseen place from the perspective of the robot.

Acknowledgments:

1. Sci-Tech- Chinguacousy Secondary School: Provided funds, parts, workspace and time.
2. Mr.Rattray - Time and Advice

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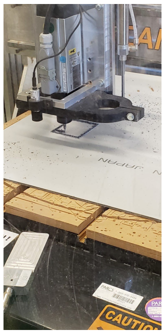
Link to timeline:
https://docs.google.com/document/d/1i3KmciDfkAp2kn9POZHUcdbvpCZYdpWV3oVyDLum5_8/edit?usp=sharing

Link to Work distribution form:
https://drive.google.com/file/d/19KbkjkbsuOcidnoCkBPzlQUMh3xV94R5/view?usp=sharing

Link to google drive:
https://drive.google.com/open?id=1Kz-AB55waAf-B5RPNivMh0-YztdmOPcK

Appendices:


CAUTION


Initialize
Park
Zero XY
Zero Z
Touch Top
Go 2 X0Y0
Measure T1