Assignment 4 – Design Concept Analysis (Individual Assignment)
(/70 points)

Due date: See CANVAS for submission deadline and instructions

Objective: The goal of this assignment is to conduct "back-of-the-envelope" engineering analysis on a preliminary design concept generated in Assignment 3 to determine if the design concept will be feasible. This is an individual assignment.

1. Pick a design concept from Assignment 3 to use for your analysis. Each person on your team must pick a different concept to analyze or a different design aspect of the same concept (i.e. no two people on your team should be doing the exact same analysis).
2. Decide what engineering calculations are important to determine whether your chosen design concept will "work" (i.e. fulfill your design objectives according to the metrics you developed in Assignment 2).
3. Complete your engineering analysis by performing "back-of-the-envelope" type calculations. You will likely need to make simplifying assumptions and approximations. Expected level-of-effort is 1-2 pages of handwritten, Excel, or Matlab calculations.
4. Write a paragraph summarizing your analysis (~ ½ page) (/20 points). This paragraph should include the following information:
   - What is the design concept you have chosen to analyze?
   - What is the goal of your analysis? (i.e. what calculations are important to determine whether your chosen design concept will "work"?) (/5 points)
   - What is your analysis approach? (/5 points)
   - What assumptions did you have to make in your analysis? Why are these assumptions valid? (/5 points)
   - What is the conclusion of your analysis? Is this design concept feasible based on your preliminary calculations? If not, what changes are required? (/5 points)
5. Provide a professionally organized, clearly annotated summary of your engineering calculations (see course reader examples, Chapters 9 and 10). This summary should clearly explain your calculations to the reader. **Must be typed.** (/50 points). Points will be allocated as follows:
   - Quality of engineering analysis (/30 points)
     i. Appropriate assumptions (/10 points)
     ii. Calculations are technically correct (/10 points)
     iii. Appropriate level-of-detail and effort for preliminary design (/10 points)
   - Calculation presentation (/20 points)
     i. Spreadsheet documentation (title, name, date, Version #) (/4 points)
     ii. Clearly labeled units (/4 points)
     iii. Clearly labeled inputs, calculated values, assumed values (/4 points)
     iv. Supporting diagrams that illustrate parameters included in calculation (/4 points)
     v. Annotated explanations of each calculation (/4 points)

PLC Trainer Platform Cost Analysis

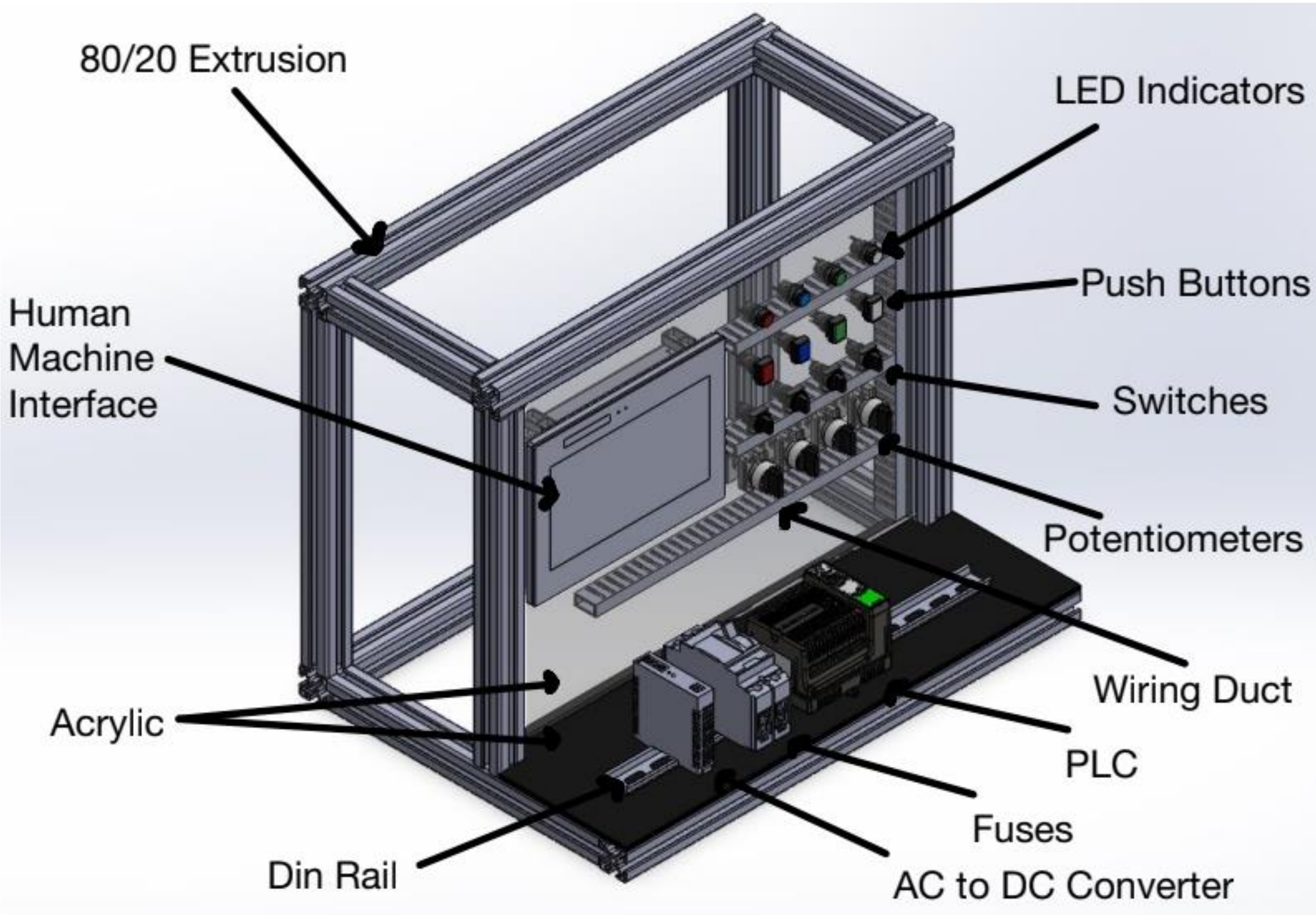

Figure 1: PLC Trainer Platform Design Concept 1

Analysis Goal:

The goal of this analysis is to find the price to produce one unit of the PLC Trainer Platform design concept shown in figure 1. This design is made of 80/20 aluminum extruded parts and hardware, acrylic panels, wiring ducts, and various PLC field devices. This will help to investigate the cost effectiveness of this particular design where my team has created multiple concepts with similar components but different means of accomplishment. For this project, it does not make sense to do mechanical and or stress calculations but rather a cost analysis because PLC trainers are something that can be purchased off the shelf but differ with capability and cost. With a loose budget of $5000, with a high potential to receive more funding from the electrical and chemical engineering departments for this PLC trainer dependent on design quality and budget limitations, a cost analysis can show the engineering departments the need for more funding to produce a high-quality product.

Analysis Approach:

As this is a design concept that will be iterated upon with different parts, materials, and devices, it will be important to approach this analysis using calculations and equations that can easily be swapped out for different options. To approach this analysis, the structural components, external devices, auxiliary device components, and raw materials will be groupings within an excel spreadsheet budget breakdown to find key information in the project cost. This will then show where budget is being spent, and what can be cleaned up to be more cost effective.

Analysis Assumptions:

Five assumptions/simplifications were made in the analysis of the PLC trainer platform. Three assumptions were made regarding raw materials, hardware, and wiring where these components were neglected or assumed to be bought in the perfect quantity per the design and manufacturing. The neglect of the hardware and wire cost was important because of their very small relative scale in comparison to the high prices of the external devices and their current unknown quantity due to other design aspects taken care of by my team members. We would like to purchase hardware and wiring in bulk when all modules that go alongside the trainer platform are completed. Though, in the end, hardware and wiring will be magnitudes smaller in cost compared to the larger purchases making this a valid simplification. The other two assumptions made were concerning market value and listed prices. The assumptions made for the analysis concerning these two criteria were neglect of shipping prices/taxes and a fixed market value. This will help the overall goal of cost display per unit platform trainer without accounting for a changing market value and potential shipping cost.

Analysis Conclusions/Summary:

Reviewing the results of the in-depth cost analysis, the results show that the PLC trainer platform design concept as shown in figure 1 is feasible based on budget impact. The total price of the PLC trainer platform comes out to $2417.48 which is about half of the initial budget of $5000 without additional funding from the other engineering departments that are involved in this project. So, in a worst-case scenario situation where there won't be any additional funding, the PLC trainer platform can be designed and manufactured with $2500 remaining for the 3 additional modules that accompany it. The 3 additional modules are significantly cheaper in their design and development which allows their development to be constrained lightly by the budget impact of the PLC trainer platform.

Compared to the modular PLC trainer platforms that are offered on the market that have similar capabilities of what our design challenge is meant to include, the cost analysis reveals that this design concept will be more cost friendly. Table 1 below shows 3 prospected PLC trainers that were considered for purchase alongside the design concept for a PLC Trainer shown in figure 1.

PLC Trainer	Cost
LEARNLAB Training System: PLC - Programmable Controls (Multi-Brand) Training System, Freestanding	$3,358.26
LEARNLAB Training System: Portable PLC - Programmable Logic Controls (Multi-Brand) Training System	$3,746.50
Allen Bradley Deluxe Complete Elevator PLC Trainer with MicroLogix 1400	$5,499.95
University of Utah Senior Design PLC Trainer Platform	$2,417.48

Table 1: PLC Trainer Platform Price Comparison

As seen from these results, the design concept PLC trainer is more cost effective than the PLC trainers that are offered on the market with an average cost savings of $1783.76 based on the three prospected platforms shown in Table 1.

Title	Cost Analysis of the PLC Trainer Platform Design Concept 1
Author	Brandon Lim
Project	ME EN 4000: Assignment 4
Date	10/6/2024
Version	1
QA/QC	

PLC Trainer Platform Single Unit Price
$2,417.48

Overview

The goal of this analysis is to find the price to produce one unit of the PLC Trainer Platform design concept. This design is made of 80/20 aluminum extruded parts and hardware, acrylic panels, wiring ducts, and various PLC field devices. This will help to investigate the cost effectiveness of this particular design where my team has created multiple concepts with similar components but different means of accomplishment.

Cost Analysis Assumptions/Simplifications

1. All structural material (i.e 80/20 extrusion, acrylic, hardware) are used/built without error or extra material
2. All prices and calculations are without taxes and or shipping fees
3. Component prices are listed at the time of the analysis and have not been updated (unless stated otherwise) to current market value
4. Hardware components for assembly have been neglected due to their small relative price and uknown quantities at the time of the analysis
5. Wire has been negelected due to its small relative price and unknown power requirmenets with module interaction (Other parts of the design not included in this analysis)

Calculation Explanations

The" Total Cost of Component" was calculated with the formula: **Total Cost of Component = Item Quantity x Cost Per Unit**

The total cost of the external devices, auxillary devices , and structural components was calculated with the formula: **"Total Cost of "..." = sum (Total Cost of Component Column)**

The PLC Trainer Platform Single Unit Price was calculated with the formula: **PLC Trainer Platform Single Unit Price = Total Cost of Structural Components + Total Cost of External Devices + Total Cost of Auxillary Components**

Structural Components

Item	Purpose	Dimensions	Vendor	Web-Link	Quantity	Cost Per Unit	Total Cost of Component
80/20 Extruded Aluminium	X-axis frame	1.5" X 1.5" X 25"	80/20	https://8020.net/1515.html	4	$22.04	$88.16
80/20 Extruded Aluminium	Z-axis frame	1.5" X 1.5" X 8"	80/20	https://8020.net/1515.html	4	$8.95	$35.80
80/20 Extruded Aluminium	Y-axis frame	1.5" X 1.5" X 17"	80/20	https://8020.net/1515.html	4	$15.88	$63.52
Acrylic Panel	Front control panel	0.25" X 24" X 18"	80/20	https://8020.net/2601.html	1	$43.00	$43.00
		Total Cost of Structural Components :	$230.48				

External Devices

Item	Purpose	Dimensions	Vendor	Web-Link	Quantity	Cost Per Unit	Total Cost of Component
BX-DM1E-10ER3-D	PLC CPU	2.41" X 4.25" X 3.59"	Automation Direct	https://www.automationdirect.	1	$307	$307
DR16F0N-E3G	LED indicators	N/A	Automation Direct	https://www.automationdirect.	4	$13	$52
AR16F0N-C2E3G	Push button	N/A	Automation Direct	https://www.automationdirect.	4	$17.50	$70
AF16PR-2C1B	Selector Switches	N/A	Automation Direct	https://www.automationdirect.	2	$18.50	$37
ECX2300-10K	Potentiometer Dial	N/A	Automation Direct	https://www.automationdirect.	2	$41.50	$83
GCX1131	Emergency Stop	N/A	Automation Direct	https://www.automationdirect.	1	$14.50	$15
2787-2144	120VAC to 24VDC Converter	N/A	Automation Direct	https://www.automationdirect.	1	$179.00	$179
BX-4AD4DA-3	Analog I/O module	N/A	Automation Direct	https://www.automationdirect.	1	$330.00	$330
BX-08CD3R	Digital I/O module	N/A	Automation Direct	https://www.automationdirect.	1	$69.00	$69
KN-T12GRY-100	Power Terminal Block	Pack of 100	Automation Direct	https://www.automationdirect.	1	$34.50	$35
CM5-T10W	HMI	10" Screen	Automation Direct	https://www.automationdirect.	1	$769.00	$769
ZL-BX-CBL15	I/O Terminal Block Cable	0.5 meters	Automation Direct	https://www.automationdirect.	3	$30.50	$92
ZL-RTB20	I/O Terminal Block	N/A	Automation Direct	https://www.automationdirect.	3	$31.50	$95
FAZ-B1P5-1-NA-L-SP	1.5 amp circuit breaker	N/A	Automation Direct	https://www.automationdirect.	1	$23.00	$23
		Total Cost of External Devices:	$2,154				

Auxillary Device Components

Item	Purpose	Dimensions	Vendor	Web-Link	Quantity	Cost Per Unit	Total Cost of Component
DN-R35S1-2	Din Rail	35mm X 7.5 mm X 1 m (Pack of 2)	Automation Direct	https://www.automationdirect.	1	$11.00	$11.00
T1E-1015G-1	Wire Duct	1" X 1.5" X 2m (Narrow finger duct)	Automation Direct	https://www.automationdirect.	1	$22.00	$22.00
		Total Cost of Auxillary Components:	$33				