Project 3 Report
Team 21

Andrew Berkeland, Andrew (AJ) Eubanks, Steven Johnson, Eric Mitchell, Alvi Topuzi

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Executive Summary

Project 3 required that we implement a DC motor as a controlled pointer. We had to create a graphical user interface (GUI) so users could select a shape and color for the pointer to point to. We refined our motor response using PID (Proportional-Integral-and-Derivative) control. To train our financial and planning skills, we completed four documents related to product life cycle, financial analysis, employee training, and safety. From this project, we learned how to implement PID control and wire a DC motor with hall effect sensors. On the administrative side, we learned about managing a new company, fringe benefits, and selecting materials with lesser effects on the environment.

Control Subsystem Design - Hardware-in-the-Loop

Hardware-in-the-loop means using the actual component for feedback instead of a simulated plant. A full simulation uses a device's theoretical transfer function. This is subject to approximation error because the physical device's transfer function may differ from the theoretical one. Simulating with hardware-in-the-loop gives the exact results that occur with a device and is subject to less error. Engineers should prefer this method because they can search for the best PID gains for each individual motor.

Control Subsystem Design - Hardware

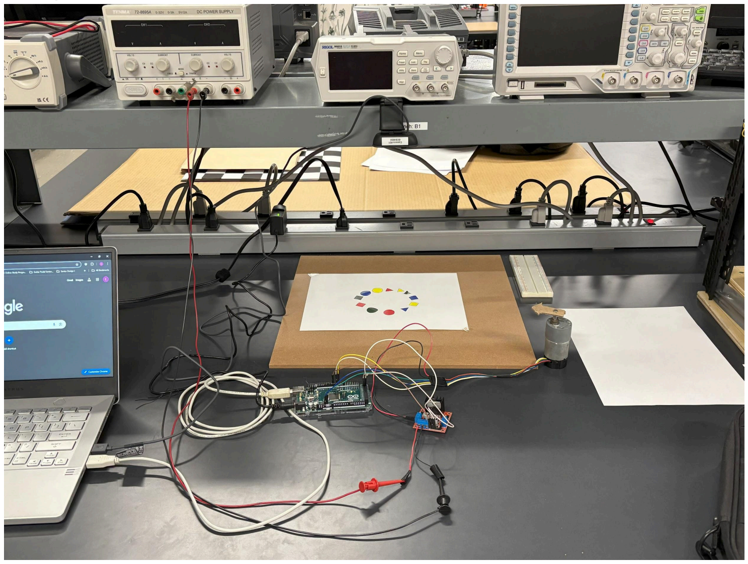


Figure 1: Hardware setup for the camera and motor system.

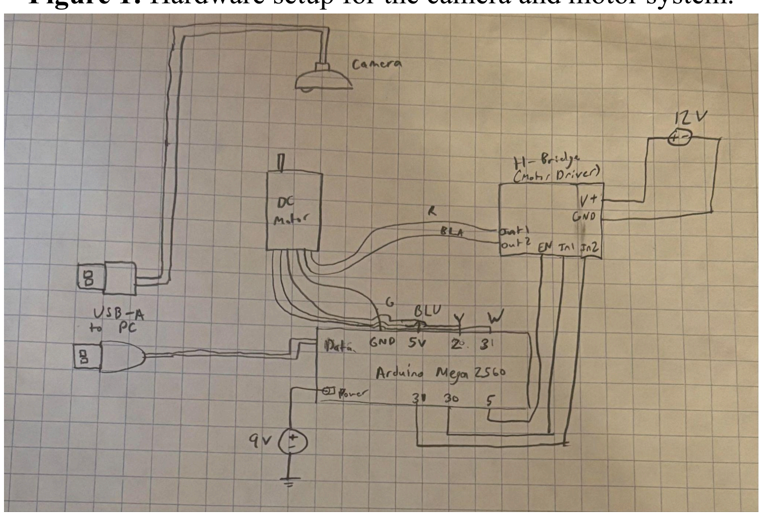


Figure 2: Wiring diagram for the DC motor and Arduino.

In our hardware setup, we positioned the camera approximately fourteen inches above the background. Figure 1 shows our demo environment. The Arduino is connected to the L298N H-bridge Motor Driver and the DC motor's Hall Effect sensor ports, 5 V power, and ground. The H-bridge is connected to 12 V, the Arduino is connected to 9 V. Figure 2 shows the wiring connections for our setup. Our calculation of camera pixels per inch squared is shown below:

$$\text{Width: } \frac{640\, pixels}{11\, inches} \approx 58\, pixels/inch$$

$$\text{Height: } \frac{480\, pixels}{8.5\, inches} \approx 56\, pixels/inch$$

$$(1\, inch \;*\; 56\, pixels/inch) \;*\; (1\, inch \;*\; 58\, pixels/inch)$$

$$= 1\, inch^2 \,*\, 3248\, pixels/inch^2 \approx 3248\, pixels$$

Control Subsystem Design - Software

```
shapeData =

  12×3 cell array

    {["RED"   ]}    {["Square"  ]}    {[ 157.8950]}
    {["GREEN" ]}    {["Triangle"]}    {[-170.6572]}
    {["YELLOW"]}    {["Triangle"]}    {[ 134.9220]}
    {["YELLOW"]}    {["Circle"  ]}    {[-136.6952]}
    {["RED"   ]}    {["Triangle"]}    {[ 109.7583]}
    {["YELLOW"]}    {["Square"  ]}    {[-106.1672]}
    {["GREEN" ]}    {["Square"  ]}    {[  86.0948]}
    {["BLUE"  ]}    {["Square"  ]}    {[ -81.7527]}
    {["BLUE"  ]}    {["Circle"  ]}    {[  54.9134]}
    {["GREEN" ]}    {["Circle"  ]}    {[ -50.6359]}
    {["RED"   ]}    {["Square"  ]}    {[ -15.7430]}
    {["BLUE"  ]}    {["Triangle"]}    {[  13.3749]}
```

Figure 3 - Data Structure to Hold Shape Data

The software begins by running our code that performs image processing. This is the same as the previous lab, which will take a series of images and identify objects by their shape, color, and position. For this project, we modified this slightly to also store the data from each image in a structure that includes only the color, shape, and angle for each object. This can be seen above in Figure 3. Once the image processing is complete, a GUI pops up that includes a dropdown menu for color as well as shape and a blue “Find” button. This user interface is meant for the user to select what they would like to motor to point to. Once the user indicates that they would like to find an object with a certain shape and color, the app finds a match in our data structure and sends the corresponding angle to the DC motor model. This number is attached to a PID block, which will allow the motor to point to the correct location. The user then has the ability to select another object to find if they would like to or they can end the program. The motor will continue to find these objects as long as the user continues to click the blue “Find” button. Figure 4 displays the software flowchart for this project.

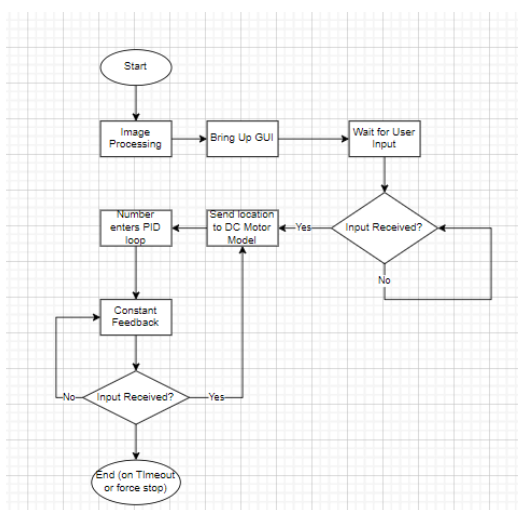


Figure 4: Software flowchart for the entire system.

Control Subsystem Design - Motor Experiments

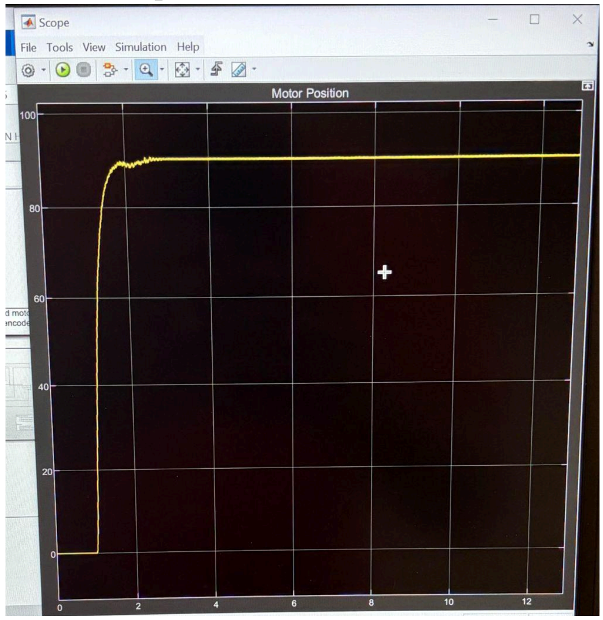


Figure 5: First attempt at tuning PID gains. The signal does not achieve the desired final value.

To tune our PID gains, we first tried experimenting with the proportional and derivative gains to attempt to get a flat response. We found values for each gain that cause the final position to level off. Figure 5 shows the response for our first attempt. However, the response did not fully settle on the final output in a reasonable time frame.

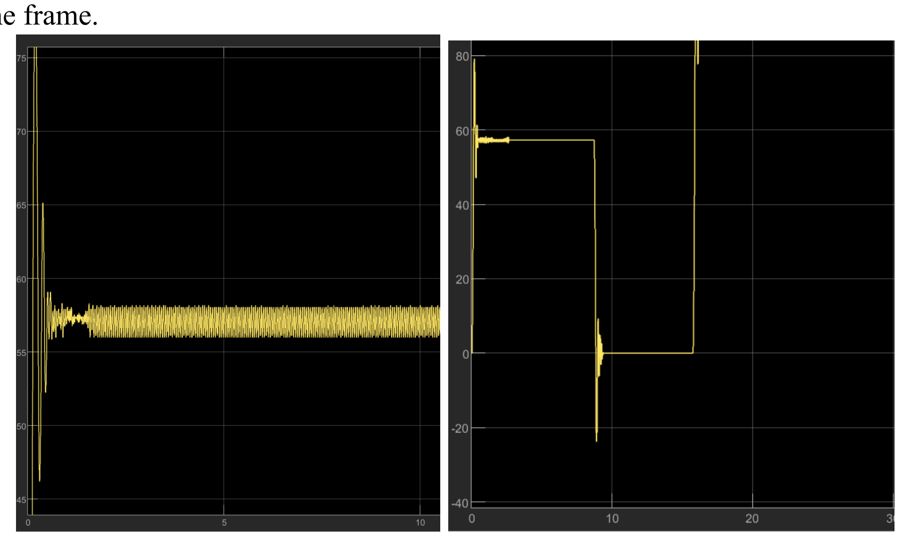


Figure 6: Left: Output with even oscillations used for the Ziegler-Nichols method. Right: Output using tuned Zeigler-Nichols parameters.

Once we realized our method of random testing was not giving us the results we wanted, we tried using the Ziegler-Nichols method. We increased the proportional gain, K, until we saw even oscillations in the output, shown by Figure 6. We recorded K=45 and the oscillating period as .04 seconds. Using the approximations for the method, we obtained a proportional gain $K_p = 26.47$ and a derivative gain of $K_d = .005$. With those values as our baseline, we continued changing our derivative gain until we obtained our desired response, also shown in Figure 6. This response has around 33% peak overshoot and a settling time of 3 seconds. Our final gain values are $K_p = 26.47$ and $K_d = 0.03$.

Control Subsystem Design - User Interface

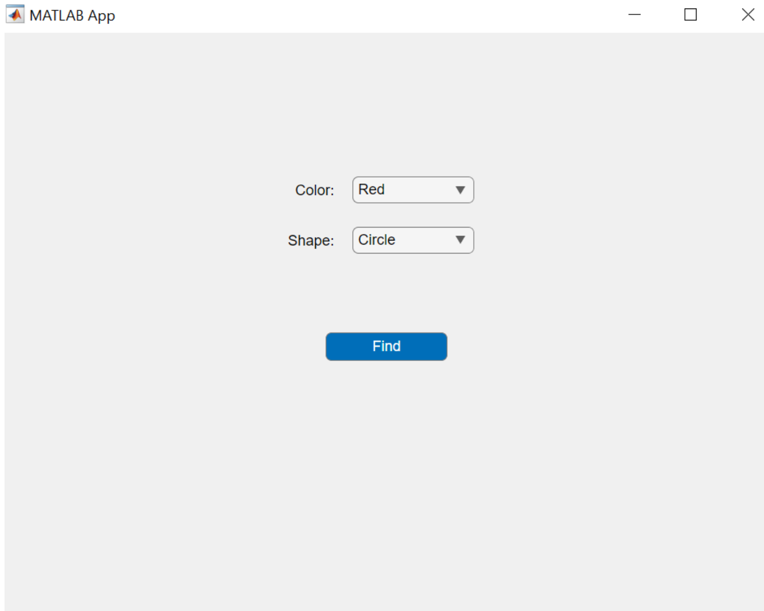
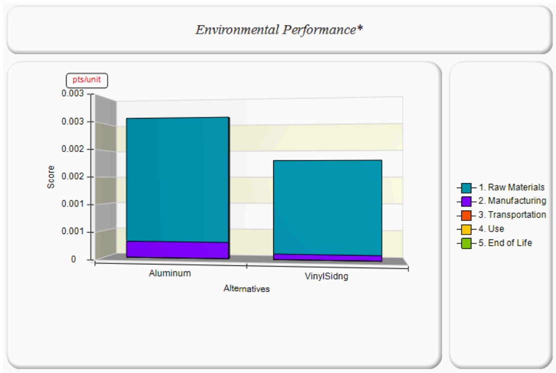


Figure 7: Graphical user interface for motor position selection

The user interface connects the camera-as-a-sensor and the motor by allowing the user to select a color and position for the motor to point to. The camera takes multiple images that perform image recognition, storing data for each shape it finds. This includes but is not limited to the shape, color, and angle from the center of the image.

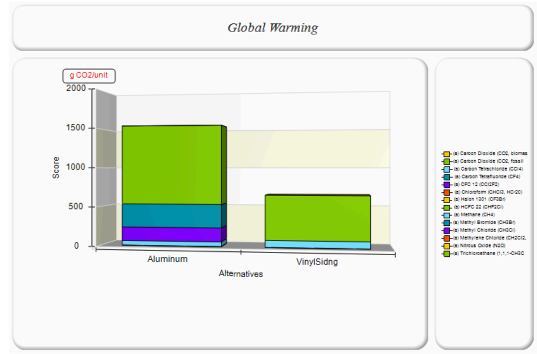
Our user interface, shown in Figure 7, consists of two dropdown menus, one for the color of the shape and one for the shape. Once the user is happy with their selection, they can press the blue button that says "Find." This is meant to be simple and clear so that the user knows when they click the button, the goal is to find what they have selected. Once pressed, the program attempts to find a match in the data from the camera with a matching color and shape. It then grabs the corresponding angle and provides the motor simulation with the angle that the motor should point to. The motor then correctly points to the shape and color that was selected, completing the connection from the user interface to the camera-as-a-sensor and the motor. This process can be continued as long as the user would like, so they can then change the drop down selections and the system will find a new shape and color that matches their selection.

Life Cycle Analysis



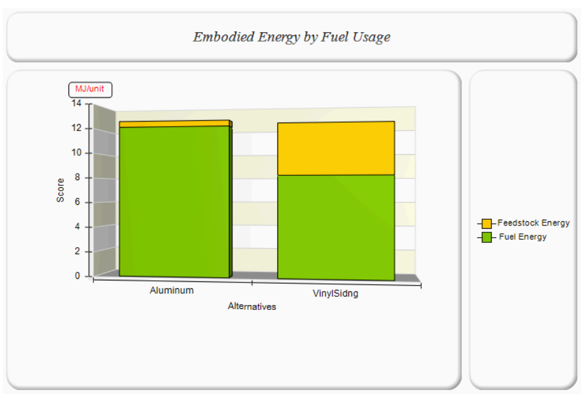
Note: Lower values are better

Category	Aluminum	VinylSidng
1. Raw Materials	0.0023	0.0017
2. Manufacturing	0.0003	0.0001
3. Transportation	0.0000	0.0000
4. Use	0.0000	0.0000
5. End of Life	0.0000	0.0000
Sum	0.0026	0.0018

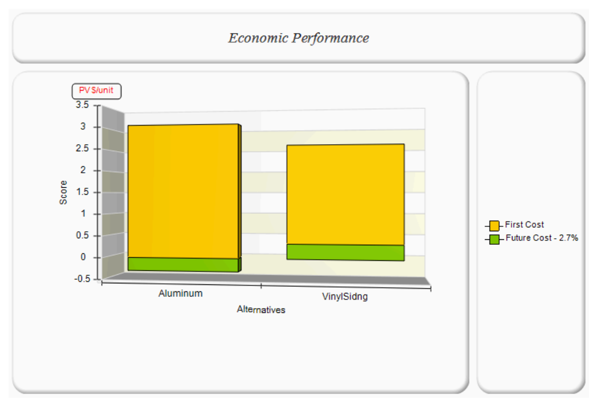


Note: Lower values are better

Category	Aluminum	VinylSidng
(a) Carbon Dioxide (CO2, biomas	0.0016	0.1934
(a) Carbon Dioxide (CO2, fossil	1004.4803	565.1632
(a) Carbon Tetrachloride (CCl4)	0.0032	0.0301
(a) Carbon Tetrafluoride (CF4)	297.9217	0.0062
(a) CFC 12 (CCl2F2)	175.4912	0.0001
(a) Chloroform (CHCl3, HC-20)	0.0000	0.0000
(a) Halon 1301 (CF3Br)	0.0000	0.0005
(a) HCFC 22 (CHF2Cl)	0.0000	0.0010
(a) Methane (CH4)	58.5673	86.2281
(a) Methyl Bromide (CH3Br)	0.0000	0.0000
(a) Methyl Chloride (CH3Cl)	0.0000	0.0000
(a) Methylene Chloride (CH2Cl2,	0.0004	0.0001
(a) Nitrous Oxide (N2O)	1.5330	2.5951
(a) Trichloroethane (1,1,1-CH3C	0.0000	0.0000
Sum	1537.9987	654.2178



Category	Aluminum	VinylSidng
Feedstock Energy	0.4661	4.1403
Fuel Energy	12.1329	8.1830
Sum	12.5990	12.3233



Category	Aluminum	VinylSidng
First Cost	3.05	2.22
Future Cost - 2.7%	-0.30	0.34
Sum	2.75	2.56

Figure 8: Results from the online system. These images show the environmental and economic impact of our packaging choice.

We wanted to predict the environmental impact of our product's storage and shipping container. We chose two materials, aluminum and vinyl siding, to compare as alternatives. We used the Building for Environmental and Economic Sustainability (BEES) system to conduct our analysis. From the results in Figure 8, we observed that vinyl siding is superior to aluminum in many ways. Vinyl has less raw materials and manufacturing impact, way less contribution to global warming, and a smaller economic impact. Both vinyl and aluminum have about the same net fuel use. Since vinyl siding is more sustainable than aluminum, we will use vinyl for our packaging container. We could conduct a similar analysis for the rest of our design to reduce the environmental impact of all components in our system.

Financial Analysis

21 -TEK Engineering
Estimated Financial Scenario

Start-up Costs

Personnel	5 Engineers @ $55K/yr + President @ $75K/yr + Admin. Asst. @ $25K/yr = $ 375,000
Fringe Benefit (FB)	A fringe benefit is a form of pay for the performance of services. For example, you provide an employee with a fringe benefit when you allow the employee to use a business vehicle to commute to and from work. Assume Fringe Benefit Package @ 36% (incl. employee's SS tax, vacation, holidays, medical, retirement (401K), dental, life insurance, relocation, unemployment insurances, etc): (5 x $55,000 + $75,000 + $25,000) x 0.36 = $ 135,000 *Note: Federal Insurance Contributions Act (FICA) tax (Social Security and Medicare) is imposed by the federal government on both employees and employers. The entire FICA percentage of 15.3%* ● *Employee's pay 6.2% for SS and 1.45% for the Medicare (this is not included in your cost)* ● *The employer is liable for 6.2% Social Security and 1.45% Medicare taxes=7.65%*
Building	Initially rent a suite of offices with 2 engineers/office (12' x 14'), an office/conference room for President (12' x 20'), and a reception/office area of 16' x 20'. (3 cubicles) x (12' x 14'/cubicle) + President office of (12'x 20') + Reception/office area of (16' x 20') = 1064 sq ft Use nominal figure for office space in industrial park sectors of` Clemson area, $9.50/sq ft/mo. Then the lease rate for office space will be $0.79/sq ft/mo x 1064 sq ft = $ 841 /mo. = $10,087 /yr.
Furniture	Rental of a desk, chair, credenza set will run about $60/mo. Need 7 sets for a total monthly expenditure of $420/mo = $5,040/yr The remaining equipment, furniture and software expenses are estimated to be about 7 computers @ $1500/computer — $10,500 7 sets of general software @ $1000/set — $7,000 Specialized software — $18,000 Copier, printer — $4,000 Table and chairs for conference room — $3,888 7 telephones @ $35/ea — $ 245 Total — $48,673

Phone and Internet	According to Bell South, the cost of a combined voice/data line, is $70.00/mo for operation. For 7 telephones the total cost will be $5,880 /year. Assume that long distance calls add another 40% to this to get a total estimated annual phone cost of $8,232
Travel	Another cost item which will be important is travel. There will have to be continual contact with potential clients, attendance at selected technical conferences and workshops, and visits to plants or other locations where potential clients might be. Assume (modestly) that the cost per local trip is $400 and the cost per out-of-state trip is $6,000, and there will be 2 of each trip each month $6,400/mo for the first year, or an annual total of $76,800
Interest	Capital (i.e. money) is needed to fund these initial purchases as well as to underwrite operating expenses until a revenue stream is established by selling engineering services to customers. Assume that through personal contacts a credit line of $800,000 has been established. This is to be repaid over the period of a year with 11 equal payments starting 1 month after the loan date. The negotiated interest rate is 5% per year. The monthly payment M is calculated from = $74,726 Where P is the principal amount ($800,000), I is the interest rate (5%), and q is the number of payments to be made (11). From this, Debt Service = Total interest paid in year = 11 x M - P = $21,983

Cost Estimate

Salaries	$375,000
FB @ 36%	$135,000
Building	$10,087
Furniture	$5,040
Debt service	$21,983
Travel	$76,800
Internet and Phone Service	$8,232
Total Costs	$675,775

Overhead Calculation

Now we will estimate the Overhead (Indirect Technical Expense) we must charge to recover our costs. This cannot be too large, or else we will price ourselves out of business. On the other hand, we must be realistic, or else we will go broke, and therefore out of business.

Assume that the first year, the 5 engineers will be at least 75% "sold", i.e., 75% of their total time can be charged to customers. Then we can bill

5 engineers @ 75% sold (salaries billable to clients)	$206,250
FB @ 36% (FB billable to clients)	$74,250
Total Billable to Clients	$280,500

The remaining salary dollars and FB's must be charged to overhead.
Total Expenses = Total Costs - Total Billable to Clients = $395,275 (Overhead Number)

This implies an Overhead rate of

OH rate = ($395,275/$280,500) x 100% = 140.92%
= (Overhead Number / Total Billable to Clients) x 100%

This implies that every labor dollar (at the "loaded" rate, i.e. with FB's) must be increased by a factor of 2.4592 (1+ (OH rate/100%) + (5% profit/100%)) in order to recover the costs of doing business and make a profit (assuming a 5% profit). This is the figure that you will use when estimating the cost of a contract to a customer in a proposal. An overhead rate of 150% means that for each $1.00 of direct labor budgeted for a project; $1.50 needs to be budgeted for overhead costs.

Using the Overhead Number

You estimate that a project will take 1 week (40 hours) of your time, i.e. what does it cost for one week of an engineer's time. How much do you bill your client for this time?

Bill to Client

$$=\left[\frac{1\ week\ work}{52\ weeks\ per\ year}\bullet\left(\frac{salary=\$55K}{year}+\frac{FB=0.36*\$55K}{year}\right)\bullet\left(1+\frac{overhead\ rate}{100\%}+\frac{profit=5\%}{100\%}\right)\right]$$

$$=\left[\frac{1}{52}*(\$55,000+\$19,800)*\left(1+\frac{140.92\%}{100\%}+\frac{5\%}{100\%}\right)\right]$$

= $3537.47

Employee Training Program

Archetype 1: A newly graduated engineer such as yourselves who will solve technical problems/projects

Activity	**Benefit**	**Cost**
Attend an in-person workshop on PLC Programming one day a week for 5 weeks	Learning how to program PLCs can be essential for automation systems in a manufacturing setting. Spending one day a week will allow the engineer to gain skills in a short amount of time but also still have plenty of time to work on other projects and get acclimated to the company.	8 hours per week * 5 weeks * $100 per hour (cost to pay the person training the engineer) = $4000
Take an online Python Course that goes into machine learning and parsing data	Python is a widely-used programming language that can be very beneficial when dealing with data. It also has many advanced libraries for machine learning, which will prove to be advantageous for the company in order to keep up with the advancing technologies of the world. There are many online courses on the internet as well as video courses on youtube that are free.	Free
Training with Networking and Industrial Communication Protocols	This is essential to allow communication between machines in an industrial setting. These networks are designed to handle real-time communication between machines that have varying ranges in between them. This may involve communication for PLCs, sensors, computers, and AOI systems.	Initial setup cost of systems may require outside company = $10000. Training after that can be done in group sessions which may be equal to 8 hours per day * 1 day * $100 per hour (cost to pay the trainer) = $800 per workshop

Archetype 2:A newly graduated engineer such as yourselves who will manage technical projects

Activity	**Benefit**	**Cost**
Take an Advanced Excel Course	Excel is a necessary tool to be able to manage projects. It allows for financial planning, keeping progress on tasks to be	Free

	done, and data analysis. It can be connected to databases such as SQL databases to manage data and view reports. The new engineer will learn how to create timelines, advanced charts and graphs, and tools to understand and calculate costs more efficiently.	
Attend an Engineering Management Conference	There are multiple engineering management conferences each year, so the specific one depends on the time of hire. These conferences will allow the new engineer to learn different types of project management techniques as well as new technologies in the field. It also gives them the opportunity to network with other professionals who are specializing in the same thing.	$1000 (average conference registration) + $1000 (round trip travel) + $600 ($200 per night for a hotel) + $100 (dinner for 3 nights) = $2700

Safety Analysis

The goal of the risk assessment is to make sure there is no harm when the system fails. This can be to the overall system, the users playing the game, and any components within reach or contact with the system. This is important for improved design in reliability, quality, and safety. Additionally, this can decrease development time, warranty costs, and total product and time waste. Although there is IEEE Code of Electrical Engineers related to responsibility in making decisions consistent within the safety and health of the public, this is also a moral obligation to not harm others and not design a product which can result in the loss of a life or an injury. The legal safety laws that must be include are:

OSHA
- General Industry: 29 CFR 1910.
- Construction: 29 CFR 1926

EPA
- 40 CFR261

CPSC
- 16 CFR 115

DFMEA:

Description of Component or Subsystem	Falure Mode (Hazard)	Symptom	Effect	Probability of Failure	Hazard	Risk Index
Cord / Wall Plug	Plug Broken	No power output	May have exposed energized metal	C	IV	IV-C
	Cord Frayed/ weakened	Cord endponts visible dispite insulation	May have exposed energized metal; short circuit/ fire possible	C	IV	IV-C
	Input over voltage	Output over voltage; possible internal circuit failure	Power spike; plug connected to wrong connector	A	I	I-A
	Input Transient when Connecting	Output Transients	May cause undesired output voltage waveforms	B	I	I-B
Motor Driver	Overheating	Loss of motor control	Potential for driver damage; can lead to motor failure or fire risk	C	IV	IV-C
	Short Circuit	No power output	Possible component burnout; risk of fire	C	IV	IV-C
Motor	Mechanical Jam	Motor stalls	Belt does not move; game piece movement halted	B	III	III-B
	Bearing Failure	Unusual noise or vibration	Reduced motor lifespan; ineffective piece movement	C	II	II-C
Belt System	Belt Slippage	Inconsistent movement	Game piece does not reach correct position	B	II	II-B
	Belt Breakage	Complete loss of movement	Game is unable to move pieces; requires manual intervention	C	II	II-C
Magnetic Piece	Magnetization Loss	Pieces not attracted to position	Game cannot move pieces to intended positions; gameplay interrupted	B	III	III-B
	Voltage Spike	Output over voltage	Risk of motor driver damage; potential system failure	A	I	I-A
Power Supply	Cable Fraying	Visible wires, reduced power flow	Exposed energized metal; possible shock or fire hazard	C	IV	IV-C
Controller (GUID)	Signal Loss	Loss of connection	Unable to control motor; game pieces do not move	B	II	II-B
	Input Voltage Transient	Erratic movement	May cause undesired output voltage waveforms; inconsistent gameplay experience	B	I	I-B

Figure 9: DFMEA table for our final design

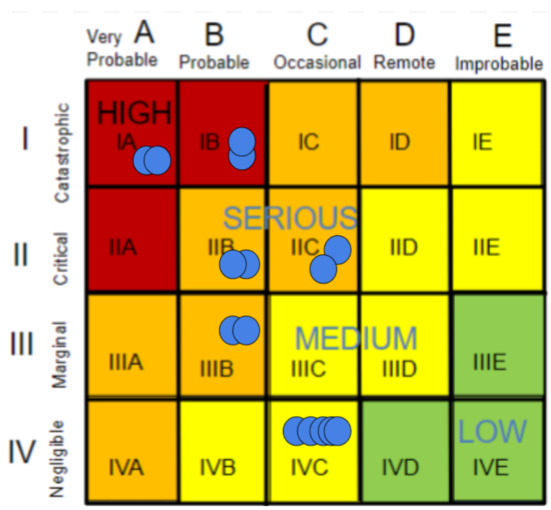


Figure 10: Risk Assessment matrix for our final project

The Risk Assessment Matrix (Fig. 10) shows that there is a high risk for severe injury/death, and there is a high probability severe injury will occur. The DFMEA (Fig. 9) is the expanded version of it. The DFMEA shows what safety measures need to be prioritized and what the expected and consequences will be. Making both the DFMEA and the Risk Assessment Matrix realistic is important for a company's stability. In the case of a lawsuit, they show that the company did everything they could to ensure safety. In the case of a lesser injury, they provide a buffer. Preparation and over-budgeting insurance are beneficial for the stability of our company. If we do not invest enough time into the budgeting of our product safety, accidental charges may occur.

We also estimated usage based on a daily scale. High exposure would mean daily use for a year, and low exposure would imply use only for a quarter of the year. The probability values came from the Risk Analysis Chart. Additional information is shown below:

High Exposure: 365 (Daily Usage)
Medium Exposure: 180 (Semi-Annual Usage)
Low Exposure: 90 (Quarterly Usage)

A = 5 (Very Probable)
B = 4 (Probable)
C = 3 (Occasional)
D = 2 (Remote)
E = 1 (Improbable)

Risk Analysis:

Component/Subsystem	Failure Mode	Effect Severity	Exposure	Probability Level	Risk Calculation	Risk
Cord / Wall Plug	Plug Broken	Negligible (IV)	5	Probable (B)	2×5×42 \times 5 \times 42×5×4	40
Cord / Wall Plug	Cord Frayed/Weakend	Negligible (IV)	5	Probable (B)	2×5×42 \times 5 \times 42×5×4	40
Cord / Wall Plug	Input Over Voltage	Catastrophic (I)	5	Probable (B)	5×5×45 \times 5 \times 45×5×4	100
Cord / Wall Plug	Input Transient	Marginal (III)	4	Occasional (C)	4×4×34 \times 4 \times 34×4×3	48
Motor Driver	Overheating	Critical (II)	5	Occasional (C)	4×5×34 \times 5 \times 34×5×3	60
Motor Driver	Short Circuit	Critical (II)	5	Probable (B)	4×5×44 \times 5 \times 44×5×4	80
Motor	Mechanical Jam	Marginal (III)	4	Occasional (C)	3×4×33 \times 4 \times 33×4×3	36
Motor	Bearing Failure	Marginal (III)	3	Occasional (C)	3×3×33 \times 3 \times 33×3×3	27
Belt System	Belt Slippage	Marginal (III)	4	Occasional (C)	4×4×34 \times 4 \times 34×4×3	48
Belt System	Belt Breakage	Critical (II)	3	Occasional (C)	4×3×34 \times 3 \times 34×3×3	36
Magnetic Piece	Magnetization Loss	Marginal (III)	4	Occasional (C)	4×4×34 \times 4 \times 34×4×3	48
Magnetic Piece	Voltage Spike	Catastrophic (I)	5	Probable (B)	5×5×45 \times 5 \times 45×5×4	100
Power Supply	Cable Fraying	Marginal (III)	5	Probable (B)	4×5×44 \times 5 \times 44×5×4	80
Controller (GUID)	Signal Loss	Marginal (III)	4	Occasional (C)	4×4×34 \times 4 \times 34×4×3	48
Controller (GUID)	Input Voltage Transient	Marginal (III)	4	Occasional (C)	4×4×34 \times 4 \times 34×4×3	48

Figure 11: Risk analysis chart

The risk analysis in Figure 11 reveals that the highest risks are associated with the motor driver and the cord / wall plug. These are areas in which warrant increased safety measures or redesign to reduce the probability or severity of potential failures. After calculating the risks, we created design changes to mitigate high-risk items. Examples of these high risk items and their associated solutions are listed below:

- Motor Overheating Issue: Add heat shrink / implement thermal cutoffs to prevent components from reaching unsafe temperatures.

- Power Supply Voltage Spikes: Add protective circuitry such as fuses or transient voltage suppression diodes to protect against over voltage.
- Mechanical Jam in Motor: Add torque limiters / implement auto-stop feature when resistance is detected.

Adding components like heat shrinks, surge protectors, and wiring insulation can prevent short circuits from wire fraying and overheating components in order to make a safer product. The cord / wall plug shows the highest risk at 288, indicating it requires immediate attention in our design. We believe that with the changes mentioned above, our design will be safe.

ECE 4950 Project 3 –Closed-Loop Motor Control, Life-Cycle Analysis, and Risk Assessment

Use the guidelines below to complete your report and add at the end of your report.

Group Number and Member Names: Team 21, Andrew Berkeland, Andrew (AJ) Eubanks, Steven Johnson, Eric Mitchell, Alvi Topuzi

Score	Pts	
	5	**General Format - Professional Looking Document/Preparation (whole document)** a)Fonts, margins (11pt, times new roman, single spaced. 1" margins on all sides). b)Spelling and grammar are correct c)Layout of pictures – all figures need numbers and captions and must be referenced inthe text d)Follows the page limitations below. e)References. Use IEEE reference format. f)This grading sheet is included as the final page.
	5	**Page 1: Title, Group Name, Group Members, and Date** **Executive Summary** (1 concise, well-written paragraph) Provide an overview of this project. Briefly describe what you did and what you learned.
	 5 10 10 10 15	**Control Subsystem Design** **Page 2: Overview of Hardware-in-the-Loop** (~1/2 page) Describe in your own words what Hardware-in-the-Loop means. What is the difference between a full simulation and a Hardware-in-the-Loop simulation? What are the strengths of HIL? **Pages 2-3: Document Hardware** (1 page) Describe and show images of the equipment used, connection diagrams, calculation of resolution – pixels per square inch/cm on game board etc. Is the camera an appropriate sensor? **Pages 4-5: Document Software** (2 pages) Using Flowcharts, state diagrams, data structures etc. describe how the software is implemented. There is no need to include the source code. **Page 6: Document Motor Experiments** (~1 page) Plot the effect of changing gains using the reference, actual position and error signals. What happens when the proportional, derivative and/or integral gains are changed? **Pages 7: Document and Evaluate your User Interface** (~1 pages) How does the user interface connect the Camera-As-A-Sensor and the motor? What information is provided to the user and why? Document using screenshots and similar images.
	10	**Pages 8-9 Life Cycle Analysis (2 pages)** You are proposing a design that consumes resources. Follow the "Life Cycle Assessment (LCA) Exercise" for the shipping box for your project to examine the life cycle for this one part of your design. Be sure to interpret the results of the computer program. Complete this section of the report by saying that a similar analysis could be done on the entire project to reduce environmental impact.
	10	**Page 10-11: Financial Analysis** Provide a financial analysis that examines turning your group into a start-up company. Use the spreadsheet provided to make calculations and report your results using the MS Word document template and include here.
	15	**Page 12: Employee Training Program**
	15	**Pages 13-14: Safety Analysis** The project must be safe for use by the customer. Perform and Document a DFMEA for your project. Document your analysis using the DFMEA Table and Risk Assessment Matrix shown in the class slides. Show that you have implemented the results of the analysis to make your design and workspace safe – that is document what changes you made to make your system and space safe as a result of the safety analysis. Can you conclude your system is safe?
		Page 19: Grading Sheet