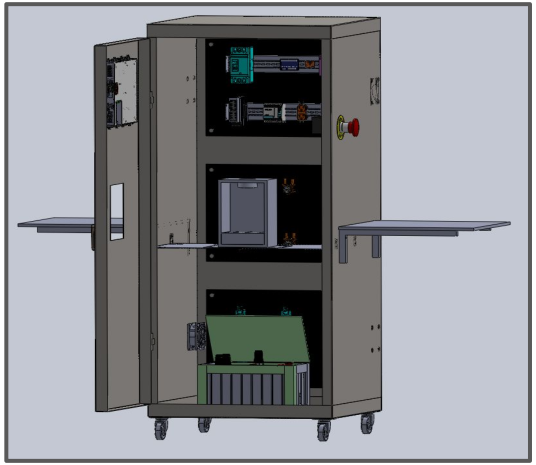
Project #10

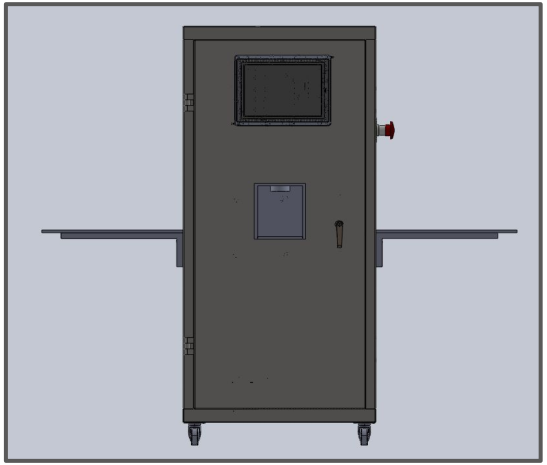
LSU College of Engineering Department of Mechanical & Industrial Engineering

College of Engineering School of Electrical Engineering & Computer Science

Speaker Name **Christopher Hall** Prepared By: **Christopher Hall**

Automated Bartender





Team Members:
Cade Farragut (ECE), Christopher Hall (ME),
Connor Regard (EE), Myles Bourgeois (ME)

Sponsor: Eric Belgard, Peter Laperouse
Advisors: Captain Dave, Dr. Knapp
Instructor: Dr. Li

Project Background

Speaker Name Christopher Hall Prepared By: Christopher Hall

- Manual drink preparation leads to:
  - Inconsistency
  - Inefficiency
  - Drink Spillage
  - Warm drinks

Problem Background

- Manual drink preparation leads to:
  - Inconsistency
  - Inefficiency
  - Drink Spillage
  - Warm drinks
- Sponsor wants something cool to Showcase

The objective of this project is to …

“design and develop an automated bartender system that efficiently dispenses a variety of mixed drinks using a user-friendly interface while ensuring accurate measurements and consistency”

Barsys 360

~400$

Bartesian Professional Cocktail Machine

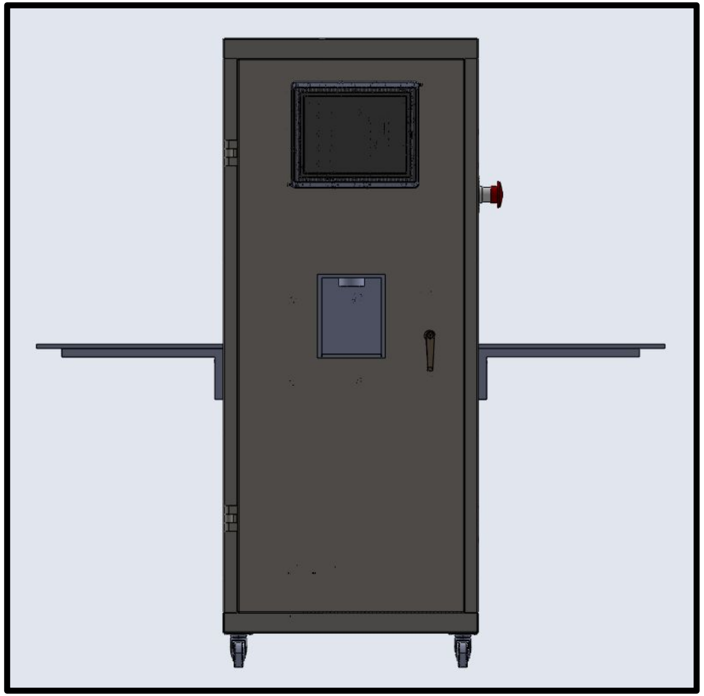
~400$

BLACK+DECKER™ BEV Cocktail Maker

~200$

Existing/Competing Technologies with Critique

Speaker Name **Myles Bourgeois** Prepared By: **Connor Regard**



Competing Technologies Limitations

1. Limited ingredient options
2. Not scalable
3. Minimal customization

Qualitative Constraints

#	Weight	Constraint	Descrition	Imposed By
1	0.25	User-Friendly	Easy to use and operate for all users	Sponsor
2	0.20	Durability	Withstands wear and tear over time	Team
3	0.20	Safety & Hygiene	Ensures safe and sanitary operation	Team
4	0.20	Portability	Convenient to move and transport	Sponsor
5	0.15	Customization	Extensive options for beverage recipes and personalization	Team

Quantitative Constraints

#	Weight	Constraint	Value	Imposed By
1	0.25	Liquid Dispensing Speed	< 15 s	Team
2	0.20	Operating Temperature Range	32°F - 120°F	Sponsor
3	0.15	Height	~ 6 ft	Sponsor
4	0.15	Temperature of Mixers	~ 35°F	Team
5	0.15	Hold Fluids	6 Bottles	Sponsor
6	0.10	Communicate with User	> 1 s	Sponsor

Function Objective Tree

Automated Bartender

- Fluid Flowing
- Automating
- User Interacting
- Ensuring Safety

Function Objective Tree

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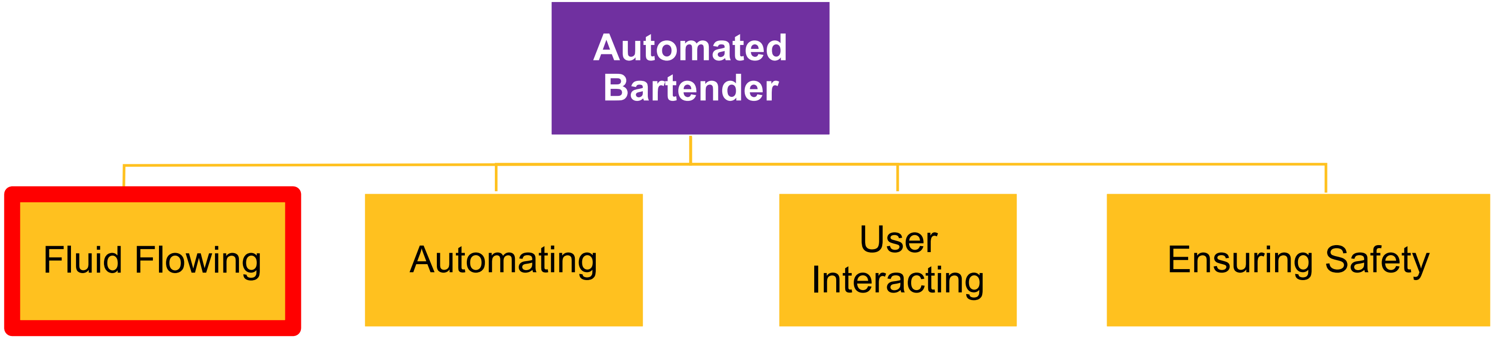
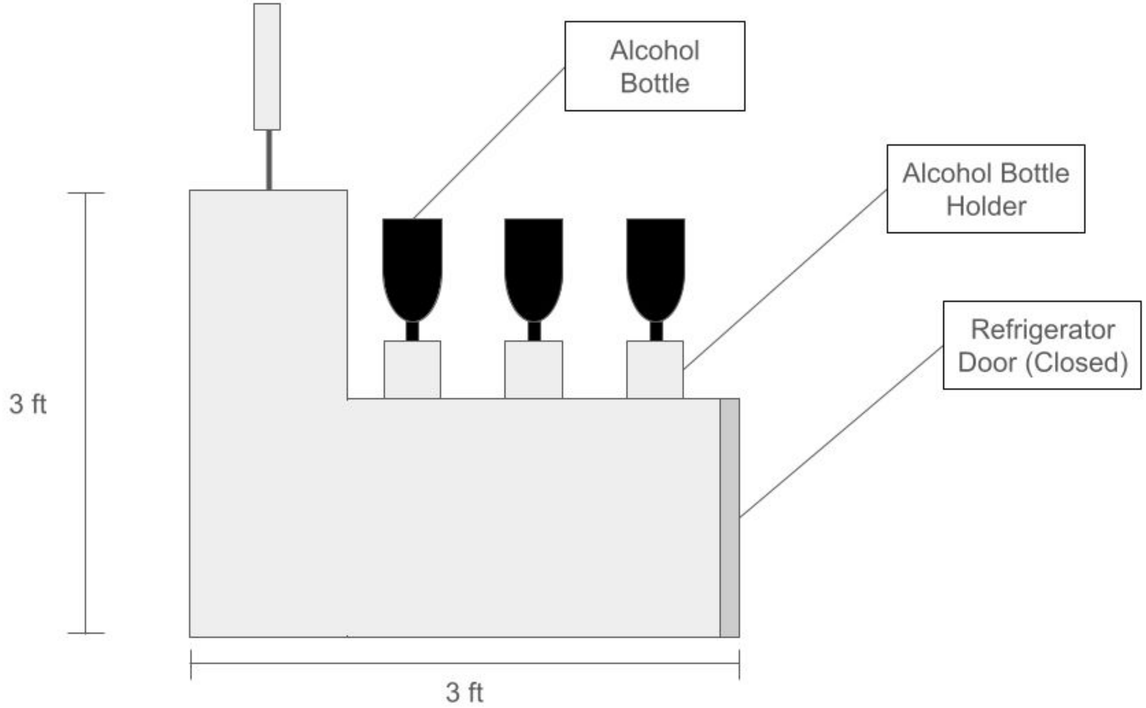


Considerations

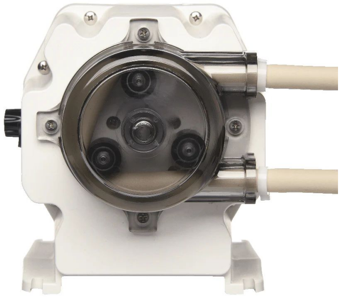
- **Pumps**: Peristaltic, Diaphragm, Gravity
- **Valves**: Plug, Ball
- **Tubing**: PVC Piping (0.25")
- **Flow Measurement**: Flow-Meter, Time-Based



Alcohol Bottle
Alcohol Bottle Holder
Refrigerator Door (Closed)
3 ft
3 ft

Concept Evaluation/Selection (Pumps)

Criteria	Weight	Peristaltic Pump	Diaphragm Pump	Gravity Fed
Cost	0.10	4	3	5
Complexity	0.15	4	2	2
Flow Control Accuracy	0.30	4	4	1
Ease of Maintenance	0.15	4	2	5
Safety and Health	0.30	5	4	5
Total Score	**1.00**	**4.20**	**3.00**	**3.60**



Peristaltic Pump

Diaphragm Pump

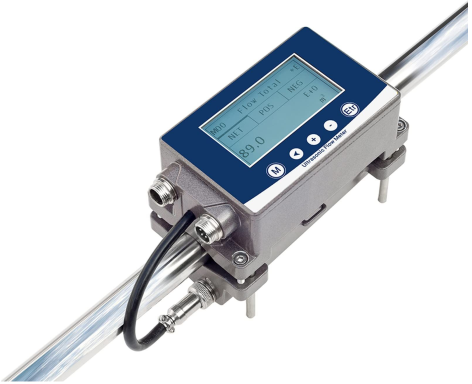
Concept Evaluation/Selection (Valves)

Criteria	Weight	Plug Valve	Ball Valve
Cost	0.10	4	4
Complexity	0.15	4	4
Flow Control Accuracy	0.30	5	2
Ease of Maintenance	0.15	4	4
Safety and Health	0.30	4	4
Total Score	**1.00**	**4.20**	**3.60**

Plug Valve

Ball Valve

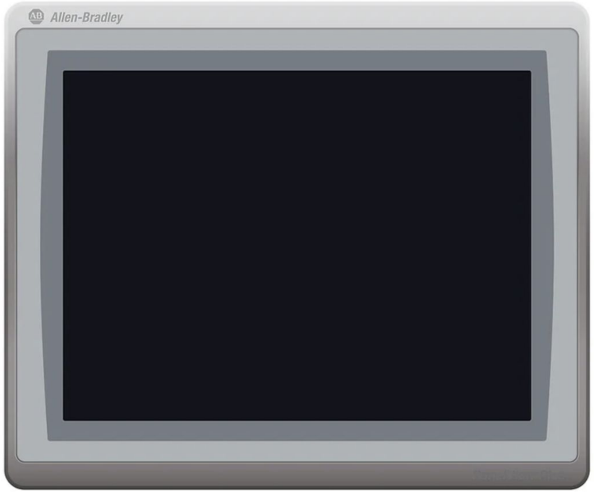
Criteria	Weight	Flow-Meter	Time-Based
Cost	0.30	1	5
Complexity	0.15	2	4
Flow Control Accuracy	0.30	5	4
Ease of Maintenance	0.10	3	5
Safety and Health	0.15	4	4
Total Score	**1.00**	**3.00**	$\boxed{\textbf{4.40}}$



Flow-Meter

Automated Bartender

- Fluid Flowing
- Automating
- User Interacting
- Ensuring Safety



Human-Machine Interface (HMI)

Programmable Logic Controller (PLC)

Function Objective Tree

- **Automated Bartender**
  - Fluid Flowing
  - Automating
  - User Interacting
  - Ensuring Safety

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Cooling

- Thermoelectric Cooling
- Refrigeration Unit
- Ice Chest
- Insulation
- AC

Emergency

- Emergency Stop

Cleaning

- All flush system

Concept Evaluation/Selection

Speaker Name **Cade Farragut** Prepared By: **Connor Regard**

Criteria	Weight	Insulation	Refrigeration Unit	Ice Chest	Thermoelectric Cooling
Cost	0.15	5	4	3	3
Power Efficiency	0.20	5	3	5	4
Portability	0.30	4	2	5	4
Temperature Control	0.25	3	4	3	5
Ease of Maintenance	0.10	4	3	5	4
Total Score	**1.00**	**4.20**	**3.20**	**4.20**	**4.00**

Criteria	Weight	Water Bucket	Water Tank System
Effectiveness	0.30	4	4
Ease of Use	0.25	3	3
Cost	0.20	5	4
Reliability	0.15	4	4
Maintenance Effort	0.10	4	4
Total Score	**1.00**	$\boxed{\textbf{4.00}}$	**3.80**

Design Synthesis - Product Architecture

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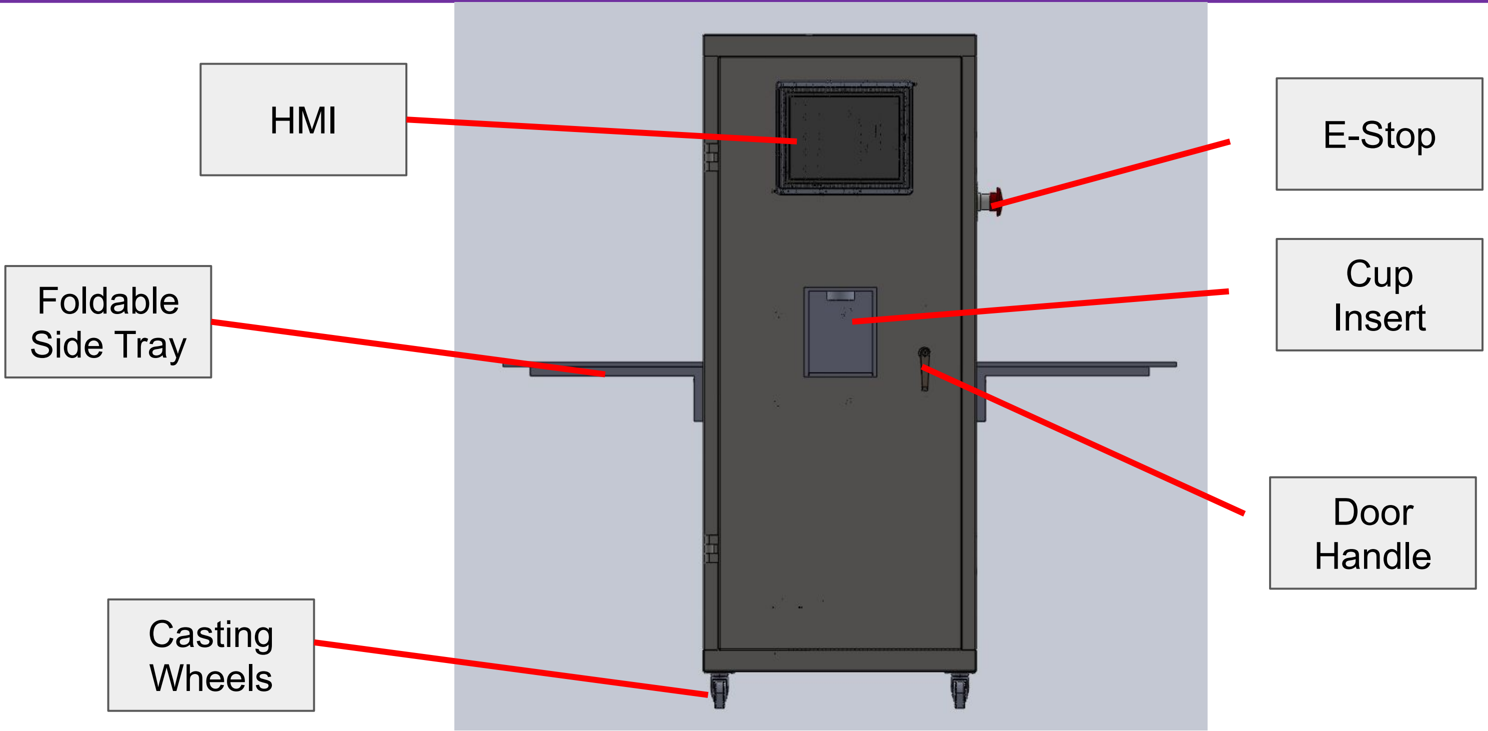

Design Synthesis - Product Architecture

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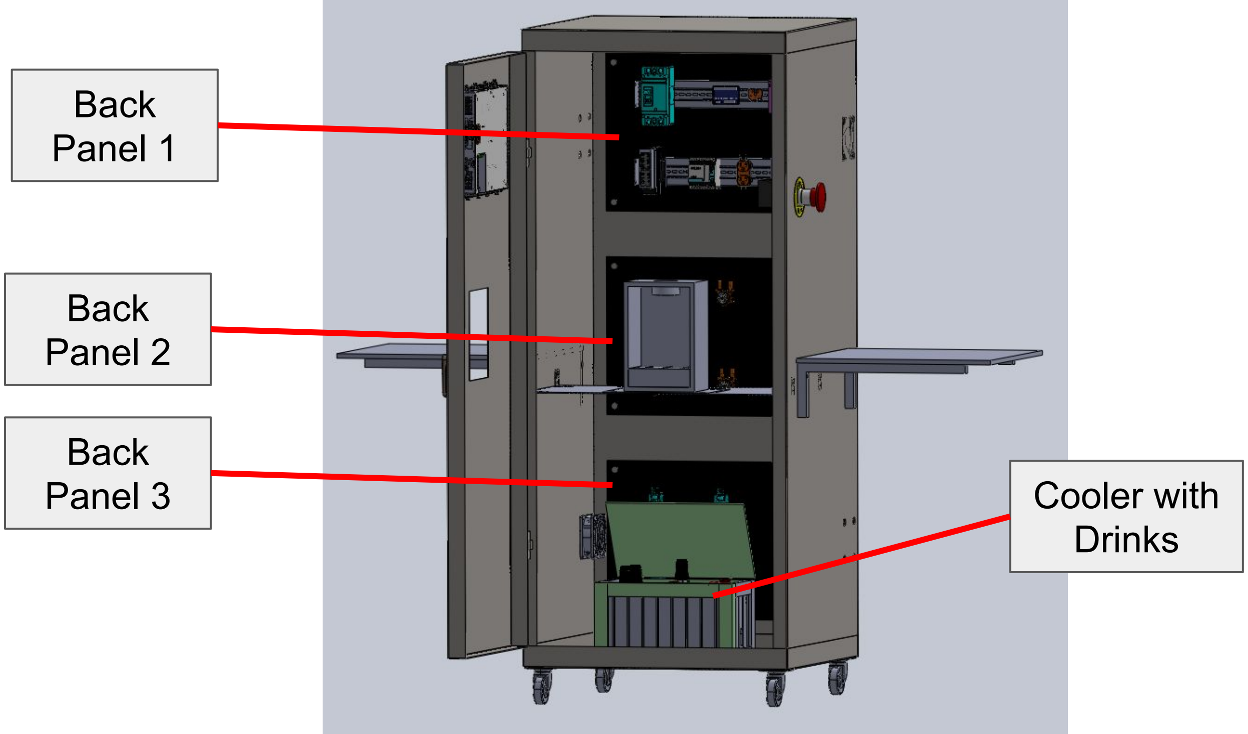

Design Synthesis - Product Architecture

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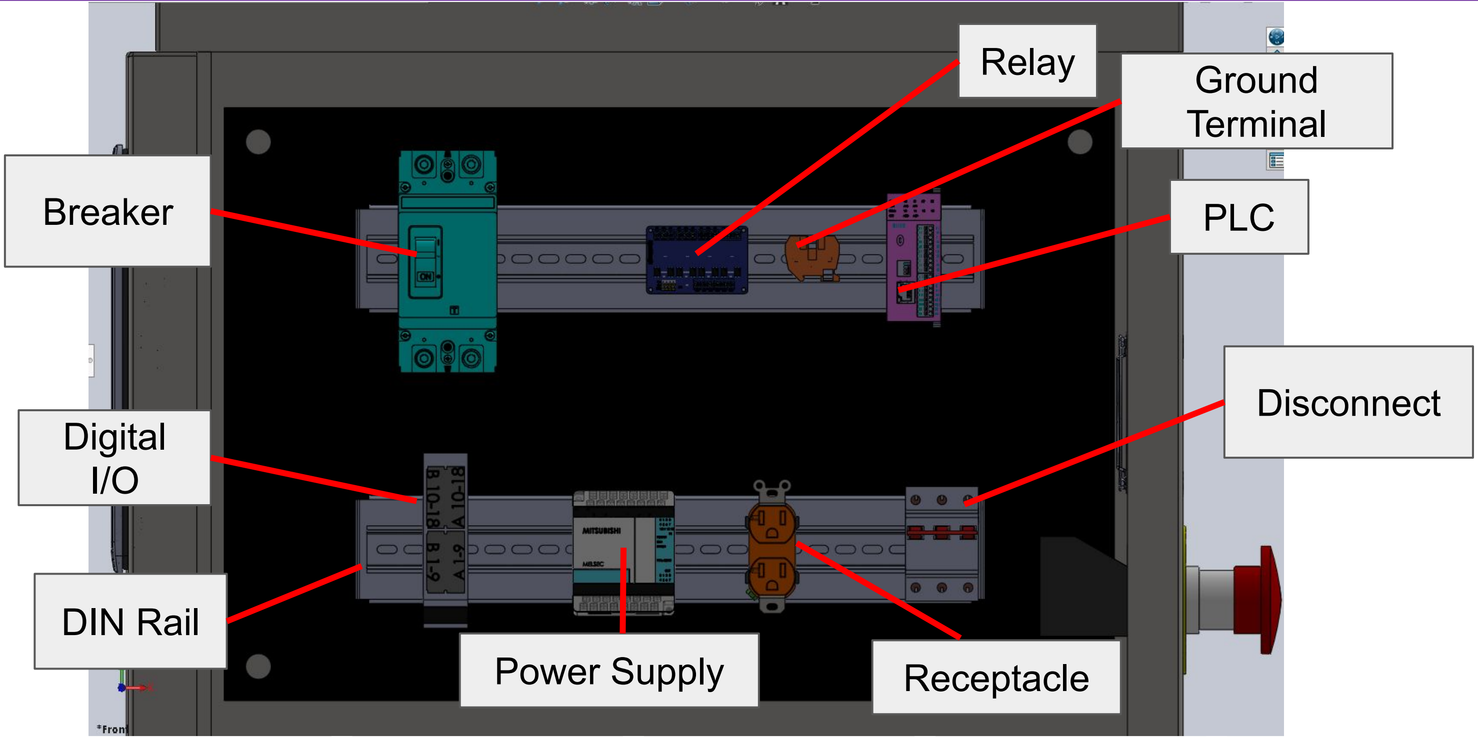
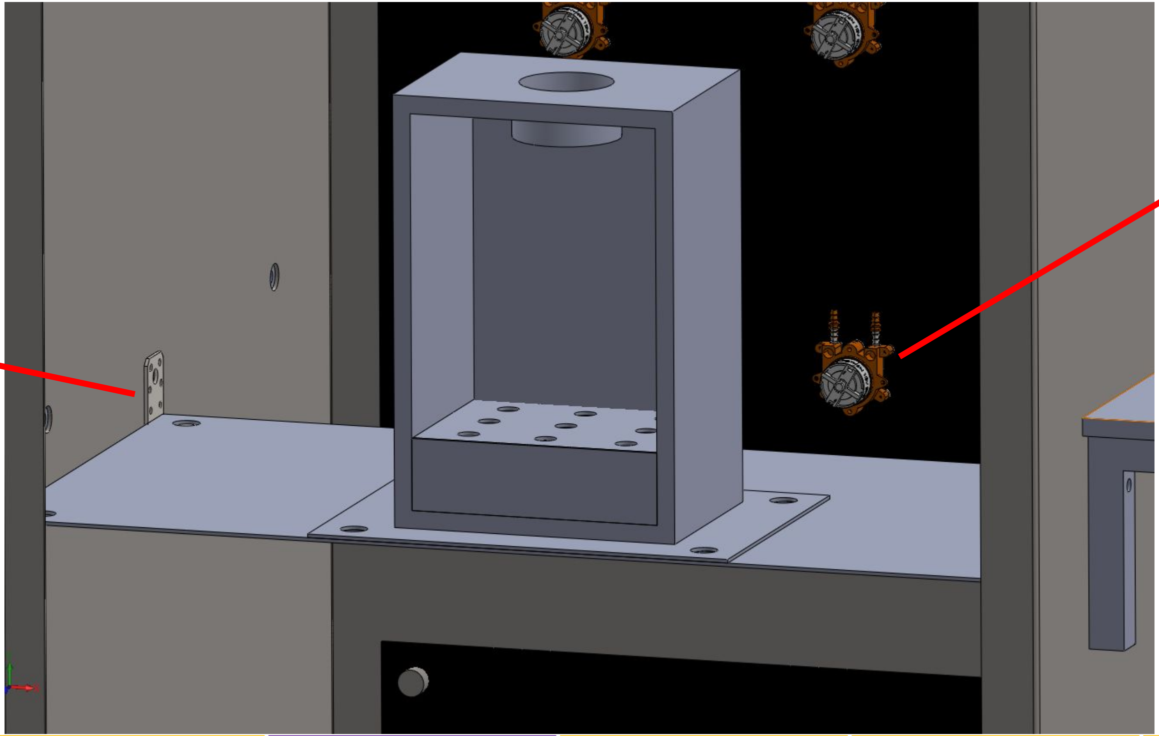


Design Synthesis - Product Architecture

Speaker Name **Christopher Hall** Prepared By: **Christopher Hall**

Mounting Bracket



Peristaltic Pump

Design Synthesis - Product Architecture

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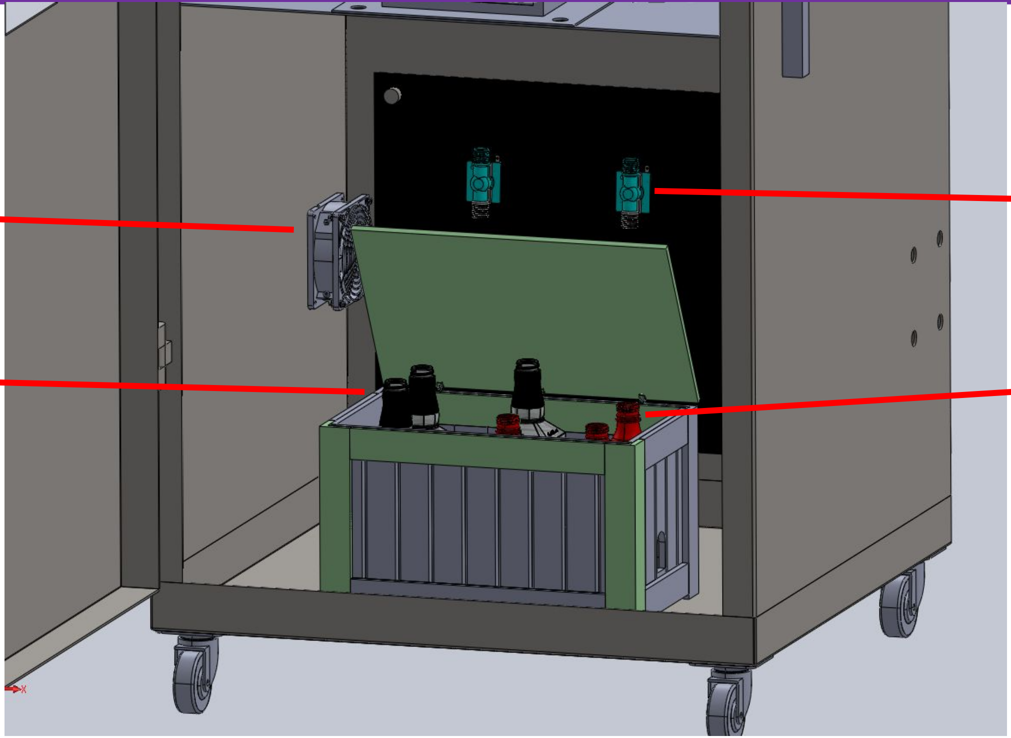
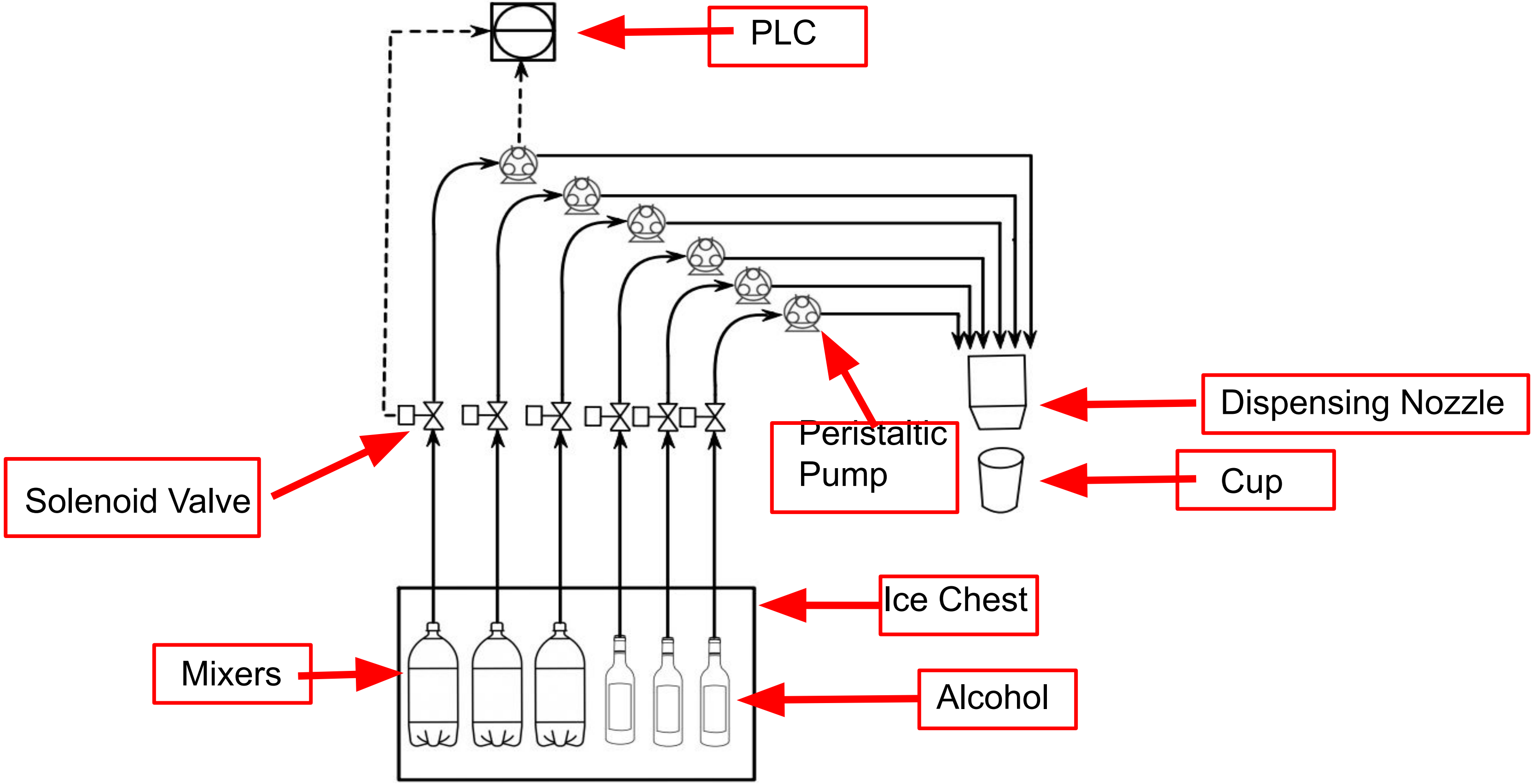
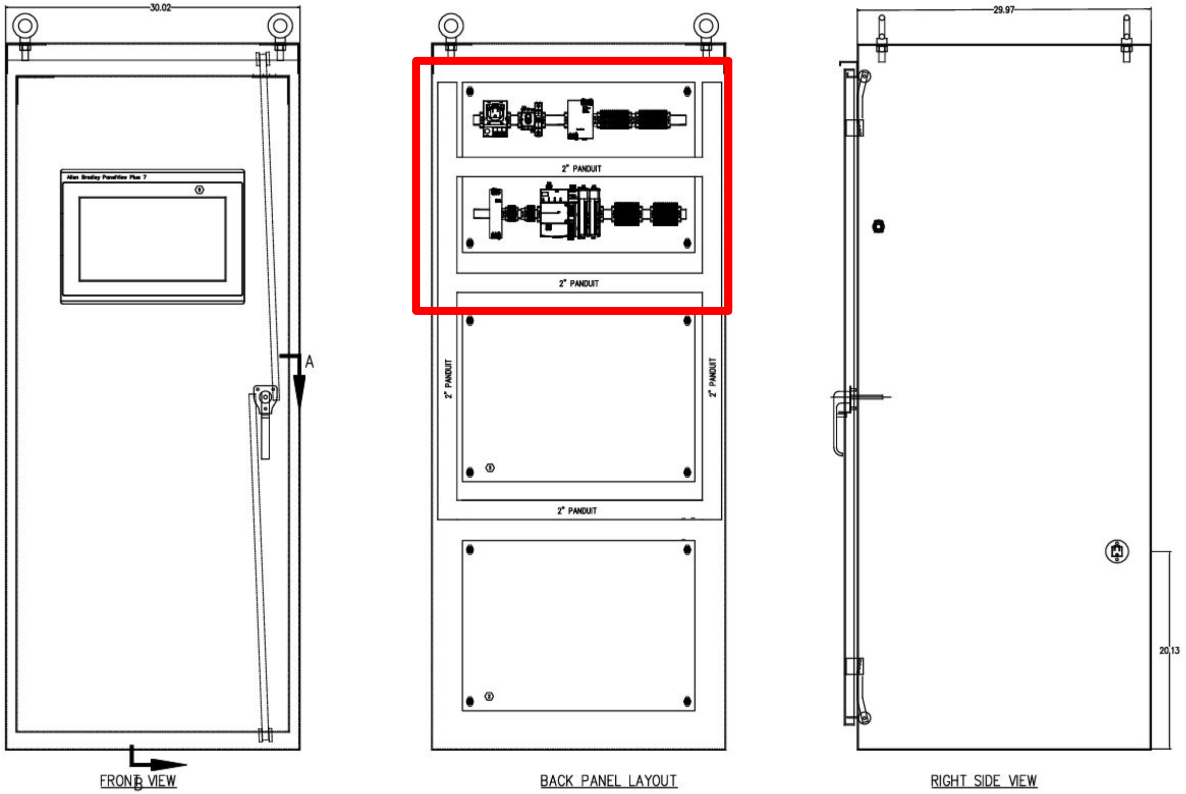


Tubing Diagram



Cabinet Layout

- Dimensions: 72" H x 30" W x 30" D.
- Electrical components housed in upper back panel section



Electrical System Layout

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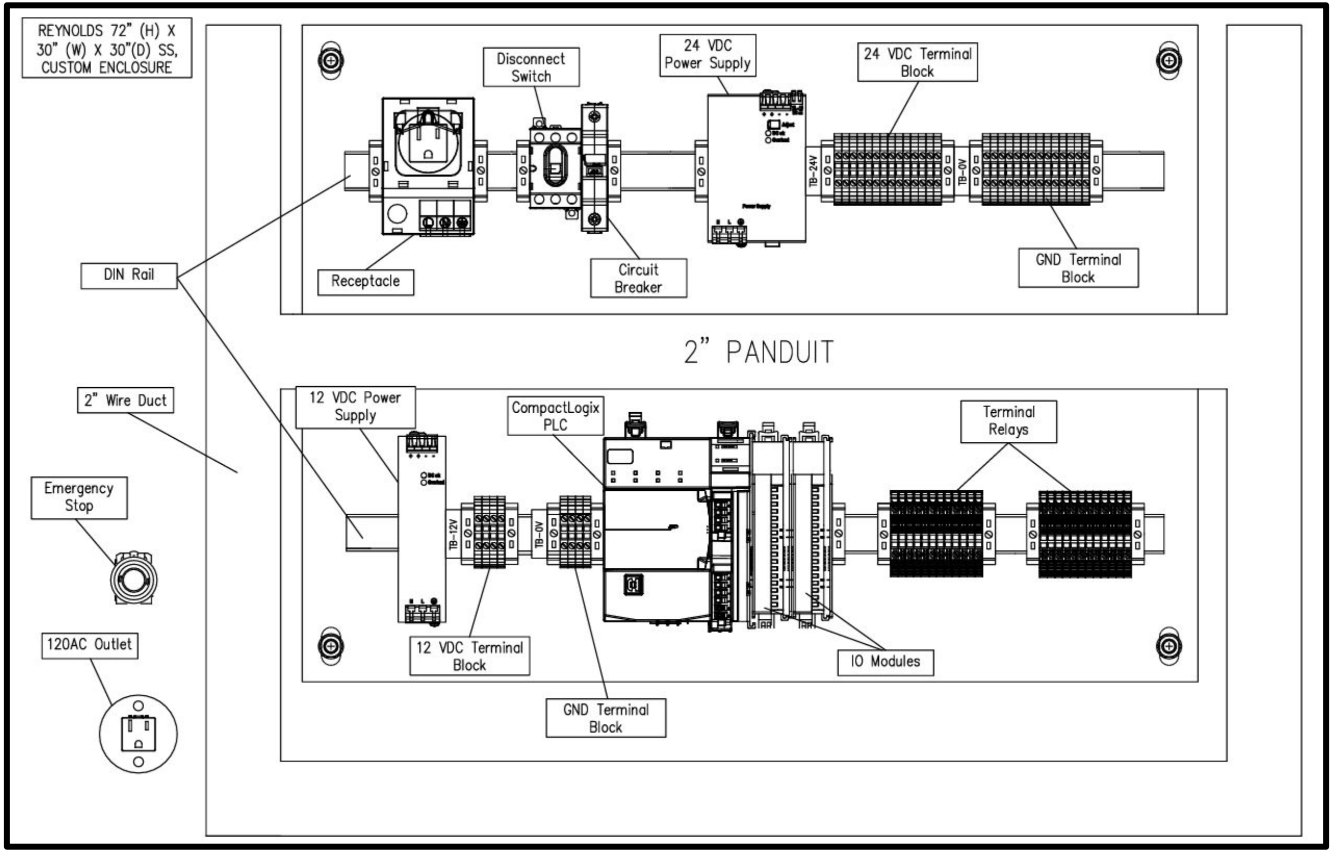

Electrical System Layout - Voltage Sources

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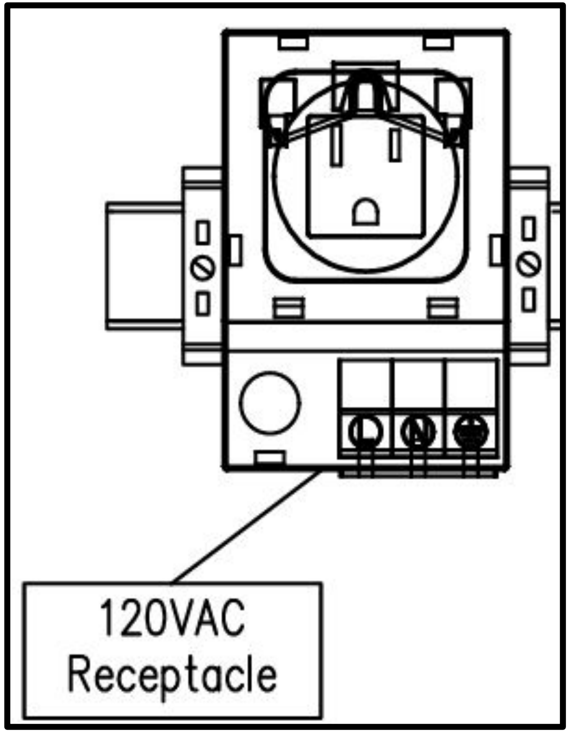

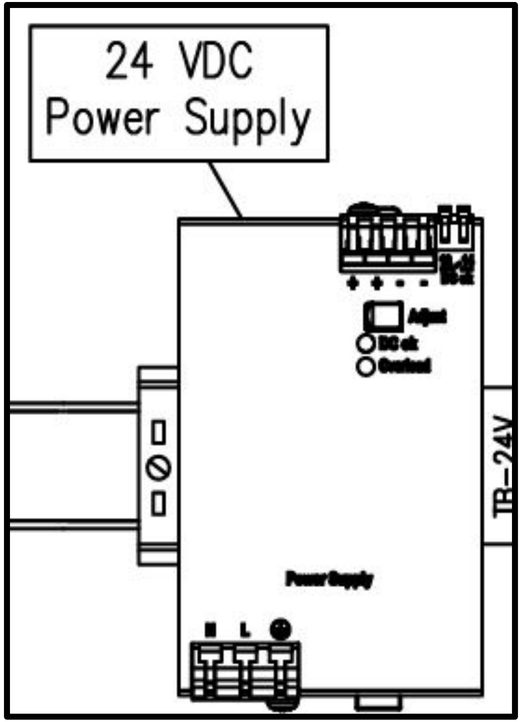

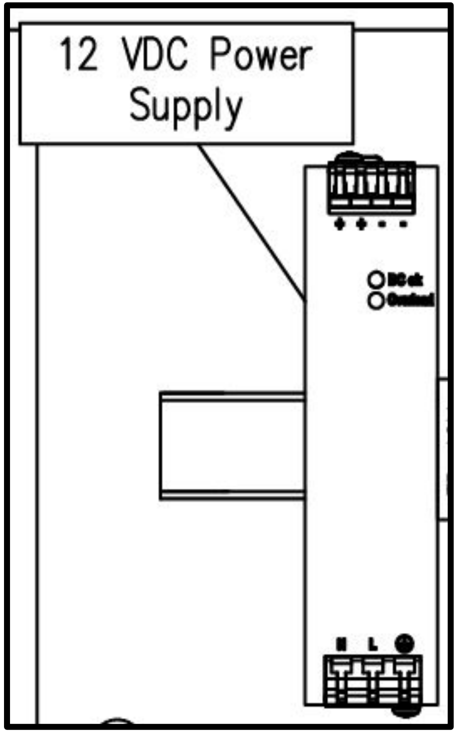

Electrical System Layout - Safety/Maintenance

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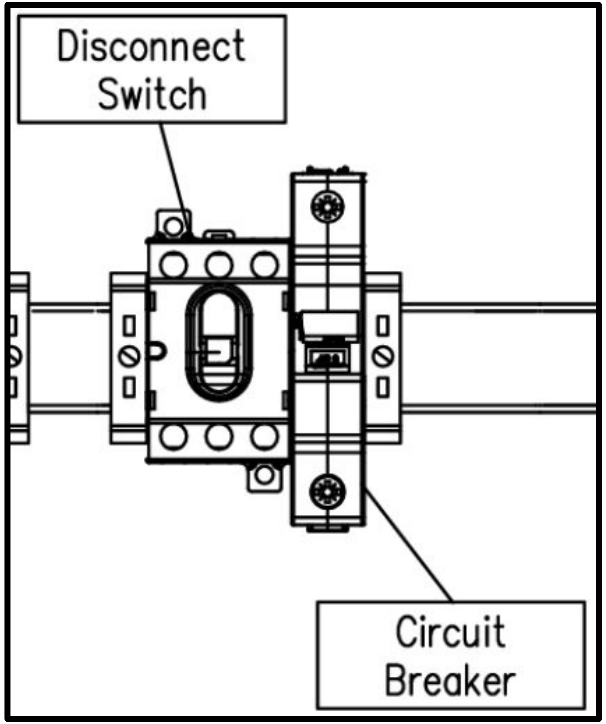

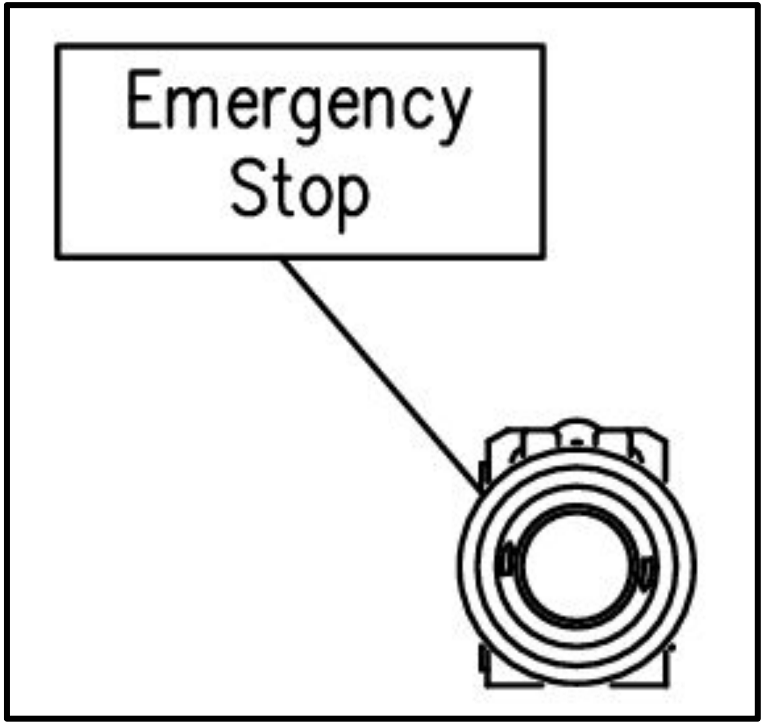

Electrical System Layout - Controller/IO Modules

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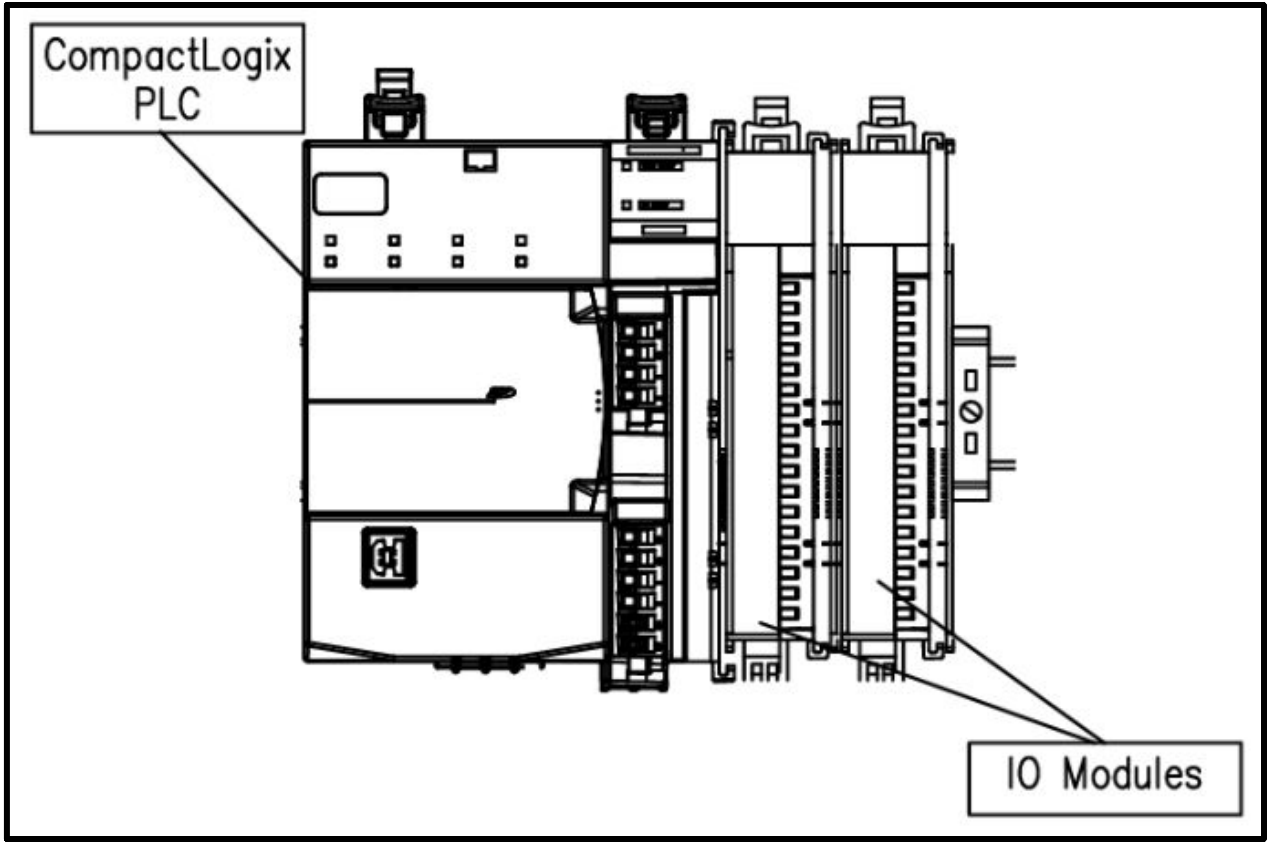

System Load Calculations

LOAD				
component	quantity	voltage (VDC)	current (A)	total power (w)
compactlogix plc	1	24	1.5	36
panel view 7 hmi	1	24	2	48
solenoid valve	6	24	0.5	12
peristaltic pump	6	24	1	24
intake fan	1	12	0.5	6
exhaust fan	1	12	0.5	6
TOTAL				312

$$Total\ System\ Load = (Load\ Voltage) \times (Load\ Current) = \boxed{312\ W}$$

Wire Gauge

Speaker Name Connor Regard Prepared By: Connor Regard

LENGTH IN FEET

AMPERES

	0-4 ft	4-7 ft	7-10 ft	10-13 ft	13-16 ft	16-19 ft	19-22 ft
0-20	20-24 AWG	20-24 AWG	16 AWG	16 AWG	18 AWG	18 AWG	18 AWG
20-35	20-24 AWG	16 AWG	16 AWG	16 AWG	18 AWG	18 AWG	18 AWG
35-50	16 AWG	16 AWG	14 AWG	14 AWG	18 AWG	18 AWG	18 AWG
50-65	16 AWG	16 AWG	14 AWG	14 AWG	18 AWG	18 AWG	18 AWG
65-85	14 AWG	14 AWG	14 AWG	14 AWG	18 AWG	18 AWG	18 AWG
85-105	14 AWG	14 AWG	12 AWG	12 AWG	18 AWG	18 AWG	18 AWG
105-125	12 AWG	12 AWG	12 AWG	12 AWG	18 AWG	18 AWG	18 AWG
125-150	12 AWG	12 AWG	12 AWG	12 AWG	18 AWG	18 AWG	18 AWG

Wiring Diagram

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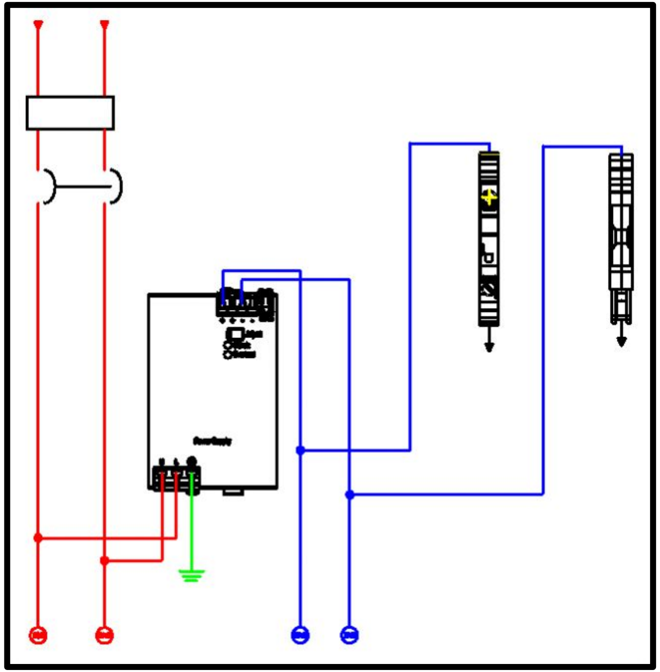
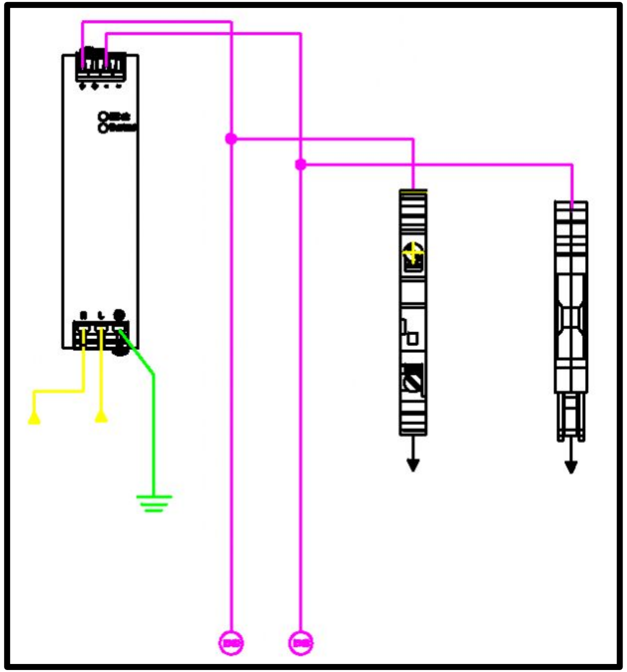
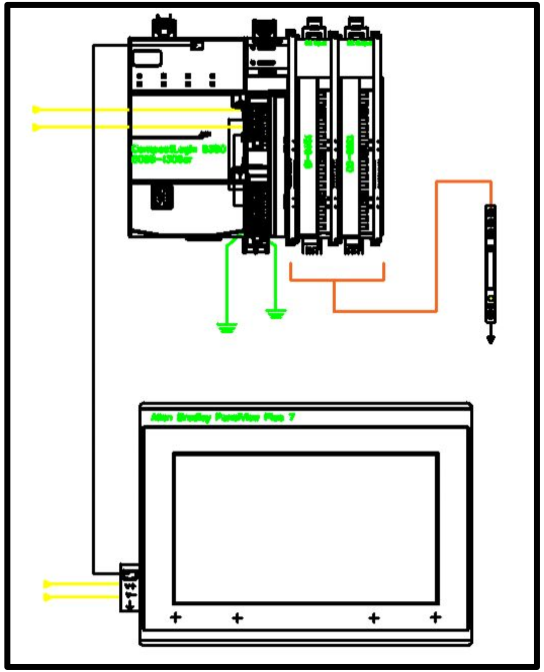
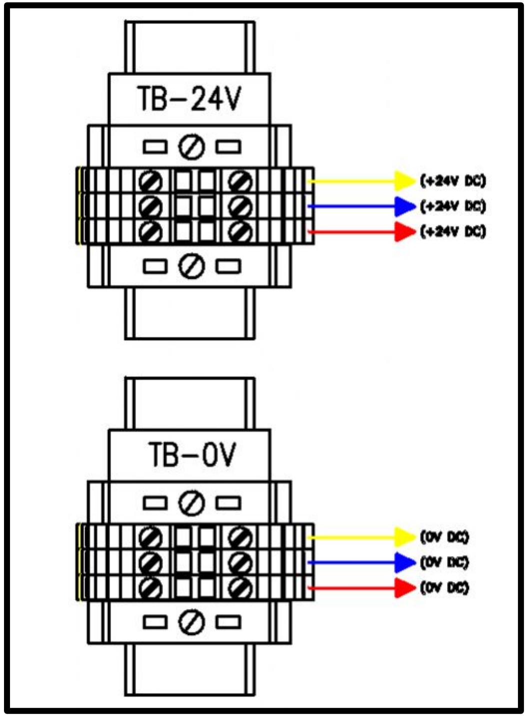
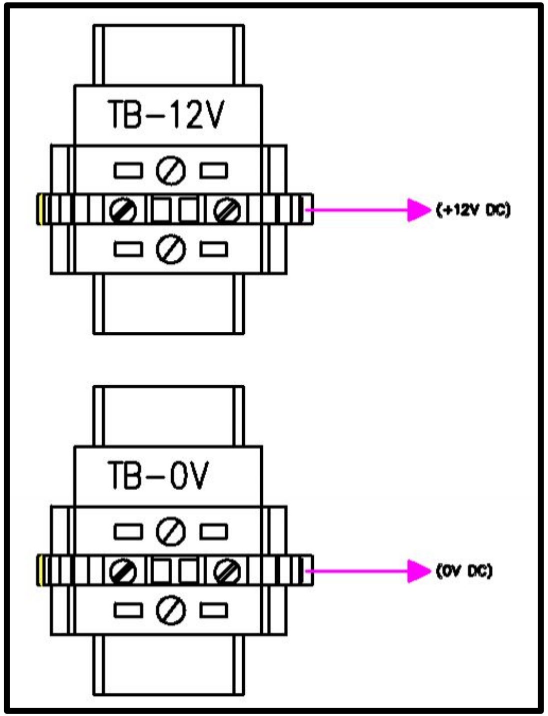


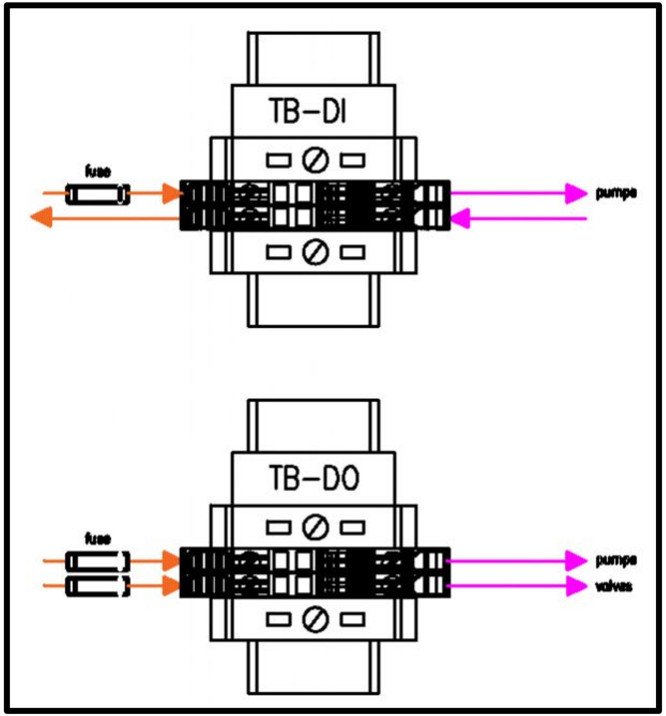




Wiring Diagram







Relay Control With Fuse Protection

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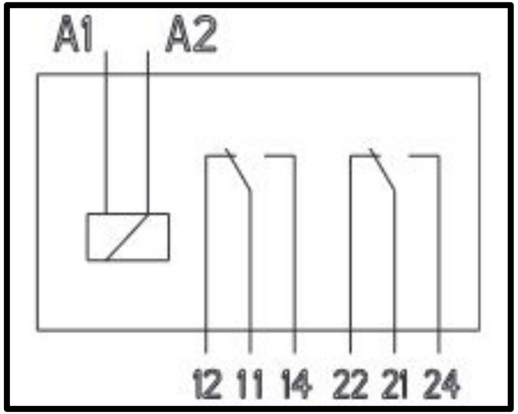

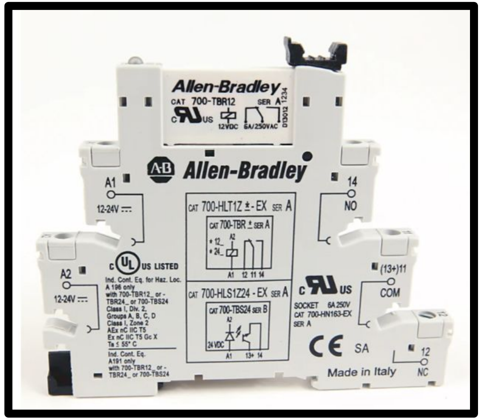

$$I_{fuse} = I_{normal} \times safety\,margin$$

$$I_{fuse} = 37ma \times 2.5 \approx \boxed{0.1\,A}$$

$$I_{total} = 6(1\,A) + 6(0.5\,A) = 9\,A$$

$$I_{relay} = 37mA \times 12 = \boxed{0.444\,A\,(total\,with\,relay)}$$

Calculation

Heat Transfer - Electronics: Analysis

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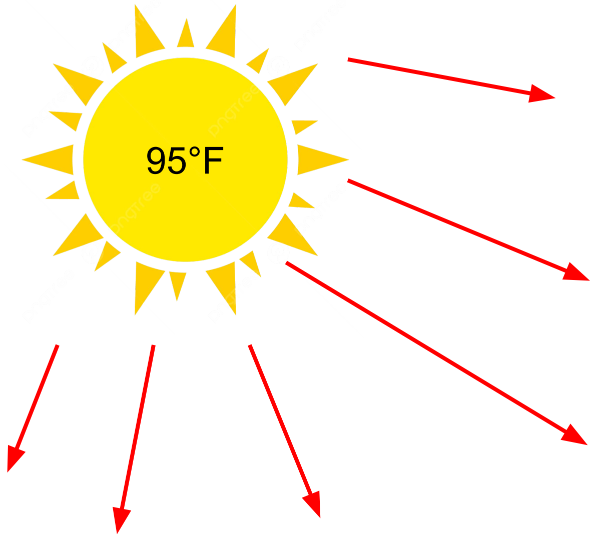
Speaker Name **Christopher Hall** Prepared By: **Christopher Hall**



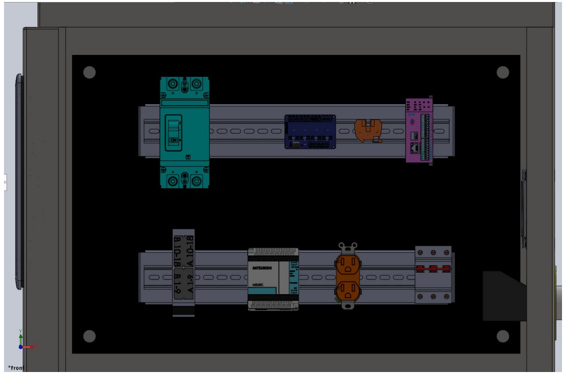
Maximum Temperature for Electronics	158°F (70°C)
Internal Temperature (With Fans)	95°F (35°C)

$$Q_{fans} = Vdot \cdot \rho_{air} \cdot C_p \cdot \Delta T$$

$$Q_{fans} = 1015.16\,W$$ Heat removed

$$Q_{fans} >> Q_{generated}$$

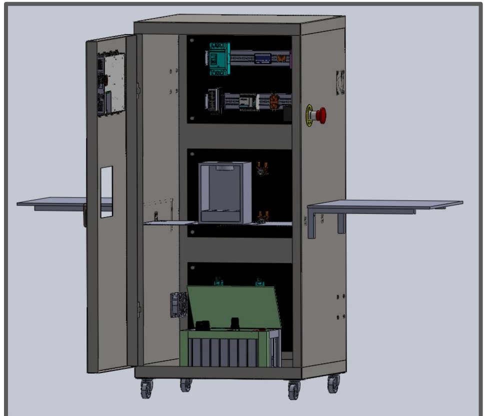
$$T_{internal\,(w/\,fans)} = T_{ambient} = 95\,°F$$



Max Load - Top of Frame: Analysis

- 32'' HD TV
- 10.8 lbs

Assumptions:
- Load is in center
- Max deflection abides L/360 standard



Max Load on Top of Frame

$$I = \frac{w \cdot t^3}{12}$$

$$\delta = \frac{L}{360}$$

$$\delta = \frac{W \cdot L^3}{48 \cdot E \cdot I}$$

$$\boxed{W = \frac{\delta \cdot 48 \cdot E \cdot I}{L^3} = 13.1\ lbs}$$

Frame Analysis - Impact Force

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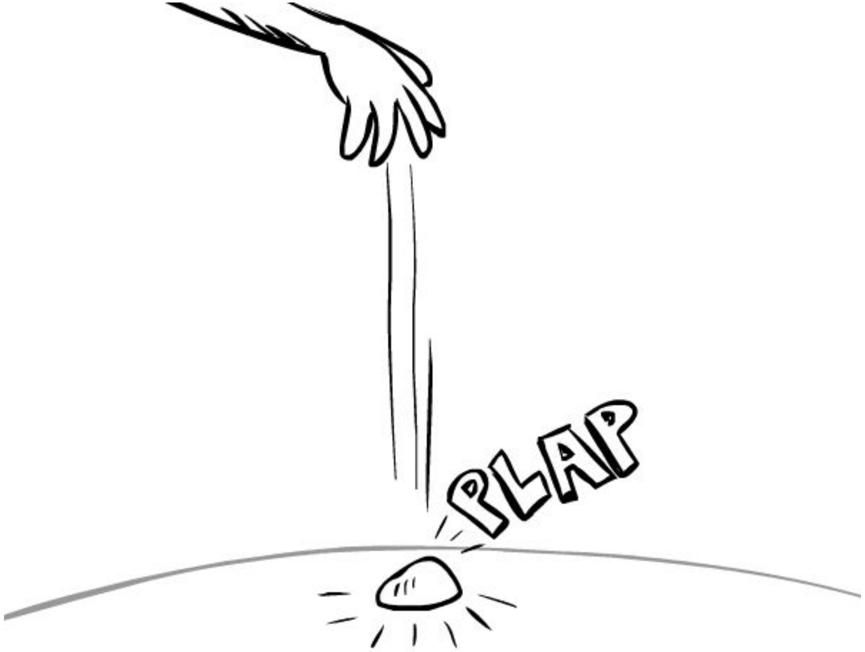
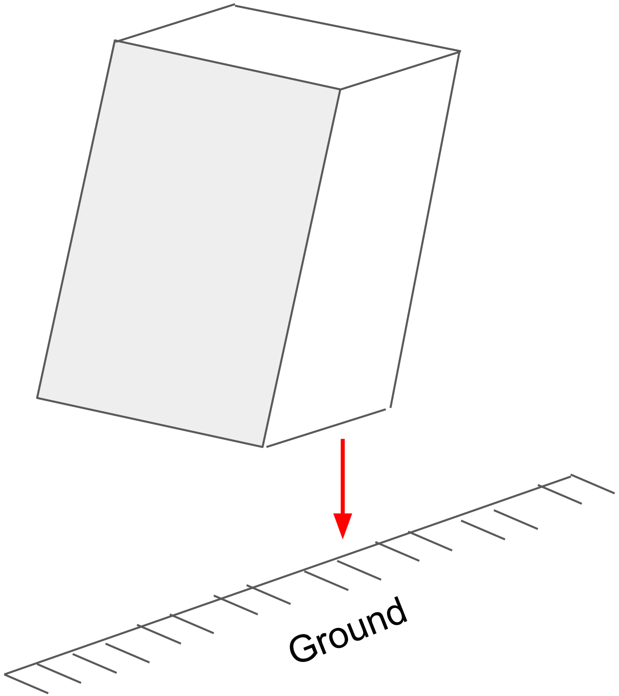


Frame Analysis - Impact Force



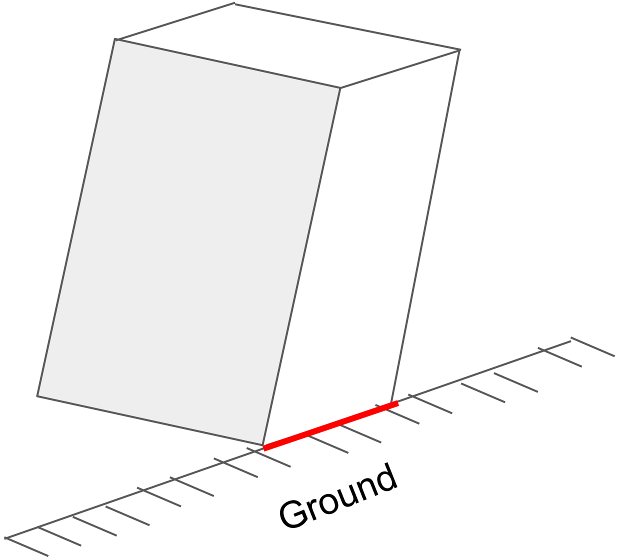
$$v = \sqrt{2 \cdot g \cdot h}$$

$$\int_0^t F dt = m \cdot (v_f - v_0)$$

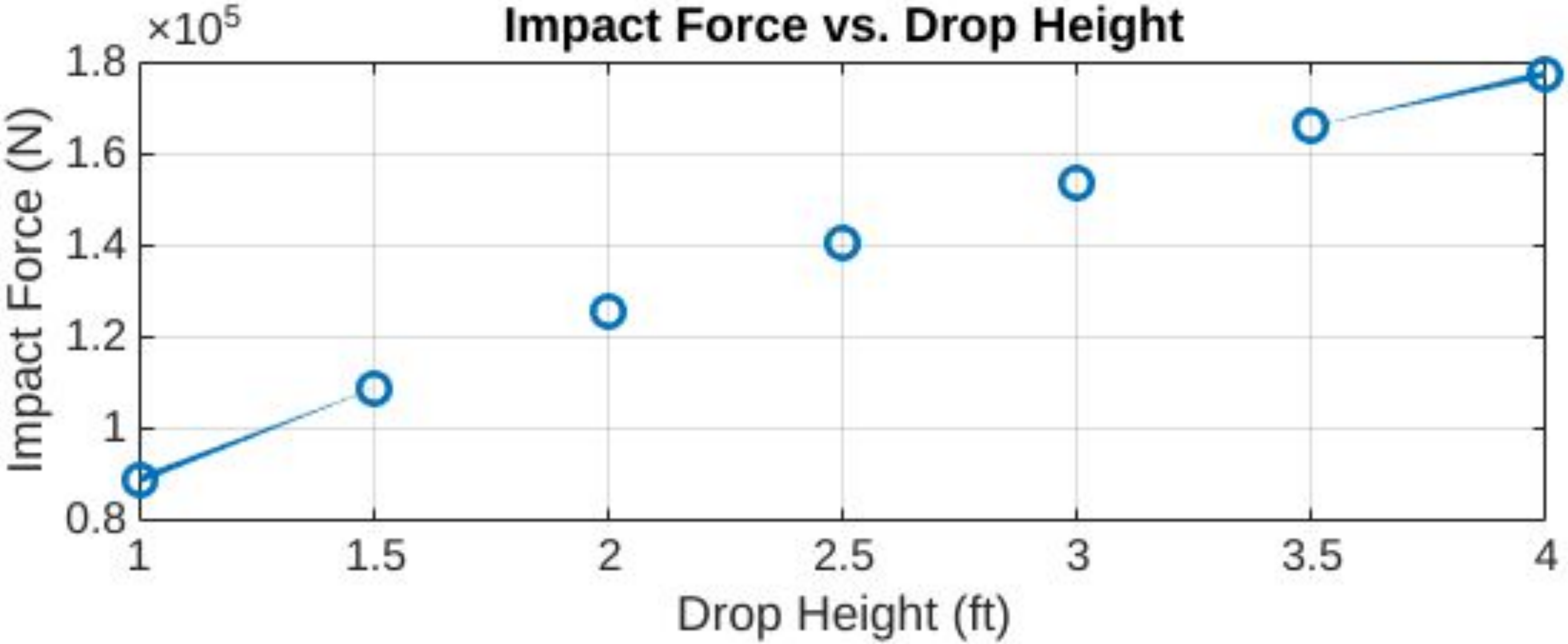
$$F = m \cdot \frac{v}{\Delta t}$$

$$\sigma = \frac{F}{A}$$

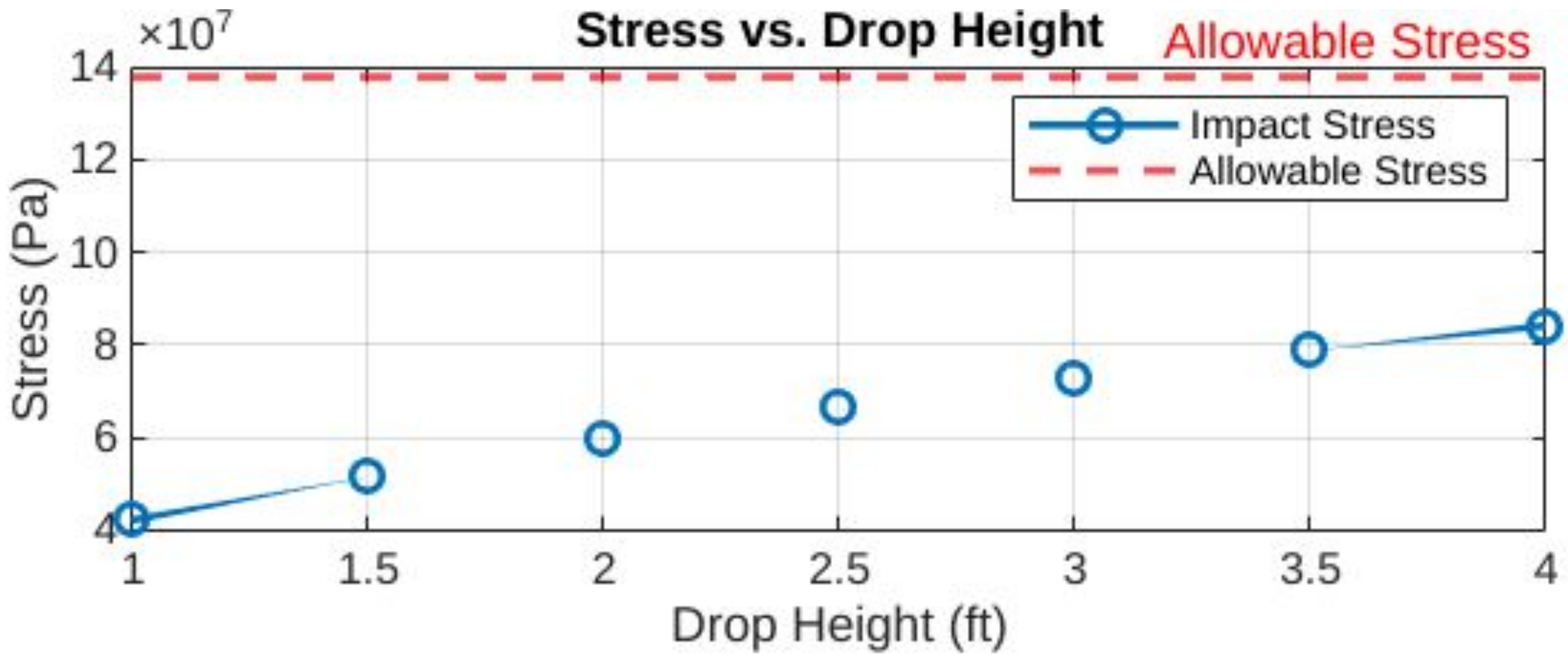
Assume Edge Impact



Frame Analysis - Impact Force



Frame Analysis - Impact Force



Touch Screen Interface

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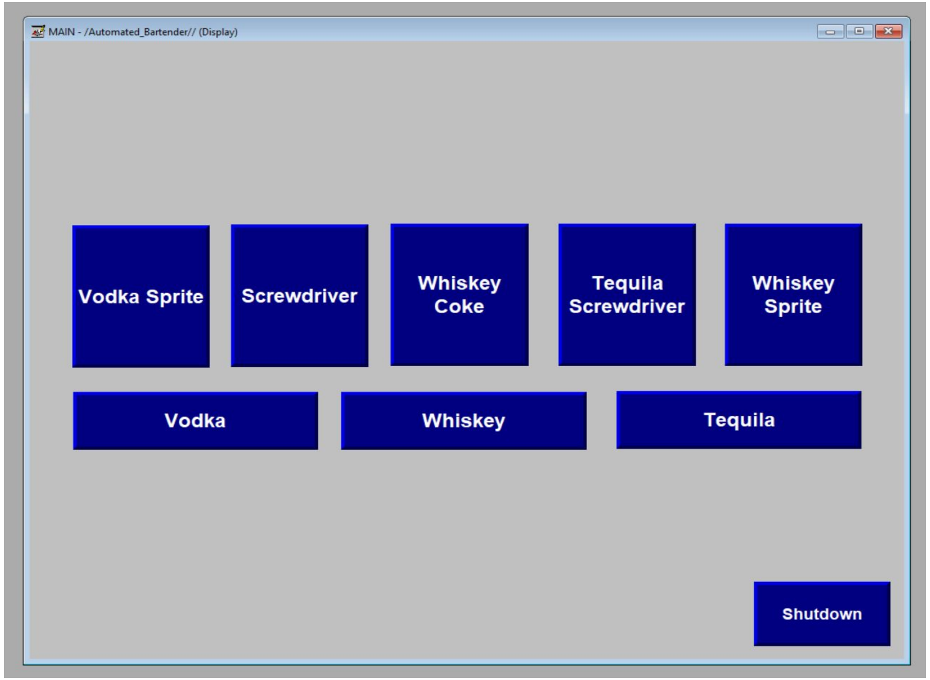

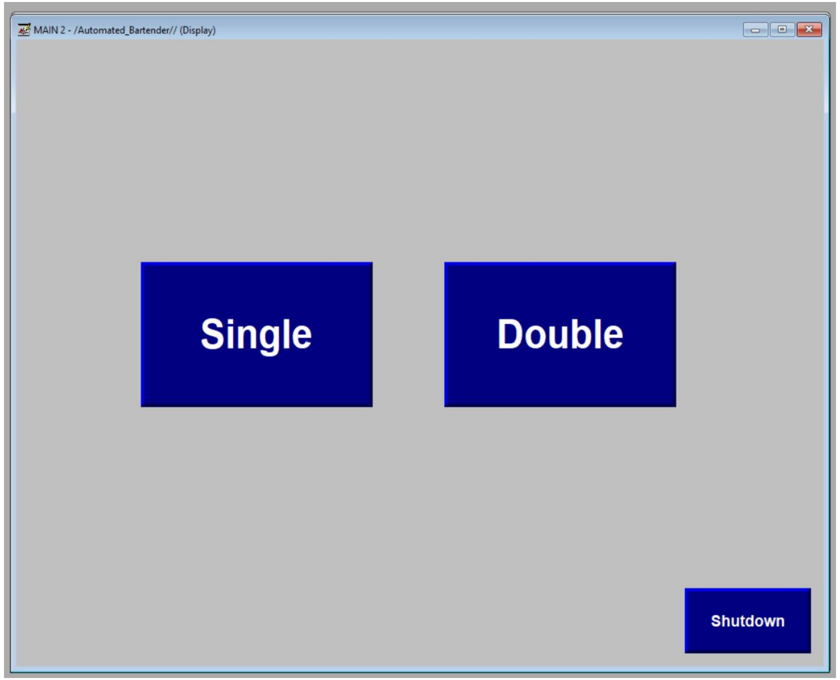

Automation: Drink Selection

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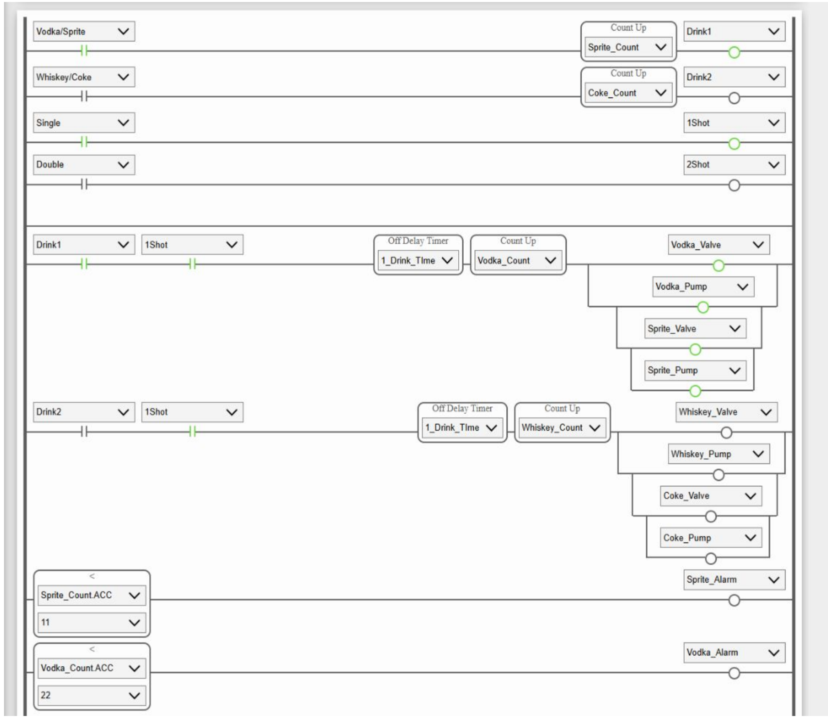
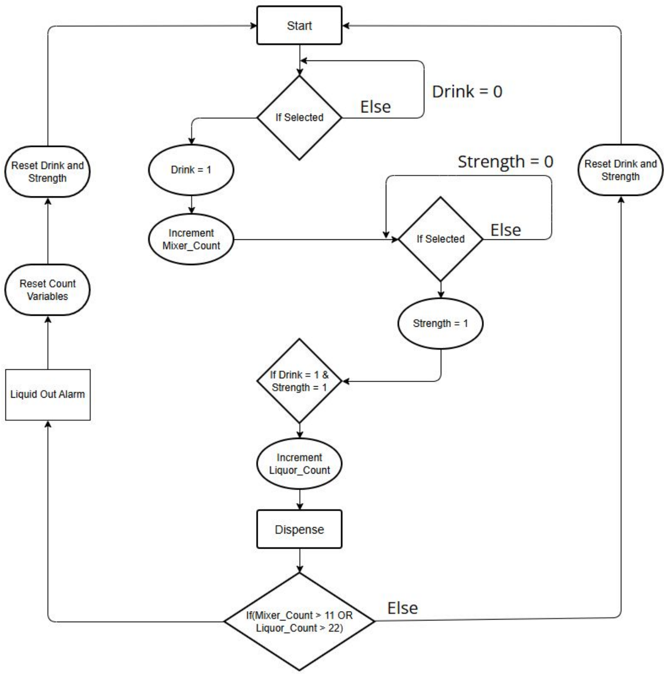
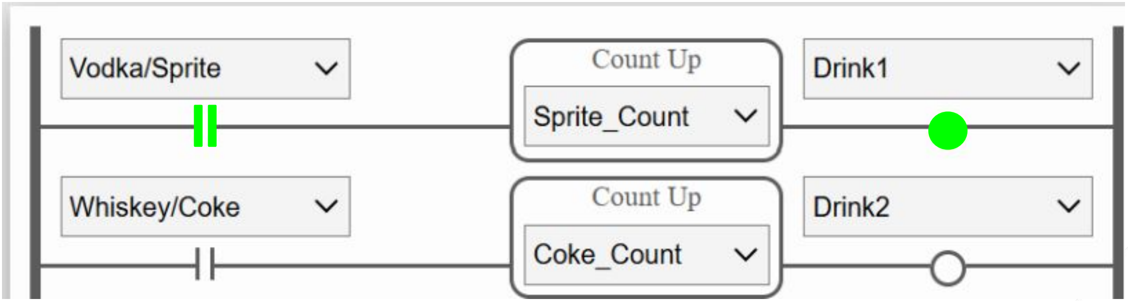
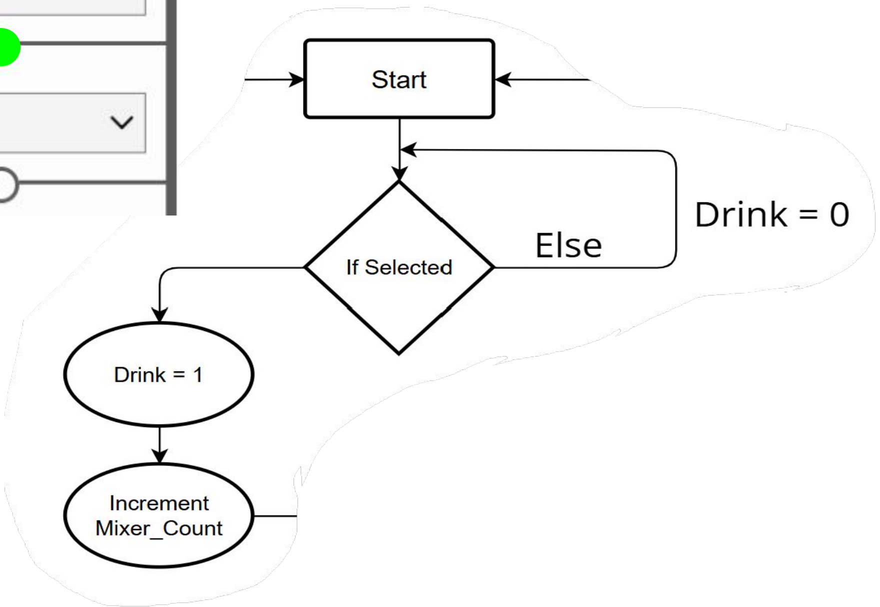
Speaker Name **Cade Farragut** Prepared By: **Cade Farragut**



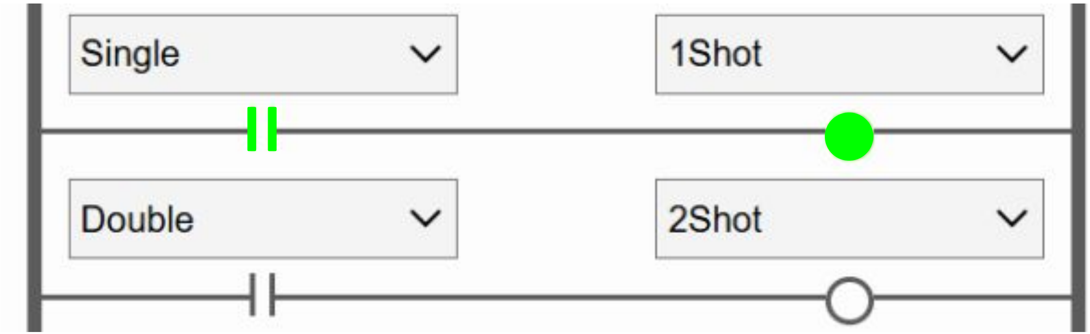




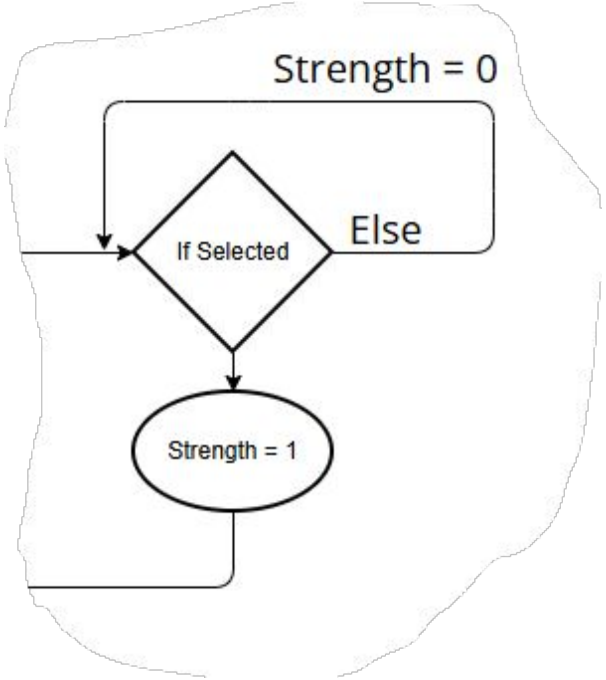
Vodka/Sprite
Count Up
Sprite_Count
Drink1
Whiskey/Coke
Count Up
Coke_Count
Drink2



Start
If Selected
Else
Drink = 0
Drink = 1
Increment Mixer_Count



Single
1Shot
Double
2Shot



Strength = 0
If Selected
Else
Strength = 1

Automation: Drink Selection

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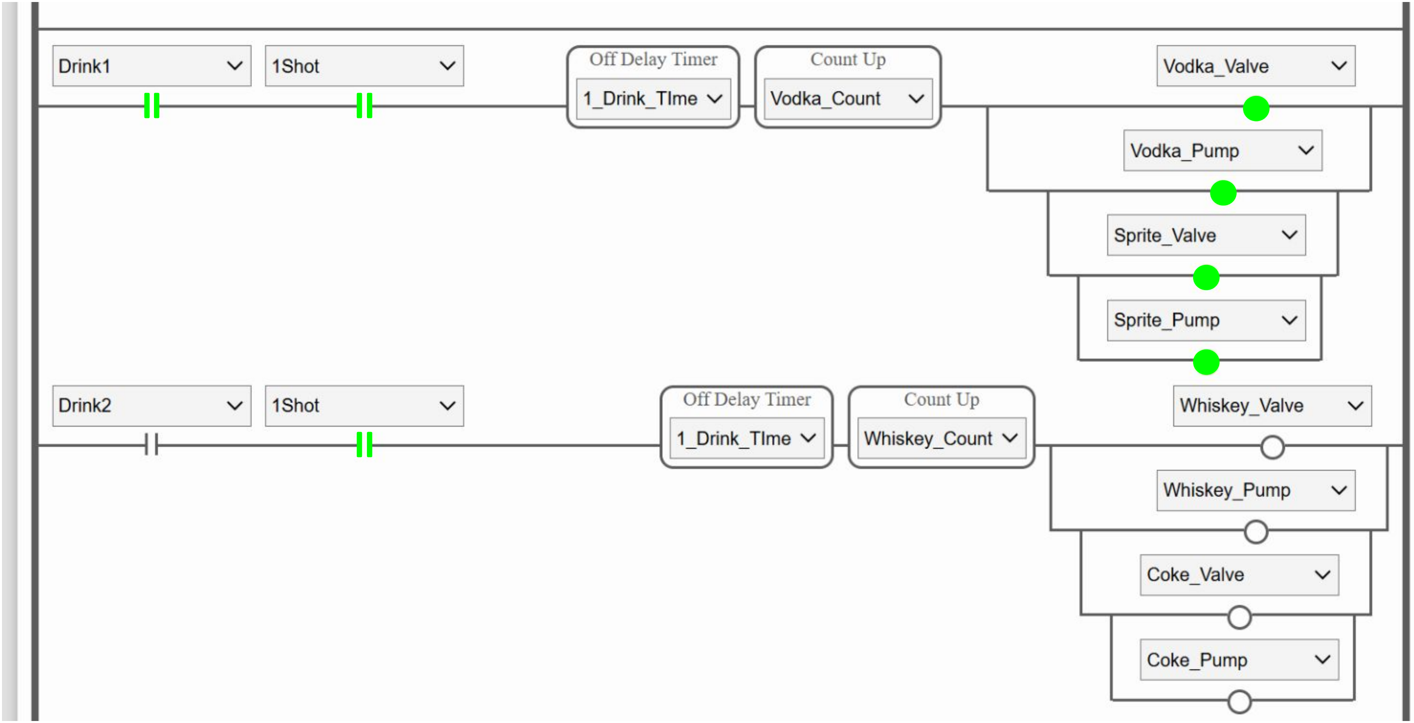

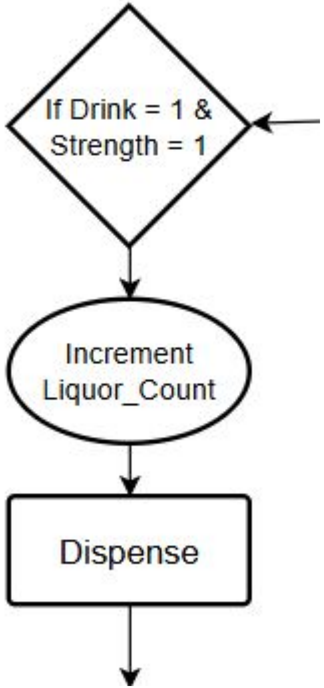

Automation: Alarm System

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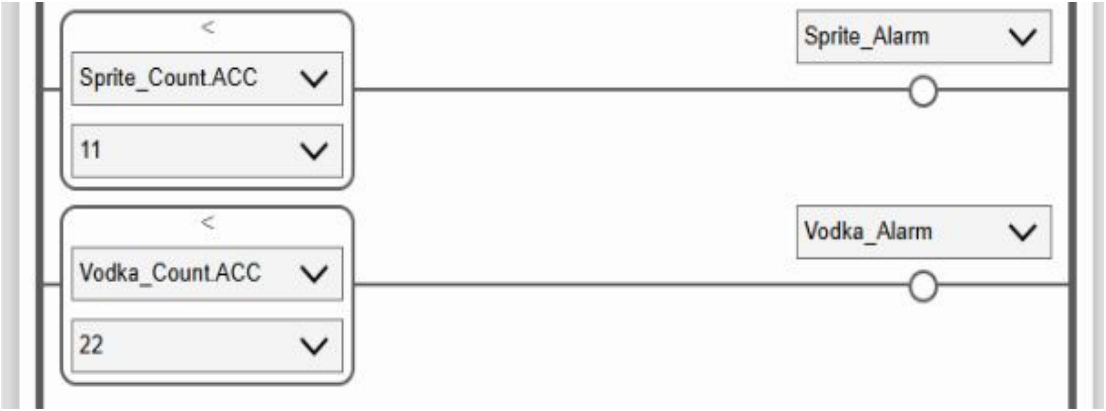
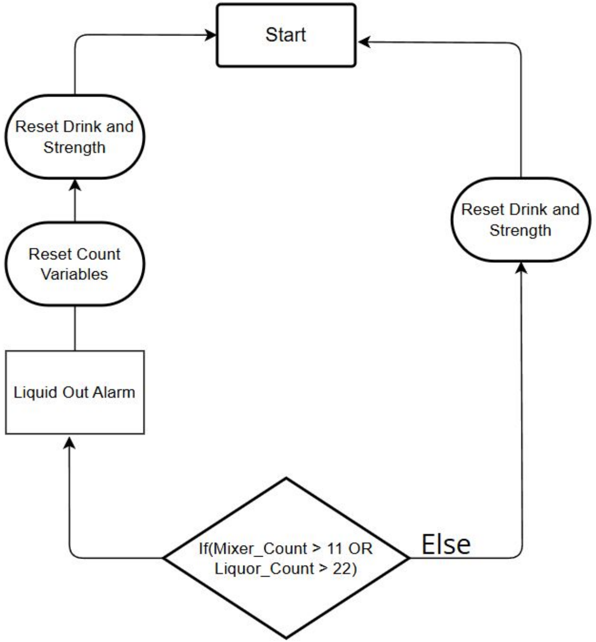




Concept Generation:

1. Standard shot size: **45 mL**
2. 24 VDC peristaltic pump: **1000mL/min**
3. Dispensing method: **PLC timer for accuracy**

Pump runtime: 2.7 seconds

Calculation

Soda Volume: $6\ oz$

Alcohol Volume: $1.5\ oz$

$$Tubing\ Length = 4\ ft$$

$$Tube\ Diameter = \frac{1}{4}''$$

$$Tube\ Volume = \pi \cdot \left(\frac{d}{2}\right)^2 \cdot L$$

$$Priming\ Time = \frac{Tubing\ Volume}{FlowRate}$$

$$Priming\ Time = 2.25\ sec$$

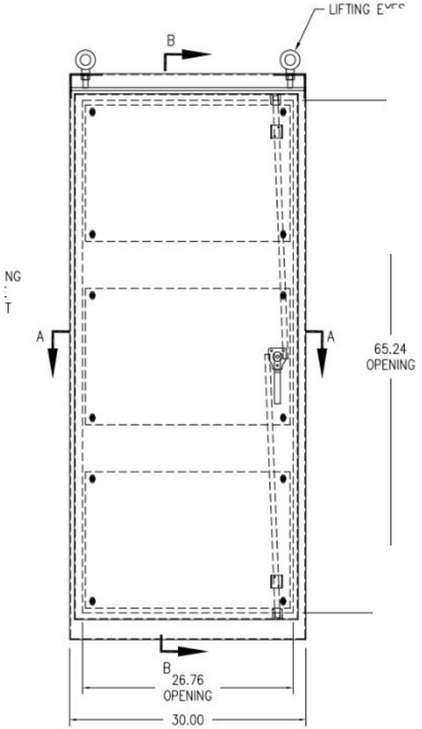
Calculation

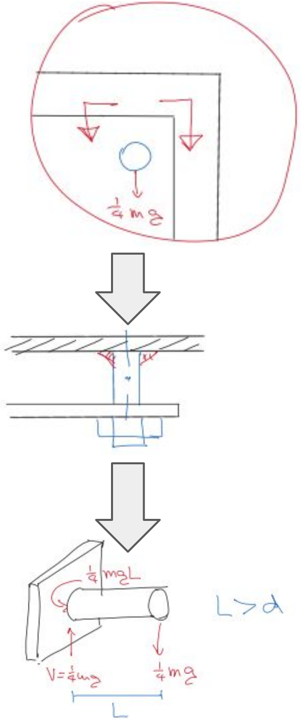
$$Dispensing\ Time = \frac{\text{Total}\ \ Volume}{FlowRate}$$

$$Dispensing\ Time = 10.2\ sec$$

$$Total\ Time = Priming\ Time + Dispensing\ Time$$

$$\boxed{Total\ Time = 12.45\ sec}$$





Bending Stress

$$\sigma_b = \frac{M}{\frac{\pi}{64}d^4} = \frac{32(\frac{1}{4}mgL)}{\pi d^3} = \left(8\frac{L}{d}\right)\left(\frac{mg}{\pi d^2}\right) = 1615\ psi$$

Shear Stress

$$\tau_v = \frac{4V}{3A} = \frac{4\left(\frac{1}{4}mg\right)}{3\left(\frac{\pi}{4}d^2\right)} = \frac{4}{3}\frac{mg}{\pi d^2}$$

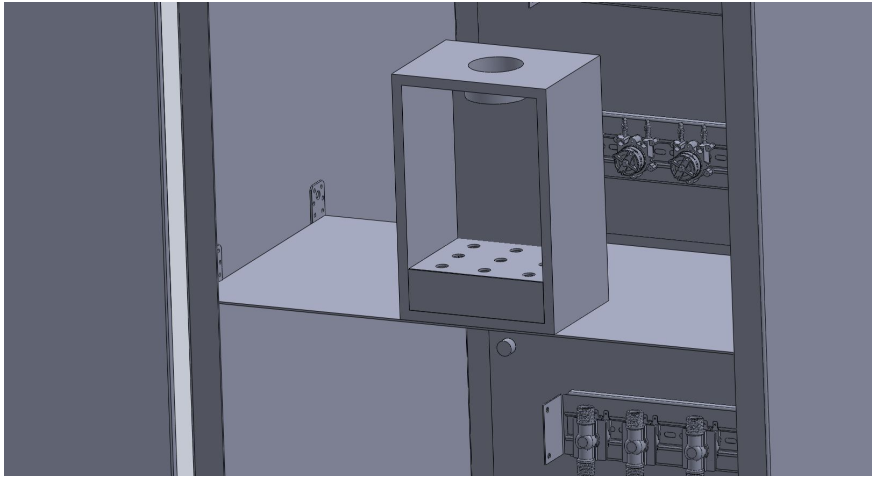
If $L > \frac{1}{6}d$ $(1in > \frac{1}{6}\cdot 0.38)$, then $\sigma_b > \tau_v$ $\left(21.05\frac{mg}{\pi d^2} > 1.33\frac{mg}{\pi d^2}\right)$ meaning σ_b is the critical stress.

Bending Stress (σ_b) vs Yield Strength (S_y)

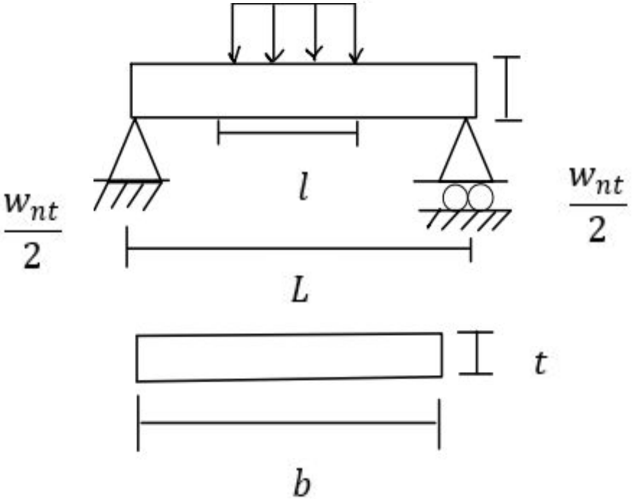
$$1615\ psi < 30{,}0000\ psi$$

F.S.: Factor of Safety

$$\frac{S_y}{\sigma_b} = F.S. = 18.57$$



$$q(x) = \frac{w_{nt}}{l}$$



$$EI\frac{d^4v}{dx^4} = q(x) \qquad (1 - D\ beam)$$

Bending stress on Shelf

Maximum Moment

$$M_{max} = M\left(\frac{L}{2}\right) = \frac{-2\,w_{nt}L^2 - 6w_{nt}Ll - 3w_{nt}l^2}{16l} = 97.92\ lbf - in$$

Moment of Inertia

$$I = \frac{1}{12}bt^3 = 1.563 \times 10^{-2} in^4$$

Maximum Bending Stress

$$\sigma_{b,max} = \frac{M_{max}\left(\frac{t}{2}\right)}{I} = 783.08\ psi$$

Bending Stress ($\sigma_{b,max}$) vs Yield Strength (S_y)

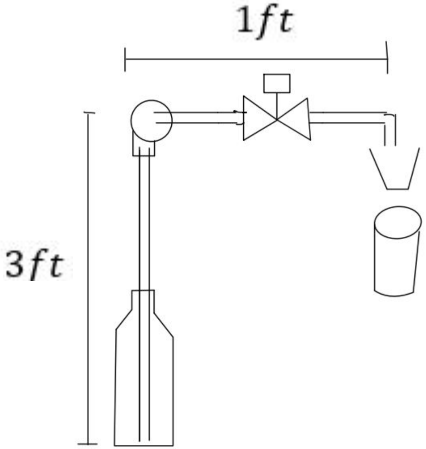
$$783.08\ psi < 40{,}000\ psi$$

F.S.: Factor of Safety

$$\frac{S_y}{\sigma_b} = F.S. = 51.09$$

Head loss (Orange Juice)

Speaker Name **Myles Bourgeois** Prepared By: **Myles Bourgeois**



Brenoulli's Equation

$$\frac{1}{2}\rho v_1^2 + p_1 + \rho g z_1 = \frac{1}{2}\rho v_2^2 + p_2 + \rho g z_2$$

Head of Pump

$$h_{\text{pump}} = \left(1 + f\frac{L}{D} + K_L\right)\frac{v^2}{2g} + (z_2 - z_1) = 6.88\ ft$$

Renolds Number

$$Re = \frac{\rho v D}{\mu} = 157.8$$

Fricton Factor for Laminar Flow

$$f = \frac{64}{Re} = 0.406$$

Volumetric Flow Rate

$$\dot{Q} = \frac{\pi}{4}D^2 v = 1.727\ ft/s$$

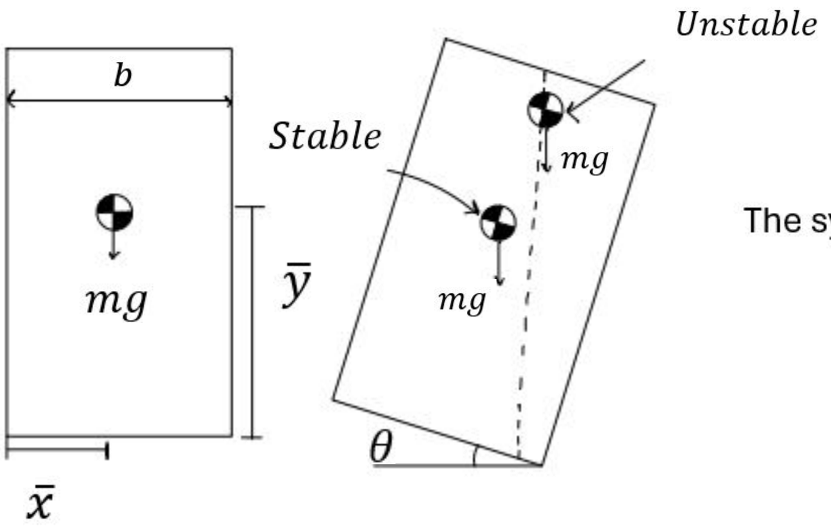
Pump Power

$$P_{\text{pump}} = \frac{h\dot{Q}SG}{3956} = 6.44x10^{-4}hp$$

$$8.04x10^{-4} > 6.44x10^{-4}hp$$

Head loss (all Fluids)

Head Loss of Fluids					
	Velocity (ft/s)	**Reynolds Number**	**Friction Factor**	**Head Pump (ft)**	**Power Pump (hp)**
Mixers					
Orange Juice	1.726683946	157.8151994	0.405537618	6.676327049	0.00062506
Sprite	1.726683946	2895.004624	0.022107046	3.257488121	0.00022649
Coke	1.726683946	2895.004624	0.022107046	3.257488121	0.00022649
Alcohol					
Whiskey	1.726683946	2641.243067	0.024231015	3.276426381	0.000207507
Tequila	1.726683946	3166.964175	0.020208628	3.240560974	0.000205236
Vodka	1.726683946	2895.004624	0.022107046	3.257488121	0.00022649

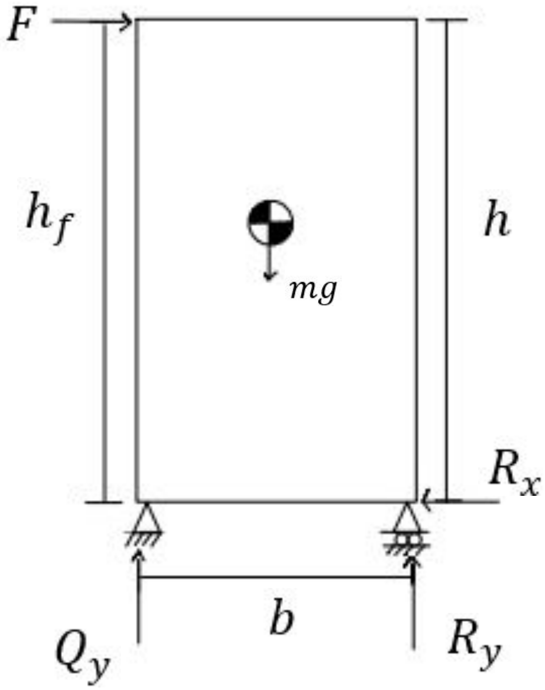


Critical Angle

$$\theta_c = \arctan\left(\frac{b}{2\bar{y}}\right) \quad (\text{if } \bar{x} = \frac{b}{2})$$

The system is stable if $\theta < \theta_c$ with $\bar{y} = \frac{\sum m_i \bar{y}_i}{\sum m_i}$

$$\theta_c = \arctan\left(\frac{b}{2\bar{y}}\right) = 23^o$$



Sum of the Moments

$$\Sigma M_R = 0: -Q_y b - F h_f + mg\left(\frac{b}{2}\right) = 0$$

$$6Q_y + F h_f = \frac{1}{2}$$

if F is big enough, at some point $Q_y = 0$

Critical Force

$$F_c = \frac{6}{2h_f} mg = 83.3lbf$$

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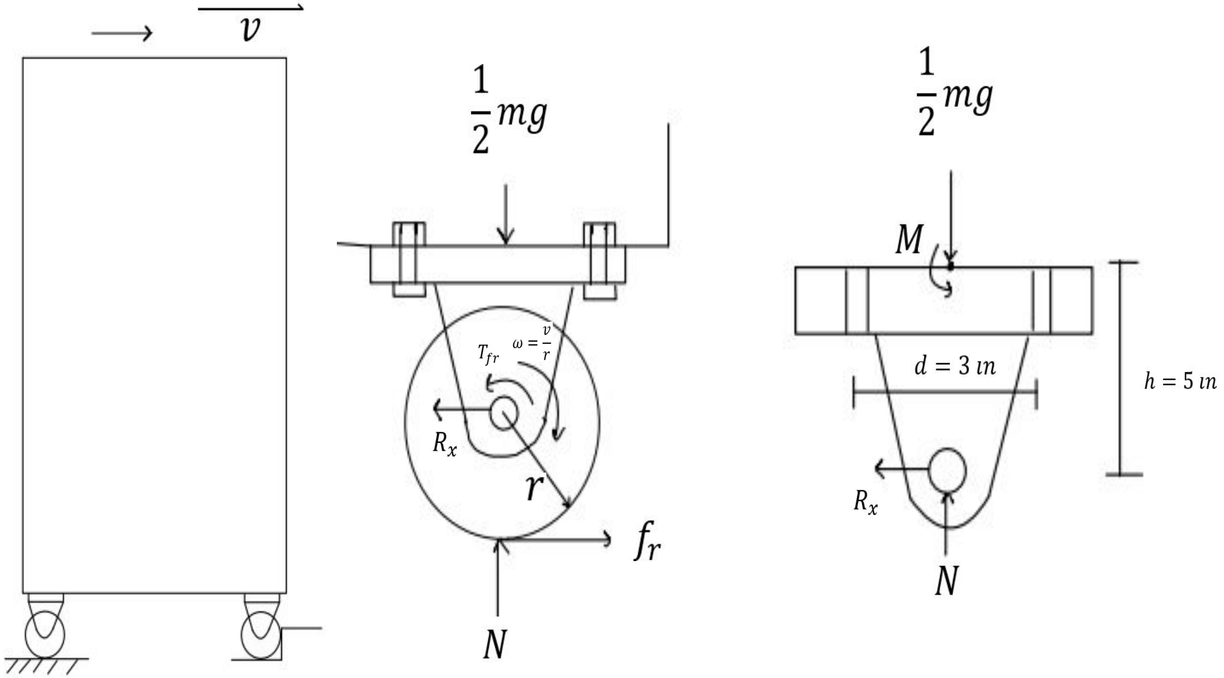

$$M - R_x h = 0$$

$$R_x = \mu N = \frac{1}{2}\mu \cdot m \cdot g = 200\ lbf$$

$$M = \frac{1}{2}\mu \cdot m \cdot g \cdot h$$

$$F = \frac{1}{2d} M = 166.67\ lbf$$

Stress

$$\sigma = \frac{F}{A} = 1509\ psi$$

Shear Stress

$$\tau = \frac{4R_x}{3A} = 7243\ psi$$

Principal Stress

$$\sigma_{1,2} = \frac{\sigma}{2} \pm \sqrt{\frac{\sigma^2}{4} + \tau^2} = 8037\ psi$$

Principal Stress(σ_1) vs Yeild Strength (S_y)

$$8037\ psi < 130{,}000\ Psi$$

Factor of Saftey

$$F.S. = \frac{S_y}{\sigma_1} = 16.18$$

Power Supply

Speaker Name **Connor Regard** Prepared By: **Connor Regard**

24 VDC 480 W Power Supply

12 VDC 120 W Power Supply

Allen Bradley CompactLogix

- 24V DC
- Ethernet/IP
- Ladder Logic (Studio 5000)

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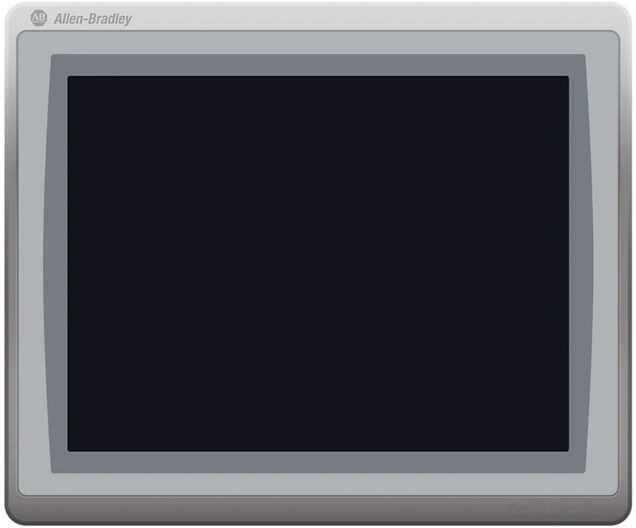
Speaker Name **Cade Farragut** Prepared By: **Cade Farragut**



PanelView Plus 7 (15’)

- 24V DC
- Ethernet
- FactoryTalk View ME (RsLinx)

Cooling System

AC Infinity AIRFRAME T7 Black

- 12 Volts
- 200 Cubic Feet per Minute (CFM)
- Aluminum
- 17''
  - 16.5"L x 6.5"W x 2.3"H

YETI® TUNDRA™ SERIES										
SIZE	WEIGHT (lbs)	OUTSIDE DIMENSIONS			SECONDARY DIMENSIONS			INSIDE DIMENSIONS		
		L1	W1	H1	L2	W2	H2	L3	W3	H3
Tundra™ 35	17 lbs	21	15 1/2	15 1/2	20 1/2	14	10 1/2	14 5/8	10 1/2	11 1/4
Tundra™ 45	22 lbs	25 1/2	15 1/2	15 1/2	25	14	10 1/2	18 7/8	10 5/8	11 1/2
Tundra™ 50	25 lbs	24 1/4	17 1/2	18 1/8	23 1/4	14 7/8	13 1/2	17 3/8	11 1/8	13 1/8
Tundra™ 65	27 lbs	30 1/2	17 1/8	16 1/4	29 1/4	14 13/16	11 1/2	24 3/8	12	12
Tundra™ 75	30 lbs	33 1/2	18	17 7/8	32 1/4	15 1/4	13 1/2	26 3/8	11 5/8	12 1/4
Tundra™ 85*	32 lbs	35	17 1/8	17 1/2	34 5/8	15 1/2	13	28 3/4	12	13 7/8
Tundra™ 105	33 lbs	30 1/2	19	19 3/4	29 1/8	16 7/8	15 3/8	23 3/4	13 5/8	15 5/16
Tundra™ 120	39 lbs	40	19 1/8	17 3/4	39 1/2	17 1/2	13	33 5/8	13 7/8	13 7/8
Tundra™ 155	45 lbs	44	19 1/8	21 1/4	43 1/4	17 1/2	16 1/4	37 1/2	13 7/8	17 1/4
Tundra™ 250	77 lbs	55	22	21 1/4	54	20 1/4	16 1/4	48 1/4	17	17 1/4

* Tundra™ 85 discontinued (low quantities available) and replaced with the Tundra™ 75

Yeti:Tundra 50

Outside Dimensions

- Length (L1): 24 1/4 inches
- Width (W1): 17 1/2 inches
- Height (H1): 18 1/8 inches

Secondary Dimensions

- Base Length (L2): 23 1/4 inches
- Base Width (W2): 14 7/8 inches

Inside Dimensions

- Length (L3): 17 3/8 inches
- Width (W3): 11 1/8 inches
- Height (H3): 13 1/8 inches

1. **Frame Preparation**
   - Build frame with C&I Enclosures
   - Cut frame for cup insert hole, fans, and other modifications
2. **Component Mounting**
   - Mount electronics on Back Panel 1
   - Mount pumps on Back Panel 2
   - Mount valves on Back Panel 3
   - *Mount interior shelf to the frame*
   - Weld drink dispensing part

1. **Frame Preparation**
   - Build frame with C&I Enclosures
   - Cut frame for cup insert hole, fans, and other modifications
2. **Component Mounting**
   - Mount electronics on Back Panel 1
   - Mount pumps on Back Panel 2
   - Mount valves on Back Panel 3
   - *Mount interior shelf to the frame*
   - Weld drink dispensing part

3. Accessories Installation

- Attach foldable side trays
- Add wheels/casters to the frame

4. Cooling System

- Install fans in designated slots
- Drill holes in cooler

5. Final Assembly

- Connect components (e.g., tubing, valves, electronics)
- Perform a wiring and system check to ensure functionality

Electrical Manufacturing

Speaker Name **Connor Regard** Prepared By: **Connor Regard**

1. **Component Preparation**
   - Gather electrical components
   - Reverse tag all wires and connectors for organization.
2. **Panel Assembly**
   - Mount electrical components

3. Subsystem Testing

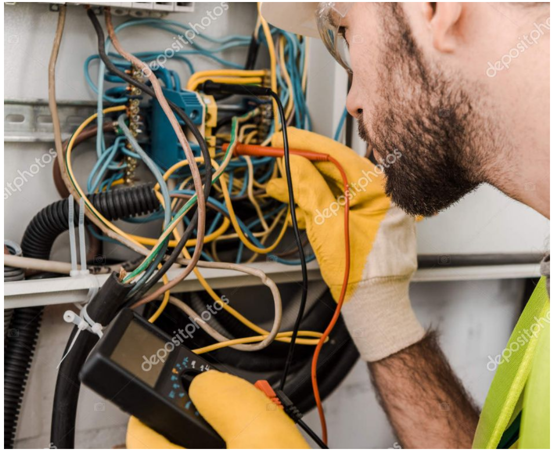
- Test power supplies and components

4. System Integration

- Connect the HMI to the PLC

5. Final Verification

- Perform safety checks
- Conduct a complete system test



Testing and Validation Plan

#	Item	Objective	Benchmark/Criteria
1	Code and Algorithms	Timing and error accuracy	No errors; response <1s
2	Pumps	Flow rate, response time	Flow deviation <5%
3	Emergency Stop	Safety functionality	Activates in <0.5s
4	Tube Connectors	Leak prevention	No leaks
5	Cooler	Maintain temperature	35°F ±5°F for 6 hours

#	Item	Objective	Benchmark/Criteria
6	HMI Button	Interface response	Response <0.5s, clear display
7	Valves	Flow control, response	Opens/closes in <1s
8	Fluid Handling	Integrated dispensing	Completes in <15s per drink
9	Mobility Test	Stability, portability	No tipping; smooth movement
10	System Validation	Full-system performance	Runs 4 hrs without error

Safety Considerations

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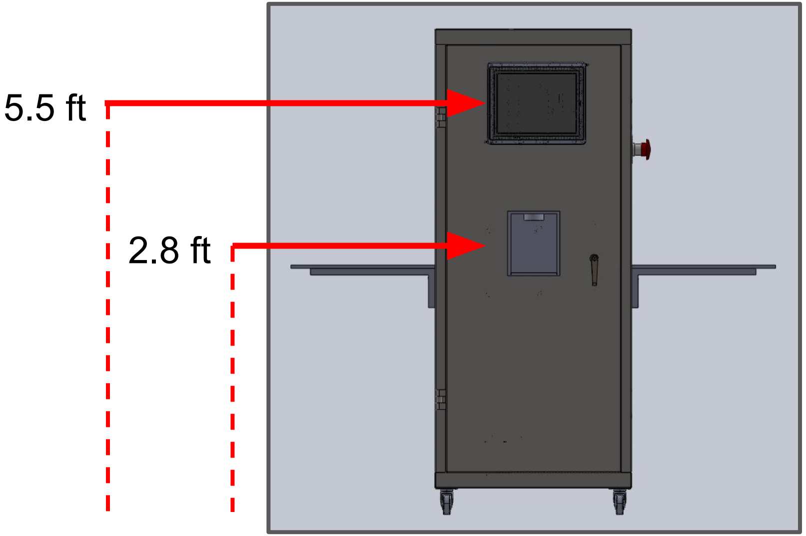
Key Safety Features	Purpose
Overheating Prevention	Maintains safe temperature
Emergency Stop (E-Stop)	Enables quick shutdown
Overload Protection	Guards against power surges

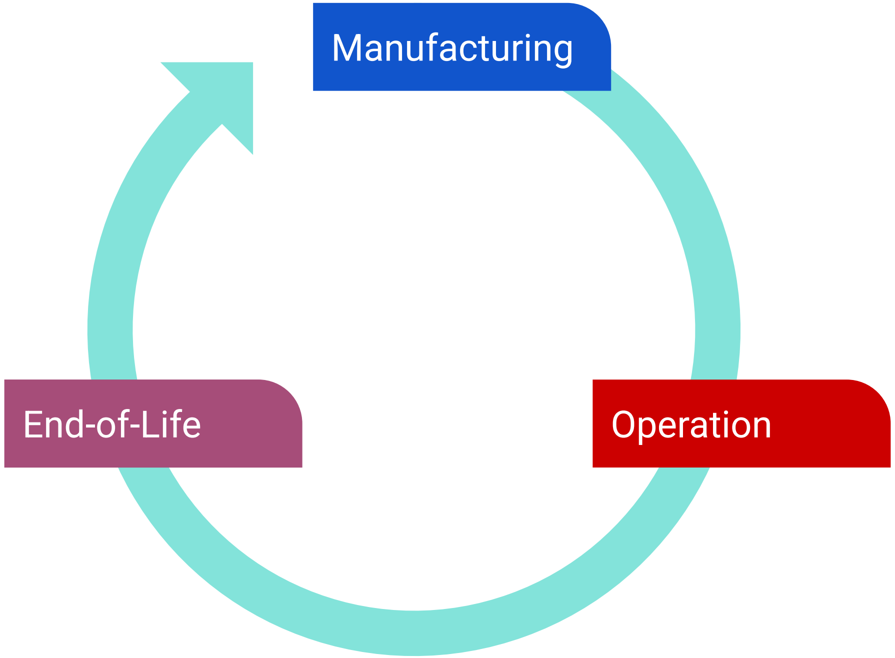
Safety Considerations



Key Safety Features	Purpose
All Flush System	Ensures hygiene and removes contaminants
Leak-Proof Tubing	Prevents fluid spills
Ergonomic Design	Reduces user strain

Environmental Impact Assessment

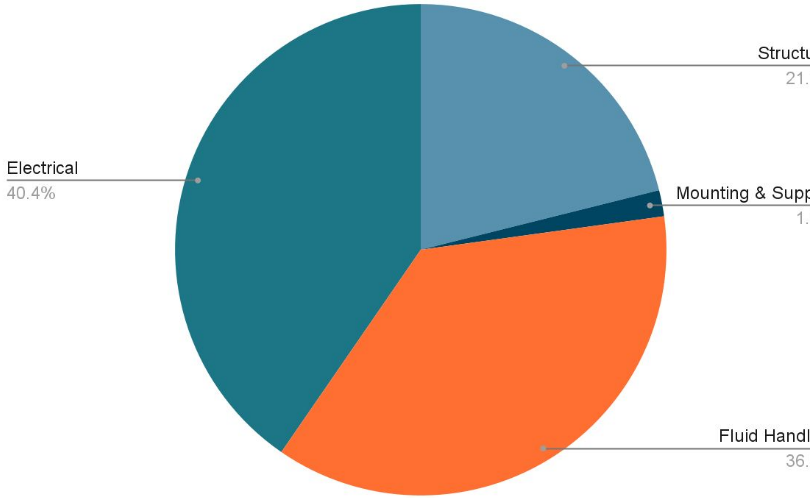
- 304 Stainless Steel
- **Minimize energy usage during production**



- Components can be recycled
- **Potential reuse of components for future projects**

- **Optimized cooling system to reduce power usage**
- Energy-efficient electronic components

Category	Items	Price (Total)
Structural Components	Frame, shelves, wheels, ect.	$700
Mounting & Support Hardware	Mounts, screws, DIN Rail, ect.	$57
Fluid Handling Components	Pumps, valves, cooler, ect.	$1,220
Electrical Components	PLC, Breaker, Disconnect, ect.	$1,340
Total		**$3,330**



Project Management: Budget breakdown

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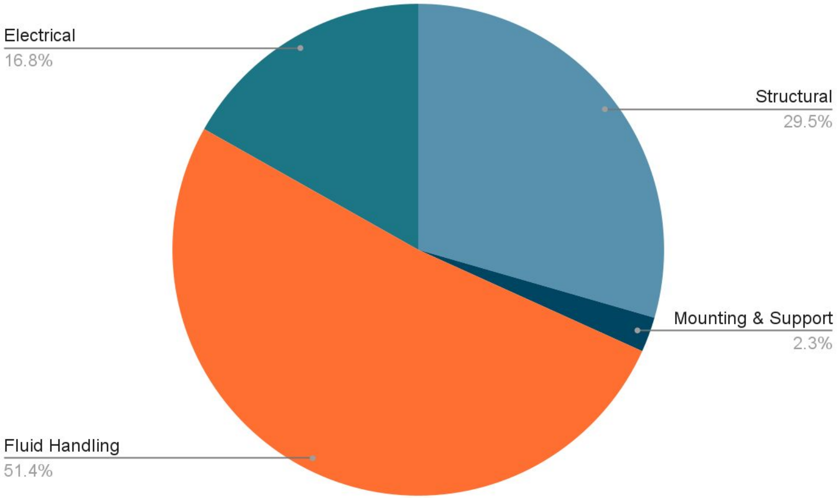
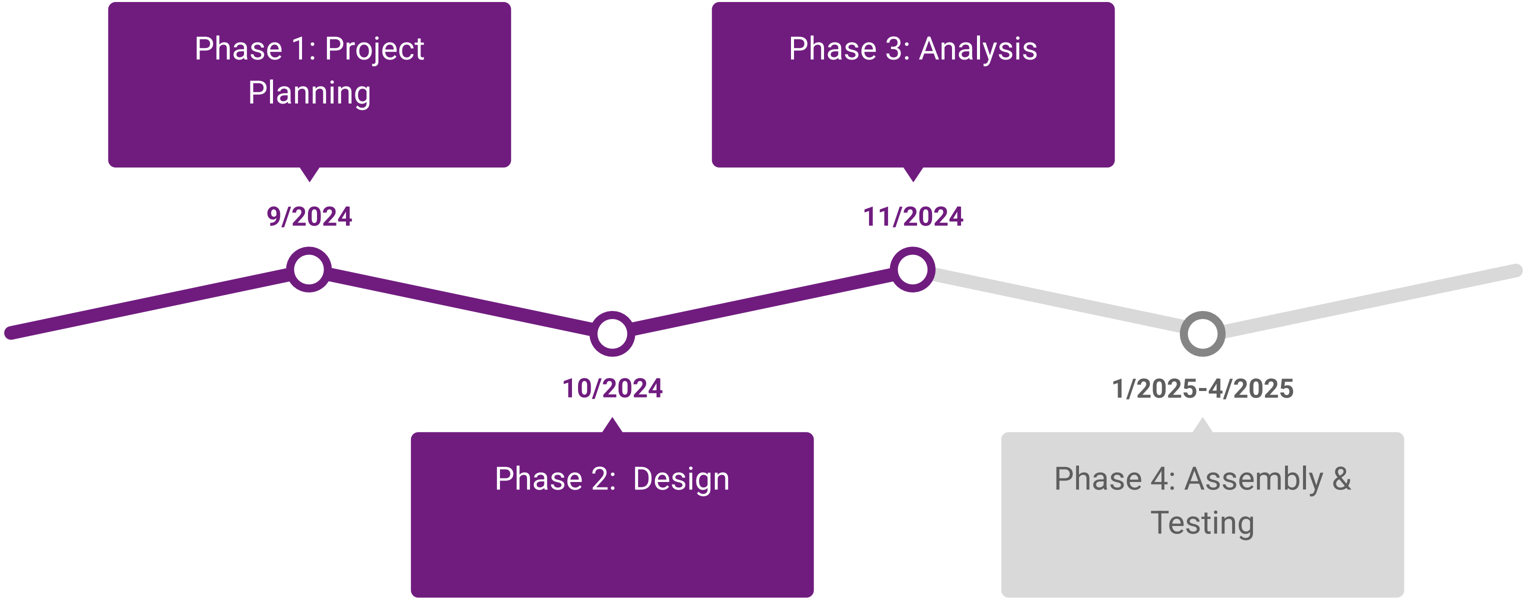
Category	Items	Price (Total)
Structural Components	Frame, shelves, wheels, ect.	$700
Mounting & Support Hardware	Mounts, screws, DIN Rail, ect.	$57
Fluid Handling Components	Pumps, valves, cooler, ect.	$1,220
Electrical Components	PLC, Breaker, Disconnect, ect.	$400
Total		**$2,377**





Phase 1: Project Planning
9/2024
Phase 3: Analysis
11/2024
10/2024
Phase 2: Design
1/2025-4/2025
Phase 4: Assembly & Testing

Project Management: Brief Timeline (major milestones)

Speaker Name **Christopher Hall** Prepared By: **Christopher Hall**

Phase One: Project Planning		
Task	**Date**	**Status**
Define Project Objectives	9/16/24	Complete
Identify Similar Projects/Systems	9/15/24	Complete
Establish Team Roles	9/20/24	Complete
Compile Research Summary	9/25/2024	Complete
Develop Project Timeline	9/30/2024	Complete

Project Management: Brief Timeline (major milestones)

Phase Two: Design		
Task	**Date**	**Status**
Define Key Functional Requirements	10/2/2024	Complete
Select Materials and Components	10/10/2024	Complete
Create 3D model	10/15/2024	Complete
Review Design with Sponsor	10/25/2024	Complete
Finalize Design	10/30/2024	Complete

Phase Three: Analysis		
Task	**Date**	**Status**
Perform Structural Analysis	11/1/2024	Complete
Conduct Power Analysis	11/3/2024	Complete
Thermal Analysis	11/5/2024	Complete
Determine Safety Factors	11/6/2024	Complete
Modify Design Based on Results	11/8/2024	Complete

Project Management: Brief Timeline (major milestones)

Phase Four: Assembly + Testing		
Task	**Date**	**Status**
Order Components	1/2025	In Progress
Build Prototype	2/2025	Upcoming
Test System Performance	2/2025 - 3/2025	Upcoming
Optimize Design	3/2025	Upcoming
Prepare Final Documentation & Testing	4/2025	Upcoming

Assembly/Parts Drawings
Frame

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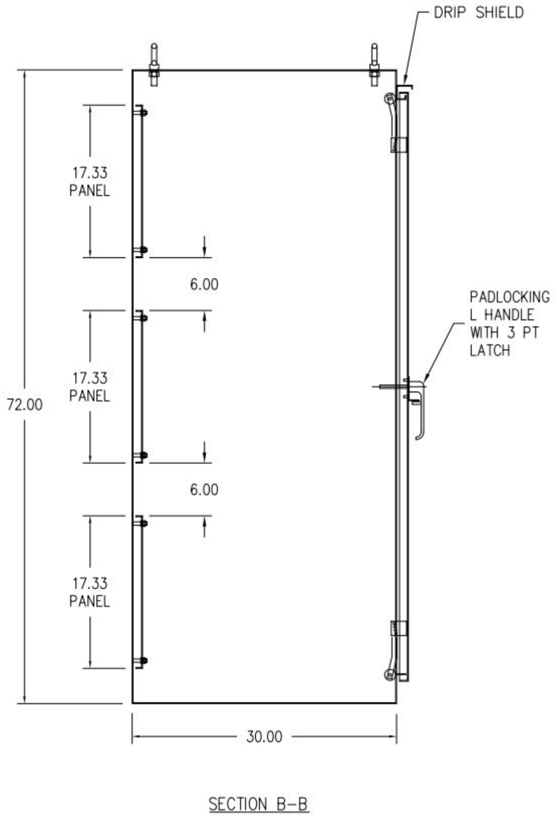
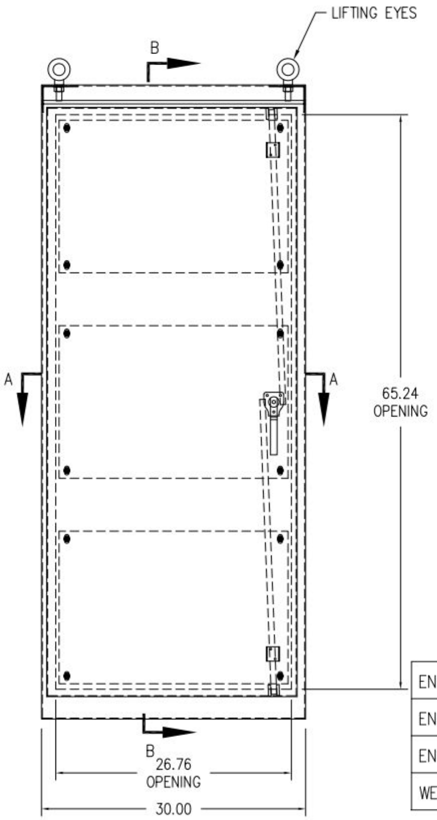
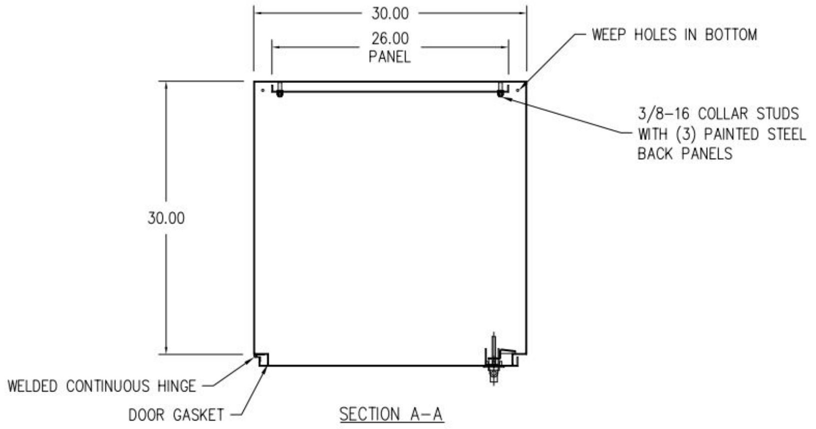
Speaker Name **Christopher Hall** Prepared By: **Christopher Hall**

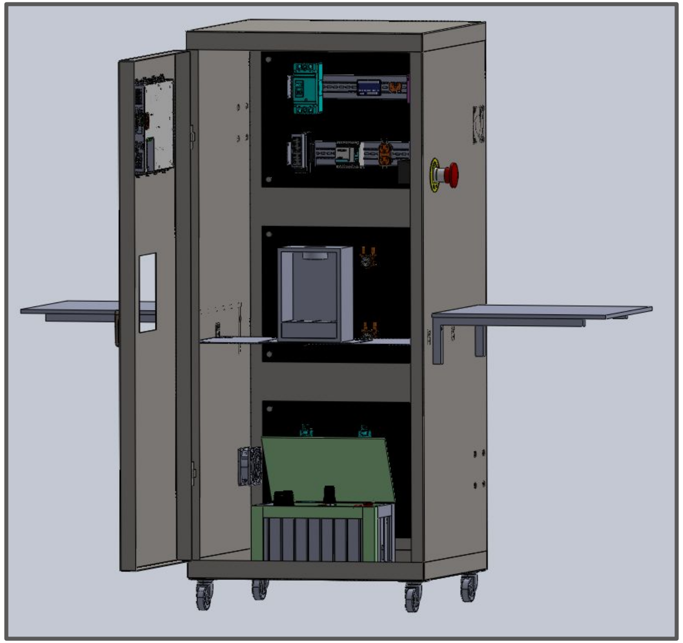


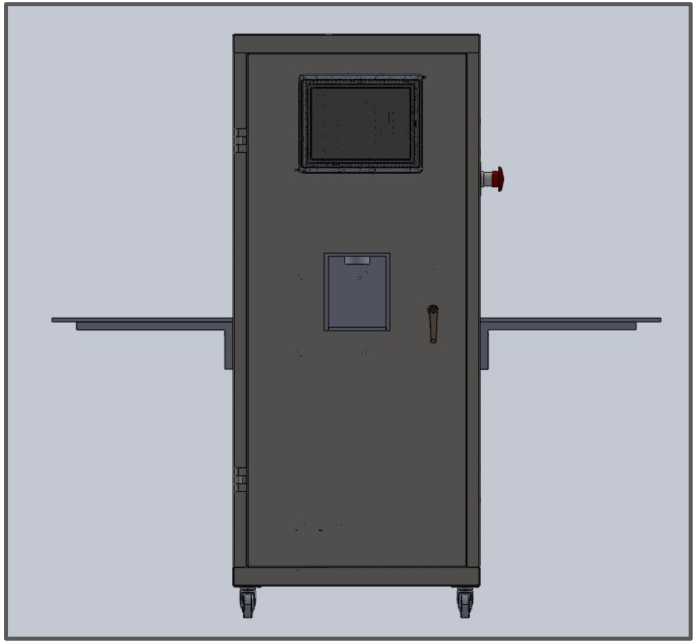




ENCLOSURE MATERIAL: TYPE 304 STAINLESS STEEL	DOOR OR COVER GASKET: YES
ENCLOSURE MATERIAL GAUGE: 12	PANEL INCLUDED: YES
ENCLOSURE FINISH: NO PAINT, BRUSHED OUTSIDE	PANEL MATERIAL: 12 GAUGE HRS
WELD: FULLY WELDED AND GROUND SEAMS	PANEL FINISH: WHITE POWDERCOAT
	CATALOG NO:

Thank You!



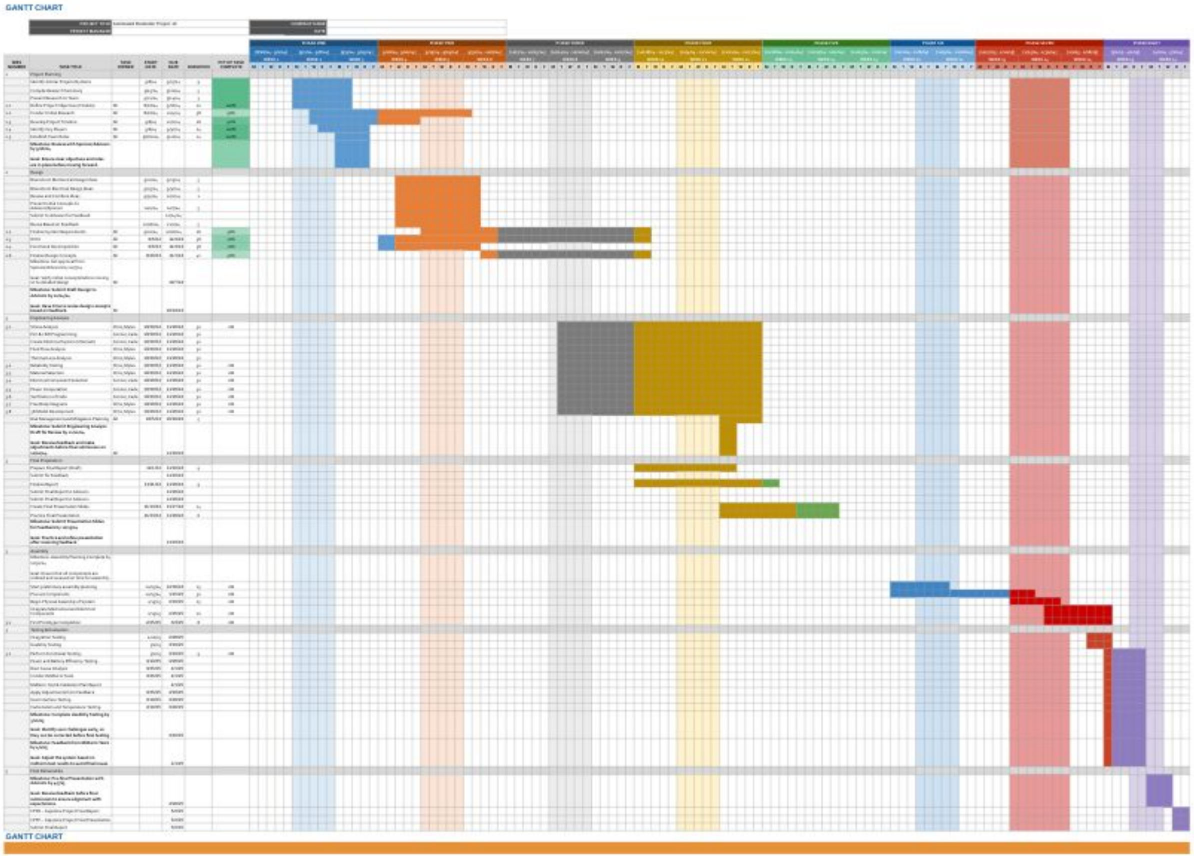


Appendix I

Table of Contents

Future Considerations

- Incorporating Sensors
  - Measure level of fluid
  - Cup Detection
- Adding caps to prevent carbonation loss
- Adding a check valve to prevent backflow
- Removing the interior shelf and bolting the drink dispenser to the door
- Fitted bushing insert in the drilled holes from the cooler

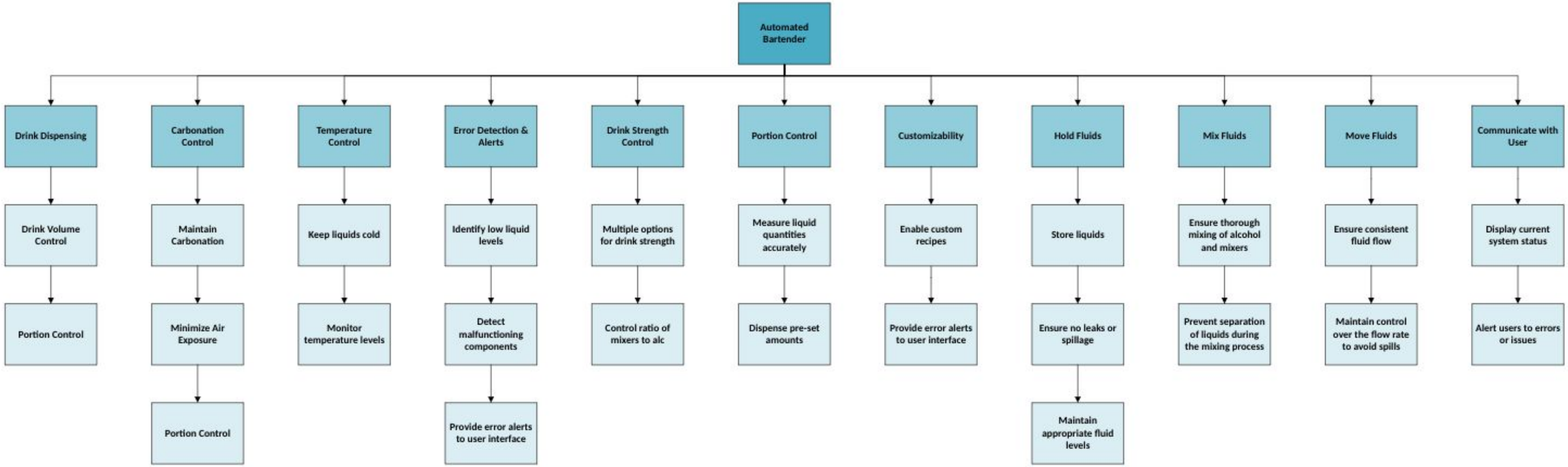

GANTT CHART
GANTT CHART

Title: p10 - Automated Bartender HOQ
Author: Connor Regard, Myles Burgeois, Christopher Hall, Cade Farragut
Date: 9/17/2024
Notes:

Legend		
S	Strong Relationship	9
M	Moderate Relationship	3
W	Weak Relationship	1
PP	Strong Positive Correlation	
P	Positive Correlation	
N	Negative Correlation	
NN	Strong Negative Correlation	
↓	Objective Is To Minimize	
↑	Objective Is To Maximize	
⊗	Objective Is To Hit Target	

Row #	Max Relationship Value	Relative Weight	Weight / Importance	Functions & Qualitative Constraints (Whats) / Quantitative Constraints ("Hows")	1 [illegible]	2 Durability	3 Modularity	4 Safety and Hygiene	5 Portability	6 Cost Efficiency	7 [illegible]	8 Automation	9 Energy Efficiency	10 Customizability	11	12	13	14	15	Our Company	BLACK+DECKER bev Cocktail	Bartesian Professional Cocktail	Barsys 360
				Direction of Improvement: Minimize (↓), Maximize (↑), or Target (⊗)	↑	↑	↑	↑	↑	↓	↑	↑	↑	↑						Competitive Analysis (0=Worst, 5=Best)			
1	48	16.5	0.15	Drink Dispensing	S	M	W	S	S	W	W	S	W	S						0	4	5	5
2	46	11.0	0.10	Carbonation Control	S	S	S	S	M	W	M	S	M	W						0	4	2	3
3	38	11.0	0.10	Temperature Control	W	S	W	M	S	W	S	M	S	W						0	5	5	3
4	30	8.8	0.08	Error Detection & Alerts	W	M	S	S	W	W	W	M	W	M						0	4	5	3
5	35	5.5	0.05	Drink Strength Control	W	M	W	M	S	S	W	S	M	S						0	3	3	5
6	34	11.0	0.10	Portion Control	S	S	M	S	W	S	W	S	M	W						0	5	5	5
7	29	8.8	0.08	Customizability	W	W	S	M	W	S	W	S	S	M						0	3	5	4
8	31	5.5	0.05	Hold Fluids	W	S	S	S	M	M	M	W	M	W						0	4	2	3
9	31	5.5	0.05	Mix Fluids	W	M	M	S	M	M	W	S	M	S						0	4	2	3
10	31	7.7	0.07	Move Fluids	M	M	S	W	M	S	W	S	S	W						0	4	2	3
11	31	8.8	0.08	Communicate with User	S	W	W	W	M	M	W	S	W	S						0	4	2	3
				Target or Limit Value for Quantitative Specs	1	3+	Easy Replaceable Components	Food-Grade Materials	<100 lbs	[illegible]	[illegible]	[illegible]	[illegible]	Customizable Recipes									
				Difficulty (0=Easy, 10=Extremely Difficult)	5	4	3	9	8	6	7	10	7	6									
				Max Relationship Value	27	20	18	20	18	24	18	22	18	20									
				Weight / Importance	0.20	0.20	0.05	0.10	0.05	0.20	0.10	0.10	0.10	0.10									
				Relative Weight	5.4	4.0	0.9	2.0	0.9	4.8	1.8	2.2	1.8	2.0									

Modified from QFD Online (http://www.QFDOnline.com)


Automated Bartender
Drink Dispensing
Drink Volume Control
Portion Control
Carbonation Control
Maintain Carbonation
Minimize Air Exposure
Portion Control
Temperature Control
Keep liquids cold
Monitor temperature levels
Error Detection & Alerts
Identify low liquid levels
Detect malfunctioning components
Provide error alerts to user interface
Drink Strength Control
Multiple options for drink strength
Control ratio of mixers to alc
Portion Control
Measure liquid quantities accurately
Dispense pre-set amounts
Customizability
Enable custom recipes
Provide error alerts to user interface
Hold Fluids
Store liquids
Ensure no leaks or spillage
Maintain appropriate fluid levels
Mix Fluids
Ensure thorough mixing of alcohol and mixers
Prevent separation of liquids during the mixing process
Move Fluids
Ensure consistent fluid flow
Maintain control over the flow rate to avoid spills
Communicate with User
Display current system status
Alert users to errors or issues

Category	Item	Qty	Price (per unit)	Weight (lbs)	Material	Link to Buy	Price (Total)
Structural Components	REYNOLDS 17" (H) X 30" (W) PAINTED STEEL, BACK PANEL	3	0	20			$0.00
Structural Components	Side Shelves	2	116.47	8.0		Side Shelves	$232.94
Structural Components	Folding Shelf Brackets	2	30	6	Steel	Shelf Brackets	$60.00
Structural Components	Drip Tray	1	28.49	10.0		Rubber Drip Tray	$28.49
Structural Components	Frame for Drink Dispenser	1	63.33		Steel	Aluminum 36 x 24	$63.33
Structural Components	Cup Holder	6	35	14.8		Cup Holder Link	$210.00
Structural Components	Casting wheels	4		32.0			$0.00
Structural Components	Interior Shelf	1	87.41		Aluminum	Aluminum Plate	$87.41
Structural Components	L Bracket	1	26.99			L Bracket	$26.99
Structural Components	REYNOLDS 72" (H) X 30" (W) X 30"(D) SS, CUSTOM ENCLOSURE	1	0	350	304 SS		$0.00
Mounting & Support Hardware	Pump Mounts	6					$0.00
Mounting & Support Hardware	U Bolts for Valves	6	5.7		black-oxide steel	Valve Mount	$34.20
Mounting & Support Hardware	Phoenix Contact UT 2.5 Terminal Block					Terminal Block	$0.00
Mounting & Support Hardware	Phoenix Contact UT 2.5 Ground Terminal Block					Ground Terminal Block	$0.00
Mounting & Support Hardware	M4 Screws	1	23.61			M4	$23.61
Mounting & Support Hardware	Allen Bradley 1492-DR8 DIN rail	2		5		DIN Rail	$0.00
Miscellaneous	2" PANDUIT						$0.00
Fluid Handling Components	Cooler with 25 qrts of ice in it	1	350	78.0			$350.00
Fluid Handling Components	tubing (ft)	50	0.53	2.0	PVC	Tubing Link	$26.50
Fluid Handling Components	fittings	1	6.17		Nylon Plastic	Fittings Link	$6.17
Fluid Handling Components	check valves	6	8.22	0.1		Check Valve Link	$49.32
Fluid Handling Components	Peristaltic Pump	6	110	1.6		Pumps Link	$660.00
Fluid Handling Components	Universal Liquid Pourer	1	18			Liquid Pourer	$18.00
Fluid Handling Components	Hose Clamps	1	8			Hose Clamps	$8.00
Fluid Handling Components	Hose to Pump Adaptper	6					$0.00
Fluid Handling Components	solenoid valve	6	17	0.1		Valve Link	$102.00
Electrical Components	Allen Bradley 1492-REC20G Receptacle	1	70.05			receptacle	$70.05
Electrical Components	ABB OT16F3 Disconnect Switch, 16A, 3-Pole, DIN Rail Mount	1	64			disconnect	$64.00
Electrical Components	Allen Bradley S201-C20, Single Pole, 20A Circuit Breaker	1	135.3			circuit breaker	$135.30
Electrical Components	Allen Bradley 800FD-NX2, Emergency Stop	1	113			estop	$113.00
Electrical Components	Phoenix Contact QUINT4-PS/1AC/24DC/20, 24VDC, 20A Power Supply.	1	770			24 VDC power supply	$770.00
Electrical Components	Mean Well DDR-120B-12	1				12 VDC power supply	$77.40
Electrical Components	Allen Bradley 1492-JG4 Terminal Block	A/R				terminal block	contact supplier
Electrical Components	Allen Bradley 1492-JG4 GND Terminal Block	A/R				ground block	contact supplier
Electrical Components	TRM1/10					0.1 A fuse	contact supplier
Electrical Components	BOJACK 5x20 mm Fuse Holder					fuse holder	$11.89
Electrical Components	Allen-Bradley CompactLogix 5069-L306ER	1	0			PLC Link	$0.00
Electrical Components	CompactLogix 5069-L306ER PLC, 16PT Digtial Input Card	1					$0.00
Electrical Components	CompactLogix 5069-L306ER PLC, 16PT Digtial Output Card	1					$0.00
Electrical Components	Allen Bradley, 700-HLT1Z24, Terminal Block Relay	1				Relay	$0.00
Electrical Components	JOURNEYMAN 10FT Outdoor outlet	1				Extension Cord	$39.97
Electrical Components	Fans	2	95.2			Fans	$190.40
Electrical Components	Allen-Bradley PanelView 7 Standard HMI	1	0			HMI Link	$0.00
Total				523.8			$3,458.97

References

References

Golf Tournament Picture
Tailgate Picture
Metal Cutter Picture
Welding Picture
Screwdriver
Drill Picture
Fan Picture
Fluid Densities
Fluid Viscosities
Ice Chest Dimensions

[1] Fox and McDonald’s Introduction to Fluid Mechanics (10th Edition)
[2] Mechanics of Materials" by Ferdinand P. Beer, E. Russell Johnston, Jr., John T. DeWolf, and David F. Mazurek
[3] Strength of Materials" by J. P. Den Hartog
[4] Introduction to Solid Mechanics" by Irving H. Shames and James M. Pitarresi

Total Time to get a Drink = Priming Time + Dispensing Time

Priming Time = Time for liquid to travel through the tube

Dispensing Time = Time for liquid to fill up cup

Soda Volume: $6\ oz\ =\ 177.44\ mL$

Alcohol Volume: $1.5\ oz\ =\ 44.36\ mL$

Total Volume: $177.44\ +\ 44.36\ =\ 221.80\ mL$

$$Dispensing\ Time\ =\ \frac{\text{Total}\ \ Volume}{FlowRate}$$

$$Dispensing\ Time\ =\ \frac{177.44}{17.32}\ =\ 10.2\ sec$$

$$Total\ Time\ =\ Priming\ Time\ +\ Dispensing\ Time$$

$$\boxed{Total\ Time\ =\ 2.25\ +\ 10.2\ =\ 12.45\ sec}$$

Priming Time

$$Tubing\ Length\ =\ 4\ ft\ \cdot\ 0.3048\ \frac{m}{ft}$$

$$Tubing\ Length\ =\ 1.22\ m$$

$$Tube\ Diameter\ =\ \frac{1}{4}''\ =\ 0.00635\ m$$

$$Tube\ Volume\ =\ \pi\ \cdot\ (\frac{0.00635}{2})^2\ \cdot\ 1.22$$

$$Tube\ Volume\ =\ \pi\ \cdot\ (\frac{0.00635}{2})^2\ \cdot\ 1.22$$

$$Tube\ Volume\ =\ 3.89\ \cdot\ 10^{-5}\ m^3$$

$$Tube\ Volume\ =\ 38.9\ \frac{mL}{s}$$

$$Priming\ Time\ =\ \frac{Tubing\ Volume}{FlowRate}$$

$$Priming\ Time\ =\ \frac{38.9}{17.32}\ =\ 2.25\ sec$$

Assembly/Parts Drawings HMI

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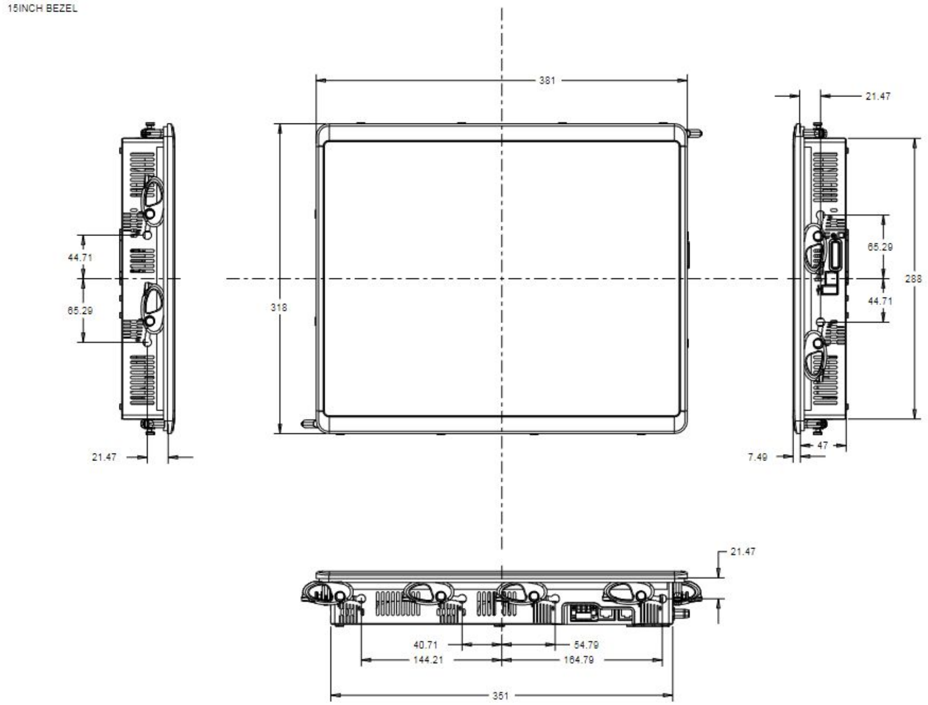

Assembly/Parts Drawings HMI

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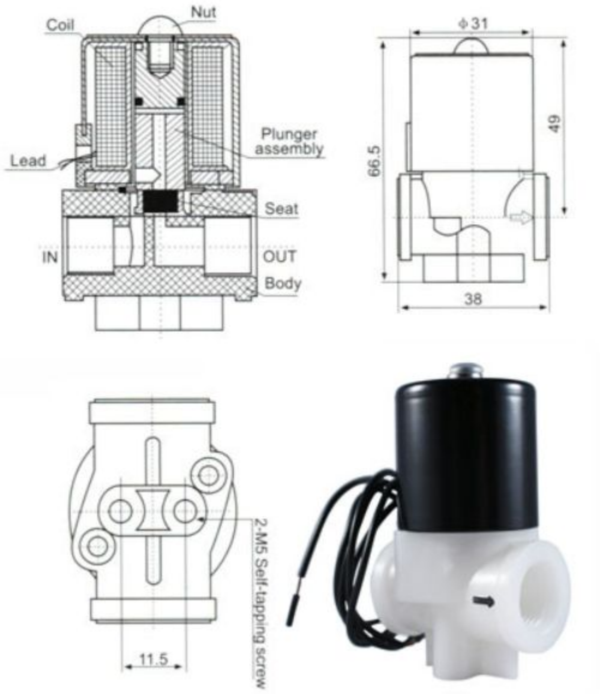

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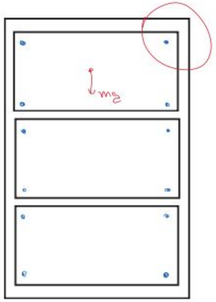
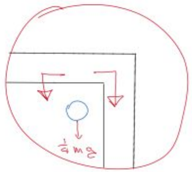
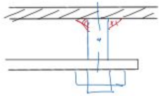
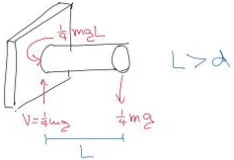
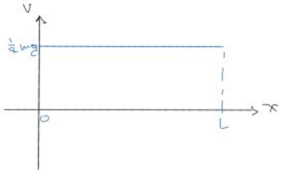




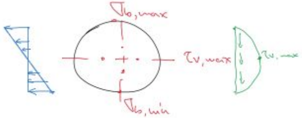


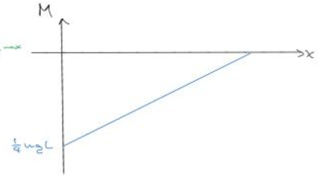




$$\sigma_b = \frac{M\left(\frac{d}{2}\right)}{\frac{\pi}{64} d^4} = \frac{32\left(\frac{1}{4}mgL\right)}{\pi d^3} = \frac{8mgL}{\pi d^3}$$

$$= \left(8\frac{L}{d}\right)\frac{mg}{\pi d^2}$$





$$\tau_v = \frac{4V}{3A} = \frac{4\left(\frac{1}{4}mg\right)}{3\,\frac{\pi}{4} d^2} = \frac{4mg}{3\pi d^2} = \frac{4}{3}\left(\frac{mg}{\pi d^2}\right)$$

$$\overset{2}{\cancel{8}}\frac{L}{d} > \frac{\overset{1}{\cancel{4}}}{3}$$

$$\Rightarrow \underset{21.05\frac{mg}{\pi d^2}}{\sigma_b} > \underset{1.33\frac{mg}{\pi d^2}}{\tau_v} \text{ if } \overset{1in}{L} > \frac{1}{6}\overset{(0.38)}{d} \Rightarrow \sigma_b \text{ is the critical stress.}$$

we need $\sigma_b < S_y$ $\qquad$ S_y: yield strength of bolt. $\sigma_b = 8\frac{1in}{0.38in}\frac{(19.8+15)lbf}{\pi(0.38in)^2} = 1615\,psi$

$$\Rightarrow \frac{S_y}{\sigma_b} = F.S. \qquad F.S.\text{: factor of safety} \qquad S_y = 30\,000\,psi$$

$$\sigma_b = \frac{S_y}{F.S.} \Rightarrow \frac{8mgL}{\pi d^3} = \frac{S_y}{F.S.} \Rightarrow F.S. = \frac{30\,000\,psi}{1615\,psi} = 18.57$$

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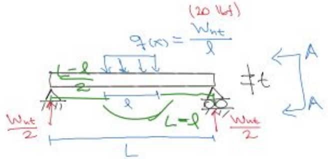
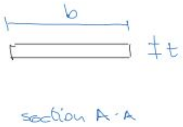
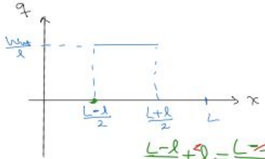
Central tray: Euler-Bernoulli beam: $EI \frac{d^4 v}{dx^4} = q(x)$ (1-D beam)

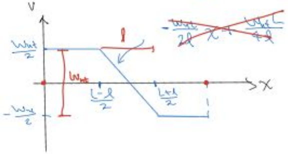




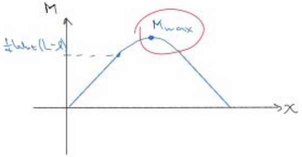
$I = \frac{1}{12} b t^3$



$\frac{L-l}{2} + \frac{l}{2} = \frac{L - \cancel{l} + \cancel{2}l}{2} = \frac{L+l}{2}$



$\cancel{-\frac{W_{nt}}{2l}x + \frac{W_{nt}L}{4l}}$ $V(x) = -\frac{W_{nt}}{l}x + \frac{W_{nt}L}{2l}$ ✓



$M(x) = -\frac{W_{nt}}{2l}x^2 + \frac{W_{nt}L}{2l}x + C$

$M\left(\frac{L-l}{2}\right) = \frac{1}{4}W_{nt}(L-l)$ ✓

$\Rightarrow \frac{1}{4}W_{nt}(L-l) = -\frac{W_{nt}}{2l}\left(\frac{L-l}{2}\right)^2 + \frac{W_{nt}L}{2l}\left(\frac{L-l}{2}\right) + C$

Center Tray Analysis

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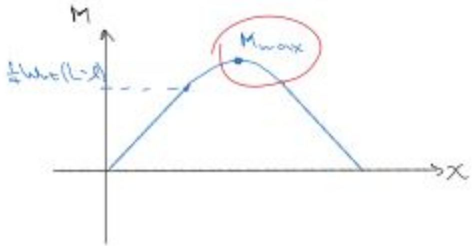

$$M(x) = -\frac{w_{ut}}{2\ell}x^2 + \frac{w_{ut}L}{2\ell}x + \mathcal{C}$$

$$M\left(\frac{L-\ell}{2}\right) = \frac{1}{4}w_{ut}(L-\ell) \checkmark$$

$$\Rightarrow \frac{1}{4}w_{ut}(L-\ell) = -\frac{w_{ut}}{2\ell}\left(\frac{L-\ell}{2}\right)^2 + \frac{w_{ut}L}{2\ell}\left(\frac{L-\ell}{2}\right) + \mathcal{C}$$

$$\Rightarrow \mathcal{C} = \frac{1}{4}w_{ut}(L-\ell) - \frac{1}{2}w_{ut}\left(\frac{L}{\ell}\right)(L-\ell) + \frac{1}{2}w_{ut}\frac{(L-\ell)^2}{4\ell}$$

$$= \frac{1}{4}w_{ut}(L-\ell)\left[1 - 2\frac{L}{\ell} + 2\frac{L-\ell}{4\ell}\right]$$

$$= \frac{1}{4}w_{ut}(L-\ell)\left(1 - 2\frac{L}{\ell} + \frac{1}{2}\frac{L}{\ell} - \frac{1}{2}\right)$$

$$= \frac{1}{4}w_{ut}(L-\ell)\left(\frac{1}{2} - \frac{3}{2}\frac{L}{\ell}\right)\frac{\ell}{\ell} = -\frac{1}{8\ell}(L-\ell)(3L-\ell)w_{ut}$$

Center Tray Analysis

$$\Rightarrow M_{(x)} = -\frac{w_{wt}}{4\ell}x^2 + \frac{w_{wt}L}{4\ell}x - \cancel{\frac{3}{16}\frac{w_{wt}(L-\ell)^2}{\ell}} - \frac{1}{8\ell}(L-\ell)(3L-\ell)w_{wt}$$

$$M_{max} = M(L/2) = -\frac{w_{wt}}{4\ell}(L/2)^2 + \frac{w_{wt}L}{4\ell}(L/2) - \cancel{\frac{3}{16}\frac{w_{wt}(L-\ell)^2}{\ell}} - \frac{1}{8\ell}(L-\ell)(3L-\ell)w_{wt}$$

$$= -\frac{w_{wt}L^2}{16\ell} + \frac{2\,w_{wt}L^2}{2\cdot 8\ell} - \cancel{\frac{3}{16}\frac{w_{wt}(L-\ell)^2}{\ell}} - \frac{1}{8\ell}(L-\ell)(3L-\ell)w_{wt}$$

$$= \frac{-w_{wt}L^2 + 2w_{wt}L^2 - \overset{2w_{wt}(L-\ell)(3L-\ell)}{\cancel{3w_{wt}(L-\ell)^2}}}{16\ell}$$

$$= \frac{w_{wt}L^2 - 2w_{wt}\overset{(3L^2-4\ell L+\ell^2)}{\cancel{(L^2-2\ell L+\ell^2)}}}{16\ell}$$

$$= \frac{-5w_{wt}L^2 + 8w_{wt}L\ell - 2w_{wt}\ell^2}{16\ell} = (20\,lbf)\frac{-5(29in)^2 + 8(29in)(15in) - 2(15in)^2}{16(15in)} = \overset{-97.92\,lbf\text{-}in}{\cancel{21.08\,lbf\text{-}in}}$$

$w = 12in$

$L = 29in$

$\ell = 15in$

$t = 0.25in$

$I = \frac{1}{12}wt^3 = \frac{1}{12}(12in)(0.25in)^3 = 1.563\times10^{-2}\,in^4$

$$\sigma_{b,max} = \frac{M_{max}(t/2)}{I} = \frac{\overset{97.92}{\cancel{(21.08}}\,lbf\text{-}in)\left(\frac{0.25in}{2}\right)}{1.563\times10^{-2}\,in^4} = \overset{783.08\,psi}{\cancel{168.64}\,psi}$$

$S_y = 40\,000\,psi$ (Aluminum)

$$\Rightarrow F.S. = \frac{40000psi}{\underset{783.08}{\cancel{168.64}}\,psi} = \overset{51.09}{\cancel{237.19}}$$

Critical Angle Analysis

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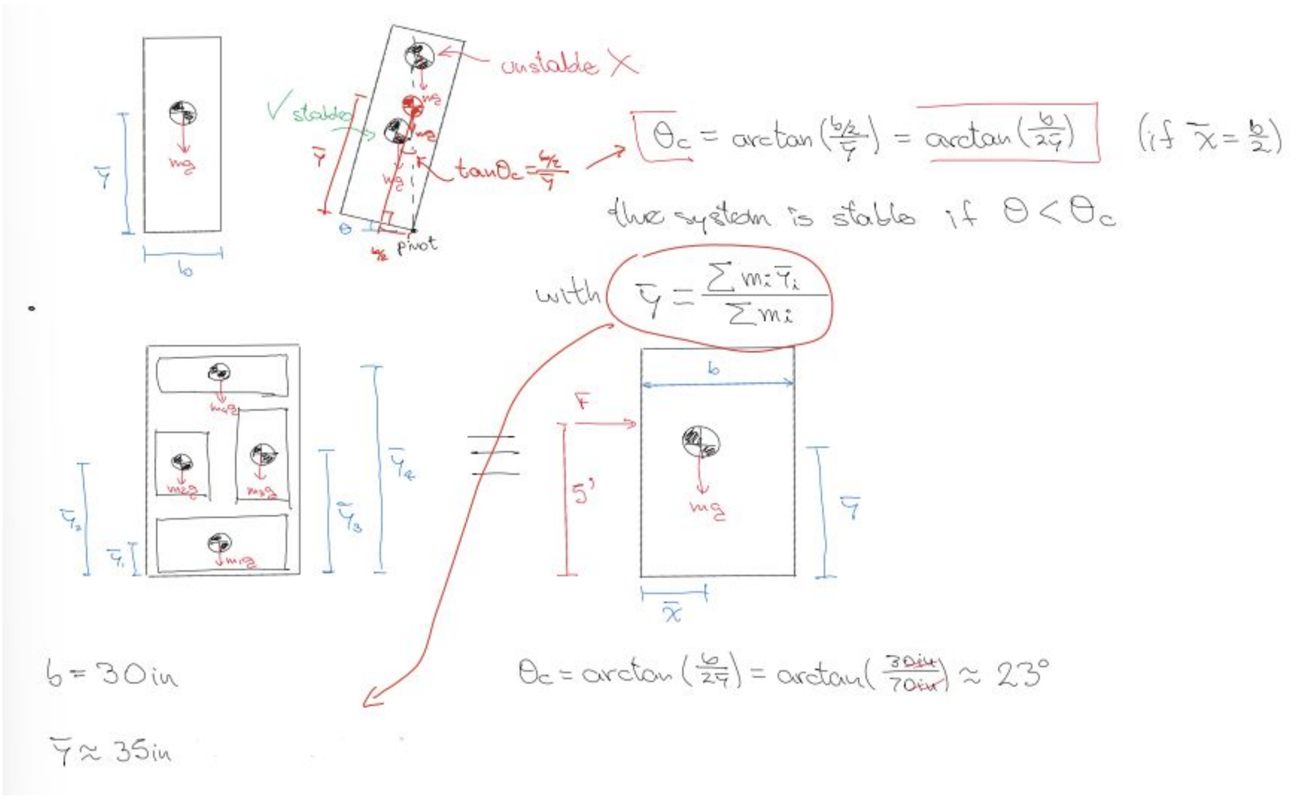

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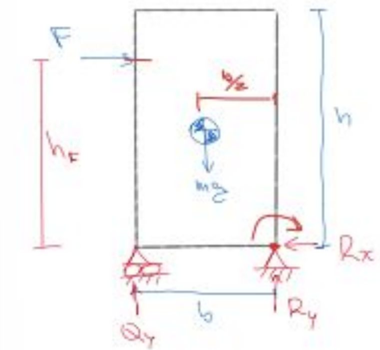
FBD:



Assume the wheels are locked (they can't rotate)

$$\sum F_x = 0 : F - R_x = 0 \Rightarrow \boxed{F = R_x} \quad ①$$

$$\sum F_y = 0 : R_y + Q_y - mg = 0 \Rightarrow \boxed{R_y + Q_y = mg} \quad ②$$

$$\sum M_R \overset{I\alpha}{=} 0 : -Q_y b - F h_F + mg(b/2) \overset{I\alpha}{=} 0$$

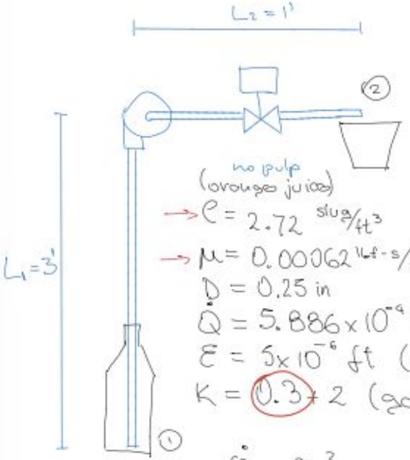
$$b Q_y + h_F F = \frac{b}{2} mg$$

if F is big enough, at some point $Q_y = 0$ (F_c)

$\Rightarrow$ from ③: $\boxed{F_c = \frac{b}{2h_F} mg}$

$$\boxed{F_c = \frac{30\,in}{2(72\,in)}(400\,lbf) = 83.3\,lbf}$$

Head Losses (continued)



$$\frac{1}{2}\rho v_1^2 + P_1 + \rho g z_1 = \frac{1}{2}\rho v_2^2 + P_2 + \rho g z_2$$

$$\cancel{\frac{v_1^2}{2g}}^{\,0} + \cancel{\frac{P_1}{\rho g}}^{\,P_{atm}} + z_1 + h_{pump} = \frac{v_2^2}{2g} + \cancel{\frac{P_2}{\rho g}}^{\,P_{atm}} + z_2 + h_L \qquad h_L = f\frac{L_{total}}{D}\frac{v^2}{2g} + K_L\frac{v^2}{2g}$$

$$\Rightarrow h_{pump} = \left(1 + f\frac{L_{total}}{D} + K_L\right)\frac{v^2}{2g} + (z_2 - z_1)$$

no pulp
(orange juice)

$\rho = 2.72\ \text{slug/ft}^3$

$\mu = 0.00062\ \text{lbf-s/ft}^2$

$D = 0.25\ \text{in}$

$\dot{Q} = 5.886 \times 10^{-4}\ \text{ft}^3/\text{s}$

$\varepsilon = 5 \times 10^{-6}\ \text{ft}$ (plastic tube)

$K = 0.3 + 2$ (gate open $d = \frac{1}{2}$ in + 90° elbow $d = \frac{1}{2}$ in)

$$Re = \frac{\rho v D}{\mu} = \frac{(2.72\ \text{slug/ft}^3)(1.727\ \text{ft/s})(\frac{0.25}{12}\ \text{ft})}{0.00062\ \text{lbf}\cdot\text{s/ft}^2} = 157.8$$

$$\dot{Q} = \frac{\pi}{4}D^2 v \Rightarrow v = \frac{\dot{Q}}{\frac{\pi}{4}D^2} = \frac{5.886 \times 10^{-4}\ \text{ft}^3/\text{s}}{\frac{\pi}{4}(0.25\ \text{in})^2} \cdot \frac{(12\ \text{in})^2}{1\ \text{ft}^2} = 1.727\ \text{ft/s}$$

$$f = \frac{64}{Re} = \frac{64}{157.8} = 0.406$$

$$\Rightarrow h_{pump} = \left(1 + 0.406\frac{4\ \text{ft}}{\frac{0.25}{12}\ \text{ft}} + 2.3\right)\frac{(1.727\ \text{ft/s})^2}{2(32.2\ \text{ft/s}^2)} + 3\ \text{ft} = 6.88\ \text{ft}$$

$$P_{pump} = \frac{h\dot{Q}\,SG}{3956} = \frac{(6.88\ \text{ft})(5.886 \times 10^{-4}\ \text{ft}^3/\text{s})(\frac{2.72}{1.94})}{3956} \cdot \frac{7.48\ \text{gal}}{1\ \text{ft}^3} \cdot \frac{60\ \text{s}}{1\ \text{min}} = 6.44 \times 10^{-4}\ \text{hp}$$

Casting Wheel Bolts Analysis

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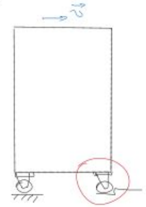
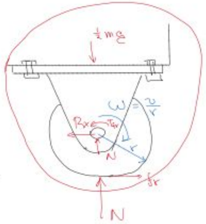
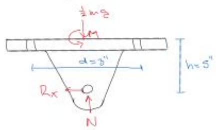
Wheels:





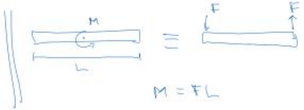
F.B.D.:



$R_x = \mu N = \frac{1}{2}\mu m g$

$M - R_x h = 0$

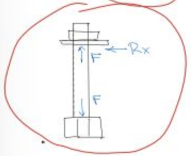
$\Rightarrow \boxed{M = \frac{1}{2}\mu m g h}$



$M = FL$

$M = Fd \Rightarrow \boxed{F = \frac{1}{2d}M = \frac{1}{4}\mu\left(\frac{h}{d}\right)mg}$

$\mu = 0.8$ (rubber - concrete)



$d_b = \frac{3}{8}$ in

$\boxed{F \doteq \frac{1}{4}(0.8)\left(\frac{5\,in}{3\,in}\right)(500\,lbf) = 166.67\ lbf}$

$\boxed{R_x = \frac{1}{2}(0.8)(500\,lbf) = 200\ lbf}$

$\sigma = \frac{F}{A} = \frac{F}{\frac{\pi}{4}d_b^2} = \frac{4F}{\pi d_b^2} = \frac{4(166.67\,lbf)}{\pi(3/8\,in)^2} = 1509\ psi$

$\tau = \frac{4R_x}{3A} = \frac{4R_x}{\frac{3\pi}{4}d_b^2} = \frac{16R_x}{3\pi d_b^2} = \frac{16(200\,lbf)}{3\pi(3/8\,in)^2} = 7243\ psi$

$\sigma_{1,2} = \frac{\sigma}{2} \pm \sqrt{\frac{\sigma^2}{4} + \tau^2}$ (principal stresses)

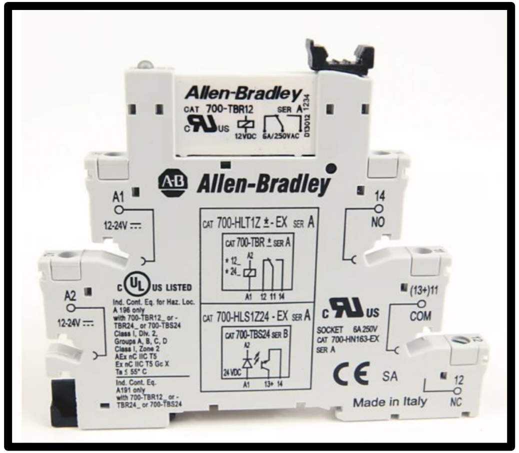
$\sigma_1 = \frac{\sigma}{2} + \sqrt{\frac{\sigma^2}{4} + \tau^2} = \frac{1509\,psi}{2} + \sqrt{\frac{(1509\,psi)^2}{4} + (7243\,psi)^2}$

$= 8037\ psi$

$S_y = 130\,000\ psi$

$\Rightarrow F.S = \frac{130\,000\,psi}{8037\,psi} = 16.18$

$$\begin{aligned} Time &= (V\,(mL)) \times (Flow\ Rate) \times 60\,(seconds) \\ &= (45\,mL \div 1000\,mL/min) \times 60 \\ &= \boxed{2.7\ seconds\ of\ run\ time} \end{aligned}$$



PLC Power Consumption

$$I_{relay} = \frac{V}{R} = \frac{24\,V}{650\,\Omega} = 37\,mA$$

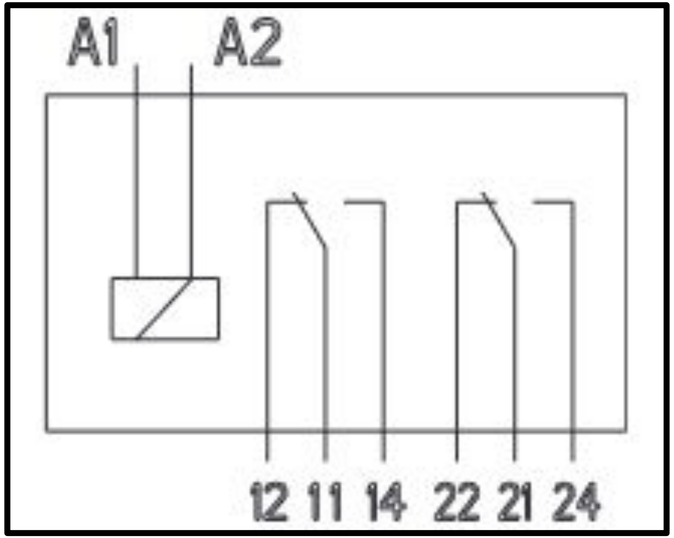
$$I_{total} = 37\,mA \times 12 = 0.444\,A$$

$$I_{valves} = 0.5\,A \times 6 = 3\,A$$

$$I_{pumps} = 1\,A \times 6 = 6\,A$$

$$I_{total} = I_{relay} + I_{valves} + I_{pumps} = 0.444 + 3 + 9 = 9.444\,A$$

$$P_{total} = V \times I = 24\,V \times 9.444\,A = \boxed{227\,W}$$



Frame Analysis - Impact Force

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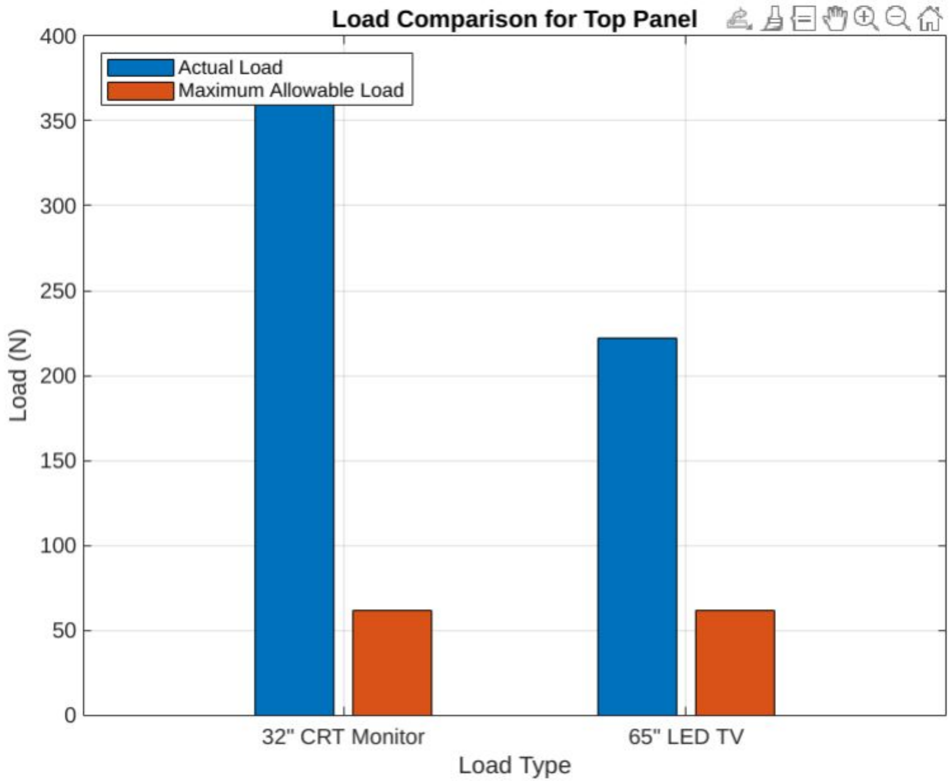
1. **Impact Velocity:**
   - $h = 4\,ft$
   - $v = \sqrt{2 \cdot g \cdot h}$
   - $v = 4.9\,m/s$
2. **Impact Force Calculation:**
   - Convert weight to mass: $400\,lb = 181.4\,kg$
   - $\int_0^t F dt = m \cdot (v_f - v_0)$
   - $F = m \cdot \frac{v}{\Delta t}$
   - Assume $\Delta t = 0.005\,s$
   - $F = 1.77 \cdot 10^5\,N$
3. **Stress Calculation:**
   - $A = edge\ length \times thickness$
   - $A = 0.00211 m^2$
   - $\sigma = \frac{F}{A}$
   - $\sigma = 8.4 \cdot 10^7\,Pa$
   - $\boxed{\sigma_{4ft} < \sigma_{allowable\ yield}}$

- Frame thickness: 0.109 inches
- Lands on Edge
- t = 0.005 s
- allowable yield = 13.6e7
- Material: 304 Stainless Steel
- Mass = 400 lbs


Load Comparison for Top Panel
Actual Load
Maximum Allowable Load
Load (N)
400
350
300
250
200
150
100
50
0
32" CRT Monitor
65" LED TV
Load Type

Hand Calc for Electronic Heat Transfer

LSU College of Engineering Department of Mechanical & Industrial Engineering

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Speaker Name Prepared By: Christopher Hall

Electronic cooling (no fans)

$$Q = h \cdot A \cdot \Delta T$$

$$Q = h \cdot A \cdot (T_{internal} - T_{ambient})$$

$$\frac{Q}{h \cdot A} = T_{internal} - T_{ambient}$$

$$\frac{Q}{h \cdot A} + T_{ambient} = T_{internal}$$

$$\frac{300\ W}{10\ \frac{W}{m^2 K} \cdot 6.7 m^2} + 35\ °C = T_{internal}$$

$$4.47\ °C + 35\ °C = T_{internal}$$

$$\boxed{39.47\ °C = T_{internal\ (w/out\ fans)} = 103\ °F}$$

$$Vdot = 200\ CFM \times \frac{0.0283\ m^3}{1\ ft^3} \times \frac{1\ min}{60\ s}$$

$$Vdot = 0.094\ \frac{m^3}{s}$$

$$Vdot_{total} = 0.188\ \frac{m^3}{s}$$

$$Q_{fans} = Vdot \cdot \rho_{air} \cdot C_p \cdot \Delta T$$

$$Q_{fans} = 0.188\ \frac{m^3}{s} \cdot 1.2\ \frac{kg}{m^3} \cdot 1005\ \frac{J}{kg \cdot K} \cdot 4.47°C$$

$Q_{fans} = 1015.16\ W$ Heat removed

$$Q_{fans} >> Q_{generated}$$

$$\boxed{T_{internal\ (w/\ fans)} = T_{ambient} = 95\ °F}$$

Hand Calc for Fluid Heat Transfer

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College of Engineering
School of Electrical Engineering & Computer Science

Speaker Name Prepared By: Christopher Hall

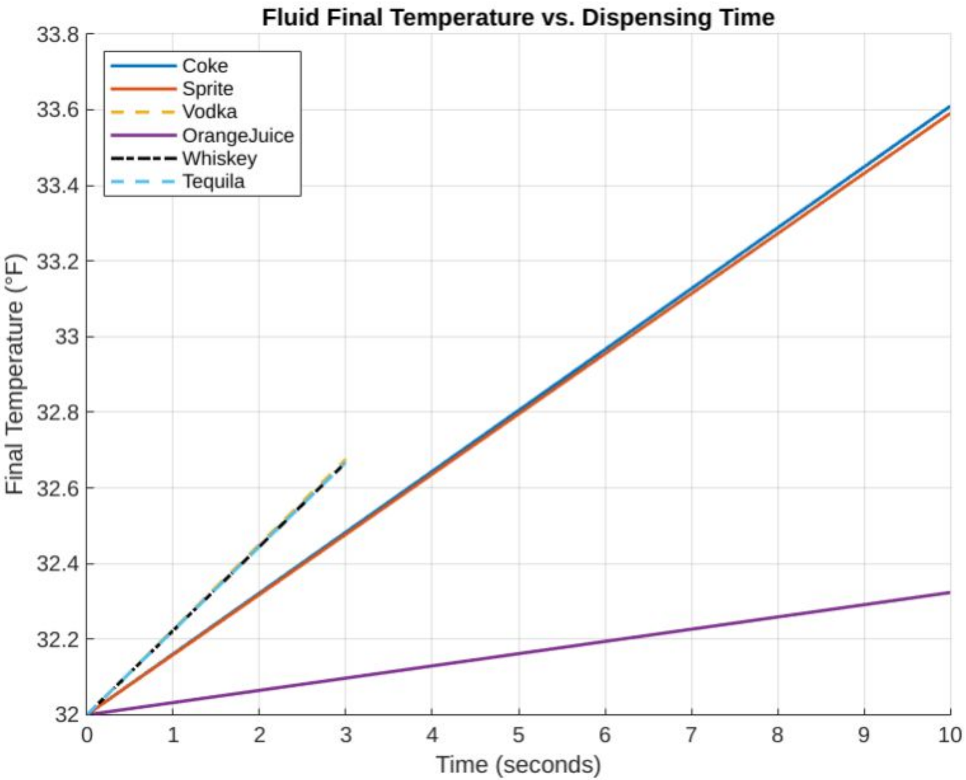
Fluid cooling

$$Q = h \cdot A \cdot \Delta T$$
$$Q = 25 \cdot (\pi \cdot (\tfrac{1}{4} in \cdot 12) \cdot 4ft) \cdot (35\,°C - 0\,°C)$$
$$Q = 21.26\,W$$

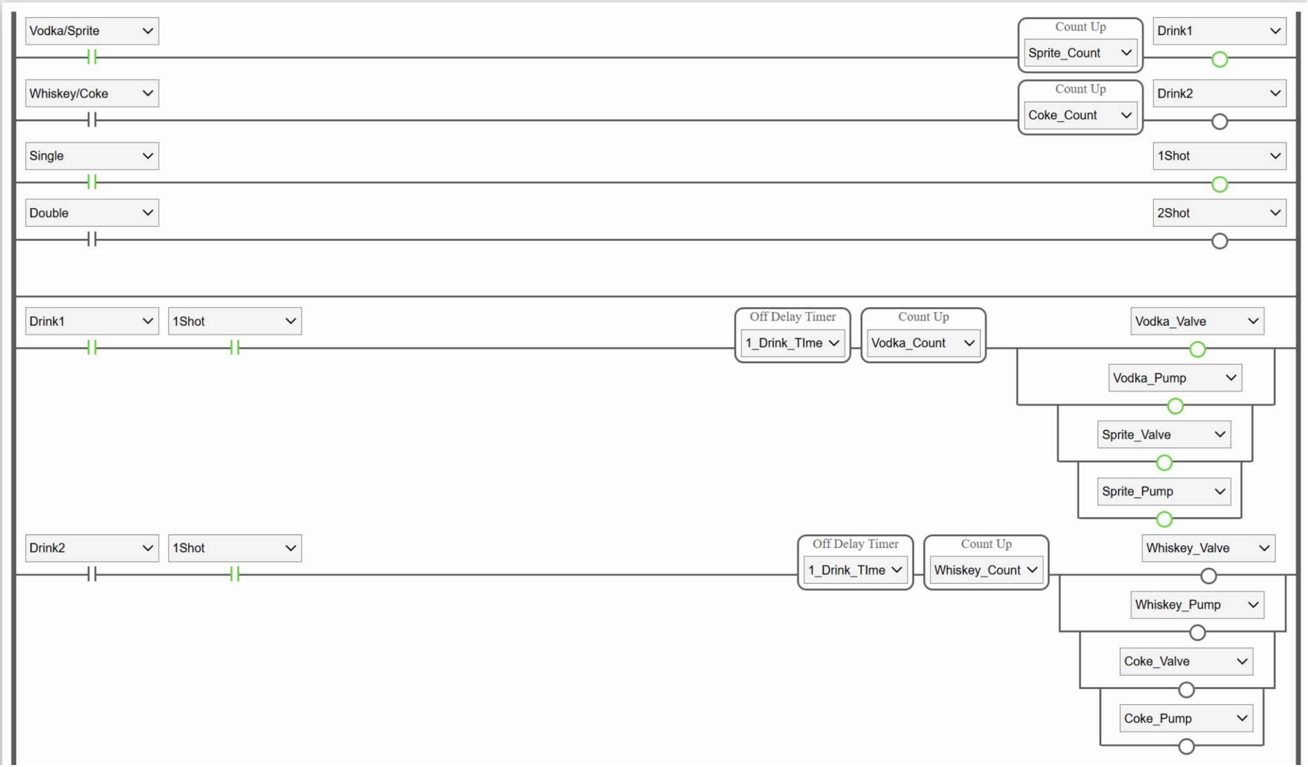
$$Q_{total} = Q \cdot t$$
$$Q_{total} = 21.26\,W \times 10s$$
$$\boxed{Q_{total} = 212.6\,J}$$

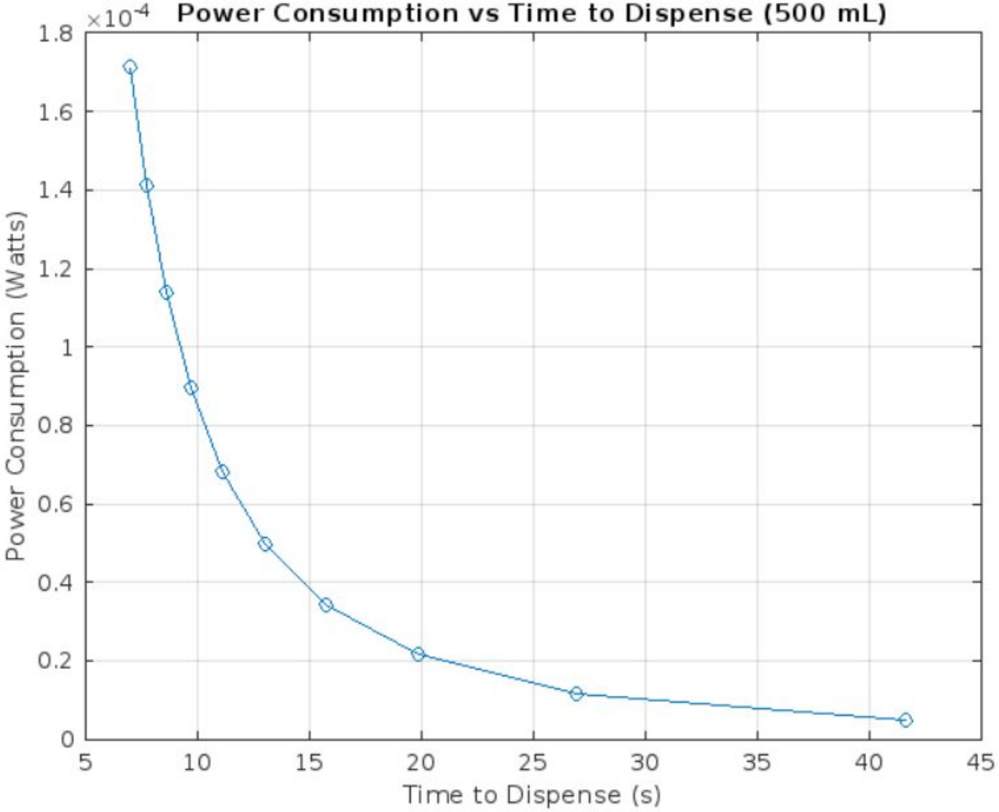
$$\Delta T = \frac{Q}{m \cdot c}$$
$$\Delta T = \frac{212.6\,J}{2.0\,kg \cdot 840\,\frac{J}{kg \cdot °C}}$$
$$\Delta T = 0.127\,°C$$

$$T_{final} = T_{initial} + \Delta t$$
$$T_{final} = 0\,°C + 0.13\,°C$$
$$T_{final} = 0.13\,°C$$
$$\boxed{T_{final} = 0.234\,°F\ increase}$$

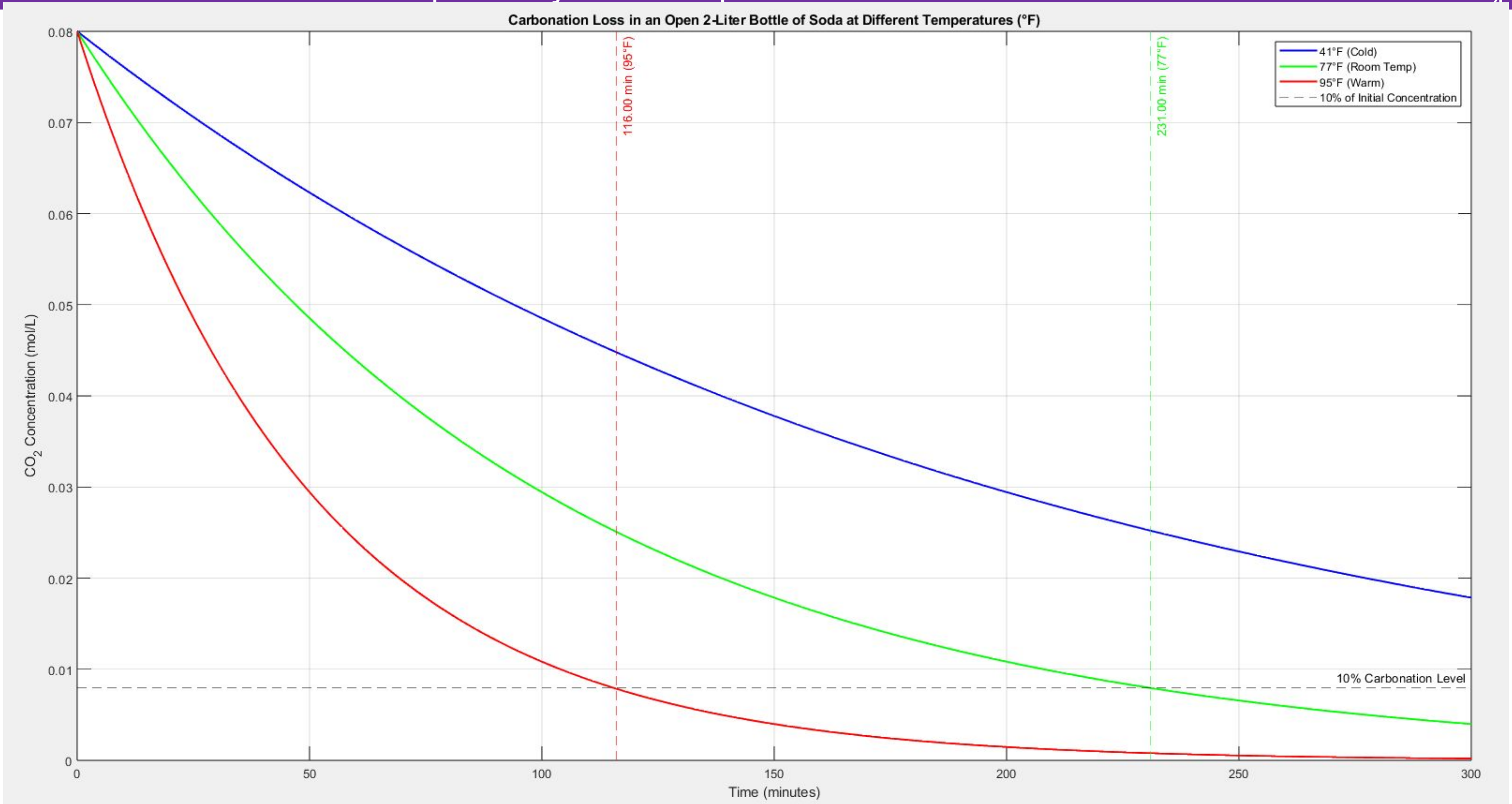


Speaker Name Prepared By:




Power Consumption vs Time to Dispense (500 mL)
$\times 10^{-4}$
Power Consumption (Watts)
Time to Dispense (s)
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
5
10
15
20
25
30
35
40
45

Plot for Carbonation Loss



Hand Calc for Carbonation Loss

Speaker Name Prepared By: Christopher Hall

Problem Statement: Find the necessary flow rate needed to fill a 12 oz cup in less than 30 seconds

Solve

1. Convert 12 oz to mL:

$$12oz \times \frac{29.5735mL}{1oz} = 354.882mL$$

2. Calculate Required Flow Rate:

$$\text{Flow Rate} = \frac{\text{Volume of cup (mL)}}{\text{Time (s)}}$$

$$= \frac{354.882mL}{30s}$$

$$= 11.83 mL/s$$

The necessary flow rate to fill a 12 oz cup in 30 sec is approx. 11.83mL/s

Assumptions

1. Constant flow Rate
2. No System Delays
3. Ideal Pump Performance
4. Negligible Resistance in Pipes/Tube
5. No influence of temperature/viscosity
6. Pressure is Constant
7. No carbonation effects

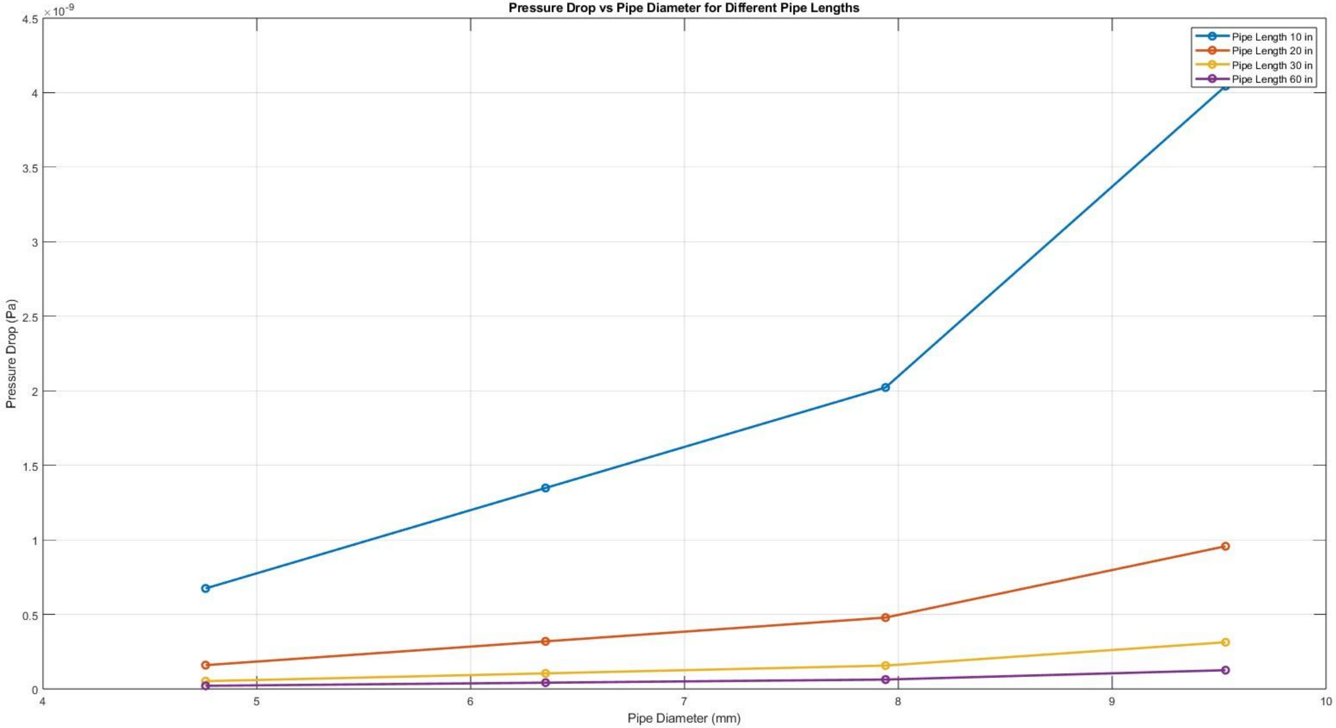
For:

20 seconds → 17.74mL/s $\quad \frac{354.882}{20} = 17.74mL/s$

10 seconds → 35.49 mL/s $\quad \frac{354.882}{10} = 35.49 mL/s$

Answer

Time	Required Flow Rate
30 sec	11.83 mL/s
20 sec	17.74 mL/s
10 sec	35.49 mL/s


Pressure Drop vs Pipe Diameter for Different Pipe Lengths
Pipe Length 10 in
Pipe Length 20 in
Pipe Length 30 in
Pipe Length 60 in
× 10^-9
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Pressure Drop (Pa)
4
5
6
7
8
9
10
Pipe Diameter (mm)

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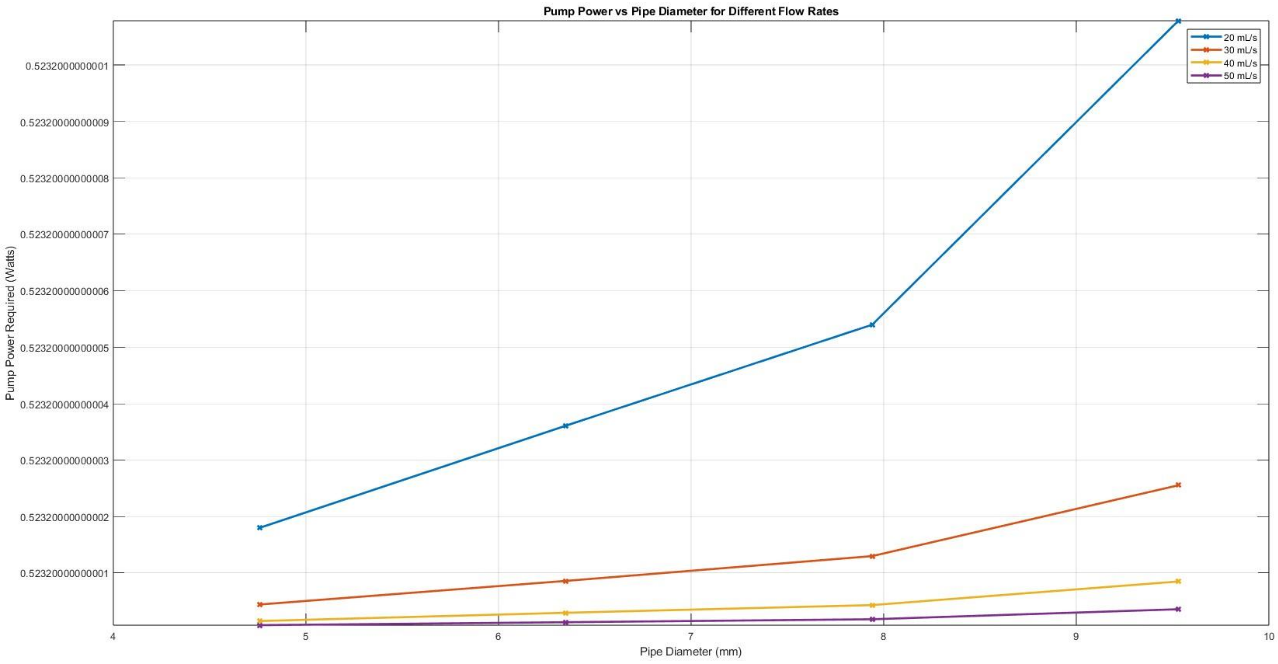
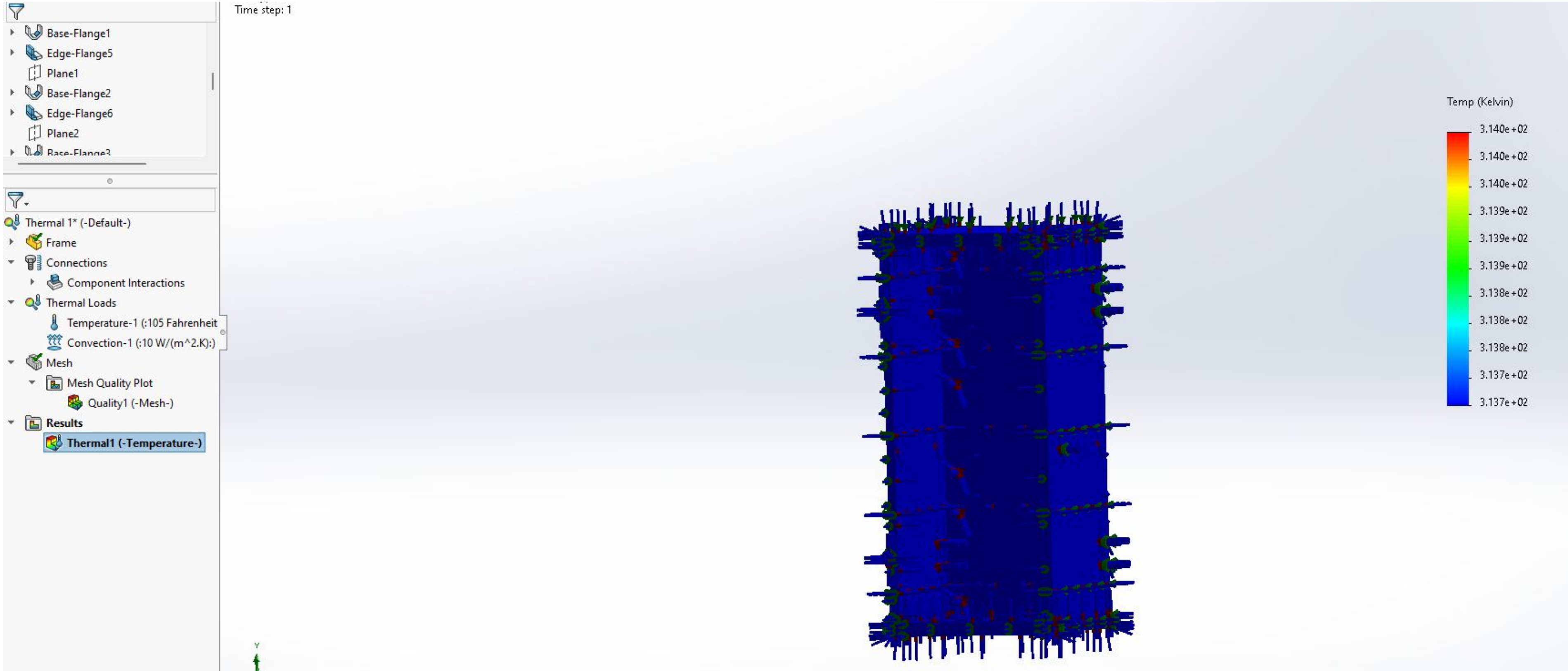
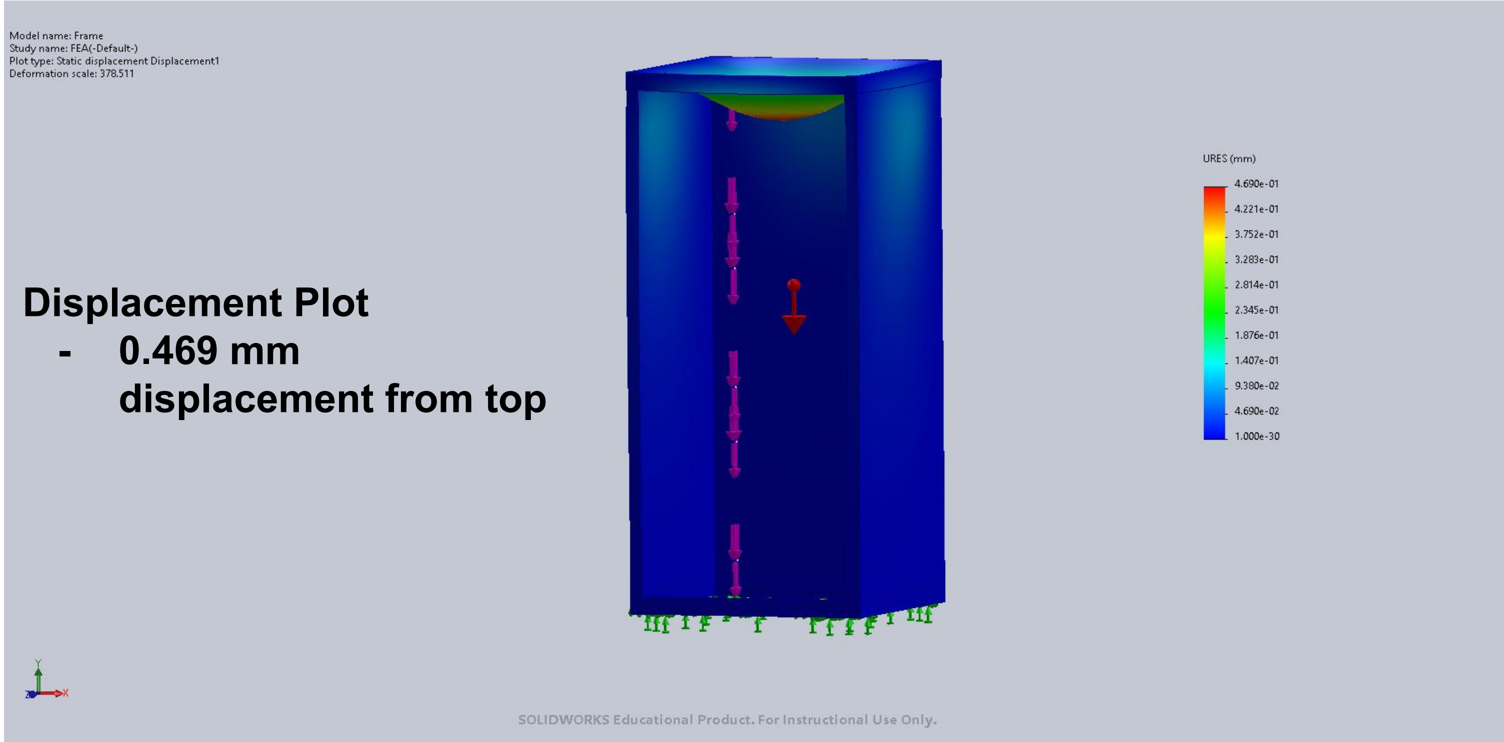
Speaker Name Prepared By: Christopher Hall




Time step: 1
Base-Flange1
Edge-Flange5
Plane1
Base-Flange2
Edge-Flange6
Plane2
Thermal 1* (-Default-)
Frame
Connections
Component Interactions
Thermal Loads
Temperature-1 (:105 Fahrenheit
Convection-1 (:10 W/(m^2.K):)
Mesh
Mesh Quality Plot
Quality1 (-Mesh-)
Results
Thermal1 (-Temperature-)
Temp (Kelvin)
3.140e+02
3.140e+02
3.140e+02
3.139e+02
3.139e+02
3.139e+02
3.138e+02
3.138e+02
3.138e+02
3.137e+02
3.137e+02

Displacement Plot

- 0.469 mm displacement from top



Concept Generation: Tubing

Criteria	Weight	⅜''	¼''	½''
Flow Rate	0.4	2	4	5
Pressure Drop	0.2	5	4	3
Cost	0.2	5	4	3
Durability	0.2	3	4	5
Total Score		3.6	$\boxed{4.2}$	4.2

Parameter	Value	Explanation
Assume Ambient Temperature	95°F (35°C)	External air temperature during operation
Maximum Temperature	158°F (70°C)	Highest allowable internal temperature
Internal Temperature (No Fans)	103°F	Stabilized temperature without cooling
Internal Temperature (With Fans)	95°F (35°C)	Stabilized temperature with cooling
Fan Activation Threshold	95°F (35°C)	Suggested temperature to activate fans
Fans maintain internal temperature at ambient ✅		

Material/Component 2

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Speaker Name Prepared By:

1/4" 24V DC Electric Plastic Solenoid Valve

Concept Generation (Beverages)

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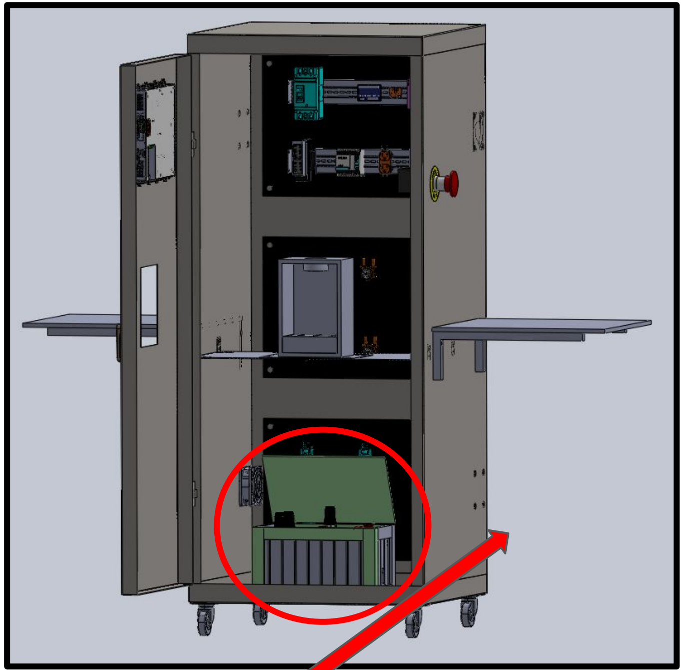
Speaker Name   Prepared By: Connor Regard

YETI 50 qt Ice chest



Project Management: Budget breakdown

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Speaker Name Prepared By: Christopher Hall

Category	Item	Qty	Price (per unit)	Weight (lbs)	Material	Link to Buy	Price (Total)
Structural Components	REYNOLDS 17" (H) X 30" (W) PAINTED STEEL, BACK PANEL	3	0	20			$0.00
Structural Components	Shelves	2		8.0			$0.00
Structural Components	Side Panel	2					$0.00
Structural Components	Folding Shelf Brackets	2	30	6	Steel	Shelf Brackets	$60.00
Structural Components	Drip Tray	1		**10.0**		Rubber Drip Tray	$0.00
Structural Components	Frame for Drink Dispenser	1			Steel		$0.00
Structural Components	Cup Holder	6	35	14.8		Cup Holder Link	$210.00
Structural Components	Casting wheels	4		32.0			$0.00
Structural Components	REYNOLDS 72" (H) X 30" (W) X 30"(D) SS, CUSTOM ENCLOSURE	1	0		304 SS		$0.00
Mounting & Support Hardware	Pump Mounts	6					$0.00
Mounting & Support Hardware	U Bolts for Valves	6	5.7		black-oxide steel	Valve Mount	$34.20
Mounting & Support Hardware	Phoenix Contact UT 2.5 Terminal Block					Terminal Block	$0.00
Mounting & Support Hardware	Phoenix Contact UT 2.5 Ground Terminal Block					Ground Terminal Block	$0.00
Mounting & Support Hardware	Allen Bradley 1492-DR8 DIN rail	2		5		DIN Rail	$0.00

Project Management: Budget breakdown

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Speaker Name Prepared By: Christopher Hall

Miscellaneous	2" PANDUIT						$0.00
Fluid Handling Components	Cooler with 25 qrts of ice in it	1	350	78.0			$350.00
Fluid Handling Components	tubing (ft)	50	0.53	2.0	PVC	Tubing Link	$26.50
Fluid Handling Components	fittings	1	6.17		Nylon Plastic	Fittings Link	$6.17
Fluid Handling Components	check valves	6	8.22	0.1		Check Valve Link	$49.32
Fluid Handling Components	Peristaltic Pump	6	110	1.6		Pumps Link	$660.00
Fluid Handling Components	Universal Liquid Pourer	1	18			Liquid Pourer	$18.00
Fluid Handling Components	Hose Clamps	1	8			Hose Clamps	$8.00
Fluid Handling Components	Hose to Pump Adaptper	6					$0.00
Fluid Handling Components	solenoid valve	6	17	0.1		Valve Link	$102.00
Electrical Components	Allen Bradley 1492-REC20G Receptacle	1	70.05			receptacle	$70.05
Electrical Components	ABB OT16F3 Disconnect Switch, 16A, 3-Pole, DIN Rail Mount	1	64			disconnect	$64.00
Electrical Components	Allen Bradley S201-C20, Single Pole, 20A Circuit Breaker	1	135.3			circuit breaker	$135.30
Electrical Components	Allen Bradley 800FD-NX2, Emergency Stop	1	113			estop	$113.00
Electrical Components	Phoenix Contact QUINT4-PS/1AC/24DC/20, 24VDC, 20A Power Supply.	1	770			power supply	$770.00
Electrical Components	Allen-Bradley CompactLogix 5069-L306ER	1	0			PLC Link	$0.00
Electrical Components	CompactLogix 5069-L306ER PLC, 16PT Digtial Input Card	1					$0.00
Electrical Components	CompactLogix 5069-L306ER PLC, 16PT Digtial Output Card	1					$0.00
Electrical Components	Allen Bradley, 700-HLT1Z24, Terminal Block Relay	1				Relay	$0.00
Electrical Components	Allen-Bradley PanelView 7 Standard HMI	1	0			HMI Link	$0.00
Total				173.8			$2,676.54

Drink Calculations

Drink Calculations

Tuesday, November 12, 2024 4:50 PM

Date: 11/12/2024
Team: 10
QE Type: A
Group/Individual: Individual

Project: Automated Bartender

Team Members: Cade Farragut, Connor Regard, Myles Bourgeois, Christopher Hall

QE Entry: Today calculated the proportions to making a drink out of a red solo cup, to calculate the total amount of drinks that can be made using each liquor/mixer before they run out. I will use this calculation in my program to determine when the alarm goes off.

Constraint: Red Solo Cup, 2 Liter soda, 1 Liter Liquor

Red Solo cup = 16oz
Ice in cup = 1/3 of volume = 5.33oz
2 Shots (MAX) = 3oz

16-5.33-3 = 7.67oz for mixer
Want to leave space so it is not at the brim of cup. We will use 6oz of mixer per drink.

2 Liters = 67 oz of liquid. So we can make 11 drinks before the alarm goes off

1 Liter = 33.8oz of liquid. So We can pour 22 shots before alarm goes off.

Concept Evaluation/Selection

Speaker Name **Myles Bourgeois** Prepared By: **Myles Bourgeois**