Creation of Dynamic Input One-Handed Controller with Full Functionality

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***Abstract*—In the gaming world, controllers are required to play video games. These controllers require the use of two hands, however, there are many people who do not have the physical capabilities to use both of their hands. This means that these people cannot play video games of any kind. Due to the lack of accessibility to these people, we were motivated to create a one-handed controller. We aimed to make this controller have all of the capabilities of a standard controller and did so to a certain degree of success. We created and tested several iterations of the controller over the course of 3 months before we decided upon a final version. All in all, the project was successful, but not without issues and mistakes to be learned from.**

***Index Terms*—component, formatting, style, styling, insert**

I. Introduction

In the USA alone, there are at least 3,000,000 who have disabilities in their hands or forearms [1]. Needless to say, there are many people worldwide who are incapable of using both of their hands. In the video game world, all standard controllers require the use of two hands in order to use all of its functions, whether it be buttons, triggers or joysticks. The issue here is that all of the people who are physically incapable of using 2 hands cannot participate in the act of playing video games. In order to be accessible to everyone in the market, an alternative controller needs to exist in order to allow these people to enjoy all the games that everyone else is playing. In order to address this problem, we designed a one-handed controller that has all of the functions of a standard controller. Our main focuses in this project are usability and accessibility. In order to create a more usable and comfortable experience, we decided to create a "shift" button. This allowed us to double up the functions of one input device in order to avoid clutter on the controller. When pressed, it makes the joystick change from the left stick to the right and the face buttons to the d-pad. This document will go through our research, methods of development, results and takeaways of this project.

II. Literature Review

When beginning our project, we looked into similar designs via reports and patents. This project is far from the first of its kind when approaching one handed devices, whether it be a human interface or an instrument. One such device was a bass guitar that was designed for one handed play, utilizing a fretting mechanism triggered by the feet and a midi controller in order to fret the notes. A 4x3 keypad that allows for writing Japanese characters by clicking and then flicking. It was something that was adopted into the Apple iPhone, and utilizes a second layer after clicking the first in order to type out the sounds. A patent includes a single handed controller that was placed flat on a table or lap that had modules that could be switched out so the buttons or analog stick could be placed in any slots to make it the most optimal for each individual user. Other options include the Gypard. A Wii nunchuck shaped device with an analog stick that has face buttons and triggers/bumpers alongside gyro to replace the second stick. Designed to play First person shooters. The final option that was looked at was a 3D printed option that would attach to a Dualshock 4 controller. It puts the opposing face buttons and triggers in range of the one hand, and rests on your lap for the opposing stick.

III. Methods

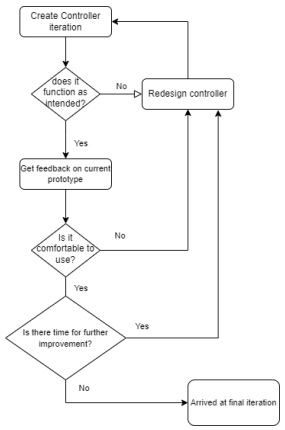


Fig. 1. Sketches for the controller design.

When it came to creating our design, we were sure to use iterative techniques. We would start with creating a given iteration of our controller. Next, we would do testing ourselves to see if it was functioning as intended. If dysfunctional, we would look into redesigning the controller and starting the process again with the next iteration. If the controller was all good, we moved on to the next step: gathering feedback. If the testers found the controller comfortable and effective then we would move to the next step. If there were major issues we would redesign the controller to alleviate these issues. For the final step, whether or not we continue to iterate is dependent

on the time we have left before the due date. If there is time for another iteration, then we would do it to improve the controller as much as possible and if not then we now have our final version (Fig. 1). For each iteration, we kept what worked and reworked what did not. We remodelled the controller in Fusion 360 each time to have better size, shape, feel and design. If electronics needed rewiring, we used TinkerCAD to redesign them, and had jumper wires to test physically.

IV. Results

A. Project Progression

The project was developed over the course of 3 months: September through November. It saw through 4 iterations of the one-handed controller. See appendix for timeline. Starting off in September, we came up with the idea to develop a one-handed controller to tackle the issue of accessibility with standard controller designs. We then began brainstorming ideas and getting feedback via ideation. Once we landed on a final concept, we began planning for physical production. We started with our first iteration, the paper prototype. This consisted of multiple drawings of the controller and the inputs it required. We included: 4 face buttons, 2 triggers, tilt switch for bumpers, one joystick, start , select, shift button, and wrist strap.

Moving into October, we began modeling the controller using Fusion 360, an engineering program for designing devices. With the completion of our model came iteration 2 of our controller. This version was mostly blocked out to get the jist of the shape and the only noteworthy change from the base design was the removal of the wrist strap due to technical issues. After its completion, we noticed that there was a sizing issue with the model. We decided to remodel it from scratch which was not an issue as we had planned to do that anyway, in order to add the proper amount of detail. After remodeling, we arrived at iteration 3. The only change here was the corrected size and added detail. Now that the ideal was fully visualized, we began searching for and ordering parts to create a physical prototype.

Finally, we arrive in November. All of our components have been received and we are ready to begin making the physical prototype. We began wiring a test version of the controller with a micro-controller and a breadboard. Meanwhile, the model was being prepped for 3D printing. Once the wiring was done, we started programming the micro-controller. Soon after we completed the 3D print of the model. We showed it off to several people to receive feedback. Once this was gathered we began redesigning the controller once again to address issues we were made aware of. The final version of our controller, iteration 4, was larger in size to better fit in people's hands and moved the locations of the start and select buttons to not get in the way of the joystick. Next up, the new model was 3D printed using better techniques than previously. During that process, soldering was done and the micro-controller programming was finished in order to put together the final physical prototype. Fig. 2

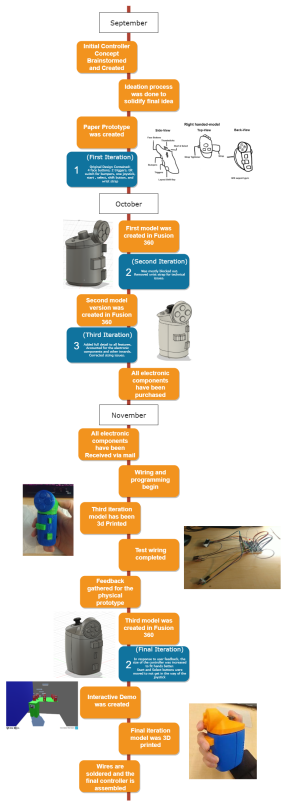


Fig. 2. Sketches for the controller design.

TABLE I
Table of SUS results

	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
Strong Disagree	0	2	0	6	0	5	1	1	0	2
Disagree	1	4	3	1	0	5	2	7	2	3
Neutral	5	2	3	2	0	1	5	2	3	2
Agree	4	2	3	1	6	0	1	0	5	3
Strong Agree	1	1	2	1	5	0	2	1	1	1

B. Quality Function Deployment (QFD) and Usability Analysis

While iterating, we created a QFD and asked 6 people about what they are looking for in this type of controller, we then compiled these answers together into our QFD (A). When looking at our functional requirements, we knew some of them would not be achievable with our prototype (namely the strap and internal battery) as we are not engineers, but we still wanted to include them for documentation sake. When we asked about how well we fulfill the customer requirements we compiled, and found that we scored decently compared to our competitors. We also noted that our key focus should be on the learning curve and functionality. We have attempted to mitigate the learning curve by changing the shape and adding an indicator for the shift mode. While getting this data, we also conducted a System Usability Scale (SUS) survey with 11 participants to try holding the controller we printed at the time (it did not function). After compiling our answers (Table I), we found that we scored below average, the main reasons

being the learning curve and the general lack of need for our device by the survey respondents. These tests helped form the final iteration created for this project, through the addition of the LED, and the polish in the shape.

V. Takeaways

During the course of this project, we learned a lot of things about creating a controller. While we were confident with our key design decisions, measuring a controller to be comfortable in a person's hand can be difficult. First we made it too small, then we over compensated and made it too large. If we could start over, we would have measured out many controller grips in order to get a better feel for the size right of the bat. 3D printing the model also created a lot of hiccups for us. The process is lengthy and can easily go wrong if you do not design with certain techniques in mind. We would have definitely used these methods from the get go if we had the experience at the time. Finally, the most important takeaway is the scope of the project. We were very ambitious with all the things we wanted on the controller and as a result we did not have the time to make it as well put together as we had wanted. For future projects, we will absolutely do better to understand our time frame and what can be done within it.

APPENDIX

APPENDIX A

QUALITY FUNCTION DEPLOYMENT

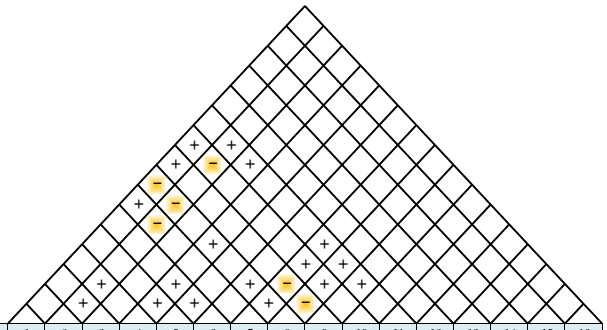
QFD: House of Quality

Project: One-Handed Controller

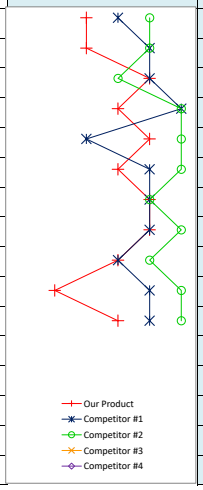
Correlations	
Positive	+
Negative	−
No Correlation	

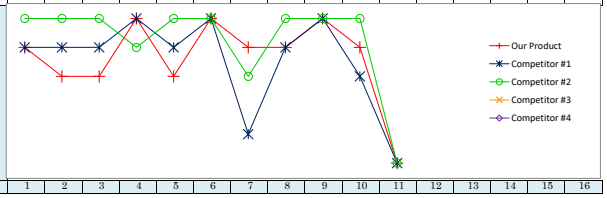
Relationships	
Strong	●
Moderate	○
Weak	▽

Direction of Improvement	
Maximize	▲
Target	◇
Minimize	▼



Row #	Weight Chart	Relative Weight	Customer Importance	Maximum Relationship	Customer Requirements (Explicit and Implicit) \ Functional Requirements	Every button as option	Good Ergonomics	Build Quality	Wireless/Bluetooth	Accessible ports	Rechargeable	Shift Key system	One-handed Useability	Analogue Triggers	Low Sensor Count	Wrist-Strap	12	13	14	15	16	Our Product	Gypard One-Handed Controller	Xbox Adaptive Controller			Row #
					Column #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16						
					Direction of Improvement	▲	▲	◇	▲	◇	◇	▲	▲	▲	◇	▲						Customer Competitive Assesment					
1		20%	9	9	Learning Curve	●	▽					●	○	▽	●							2	3	4			1
2		10%	5	9	Grip Shape		●	○				▽	▽	○	▽	●						2	4	4			2
3		5%	2	3	Mid-Light-weight			▽			▽					○						4	4	3			3
4		12%	6	9	Battery powered				○	▽	●					▽						3	5	5			4
5		7%	9	9	Button layout	●						○	○	○	●							4	2	5			5
6		7%	9	9	Ergonomics		●	▽				○	▽		○	●						3	4	5			6
7		7%	9	3	No painful shapes		○	▽		▽						○						4	4	4			7
8		7%	9	9	Ease to know which mode	○						●	○		●							4	4	5			8
9		10%	5	9	Simple Button Combinations	●						●			●							3	3	4			9
10		16%	7	9	Left + Right Stick at same time	●						●			●							1	4	5			10
11		10%	5	3	Indication for face buttons	○							▽		○							3	4	5			11
12																											12
13																											13
14																											14
15																											15
16																											16
					Target																						
					Max Relationship	9	9	3	3	1	9	9	3	3	9	9											
					Technical Importance Rating	9	9	9	6	5	6	5	9	3	6	4											
					Relative Weight	15%	15%	15%	10%	5%	10%	5%	15%	5%	10%	1%											
					Weight Chart																						
					Our One-Handed Controller	4	3	3	5	3	5	4	4	5	4	0											
					Gypard One-Handed Controller	4	4	4	5	4	5	1	4	5	3	0											
					Xbox Adaptive Controller	5	5	5	4	5	5	3	5	5	5	0											
					Technical Competitive Assessment																							
					Column #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16						

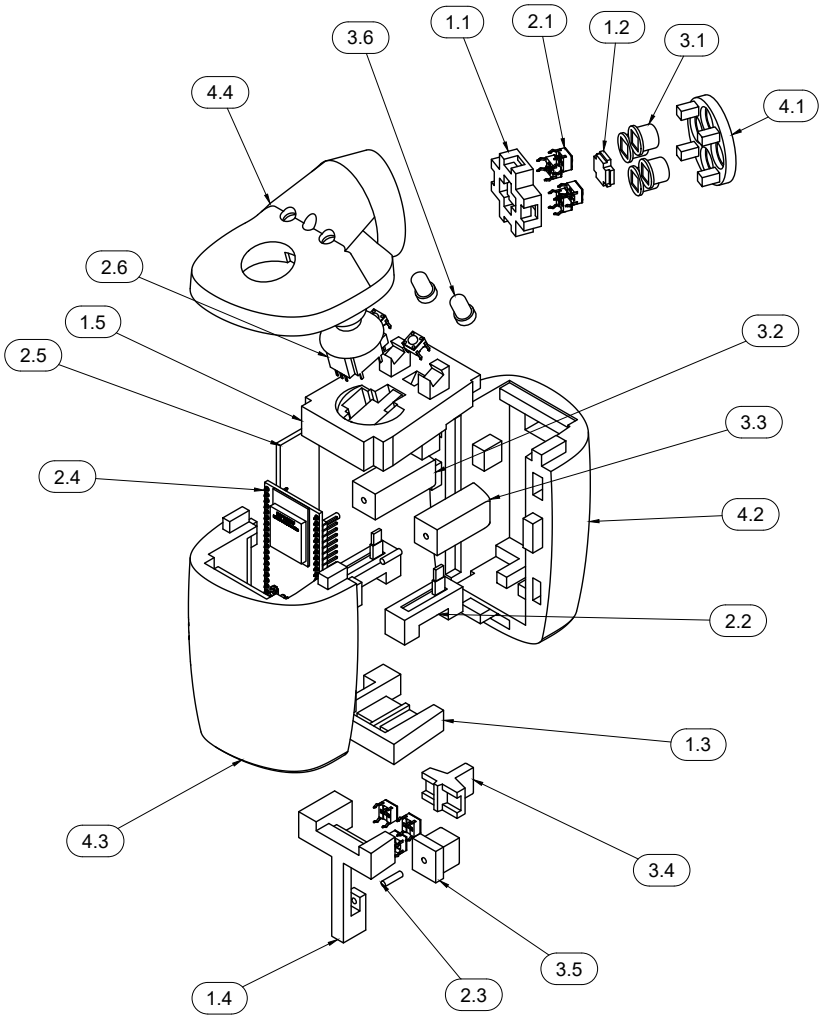




Template Revision: 0.9 Date: 4/23/2010

Christopher Battles

APPENDIX B
TECHNICAL DRAWINGS



Parts List				
Item	Qty	Part Number	Description	Material
1	1	Internals	Parent of all internals	Printed PLA Plastic
1.1	1	TactHolder	Face button holder	Printed PLA Plastic
1.2	1	Fitting	Face button support	Printed PLA Plastic
1.3	1	SliderTray	Tray for slide potentiometers	Printed PLA Plastic
1.4	1	LowerTactHolder	Support for lower buttons	Printed PLA Plastic
1.5	1	TopShelf	Support for interal buttons	Printed PLA Plastic
2	1	Not Printed	Parent of all non-printed	Steel
2.1	9	Tact Switch		Steel
2.2	2	Slider		Steel
2.2.2	1	Handle		Steel
2.3	3	Spring		Steel
2.4	1	ESP32 Microcontroller		Steel
2.5	1	ProtoBoard		Steel
2.6	1	Joystick		Steel
2.6.1	1	Top		Steel
3	1	Buttons	Parent of all buttons	Printed PLA Plastic
3.1	4	FaceButton	ABXY/Dpad buttons	Printed PLA Plastic
3.2	1	LeftTrigger	Left linear trigger	Printed PLA Plastic
3.3	1	RightTrigger	Right linear trigger	Printed PLA Plastic
3.4	1	Tilt	Tilt button for bumpers	Printed PLA Plastic
3.5	1	Shift	Shift button	Printed PLA Plastic
3.6	2	SmallButton	Start/select buttons	Printed PLA Plastic
4	1	Shell	Parent of all shells	Printed PLA Plastic
4.1	1	ButtonCap	Face button cover	Printed PLA Plastic
4.2	1	Back	Back shell piece	Printed PLA Plastic
4.3	1	Front	Front shell piece	Printed PLA Plastic
4.4	1	Top	Top shell piece	Printed PLA Plastic

Because of the usage of subcomponents to keep the project organized, the component's parent is shown in the parts list. Fusion 360 does not allow removing just the parent, and removing them from the project breaks the entire controller. As such, the numbering is first by parent, then by component in clockwise order.

We are also unable to change the angle of the view to be more useful, none of the options are easy to view.

To make things easier, here is how page number works:
All Internals (1.x) are at pages x
All Buttons (3.x) are at pages x + 5
All Shells (4.x) are at pages x + 11

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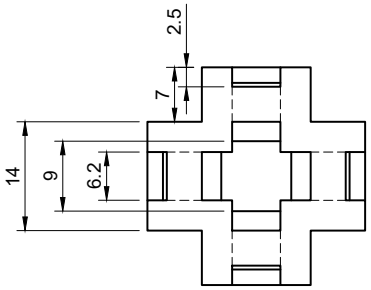

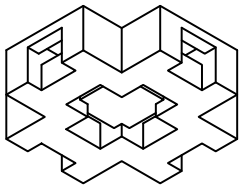

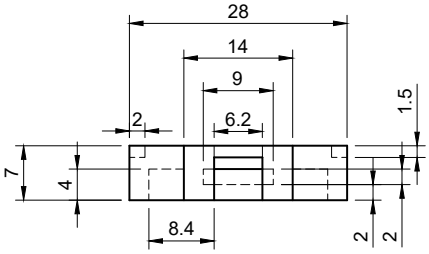

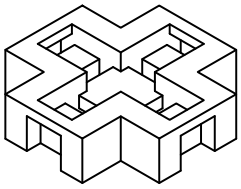

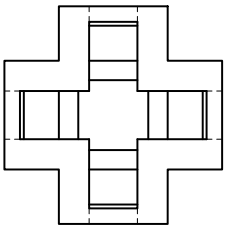

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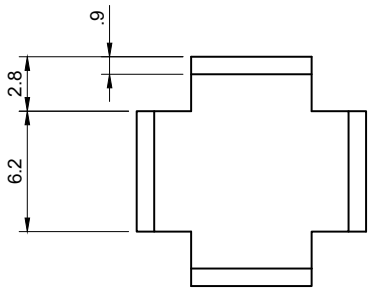

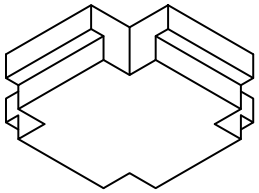

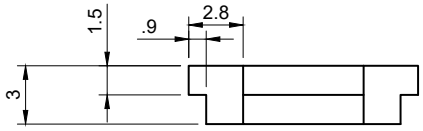

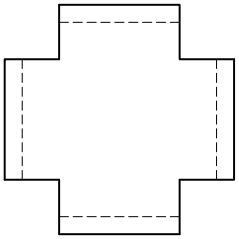

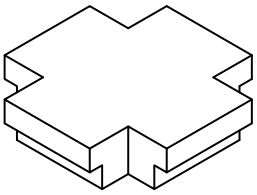

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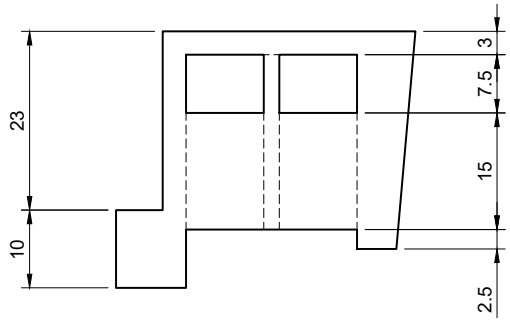

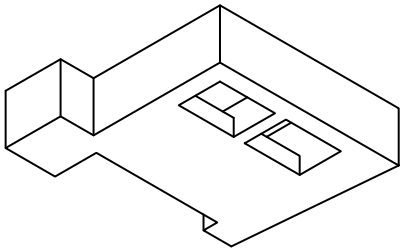

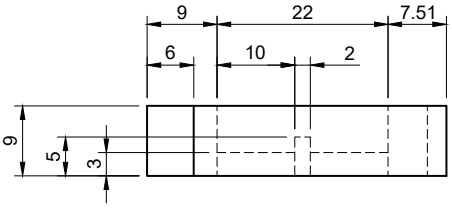

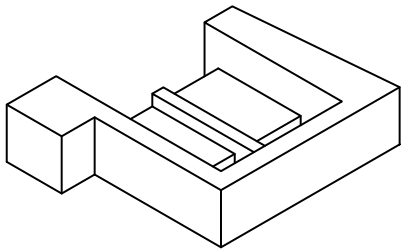

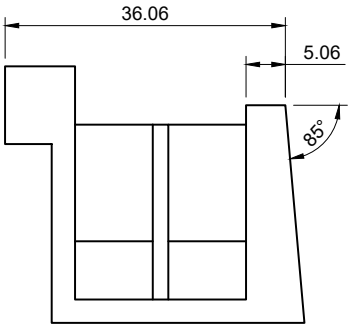

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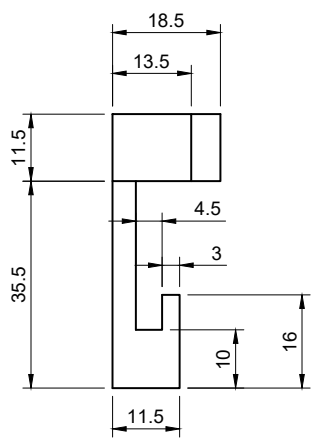

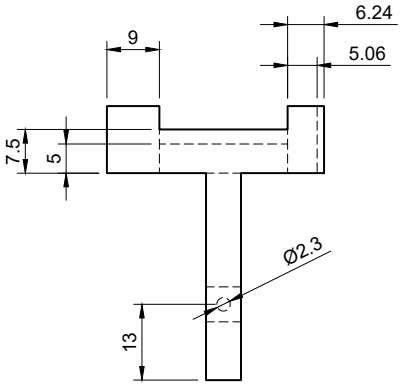

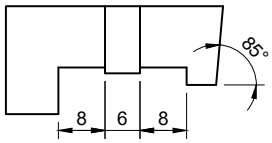

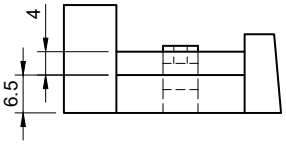

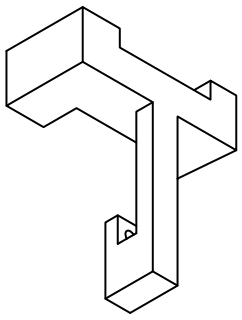

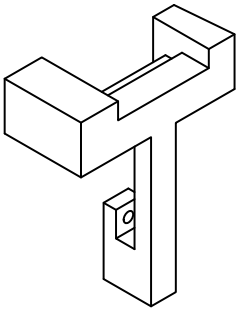

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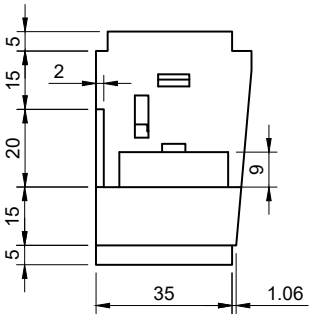
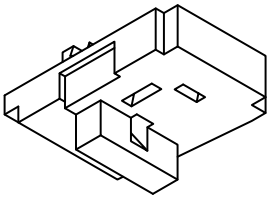
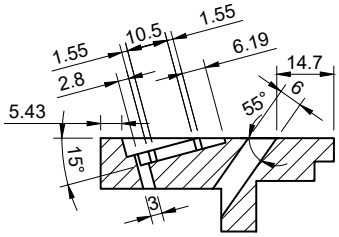
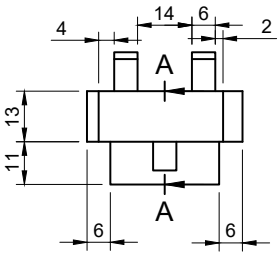
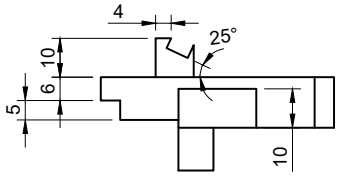


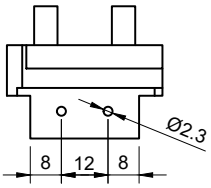


A-A (1:1)









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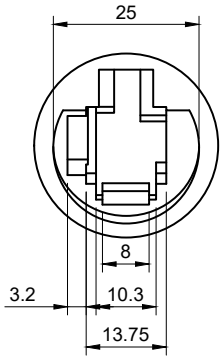
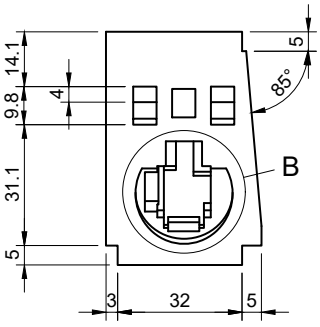
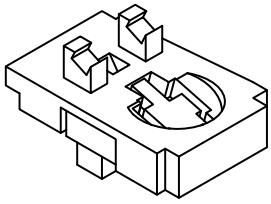
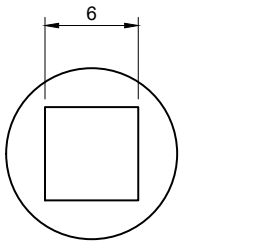
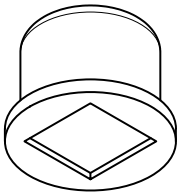


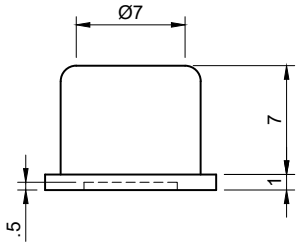


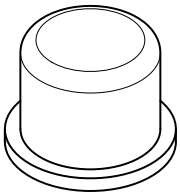


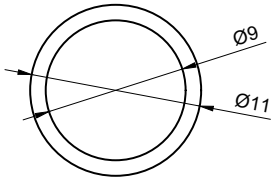
Dept.	Technical reference	Created by: Jonathan Jay 2022-11-30	Approved by:
		Document type: Technical Drawing	Document status:
		Title: Controller v3 TopShelf	DWG No.: 1.5
			Rev. / Date of issue / Sheet: 5/15



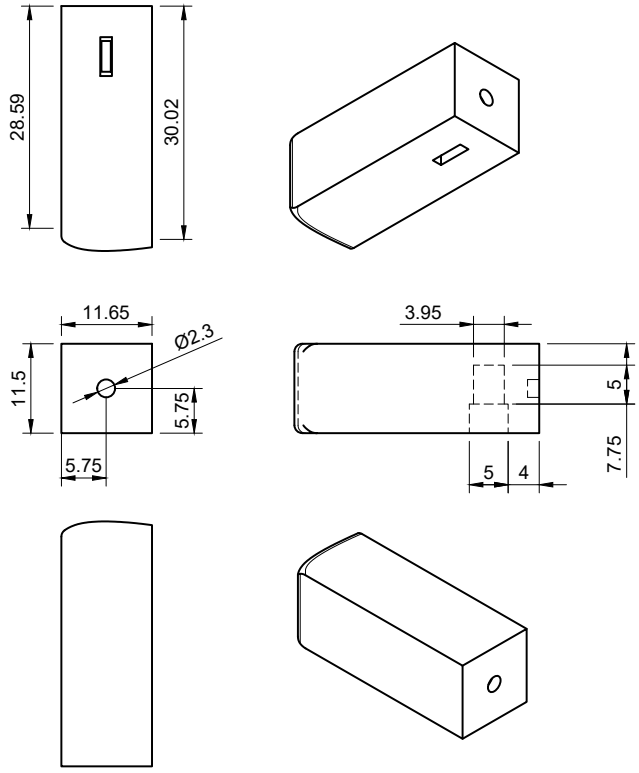




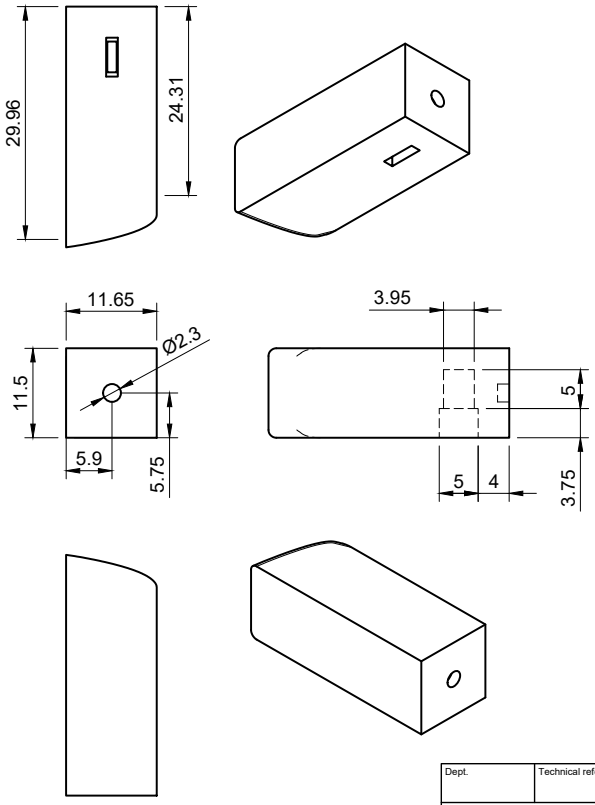




Dept.	Technical reference	Created by: Jonathan Jay 2022-11-30	Approved by:
		Document type: Technical Drawing	Document status:
		Title: Controller v3 FaceButton	DWG No.: 3.1
			Rev. / Date of issue / Sheet: 6/15



Dept.	Technical reference	Created by	Approved by
		Jonathan Jay 2022-11-30	
		Document type: Technical Drawing	Document status
		Title: Controller v3 LeftTrigger	DWG No.: 3.2
			Rev. / Date of issue / Sheet: 7/15



Dept.	Technical reference	Created by	Approved by
		Jonathan Jay 2022-11-30	
		Document type: Technical Drawing	Document status
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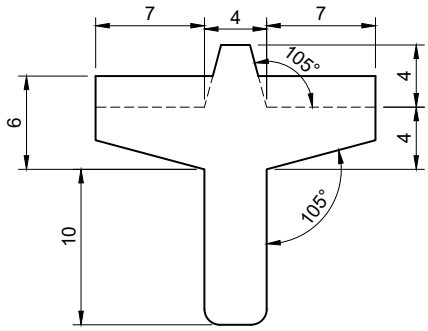
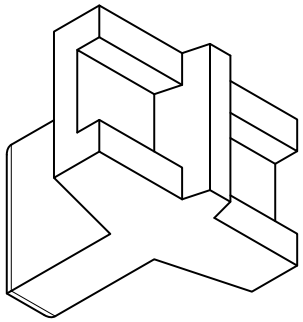
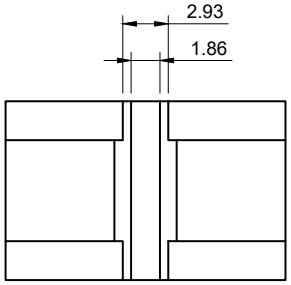
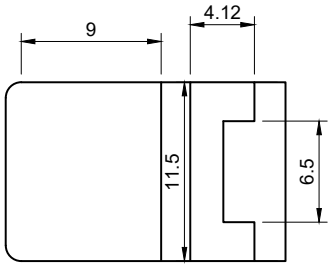
			Rev. / Date of issue / Sheet: 8/15

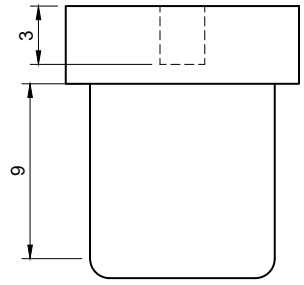


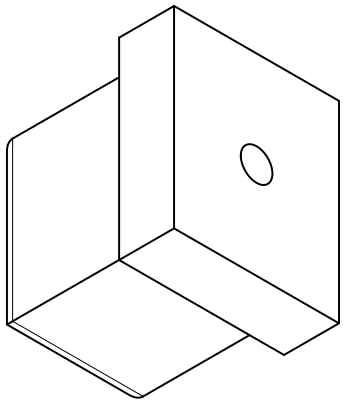


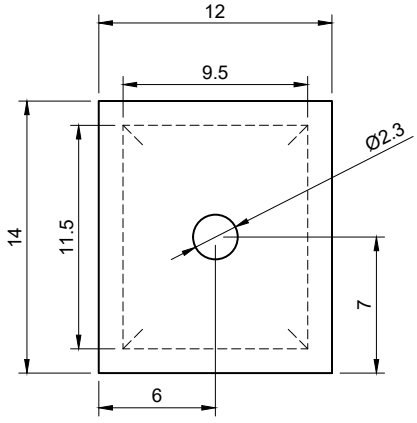


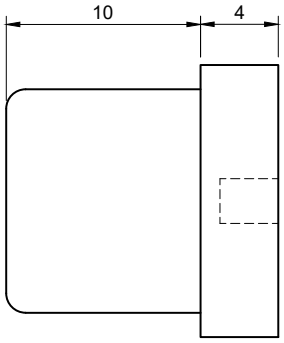


Dept.	Technical reference	Created by	Approved by
		Jonathan Jay 2022-11-30	
		Document type: Technical Drawing	Document status
		Title: Controller v3 Tilt	DWG No.: 3.4
			Rev. / Date of issue / Sheet: 9/15

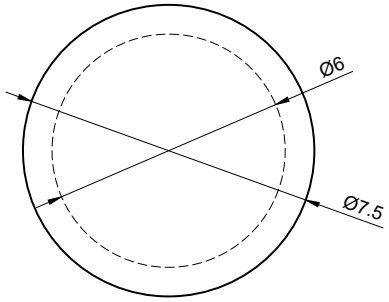


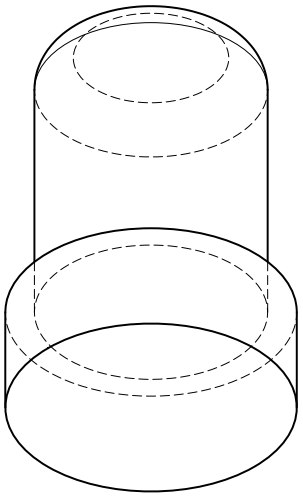


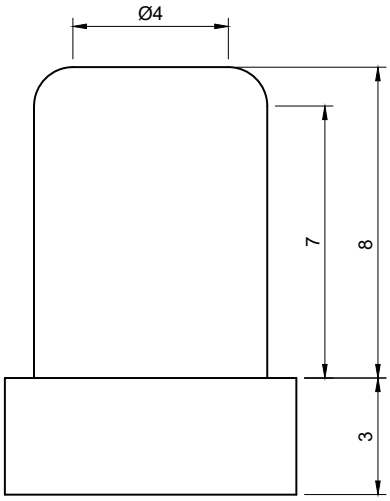




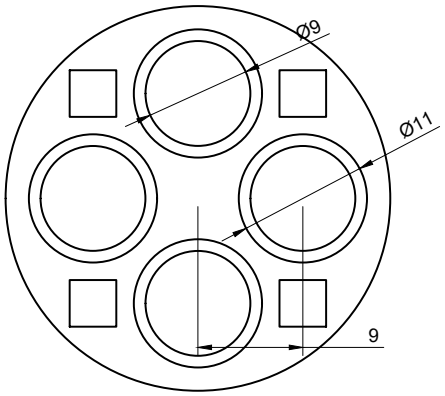
Dept.	Technical reference	Created by	Approved by
		Jonathan Jay 2022-11-30	
		Document type: Technical Drawing	Document status
		Title: Controller v3 Shift	DWG No.: 3.5
			Rev. / Date of issue / Sheet: 10/15

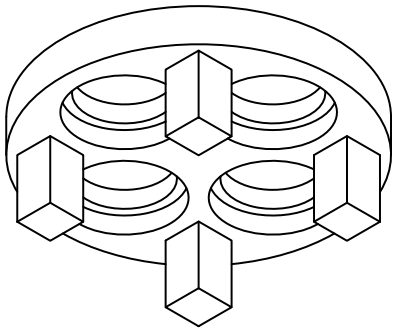


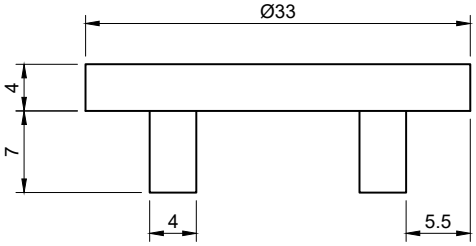


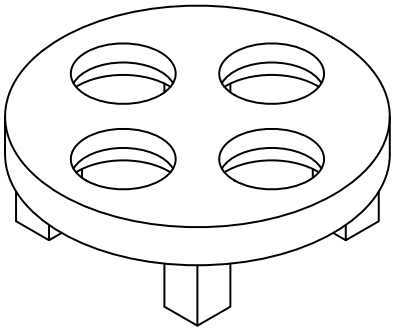


Dept.	Technical reference	Created by	Approved by
		Jonathan Jay 2022-11-30	
		Document type: Technical Drawing	Document status
		Title: Controller v3 Small Button	DWG No.: 3.6
			Rev. / Date of issue / Sheet: 11/15





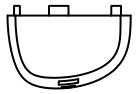


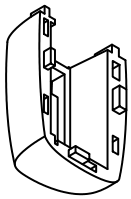


Dept.	Technical reference	Created by	Approved by
		Jonathan Jay 2022-11-30	
		Document type: Technical Drawing	Document status
		Title: Controller v3 ButtonCap	DWG No.: 4.1
			Rev. / Date of issue / Sheet: 12/15

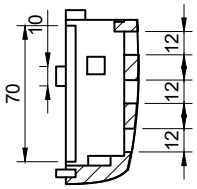
Part is too complex to get all mesurements in on time (and visibly)

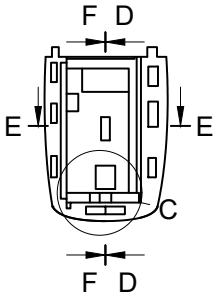
As such, it won't be complete



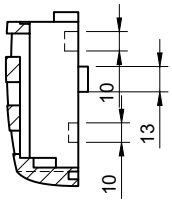


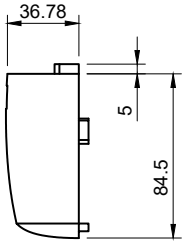
D-D (1:2)

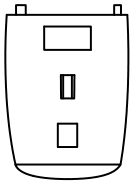




F-F (1:2)







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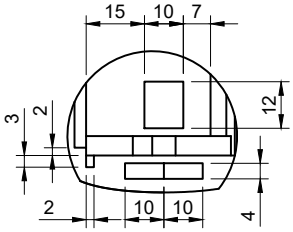

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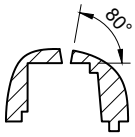
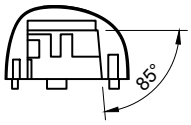
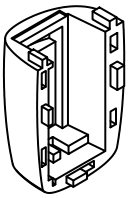


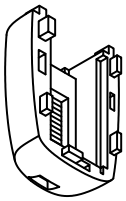


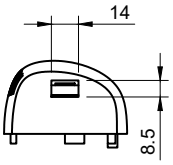


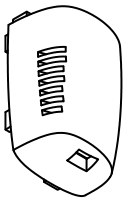
Dept.	Technical reference	Created by: Jonathan Jay 2022-11-30	Approved by:
		Document type: Technical Drawing	Document status:
		Title: Controller v3 Back	DWG No.: 4.2
			Rev. / Date of issue / Sheet: 13/15

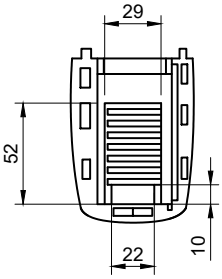
Part is too complex to get all mesurements in on time (and visibly)

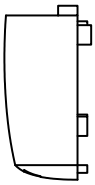
As such, it won't be complete

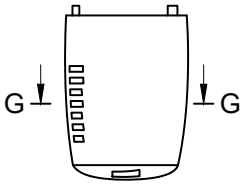




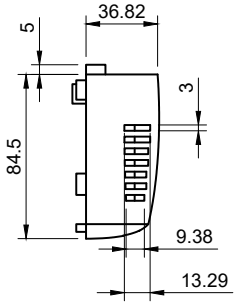


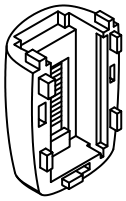


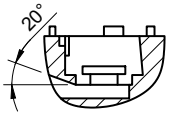


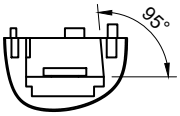


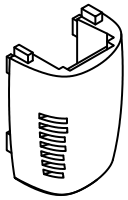
G-G (1:2)



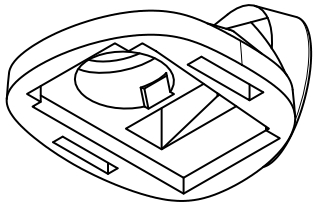


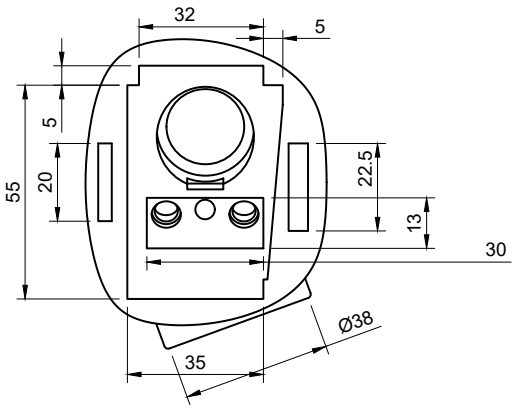






Dept.	Technical reference	Created by	Approved by
		Jonathan Jay 2022-11-30	
		Document type: Technical Drawing	Document status
		Title: Controller v3 Front	DWG No.: 4.3
			Rev. / Date of issue / Sheet: 14/15

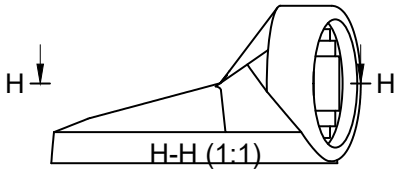


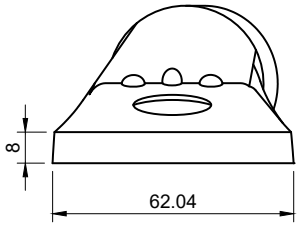


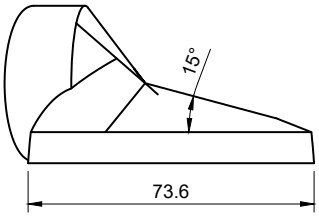
Part is too complex to get all mesurements in on time (and visibly)

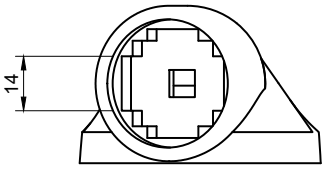
Fusion also dislikes angled faces, so some circles can't be measured

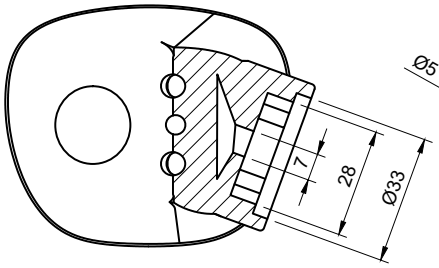
As such, it won't be complete

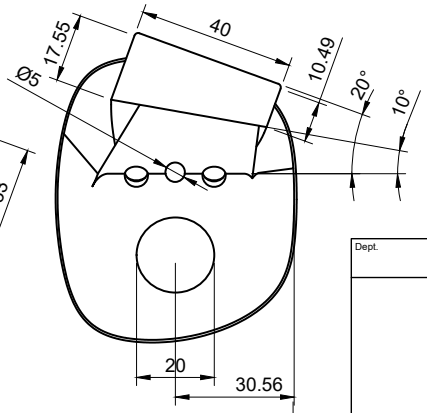


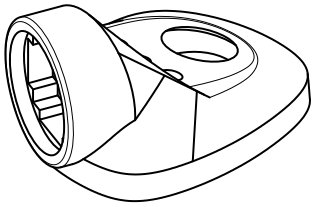












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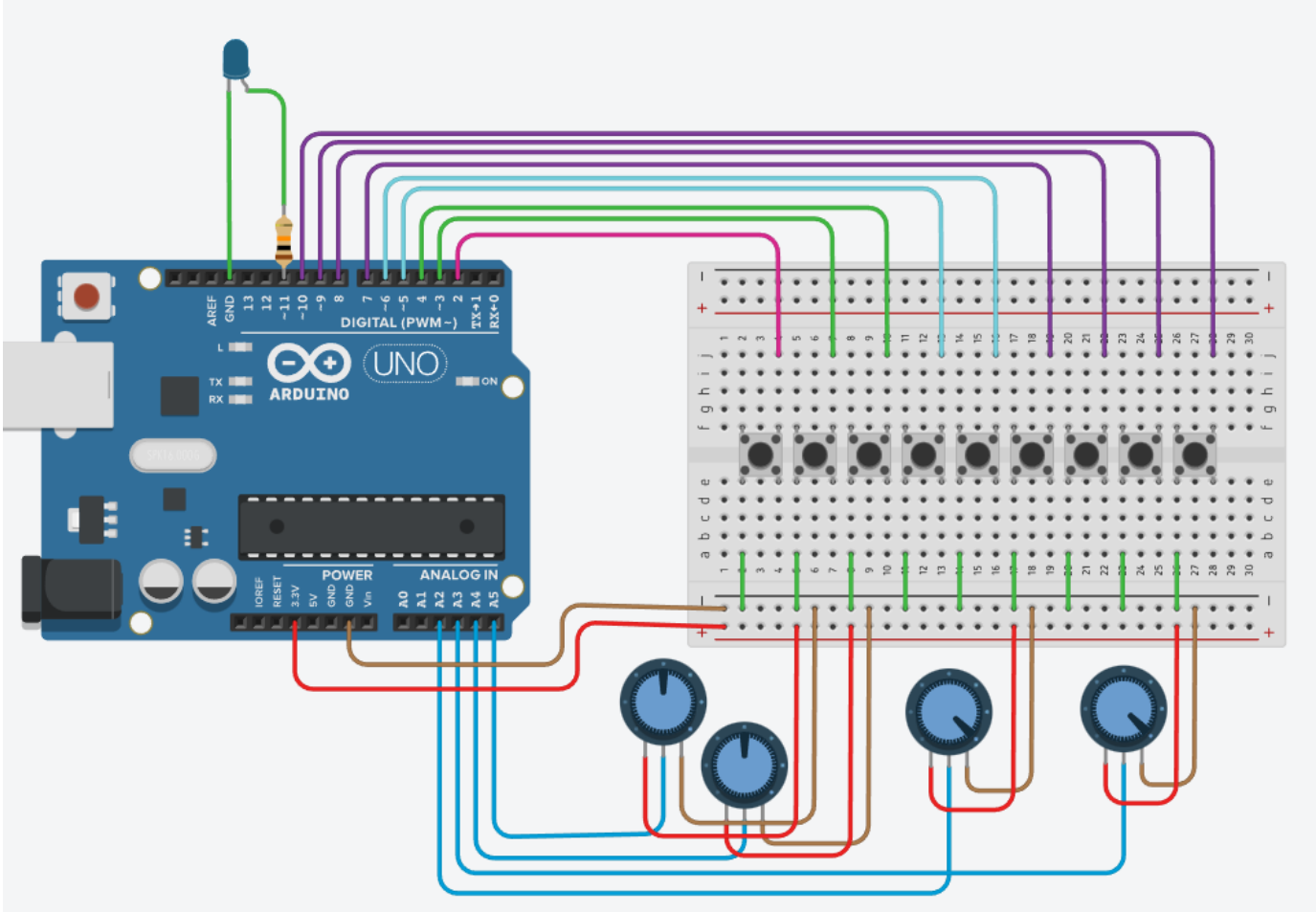
		Jonathan Jay 2022-11-30	
		Document type: Technical Drawing	Document status
		Title: Controller v3 Top	DWG No.: 4.4
			Rev. / Date of issue / Sheet: 15/15

APPENDIX C
WIRING



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