ECE445

Senior Design Lab
Sp2023
Design Document

Chip dispenser

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Team 65 Design Document

1. Introduction

1.1. Problem:

As we all know, ECE classes like ECE210 and ECE385 will provide kits with chips and electronic parts. Electronic parts can be easily distinguished because of their size and shape; chips, on the other hand, generally look the same: a small black box with several pins. When more than 200 students are in a class, sorting out the correct number of chips takes a lot of work and time. As far as we know in SP2023, these classes' chips are still collected manually by staff. The work is repetitive and tedious.

1.2. Solution:

To free people from doing so much hard work by hand, we want to make a system that can hand out chips as needed. The user only needs to give out a desired list of chips on the number pad and then hit the button to dispense one copy from the storage system.

After the dispensing system is made, if extra time allows, additional chip input functions could be added. In input mode, the user has to line up a sequence of mixed chips on the input rail. Then, our system will identify each chip and put them into separate slots.

1.3. Visual Aid:

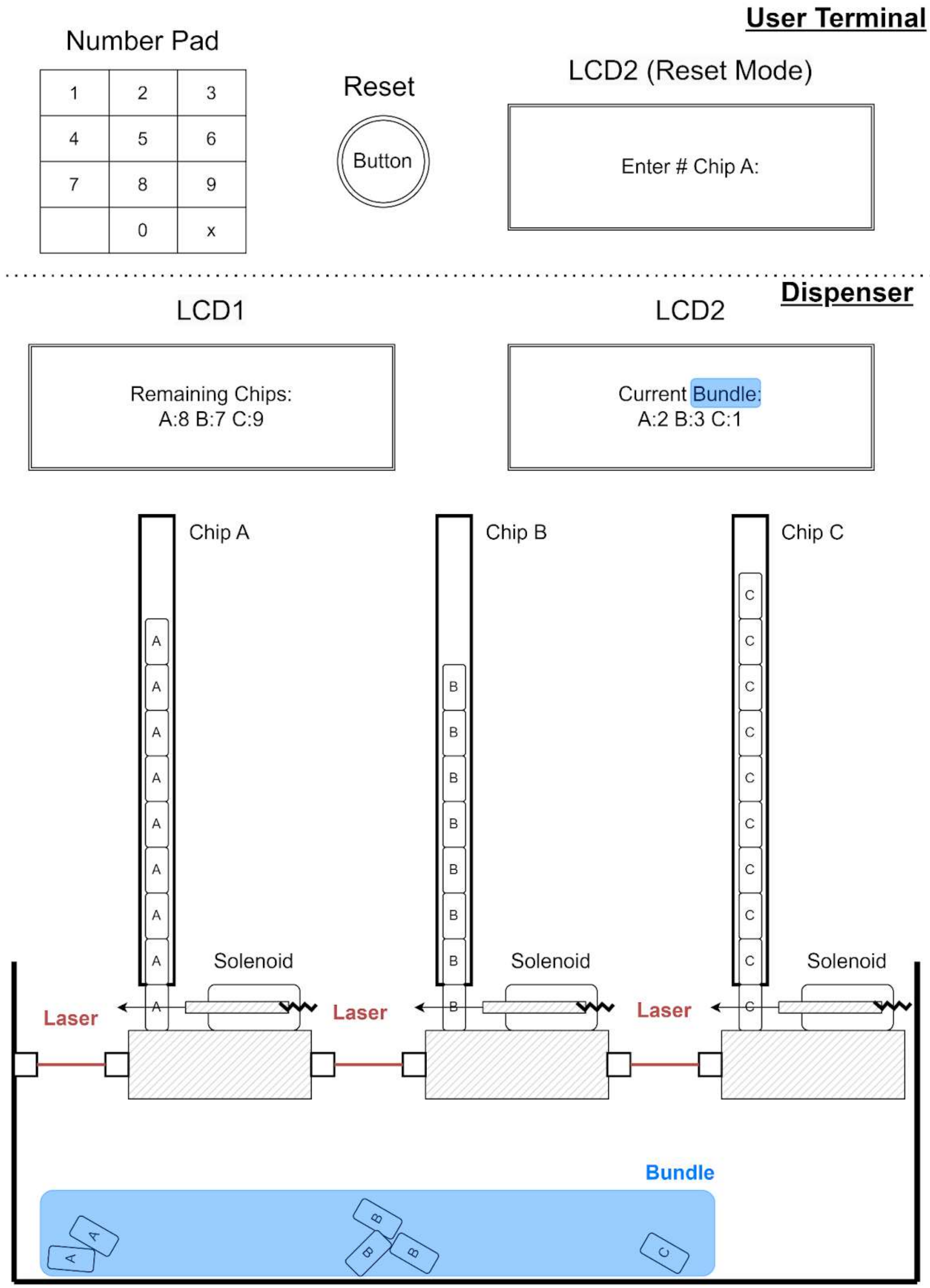

Table & graph #1

1.4. **High-level requirements list:**

1.4.1. After the user chooses desired chips, the dispenser system outputs specified chips with the correct numbers while the storage tubes are not empty. (The dispenser system can output a single chip.) The system needs to achieve at least 90% accuracy during 10 consecutive dispensing processes.

1.4.2. The system should be able to hint to the user about the number of remaining chips for all three types of chips with 98% accuracy; the system should also hint to the user about the current state of the system with 98% accuracy (input mode, output mode, or halt).

1.4.3. The capacity of the battery needs to sustain the dispensing process at least 20 times with every component of the system working correctly. (Theoretically feasible, see Sect. 2.3)

2. Design

2.1. Block Diagram:

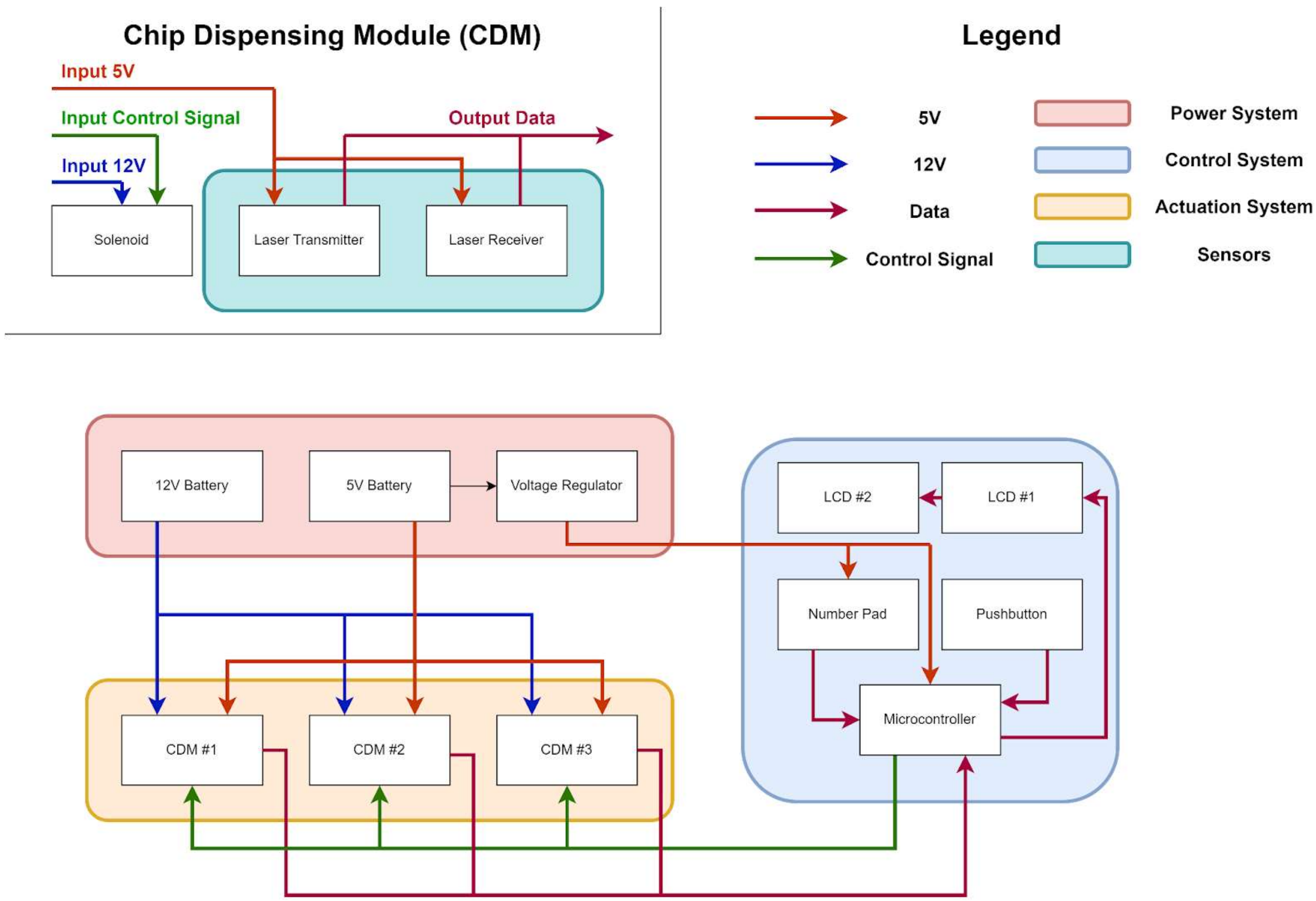

Table & graph #2

2.2. **Subsystems:**

2.2.1. Subsystem 1: Storage subsystem

Each slot will hold one specific type of chip in the tube. For example, slot #1 will hold chip HCF4072B, and slot #2 will hold chip SN74ALS21. Presumably, the chips are placed in the original tube and are already segregated. Each tube is lifted from the platform so that only one chip falls and stays output the tube every time.

Also, the storage system is equipped with a chip counter that displays the number of remaining chips in each tube on a Liquid Crystal Display(LCD); one laser transmitter and one laser receiver will be placed below each tube to detect the chip when it was dispensed and fell to the bottom. With the dispensed chip detected, the number of remaining chips will be decreased by one.

Notice that the counter needs to be manually reset to the current number of remaining chips whenever a new tube of chips is placed. By default, the counter will be reset to 10 if no specific input is detected.

Requirements	Verification
• Requirement #1: The tube can be easily placed and secured in the intended position.	• The tube can be smoothly placed and secured in the intended position in less than 30 seconds.
• Requirement #2: The counter should display the correct number of remaining chips with at least 80% accuracy.	• During the test for requirement #1, keep a record of the remaining chips. Check if the system can correctly display the number of remaining chips with 80% accuracy.

Table & graph #3

2.2.2. Subsystem 2: Dispensing subsystem

This subsystem will dispense the intended chip from the storage. The system will accommodate at most three types of chips. Each type of chip will be managed by one Chip Dispensing Module (CDM).

For every CDM, at the bottom, a solenoid can push the bottom chip into a bar-shaped wall for collection.

Requirements	Verification
• Requirement #1: The system must correctly dispense the intended amount of chips. It is important to dispense chips smoothly without getting stuck.	• Pressure tests the system using three complex combinations of chips. For instance, try (2,3,1), (3,3,4), and (1,2,4), where each number in the tuple represents the quantity of each chip. The system's reliability can be proved when the system can correctly dispense the three combinations of chips.
• Requirement #2: After falling out of the dispensing system, over 90% of all chips should remain undamaged.	• LED chips will be used for verification. The test requires 20 function chips to be outputted by the dispensing system consecutively. At least 18 chips should remain functional (could be lit up as designed).

Table & graph #4

2.2.3. Subsystem 3: Power subsystem

This subsystem is responsible for the power supply of the whole system. We will use a 12V battery to sustain the solenoid and a 5V battery to sustain the rest of the system. Since we only have three solenoids all at 12V power input, we only need one voltage regulator for the 5V battery to step down from 5V to 3.3V.

Requirements	Verification
• Requirement #1: The voltage regulator must be able to supply the correct voltage to the control system, actuation system, and sensors during the dispensing process.	• Make sure there is no malfunction during full load and no load. The output of the voltage regulator should be 3.3V(+/-0.2V) measured by an oscilloscope. Also, test if each component can be sustained with stable power during the 10 consecutive tests.
• Requirement #2: The capacity of the battery needs to sustain the dispensing process for a normal chip dissipating job of faculty.	• The power system needs to sustain the dispensing process at least 20 times. The voltage that reaches the solenoids during and after the test should be in the range of 10V-12.5V.

Table & graph #5

2.2.4. Subsystem 4: A user terminal

This subsystem is a number pad that can input the number of chips. Connected to the control system using a USB port. The user will be able to use the switch to pick from input mode and output mode[1].

Requirements	Verification
• Requirement #1: The system must correctly handle the user input by dispensing the correct amount of chips with at least 95% accuracy.	• Verify using the simulation. For instance, input (2,3,1), and check the simulation of the microcontroller to determine whether the corresponding pulses are generated. Make sure the 98% accuracy with 10 consecutive tests.
• Requirement #2: The terminal should hint to the user about the current state of the system (input mode, output mode, or halt).	• During the test for dispensing the system, check if the LED is correctly showing the current state of the system. (See Sect. 2.2.2 Verification)

Table & graph #6

1: If the input mode is not available, switching to the input mode will cause the whole system to halt.

(Additional systems are only related to input mode that depends on the use environment and may not be required)

2.2.5. Subsystem 5: Control subsystem

This subsystem will be receiving, processing, and sending signals to all other subsystems. We plan to use a development board (Arduino) as the microprocessor. Specifically, the subsystem will receive the data from each CDM to monitor the remaining chips and send control signals to each solenoid to dispense and handle the input from the number pad.

Requirements	Verification
• Requirement #1: The system must be able to calculate the number of remaining chips based on the data from the laser.	• Using three different types of chips for dispensing. The system must be able to calculate the number of the remaining chip with 90% accuracy. This test can be done along with the high-level requirement 1.

Table & graph #7

2.2.6. **[Additional]** Subsystem 1: Chip delivery system

This subsystem will accept a sequence (inline) of different chips and output them one by one for the scanner to use by using a solenoid. Notice that this is an additional system that will be only considered to be built after the previous four subsystems have been implemented and tested thoroughly. More details will be provided later.

Draft requirements:

- Requirement #1: The chip can be correctly delivered to the chip identification area at least 10 times a row.

- Requirement #2: The chip must be placed at an angle that is convenient for the chip identification subsystem, and the distance between each chip should remain constant and long enough.

2.2.7. **[Additional]** Subsystem 2: Chip identification subsystem

This subsystem will have a barcode scanner to identify the chip and tell the controller chip ID. For identification, the scanning area will have at most one chip at a time, and the chip must be placed at a proper angle to the scanner. These requirements will be fulfilled by the Chip delivery system. Notice that this is an additional system that will be only considered to be built after the previous four subsystems have been implemented and tested thoroughly. More details will be provided later.

Draft requirements:

- Requirement #1: At least 8 chips must be correctly identified in every 10 chips. (80% accuracy)
- Requirement #2: The chips must be sent to the correct slot in the Storage subsystem.

2.3. Tolerance Analysis:

How to keep the chips in the right place at the bottom of each tube is the hardest part of the dispenser system. Normal IC chips come with U-shaped tubes. Each chip's contacting surface on the platform is not flat. As a result, chips could fall over and get stuck by other upper chips. This could cause the whole dispensing system to crash. To prevent this from happening, chip-tube lifting height, platform surface texture, and solenoid pushing speed are key features we have to test. A combination of a rough and soft platform surface and a certain lifting height is likely to produce the best outcome. To reach our final goal, the chip that falls out of the tube must first stand as straight as possible. Secondly, the solenoid needs to knock exactly one chip onto the holding wall. After the very last ship is gone, finally, the second-to-last chip needs to fall on the platform and avoid bouncing. These three steps must be carried out smoothly.

Power consumption: The only components in our design with considerable power consumption are the solenoid and number pad. The power consumption of other components like the laser transmitter and receiver module, microcontroller, and pushbutton is at the mW level.

A typical 12V alkaline battery [1] has a nominal capacity of 720 mWh. Most of the power consumption will be on the actuation system, which will only run for less than 3 seconds for each execution (dispense the intended combination of chips once).

Component	Approx. Power / W	Reference
Solenoid	2.5 * 3 = 7.5	[2]
Number Pad	0.5	[3]
Low Power Devices	< 0.5	Laser[4]
Total	< 8.5	

Table & graph #8

The total power consumption of 20 iterations will be less than 8.5 W * 3s * 20 = 141 mWh. That is to say, 1 typical 12V alkaline battery (720 mWh) should be well enough to sustain 20 iterations.

3. Cost and Schedule

3.1. Cost Analysis:

3.1.1. Cost for components:

Component	Quantity	Cost
Solenoid[5]	**5(1 pack)**	**13.58**
battery[6]	**5**	**5.99**
Num pad[7]	**1**	**16.99**
Laser beam[8]	**3**	**32.97**
Laser receiver[9]	**5**	**10.99**
Microcontroller[10]	**1**	**28.5**
7-segment display[11]	**10**	**8.99**
Others	**Unknown**	**30.0**
	Total	**148.01**

Table & graph #9

3.1.2. Cost of labor

Suppose the salary of a UIUC ECE graduate is $40/hr and one team member needs to devote about 15 hours to the project every week: $40/hr * 15 hr/week * 6 weeks * 3 (members) = $10,800.

3.1.3. Total cost

Suppose the shipping fee and sales tax combined with being 15%, the cost of components will be $148 * 1.15 = $170. Thus, the total cost of this project will be $170 + $10,800 (labor fee) = $10970.

3.2 Schedule

Week	Task	Person
02/27 - 03/03	Order parts for prototyping	Everyone
	Test parts in hand (laser)	Qi
	Start designing PCB	Tianyang, Xulun
03/06 - 03/10	First Round PCBway Orders	Everyone
	Teamwork Evaluation I	Everyone
	Last day for revisions to the machine shop	Everyone
	Start board assembly	Qi, Tianyang
	Test parts received (solenoid, etc)	Xulun
03/13 - 03/17	Spring break	Everyone
03/20 - 03/24	Test parts received (solenoid, etc)	Tianyang
	Start on the Dispensing system	Tianyang
	Start on the User terminal	Qi
	Start on the Actuation system	Xulun
	Start on the Power system	Qi
	Refine design if needed	Everyone
03/27 - 03/31	Second Round PCBway Orders	Everyone
	Individual Progress Report	Everyone
	Implement and test Dispensing subsystem： Fulfill the circuit of solenoids. Build the physical connection between solenoids and chips.	Tianyang
	User Terminal: Perform unit tests on the USB keyboard, LCD, and Pushbutton. Make sure LCD can print simple strings.	Qi

	Implement and test Storage subsystem: Install laser senders and receivers. Build the connection between the laser sensor and LCD. Install the reset button and its function.	**Xulun**
	Power subsystem: Monitor the voltage of the battery during the operation, making sure the voltage is within the 10.0V to 12.5V range.	**Qi**
	Refine design if needed	**Everyone**
04/03 - 04/07	**Finish up Dispensing subsystem: Fulfill required tests as mentioned in section 2.2.2.**	**Tianyang**
	User Terminal: Perform random tests on the USB keyboard to make sure 98% accuracy; Create two modes for LCD2 display:1. Reset mode 2. Normal mode.	**Qi**
	Finish up Storage subsystem: Test the function of reset and counter based on section 2.2.1.	**Xulun**
	Power subsystem: Perform tests again with the Dispensing subsystem and storage subsystem.	**Qi**
04/10 - 04/14	**Team Contract Fulfillment**	**Everyone**
	Integration of User Terminal and Storage subsystem: Update and display the remaining number of chips in real time with 90% accuracy.	**Qi, Xulun**
	Integration of User Terminal and Dispensing subsystem: Bundle can be dispensed with a pushbutton pushed with 90% accuracy.	**Qi, Tianyang**
	Final Assembly and Test: assemble subsystems 1-5 together, and perform the high-level test 1-3.	**Everyone**
	Mock Demo preparation	**Everyone**
04/17 - 04/21	**Mock Demo**	**Everyone**
	Final Demo preparation	**Everyone**

04/24 - 04/28	**Final Demo**	**Everyone**
	Final presentation preparation	**Everyone**
05/01 - 05/05	**Final Presentation**	**Everyone**

Table & graph #10

4. Ethics and Safety

Ethics:

Dispenser is a typical design in Electrical and Computer Engineering. Our design is specifically for small electronic components such as Integrated circuits (IC). It aims to pick out a certain combination of components for the faculty in ECE when this process needs to be repeated hundreds of times. The idea is simple and original, with no references to past projects or currently available products in the market.

The potential chip damagement should not be concerned based on the design goal mentioned in 2.2.2.

As a disclaimer, this design is specifically designed for dispensing chips and is intended to reduce the workload of faculties. We are not responsible for and condemn the abuse of this design in any illegal form.

Safety:

This project uses a 12V power supply that should be safe for direct contact with the human body. The battery should be placed in the holder and connected to the PCB with wires to avoid possible damage to electronic components. However, undesired objects should not get into the tubes, otherwise, damage might be done to both the machine and the operator. The mechanical part of the dispenser is narrowly spaced and should caution against careless operations that might cause physical harm to fingers. Operators should stay away from the axis of the laser to avoid harm to the eyes.

5. **Reference**

[1]"Alkaline Manganese Dioxide Battery MN21 / A23 - Duracell." [Online]. Available: https://www.duracell.com/wp-content/uploads/2020/02/MN21_0620192.pdf. (Accessed: 01-Apr-2023).

[2]"5PCS DC 12V 4mm Stroke Mini Push Pull Type Solenoid Actuator Micro DC Solenoid Electromagnet Electric Magnet Valve Open Frame Spring Solenoid Valves Linear Motion: Amazon.com: Industrial & Scientific," ***www.amazon.com*****. https://www.amazon.com/gp/product/B098KVBH4L/ref=ox_sc_act_title_1?smid=A3SHE1R0JE35U2&psc=1 (accessed Apr. 01, 2023).**

[3]"Keypad - 12 Button", Sparkfun Electronics Available: https://media.digikey.com/pdf/Data%20Sheets/Sparkfun%20PDFs/COM-14662_Web.pdf (accessed Apr. 01, 2023).

[4]"KY-008 datasheet," ***datasheetspdf.com*****. https://datasheetspdf.com/pdf-file/1415012/AZ-Delivery/KY-008/1 (accessed Apr. 01, 2023).**

[5]"5PCS DC 12V 4mm Stroke Mini Push Pull Type Solenoid Actuator Micro DC Solenoid Electromagnet Electric Magnet Valve Open Frame Spring Solenoid Valves Linear Motion: Amazon.com: Industrial & Scientific," ***www.amazon.com*****. https://www.amazon.com/dp/B098KVBH4L?ref_=cm_sw_r_apin_dp_JFWXWP3MG8F786XFPZCP (accessed Apr. 01, 2023).**

[6]"LiCB A23 23A 12V Alkaline Battery (5-Pack)", Motion: Amazon.com,***www.amazon.com*****. https://www.amazon.com/LiCB-23A-Alkaline-Battery-5-Pack/dp/B06ZYRCP2B/ref=sr_1_2_sspa?crid=11N78M5L41EMA&keywords=12v+battery&qid=1677204687&sprefix=12v+battery%2Caps%2C98&sr=8-2-spons&psc=1&spLa=ZW5jcnlwdGVkUXVhbGlmaWVyPUE4QUU0OTI3REhOWEImZW5jcnlwdGVkSWQ9QTA0NzYwMzkxRzRJMldJSzZEVDROJmVuY3J5cHRlZEFkSWQ9QTAwMTI2NjgxMUhONUNXQ1JPSk5NJndpZGdldE5hbWU9c3BfYXRmJmFjdGlvbj1jbGlja1JlZGlyZWN0JmRvTm90TG9nQ2xpY2s9dHJ1ZQ== (accessed Apr. 01, 2023).**

[7]"Amazon.com: Rottay Number Pad, Mechanical USB Wired Numeric Keypad with Blue LED Backlit 22 Key Numpad for Laptop Desktop Computer PC Black (Blue switches): Electronics," ***www.amazon.com*****.**
https://www.amazon.com/Mechanical-Numeric-Backlit-Desktop-Computer/dp/B07FFLNF5C/ref=sr_1_3?crid=2H3AZMILYDRTW&keywords=numpad&qid=1677204548&sprefix=numpad%2Caps%2C100&sr=8-3 (accessed Apr. 01, 2023).

[8]"KingFurt Tactical Red Laser Beam Dot Sight Scope for Hunting Gun Rifle Pistol Handgun 20mm Mount with Button," ***www.amazon.com*****.**
https://www.amazon.com/KingFurt-Tactical-Hunting-Pistol-Handgun/dp/B0716ZM8JB/ref=sxin_16_pa_sp_search_thematic_sspa?content-id=amzn1.sym.17640126-9148-4700-a727-578cd66ffa9f%3Aamzn1.sym.17640126-9148-4700-a727-578cd66ffa9f&crid=3BF54HUNC28KN&cv_ct_cx=laser+beam&keywords=laser+beam&pd_rd_i=B0716ZM8JB&pd_rd_r=d933e856-4a70-4507-b87d-70ef103ce774&pd_rd_w=pJvlx&pd_rd_wg=CDiH0&pf_rd_p=17640126-9148-4700-a727-578cd66ffa9f&pf_rd_r=8YV6PMF8XYFJEDPFCHTX&qid=1677204738&sprefix=laser+beam%2Caps%2C101&sr=1-2-a73d1c8c-2fd2-4f19-aa41-2df022bcb241-spons&psc=1&smid=A14VGP6UNHZWF4&spLa=ZW5jcnlwdGVkUXVhbGlmaWVyPUExUVVINTVWWkxRSERBJmVuY3J5cHRlZElkPUEwNDAwNTIyMUZDWEc3WE5SWUREVyZlbmNyeXB0ZWRBZElkPUEwNDgzNDI2MTJSRTJIREdJQU43VCZ3aWRnZXROYW1lPXNwX3NlYXJjaF90aGVtYXRpYyZhY3Rpb249Y2xpY2tSZWRpcmVjdCZkb05vdExvZ0NsaWNrPXRydWU= (accessed Apr. 01, 2023)

[9]"Amazon.com: Geekstory 5V Laser Receiver Sensor Detection Module Non-Modulator Tube for Arduino Geekstory(Pack of 5): Electronics," ***www.amazon.com*****.**
https://www.amazon.com/Receiver-Detection-Non-Modulator-Arduino-Geekstory/dp/B07H95679S/ref=sr_1_10?crid=30U0ETV1JTJWS&keywords=laser+sensor&qid=1677204921&sprefix=laser+senso%2Caps%2C77&sr=8-10 (accessed Apr. 01, 2023).

[10]"Arduino UNO REV3 [A000066]," ***www.amazon.com*****.**
https://www.amazon.com/Arduino-A000066-ARDUINO-UNO-R3/dp/B008GRTSV6/ref=sr_1_3?crid=2OAOSU5DX52XA&keywords=microcontroller+arduino&qid=1677205276&sprefix=microcontroller+arduino%2Caps%2C91&sr=8-3 (accessed Apr. 01, 2023).

[11]"Amazon.com: uxcell Common Cathode 10 Pin 1 Bit 7 Segment Display 1.1 x 0.79 x 0.35 Inch 0.55" Red LED Display Digital Tube 10pcs: Industrial & Scientific,"

***www.amazon.com*.**
https://www.amazon.com/uxcell-Cathode-Segment-Display-Digital/dp/B07GTQZ286/ref=sr_1_2?crid=1VIBGB0VO4JAY&keywords=7%2Bsegment%2Bdisplay&qid=1677205035&sprefix=7%2Bsegment%2Bdisplay%2Caps%2C92&sr=8-2&th=1 (accessed Apr. 01, 2023).