Smart Ping Pong Ball Machine

Status

/1 Hardware present?

/1 Title Page

/1 Declaration of Joint Authorship

/1 Proposal (500 words)

|  |
| --- |
|  |
|  |

/1 Executive Summary

From: Name - Gurwarris Singh Sohi

Discipline: Computer Engineering Technology

Date: 14 January, 2020

# Declaration of Joint Authorship

We, Gurwarris Singh Sohi, Nicolas Cristiano, and Shubham Sharma, confirm that this work submitted is the joint work of our group and is expressed our own words. Any uses made within it of the works of any other author, in any form (ideas, equations, figures, texts, tables, programs), are properly acknowledged at the point of use. A list of the references used is included. The work breakdown is as follows: Each of us provided functioning, documented hardware for a sensor or effector. Gurwarris provided the functioning for a TB6621FNG Dual Motor Driver. Nicolas Cristiano provided the functioning for a SG90 micro Servo Motor. Shubham sharma provided functioning for ROB11015 Solenoid . In the integration effort Nicolas Cristiano is the lead for further development of our mobile application, Gurwarris Sohi is the lead for the Hardware, and Shubham Sharma is the lead for connecting the two via the Database.

# Proposal

We have created a mobile application, worked with databases, completed a software engineering course, and prototyped a small embedded system with a custom PCB as well as an enclosure (3D printed/laser cut). Our Internet of Things (IoT) capstone project uses a distributed computing model of a smart phone application, a database accessible via the internet, an enterprise wireless (capable of storing certificates) connected embedded system prototype with a custom PCB as well as an enclosure (3D printed/laser cut), and are documented via this technical report targeting OACETT certification guidelines.

Intended project key component descriptions and part numbers  
Development platform: Raspberry Pi 4 B+  
Servo Motor SG90: Used to adjust the horizontal rotation of the ping-pong machine  
TB6621FNG Motor Driver: Used to adjust the launch speed of the machine in addition to its vertical launch properties  
ROB 11015 5V Pull Solenoid: Used to control the time interval between balls launching

We will continue to develop skills to configure operating systems, networks, and embedded systems using these key components to cooperate with one another so they can be integrated into a fully functional ping-pong machine in addition to the ping-pong Smartphone application.

Our application will contain several play options to optimize the amount of success the player will have in being able to develop their skills, including adjustable difficulty, launch interval and horizontal launch. The application will also allow the user to save and access the user’s settings from the last 30 play sessions. These settings are stored into the application’s database after each session has ended.

During the play session, when the ball enters the machine, the solenoid will pull in the ball for however long the user has set the time interval for. Once the ball has launched, it will be able to get launched horizontally within a 180 degree radius, while the difficulty will determine the ball’s launch speed and elevation.

Our project description/specifications will be reviewed by Sebastien Dwornik, ideally an employer in a position to potentially hire once we graduate. They will also ideally attend the ICT Capstone Expo to see the outcome and be eligible to apply for NSERC funded extension projects. This typically means that they are from a Canadian company that has been revenue generating for a minimum of two years and have a minimum of two full time employees.

The small physical prototypes that we build are to be small and safe enough to be brought to class every week as well as be worked on at home. In alignment with the space below the tray in the Humber North Campus Electronics Parts kit the overall project maximum dimensions are 12 13/16" x 6" x 2 7/8" = 32.5cm x 15.25cm x 7.25cm.

Keeping safety and Z462 in mind, the highest AC voltage that will be used is 16Vrms from a wall adapter from which +/- 15V or as high as 45 VDC can be obtained. Maximum power consumption will not exceed 20 Watts. We are working with prototypes and that prototypes are not to be left powered unattended despite the connectivity that we develop.

# Executive Summary

Our team has worked towards, creating an affordable and competitive Ping Pong Ball machine. This project was started with comparing the various Ping Pong Ball machines in the market currently. The common observation was that the machines present in the market right now are either too expensive or don’t give you much competitive play features. Our Smart Ping Pong ball machine will incorporate a feasible product that allows a user to play at various difficulties, with the new smart features like database and statistic support and be controlled by an app run on any android device. This machine will achieve complex play settings using minimal and cheaper hardware but, also using smart and intricate firmware. Using less and cheaper hardware allows us to keep the cost down, and compete with currently sold machines in the market. To make manufacturing easier, we can sell the product in the form an assembly kit to keep the manufacturing costs low. Even if, the cost is low, this product can compete with the most competitive and expensive products in the market.

Contents

[Declaration of Joint Authorship 3](#_Toc30504904)

[Proposal 5](#_Toc30504905)

[Executive Summary 7](#_Toc30504906)

[List of Figures 11](#_Toc30504907)

[1.0 Introduction 13](#_Toc30504908)

[1.1 Scope and Requirements 14](#_Toc30504909)

[2.0 Background 17](#_Toc30504910)

[3.0 Methodology 19](#_Toc30504911)

[3.1 Required Resources 19](#_Toc30504912)

[3.1.1 Parts, Components, Materials 19](#_Toc30504913)

[3.1.2 Manufacturing 19](#_Toc30504914)

[3.1.3 Tools and Facilities 19](#_Toc30504915)

[3.1.4 Shipping, duty, taxes 19](#_Toc30504916)

[3.1.5 Time expenditure 19](#_Toc30504917)

[3.2 Development Platform 19](#_Toc30504918)

[3.2.1 Mobile Application 19](#_Toc30504919)

[3.2.2 Image/firmware 21](#_Toc30504920)

[3.2.3 Breadboard/Independent PCBs 21](#_Toc30504921)

[3.2.4 Printed Circuit Board 23](#_Toc30504922)

[3.2.5 Enclosure 24](#_Toc30504923)

[3.3 Integration 25](#_Toc30504924)

[3.3.1 Enterprise Wireless Connectivity 26](#_Toc30504925)

[3.3.2 Database Configuration 26](#_Toc30504926)

[3.3.3 Security 26](#_Toc30504927)

[3.3.4 Testing 26](#_Toc30504928)

[4.0 Results and Discussions 27](#_Toc30504929)

[5.0 Conclusions 29](#_Toc30504930)

[6.0 References 31](#_Toc30504931)

[7.0 Appendix 33](#_Toc30504932)

[7.1 Firmware code 33](#_Toc30504933)

[7.2 Application code 33](#_Toc30504934)

# List of Figures

[Figure 1. By Android Studio - https://developer.android.com/studio/, CC BY-SA 4.0, https://commons.wikimedia.org/w/index.php?curid=74094999 19](#_Toc29300871)

[Figure 2. Initial schematic. This work is a derivative of "http://fritzing.org/parts/" by Fritzing, used under CC:BY-SA 3.0. 20](#_Toc29300872)

[Figure 3. This work is a derivative of "http://fritzing.org/parts/" by Fritzing, used under CC:BY-SA 3.0. 20](#_Toc29300873)

[Figure 4. Breadboard prototype. 21](#_Toc29300874)

[Figure 5. PCB design This work is a derivative of "http://fritzing.org/parts/" by Fritzing, used under CC:BY-SA 3.0. 22](#_Toc29300875)

[Figure 6. Humber Sense Hat Prototype PCB. 22](#_Toc29300876)

[Figure 7. Example enclosure. 23](#_Toc29300877)

# Introduction

Our project involves creating a Smart Ping-Pong machine that includes a wide array of play options to allow for a wide range of playing styles. This will allow for players of different skillsets to improve on their ping-pong abilities in a fun and varied manner. In the playing application, the user can select their ideal play preferences to give them a comfortable play experience or to ease them into using the machine. These settings include: play difficulty, organized into easy, medium, and hard categories which affects both the launch speed and the types of shots the machine is able to perform; easy difficulty provides forehand and backhand shots at the standard elevation, whereas the hard difficulty provides the prior 2, in addition to the topspin and backspin shots at random elevations; launch angle, which changes the horizontal launch of the ping-pong ball within a 45-degree radius; and the launch interval which affects the amount of time balls launch between one another, which range from 0.3 to 5 seconds. Our playing application involves a series of databases that allow the player to save and record the fields for the play options of their past play sessions. After 30 sessions have already been input, any new sessions will gradually override the old ones to give the player a better idea of their progress using the machine. The range of elevations the balls launch depends on the difficulty set. It will be set at a permanently neutral elevation if set to easy but will fluctuate if set to a higher difficulty. In terms of scope, first we need to create a hardware prototype and then test for errors to evaluate if we need to change anything for the refined version. Afterwards, we need to create the Firebase databases, which will act as the bridge between the play application and the hardware. The default settings of the play application are set to a launch angle of 5-degrees, a time interval of 5 seconds and an easy difficulty setting. However, the database will be able to transfer the settings of the user’s last play session to their current one, in order to make for a more efficient play experience. Schedule-wise, we plan on building our firmware and application first. We will then develop our databases, which connect to the firmware and application. Lastly, we will develop the enclosure for the machine, which includes the structure for the device and the piping from where the ball launches.

## 1.1 Scope and Requirements

It is an Internet of Things (IoT) capstone project that uses a distributed computing model of a smart phone application, a database accessible via the internet, an enterprise wireless (capable of storing certificates) connected embedded system prototype with a custom PCB as well as an enclosure (3D printed/lasercut), and is documented via an OACETT certification acceptable technical report. This project will use a database hosted by Firebase which connects the mobile application to the machine. The machine hardware is developed around a Raspberry Pi 4 Model B which can connect to a wireless connections using enterprise wireless certificates. The Raspberry Pi also support good memory and processing power to be able to support multi-threading to control multiple components of the machine. The Pi outputs multiple PWMs and GPIOs to control a Servo Motor SG90 to aim the ball, TB6621FNG that control 2 9V DC motors to launch the ball and Pull type Solenoid to prevent multiple balls to be launched from being launched in a hectic way.

Report

/1 Hardware present?

/1 Introduction (500 words)

/1 Scope and Requirements

/1 Background (500 words)

/1 References

# 2.0 Background

We would like to thank our mentor Sebastian Dwornik from PDA for supporting this project. He has been instrumental in accomplishing our ideas and hopes for this project by providing support in terms of sorting through our ideas giving them objective approaches, helping with the design for the app and the hardware. Our idea was based after reviewing the designs and features of some of the available machines in the market. The current devices available are either too costly or provided minimal features (13 Best Ping Pong Robots That Will Improve Your Game Instantly, 2020). These machines are all controlled using some connected basic remote and in the age where people control everything in their households using smart switches and mobile applications (Pathan, 2019), why limit this machine to such old methods. Also, connecting the machine with the app and the database will help the user track their progress as they continue to use their machine from beginner to advanced player. Every professional player likes to keep track of their progress/status and this idea has been incorporated with training new players at a young age/beginners (Sumich, 2013). So this machine can be used to help such beginners and help save them some money to provide such training and features at a minimal cost. The more expensive machines available in the market support some different shot types but are unable to change them continuously during a single play though. This machine aims to change that and give highly random shot types to simulate the difficulty of an actual match. To complete this project we have learned how to create android applications in our software production class. We have also learned how to test and create a hardware prototypes for the components of the machine inclusive with a firmware and enclosure for the development platform and the components use in our hardware project class. We have also learned how to create and handle json based databases hosted by Firebase and to Read, write and update them using the applications we create in our software production class. We have already created and presented some hardware prototypes incorporating our individual components for the machine and now we will integrate them to create the refine prototype that can be controlled and operated through the a Firebase database.

# 3.0 Methodology

This project is called Smart Ping Pong Ball machine, which controls our prototype using our mobile application. The design for hardware uses simple hardware components with a firmware developed on a Raspberry Pi 4 Model B.

## 3.1 Required Resources

Report

/1 Parts/components/materials (500 words)

/1 PCB, case (500 words)

/1 Tools, facilities (500 words)

/1 Shipping, duty, taxes (250 words)

/1 Working time versus lead time (250 words)

### 3.1.1 Parts, Components, Materials

When constructing the circuit for our individual projects, it was expected that we use of Breadboards first to troubleshoot for any potential errors. Afterwards, we had to implement our designs onto PCB’s which would then connect to a circuit board, the Raspberry Pi 4. 40-pin outputs were used in all circuits to directly connect the PCB’s onto the Pi’s. An SD card and SD card adapter were used to transfer data and files from the computer directly onto the Pi to allow the Pi to operate properly. An Ethernet cable and a USB-to-Ethernet cable were required to connect the Pi’s directly to the computers, which allowed software such as Raspian to be activated and us to remote access it for its GUI and CLI. 3 millimeter acrylic cases were used to encapsulate our hardware designs to ensure that everything in the designs stay in place. For the servo motor design, a 3-pin serial header was used to connect the wires of the servo motor directly onto the PCB. A 220 ohm resistor and a 2.2 kilo-ohm resistor were also used in the design to moderate the amount of current that flowed through the design to ensure the circuit didn’t overheat. Additional packs of both types of resistors were required as all the remaining ones were damaged during the soldering process. It also included an NPN transistor to control the flow of the current to allow the Servo Motor to rotate both clockwise and counter clockwise. Finally, an LED was included as a visual way to confirm that the circuit was properly constructed. For the Solenoid design, another NPN transistor, a diode and a 2.2k Ohm resistor was used to amplify the current output to the Solenoid at a low voltage value. The resistor and transistor were used to form the current amplifier, and the diode was used so to cut-off the current form flowing into both directions. Female headers were used to mount the PCB onto the Pi and the input wires to the RB-1011 5V Push-Pull Solenoid onto the PCB. An external 9V power supply was used to power provide the adequate the voltage for the Solenoid and the TB6621FNG Dual Motor Diver. The motor driver drives the 2 6 to 12V bidirectional DC motors using the external power supply and the PWM and GPIO input from the Raspberry Pi 4.

### 3.1.2 Manufacturing

We all created our PCB’s using Fritzing. Once we finished our designs, we sent the designs to the prototype lab for them to print out. The printing process usually took a day from when we sent them the PCB design in gerber file format. During the construction of the Servo Motor PCB, 4 copies had to be printed for various reasons. In the initial design, the copper wiring was placed on opposite layers for some components. As a result, the schematic had to revised to ensure greater design consistency. The next couple of PCB’s had to be discarded as a result of soldering complications. As the proper soldering technique had not fully developed, some of the components were put in poor condition and parts of the copper wiring ended up getting singed out. This essentially rendered those PCB’s impractical. The final PCB includes a 3-pin serial header, a 40-pin serial header, an NPN transistor, 2 resistors and an LED. The PCB case for the Servo Motor PCB was made using the Corell software. After the design was made, it was sent to the prototype lab for them to construct using the laser cutter, which took approximately 20 minutes. This design had to be printed out a few times to make minor spacing changes to the ports. For the Solenoid, the PCB had to be printed up to 5 times, because of the fault in the initial design led to some of the components becoming unusable for the secondary attempts. During the third attempt, the design was fixed but due to unstable to testing parameters like required minimum current and maximum voltage limit and lack of knowledge regarding these factors led to the small components like transistors and diodes being short-circuited. Also, during the initial design of the PCB using Fritzing, it lacked the components being used which had to be resolved using similar components for the design. But these components not being the same ones as the ones to be used had wrong specifications that resulted in impractical PCB design. The case was laser-cut on black opaque 4mm acrylic. The design was based on a case for a Raspberry Pi 3 but was edited to support ports and nodes on the Raspberry Pi 4. For the Dual Motor driver, the PCB was required 3 attempts. The first attempt was rendered useless, because complications while soldering the sockets on the wrong side of the PCB. The second attempt was the same design which led to the Raspberry Pi crashing and corrupting its EPROM. The fault was discovered and fixed during the third attempt and solved which led to the smooth operation of the DC motors using the TB6621FNG driver. Printing the case for the DC motors component required multiple attempts. Initial designs were based on a case for a Raspberry Pi 3 and edited using Inkscape, but the designs created, and cut were not on scale with design. It took a few tries to figure out how to fix this problem, as it was discovered that the in-software measurements of the design were scrambled while saving them as .cdr format files. When I used Corel Draw for the design, I was successful in cutting the case for the Raspberry Pi. Then I created a fixture to hold the 2 DC motors at a fixed distance so that a ping pong ball could be launched through them. But it took a few recalculations and re-cutting to get the holes just right to hold them in place.

### 3.1.3 Tools and Facilities

In order to obtain the PCBs, we had to go to the prototype lab to submit our PCB cases designed using Fritzing software in gerber file format and receive the actual PCB which typically took 24 hours. In order to properly solder the various components onto the PCB’s, soldering stations from the prototype lab and room J 232 were used. The soldering station consisted of a soldering iron that melted the lead-free soldering wire in place when a component was placed on top. A de-soldering iron with suction pump was also available in case a component needed to be taken out or readjusted. After each solder, a sponge was present to moisten the soldering iron to ensure that no extra solder was left because it could dampen the heat from the soldering iron. During the soldering process, we had to use a vent as a safety precaution to ensure that we didn’t inhale any of the fumes that emitted from the solder. In addition, we had to use safety glasses when soldering to ensure that the fumes or any stray piece of metal didn’t get in our eyes. Holders were available to hold the PCBs in place while soldering. We also used microscopes with flashlights to solder accurately at small and complex joints. When soldering the PCB for the Servo Motor for the first few times, improper technique was used, resulting in too much solder getting placed onto the ports, melting parts of the copper wire, and resulting in the boards looking disorganized overall. It took about 4 weeks for this PCB to get soldered properly. When creating a case for the component prototypes, we used Inkscape and/or CorelDraw to design it and sent it to the prototype lab in .cdr format for getting laser-cut. We used the datasheets for the Raspberry Pi, solenoid, servo motor and the motor driver to design the circuits and test them. We had some tools available to test our circuits and troubleshoot them when any problems happened. For example, when I had doubts about my circuit and my testing code for the motor driver, I used the tools like oscilloscope and multimeter to first test the output from Pi for its GPIOs and PWMs. These same tools where used to troubleshoot when my Raspberry Pi was shorted by the PCB I had created. We used these devices to troubleshoot the circuit for the Solenoid circuit. We used VNC viewer and Putty to remote access our Raspberry Pi’s GUI and CLI modes for development of our prototype code. We used NOOBS software to load the Raspian OS image onto the SD card and used *Thonny* as the IDE to program in python. We are using Firebase to host the databases for our project and using it was the medium between our mobile application and the hardware. We used Android Studio to develop our mobile application written in Java. We also used LinkedIn Learning as a source, to learn various ways to implement our ideas in the both mobile application and the hardware prototypes. We used Trello to keep track of our progress and in combination with Slack that we used to contact and converse with our collaborator Sebastian Dwornik, helped us share our progress with a more featured and described means.

### 3.1.4 Shipping, duty, taxes

For the Servo Motor project, everything was ordered off of Amazon Prime with everything arriving around 1 day after the time of shipment. There weren’t any duty fees applied to the ordered parts as everything was sourced from Canadian suppliers. There weren’t shipping fees since everything was ordered through an Amazon Prime membership. Otherwise, the shipping fees would have been $6.99/shipment. There weren’t any regular taxes applied to the components, aside from the GST on the microSD card and Adapter, $1.12 (or 13%) of the initial price, $9.32.

For the Solenoid prototype, everything was ordered from Amazon and everything arrived within two days of ordering them. As none of the components were shipped from outside Canada, there were no extra duty charges and all of them were shipped together, having reached the minimum amount, no shipping charges were added. So the final invoice was just the price of the components plus the 13% Tax. But after that some small components had to be reordered and, not having reached the free shipping threshold, $6.99/shipment for two separate shipments were added with including the 13% HST.

For the Motor Driver prototype, The DC motors and the socket headers were bought from Sayal Electronics, so no shipping charges. The Raspberry Pi Kit was ordered from Amazon and having reached the no shipping threshold, only 13% HST was paid. But the motor driver was ordered from Elmwood Electronics, and including with cost of the driver, $10.56 shipping charge and 13% HST was paid.

### 3.1.5 Time expenditure

For Gurwarris’ project, he ordered his dual motor driver from Elmwood Electronics. When he ordered the component, they didn’t give him an exact delivery date, which ended up being 3 weeks. However, the male socket headers were already soldered onto the motor driver upon delivery, saving Gurwarris extra work. The Raspberry Pi kit was ordered from Amazon and arrived the day after. The kit was a product from Canakit, which included an already set up SD card with a bootable OS image for a Raspian. Which saved him some time in the working time setting up and went directly to development for the firmware code which was tested on the breadboard prototype. It took me a few hours to design the circuit for both the breadboard and the PCB. Which took up to 24 hours to print. There were some errors in the PCB that had to be led to Raspberry Pi being corrupted. So, it had to be printed again and it took some time for the PCB prototype to function. It took up to four weeks to get the prototype functioning. Also for the acrylic case, it took me up to 4 attempts to get just my case for the Raspberry Pi up to the standards and each attempt took about a couple of hours to edit/fix and 15-30 minutes to cut. The fixture for the motors also took me a whole day of a continuous process of re-measuring and re-cutting to fit it.

For Nicolas’ project, all of his components from Amazon Prime, each of which took a day to deliver. The first delivery, consisting of everything aside from the resistors, was in early October. The second delivery, consisting of the 220 and 2.2 kilo ohm resistor packs, was in late November. Complications arose from connecting the Pi to the desktop, which made it difficult to determine if the motor was working properly with the code it was given. It took roughly 5 weeks to determine if the code was working, with an additional 4 spent designing and soldering the PCB.

For the Solenoid prototype, the components arrived two days after they were ordered from Amazon. But because of clashing information and some of it being inaccurate for the circuit to be used. It took me 3 weeks to design the accurate circuit and test it out on the breadboard. This kind of wasted a lot of my time as the PCBs produced had to be soldered, but they ended up not only no working, but rendering my components useless. So I had order the again and keep testing the circuit, So the final PCB prototype was finished in 7 weeks .The case took only a couple of attempts to polish and fit for my raspberry Pi.

## 3.2 Development Platform

### 3.2.1 Mobile Application

Status

/1 Hardware present?

/1 Memo by student A + How did you make your Mobile Application? (500 words)

/1 Login activity

/1 Data visualization activity

/1 Action control activity

Include screenshots such as Figure 1. Testing. Progress.



Figure 1. By Android Studio - https://developer.android.com/studio/, CC BY-SA 4.0, https://commons.wikimedia.org/w/index.php?curid=74094999

### 3.2.2 Image/firmware

Status

/1 Hardware present?

/1 Memo by student B + How did you make your Image/firmware? (500 words)

/1 Code can be run via serial or remote desktop

/1 Wireless connectivity

/1 Sensor/effector code on repository

### 3.2.3 Breadboard/Independent PCBs

Status

/1 Hardware present?

/1 Memo by student C + How did you make your hardware? (500 words)

/1 Sensor/effector 1 functional

/1 Sensor/effector 2 functional

/1 Sensor/effector 3 functional

The initial schematic design, Figure 2, based on datasheets (Bosch Sensortec, 2019) led to a breadboard layout Figure 3 that was realized Figure 4.

How did you build your Prototype: Breadboard?

Then a PCB was designed, Figure 5, and populated (Figure 6). Bill of Materials, Case, Time commitment. Testing. Progress.



Figure 2. Initial schematic. This work is a derivative of "http://fritzing.org/parts/" by Fritzing, used under CC:BY-SA 3.0.



Figure 3. This work is a derivative of "http://fritzing.org/parts/" by Fritzing, used under CC:BY-SA 3.0.



Figure 4. Breadboard prototype.

### 3.2.4 Printed Circuit Board

Demo

/1 Hardware present?

/1 PCB Complete and correct

/1 PCB Soldered wire visible but trim, no holes or vacancies

/1 PCB Tested with multimeter

/1 PCB Powered up

How did you build your Prototype: PCB?



Figure 5. PCB design This work is a derivative of "http://fritzing.org/parts/" by Fritzing, used under CC:BY-SA 3.0.



Figure 6. Humber Sense Hat Prototype PCB.

### 3.2.5 Enclosure

Demo

/1 Hardware present?

/1 Case encloses development platform and custom PCB.

/1 Appropriate parts securely attached.

/1 Appropriate parts accessible.

/1 Design file in repository, photo in report.

How did you build your Prototype: Case?



Figure . Example enclosure.

## 3.3 Integration

Demo

/1 Hardware present?

/1 Data sent by hardware

/1 Data retrieved by mobile application

/1 Action initiated by mobile application

/1 Action recieved by hardware

Report

/1 Enterprise wireless connectivity (250)

/1 Database configuration (250 words)

/1 Security considerations (500 words)

/1 Unit testing (900 words)

/1 Production testing (100 words)

### 3.3.1 Enterprise Wireless Connectivity

How did you make a Database accessible by both your Prototype and Mobile Application?

### 3.3.2 Database Configuration

### 3.3.3 Security

### 3.3.4 Testing

Unit testing and Production testing.

# 4.0 Results and Discussions

Is your prototype perfect? What did you learn?

# 5.0 Conclusions

If you were making 1000 of these.

Report

/1 Hardware present?

/1 Checklist truthful

/1 Valid Comments

/1 Results and Discussion (500 words)

/1 Conclusion

# 6.0 References

*13 Best Ping Pong Robots That Will Improve Your Game Instantly.* (2020, January 11). Retrieved from bestpingpongtables: https://www.bestpingpongtables.review/robot/

Cheng, F. (2018). *Build Mobile Apps with Ionic 4 and Firebase: Hybrid Mobile App Development.*

OACETT. (2017, March). *I need to Complete a Technology Report*. Retrieved from The Ontario Association of Certified Engineering Technicians and Technologists: https://www.oacett.org/Membership/Technology-Report-and-Seminar

Robuck, M. (2018, 11). AWS goes deep and wide with machine learning services and capabilities. *Fierceinstaller*.

# 7.0 Appendix

## 7.1 Firmware code

Demo

/1 Hardware present?

/3 Code runs concurrently for all sensors/effectors

/1 Project repository contains integrated code

Status

/1 Memo including updates

/1 Financial update

/1 Progress update

/1 Modified Code Files in Appendix

/1 Link to Complete Code in Repository

## 7.2 Application code

Demo

/1 Hardware present?

/1 Memo by student A

/1 Login activity

/1 Data visualization activity

/1 Action control activity

Report

/1 Login activity

/1 Data visualization activity

/1 Action control activity

/1 Modified Code Files in Appendix

/1 Link to Complete Code in Repository