



Detailed Design Review

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Problem Definition

- Current pump prototype can allow for only one stroke volume and frequency at a time
- A more compact design is desired
- An easy user interface is not included with original prototype

Mission Statement

- To design, test, and refine a compact, low-cost, oscillatory-flow pump that will reproduce realistic Cerebral Spinal Fluid (CSF) flow conditions within a given range of mammal cerebral spinal models. Flow rates mimic cardiac and respiratory frequencies simultaneously and have an adjustable frequency and flow volume.

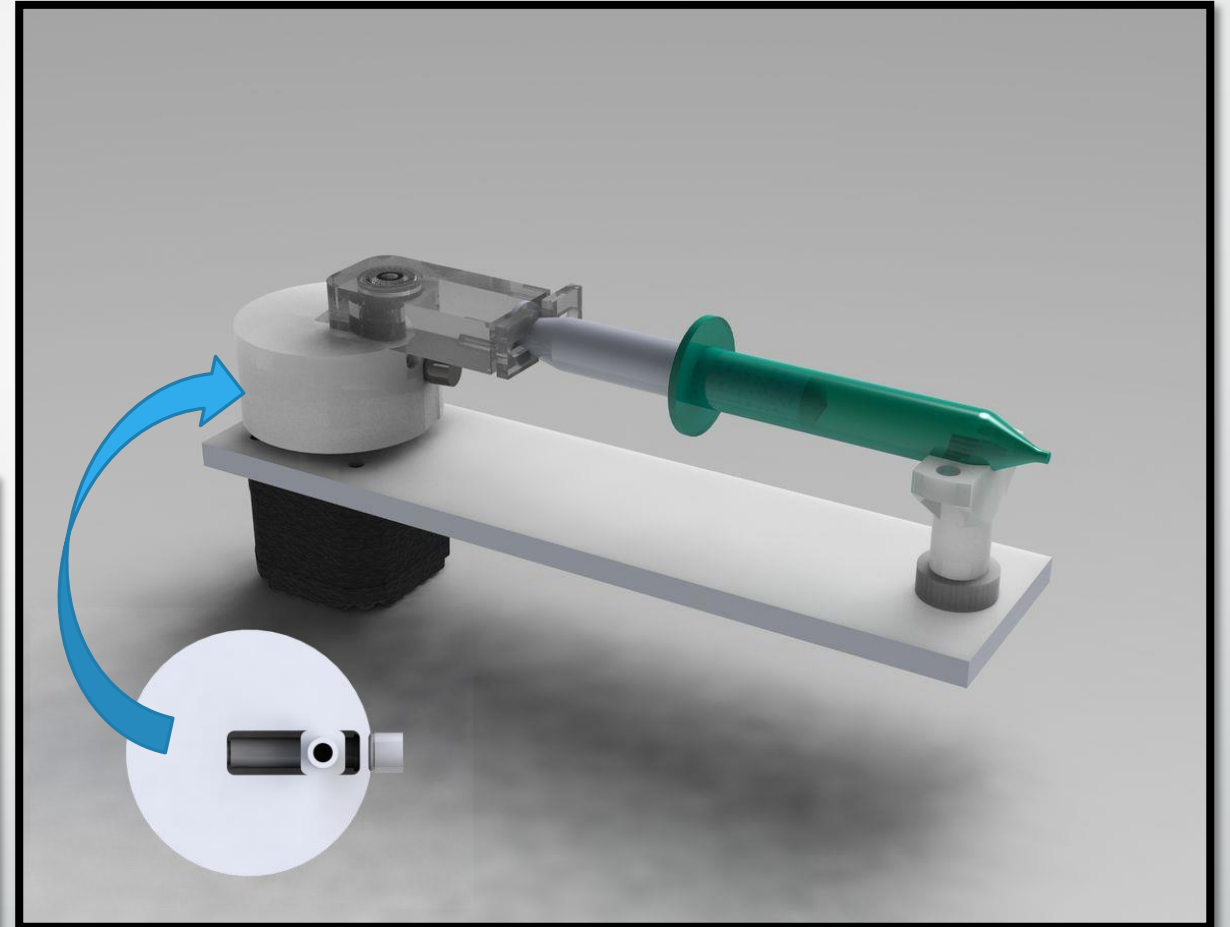
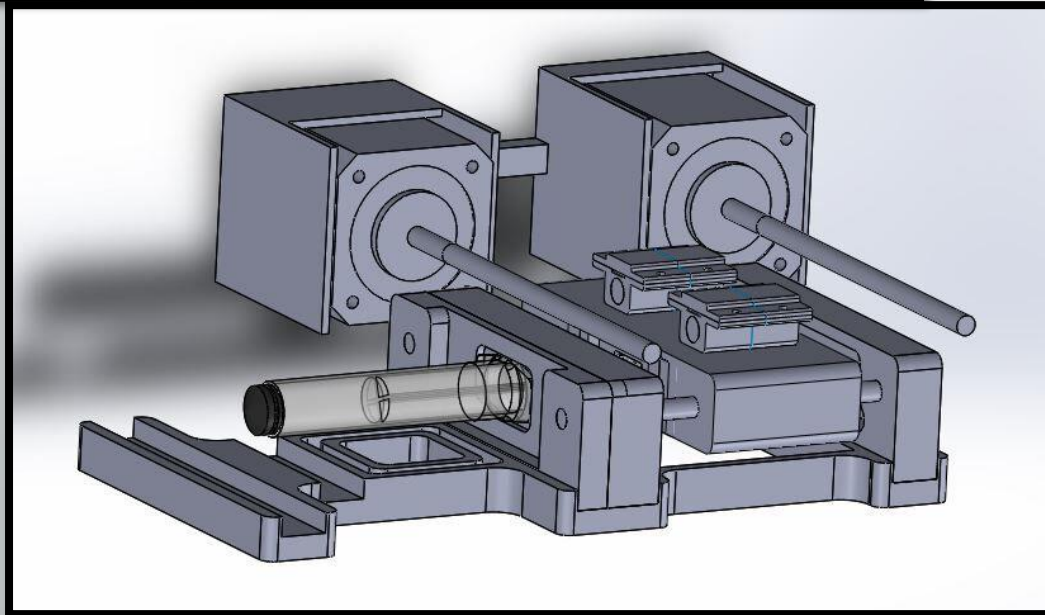
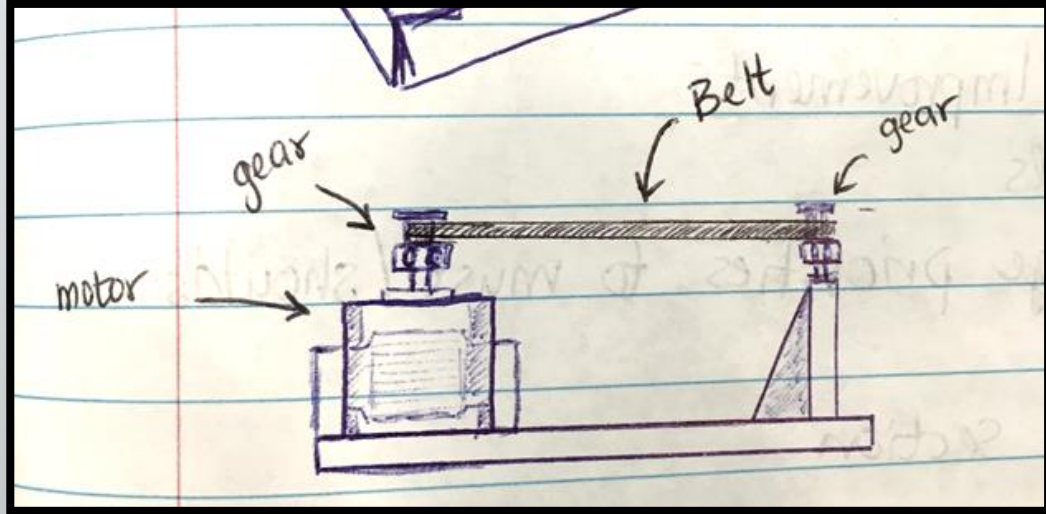
Deliverables

- Pump must produce an oscillating flow within spinal cord models ranging from the size of a human to a small vertebrate.
- Flow must be adjustable in volume and frequency.
- Pump should be low-cost and easy to operate.
- Design must also include a 5V, square-wave-form trigger.

Fall Schedule

	Description	Start Date	End Date	August	September	October	November
Fall Semester				Fall Semester			
	Book Keeping	21-Aug	30-Nov	Book Keeping Fall			
	Fabrication and refinement	21-Aug	30-Nov	Fabrication and Refinement Fabrication and Refinement			
	Mechanical Component Fabrication	21-Aug	22-Sep	Mechanical Component Fabrication			
	Trouble Shooting Mechanical	11-Sep	29-Sep	Trouble Shooting Mechanical			
	Coding and Interface	11-Sep	13-Oct	Coding and Interface			
	Code/Interface Troubleshooting	16-Oct	30-Oct	Coding and Interface Troubleshooting			
	Lit/Doc Work	1-Nov	30-Nov	Literature Work and Documentation			
	Scheduled Oh Crap Time	1-Nov	10-Nov	Scheduled Oh Crap Period			
	First Mechanical Test	11-Sep		[Red Bar]			
	First Code/Mech Test	22-Sep		[Red Bar]			
	Second Code/Mech Test	29-Sep		[Red Bar]			
	Final Code/Mech Test	13-Oct		[Red Bar]			

Previous Design Considerations



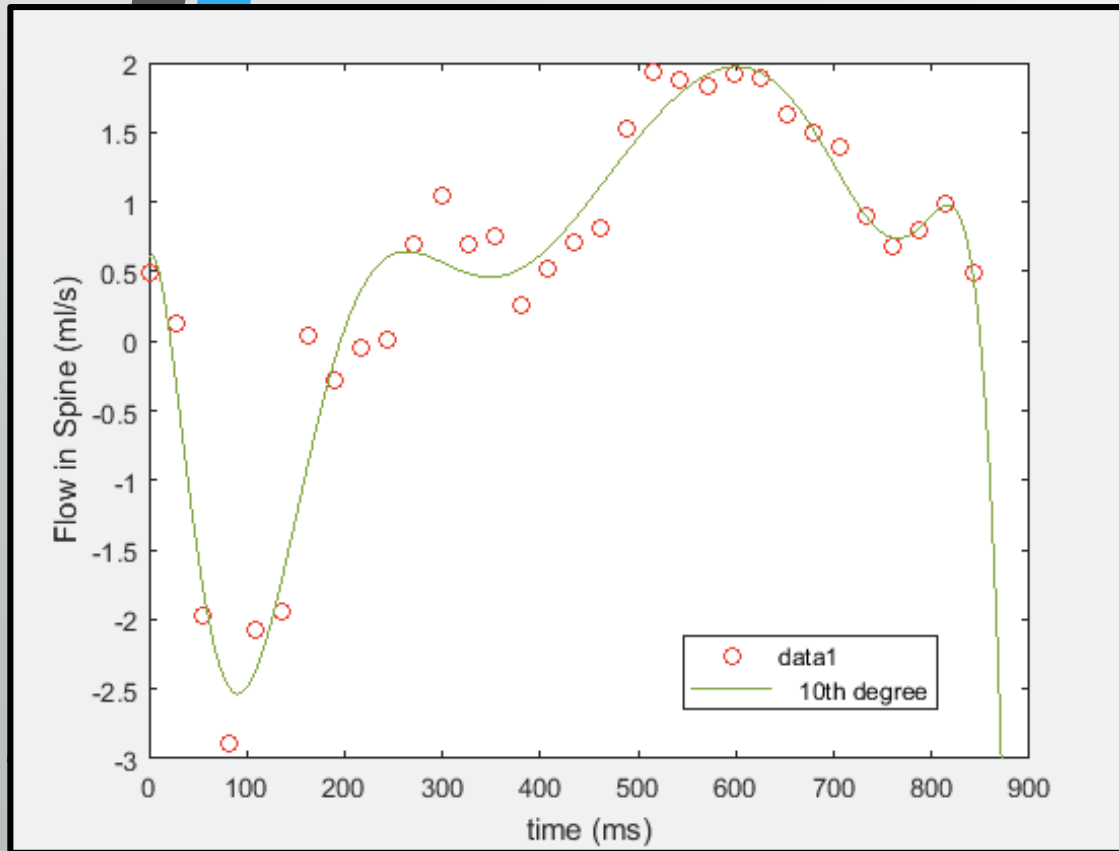
Linear Actuator



- **Pros:**
 - simple
 - Compact
- **Cons:**
 - Coding ability
 - Finding the right one that meet the specs

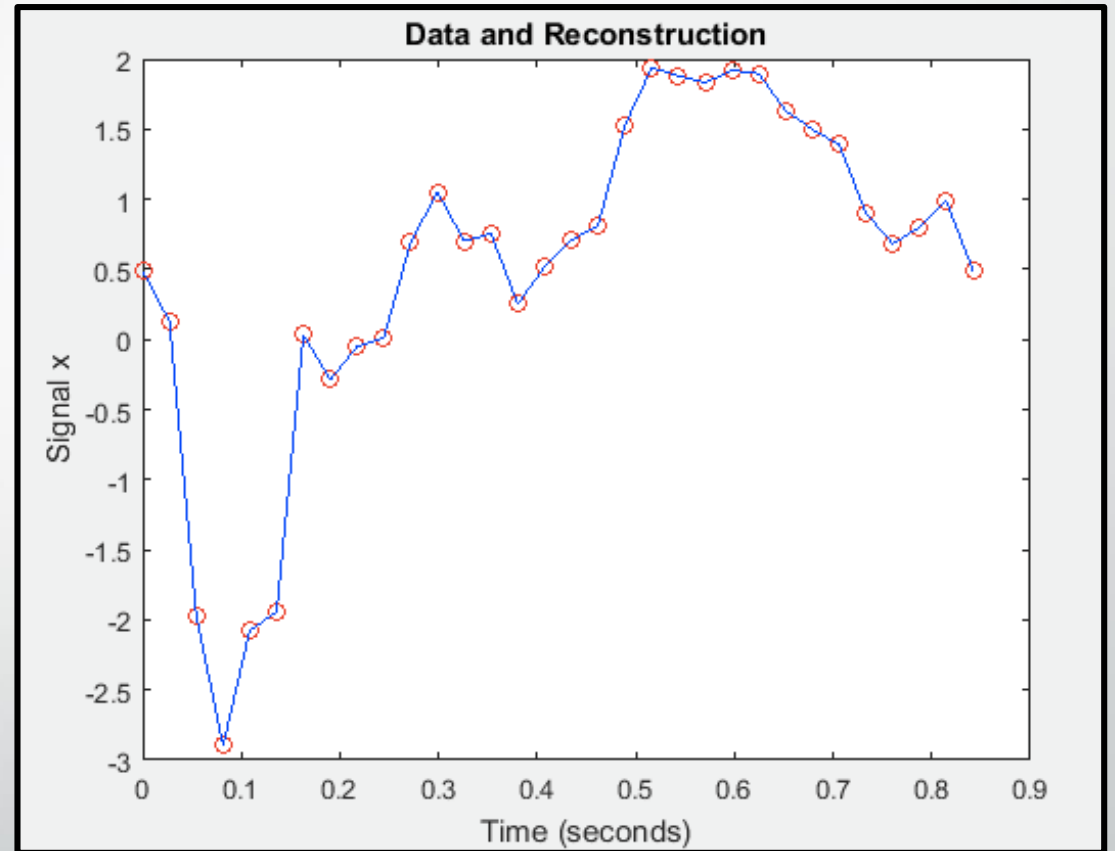
Cost Estimate: \$100

Generating a Heartbeat Function



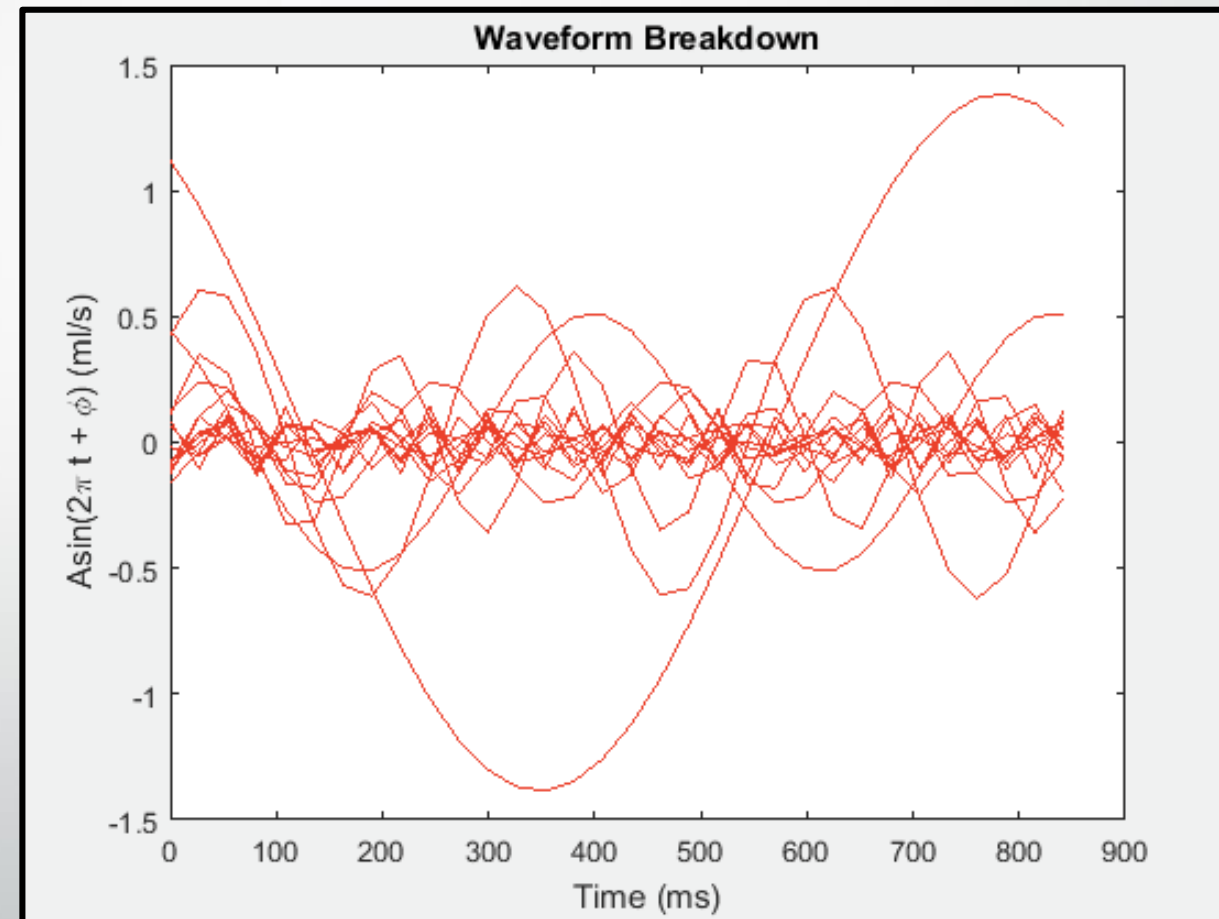
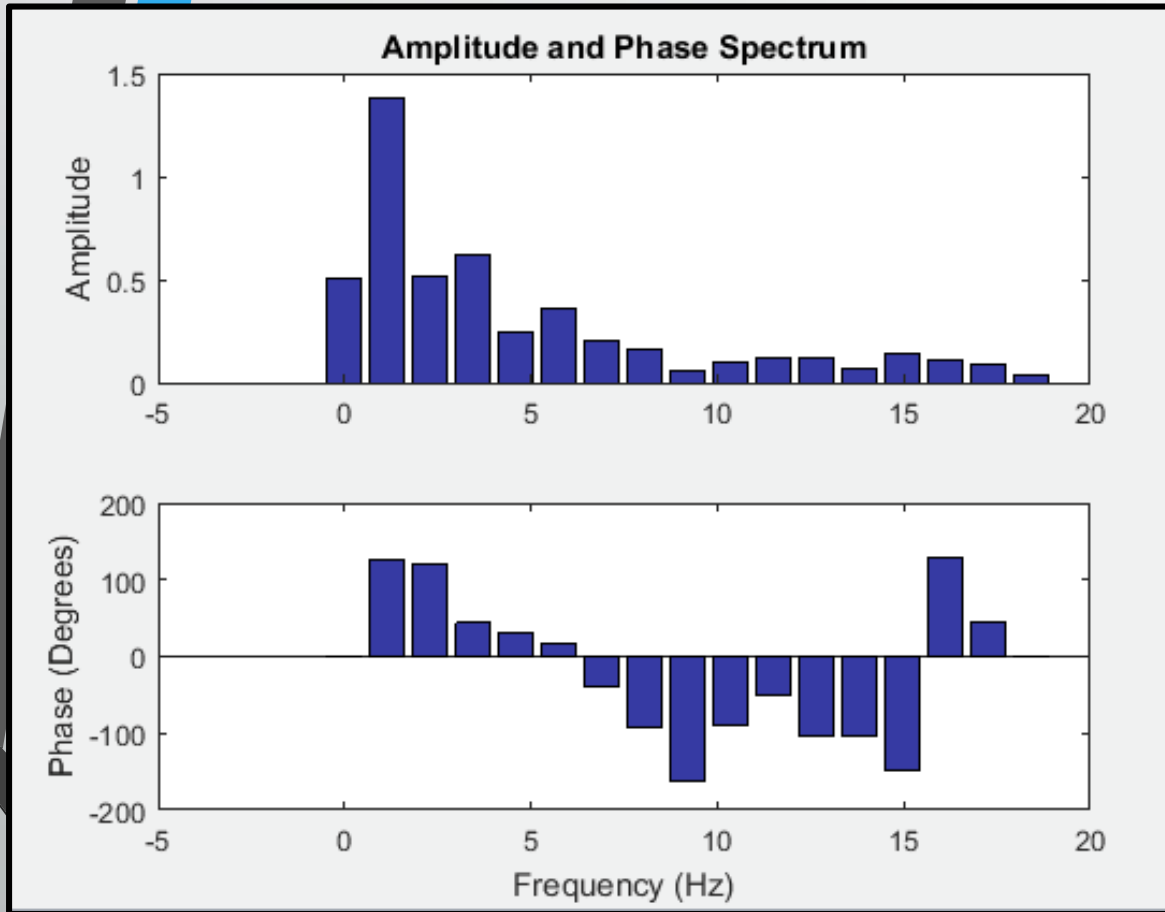
10th Degree Polynomial Fit

Vs



FFT – Generated Function

$$x(t) = A_o + \sum_{i=2}^{16} A_i \sin(2\pi f_i t + \phi_i)$$



PID Control

- *Driving Equation*

Output

$$\begin{aligned} &= K_i(X_{measured} - X_{desired}) \\ &+ K_p(\dot{X}_{measured} - \dot{X}_{desired}) \\ &+ K_d(\ddot{X}_{measured} - \ddot{X}_{desired}) \end{aligned}$$

Integral Control

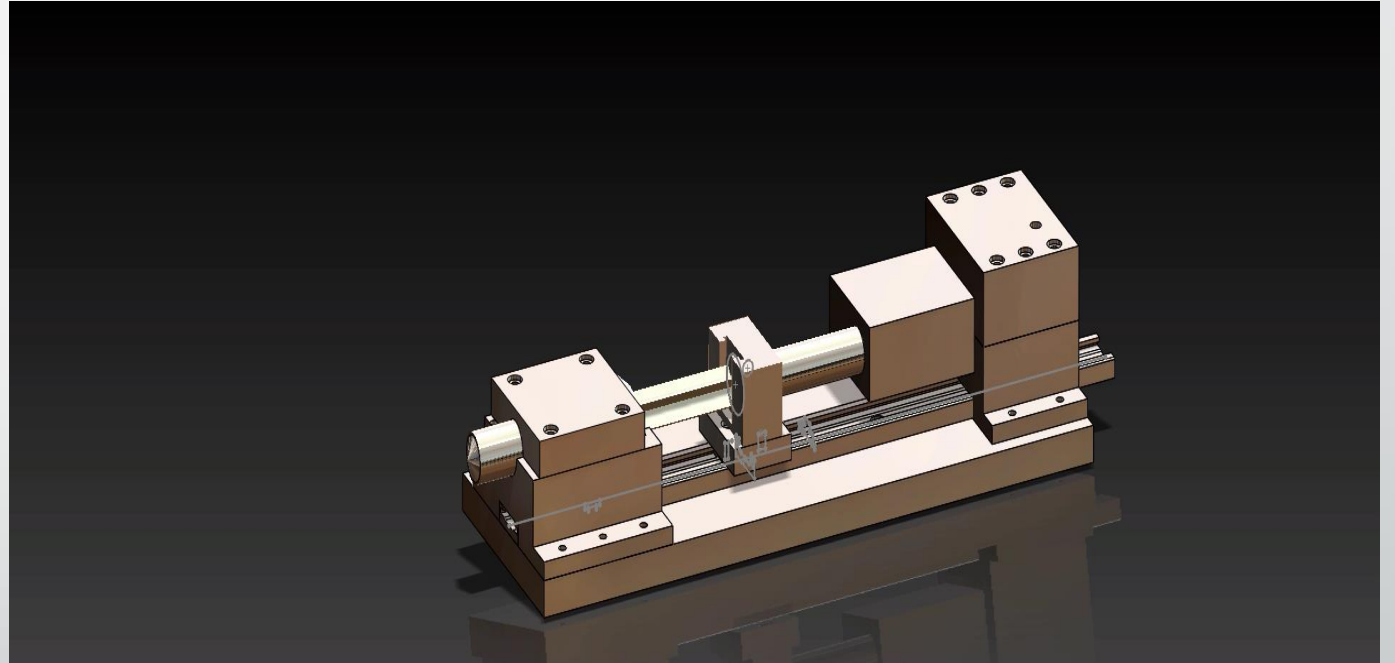
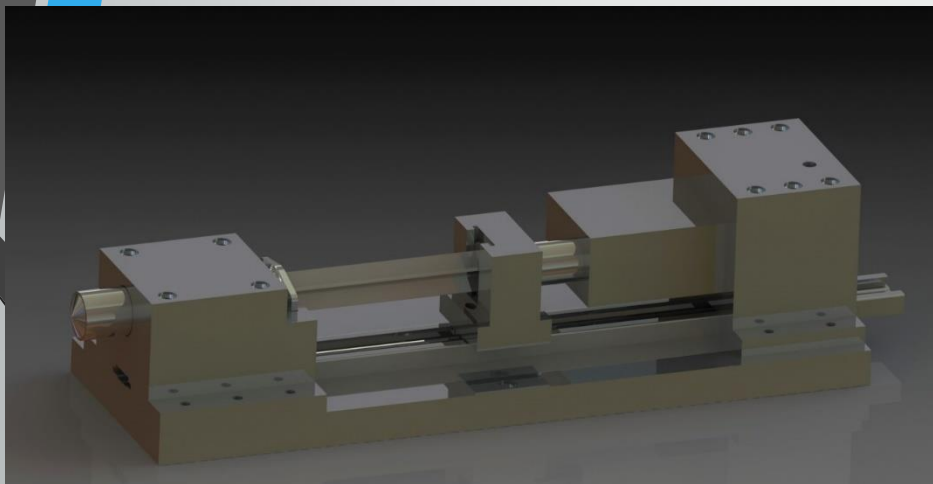
Proportional Control

Derivative Control

INTERNAL SYSTEM DESIGN

FOCUS :

- COMPACT (SMALLER IN SIZE)
- RIGID

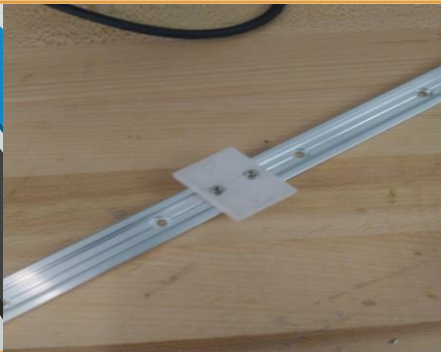


MAIN COMPONENTS

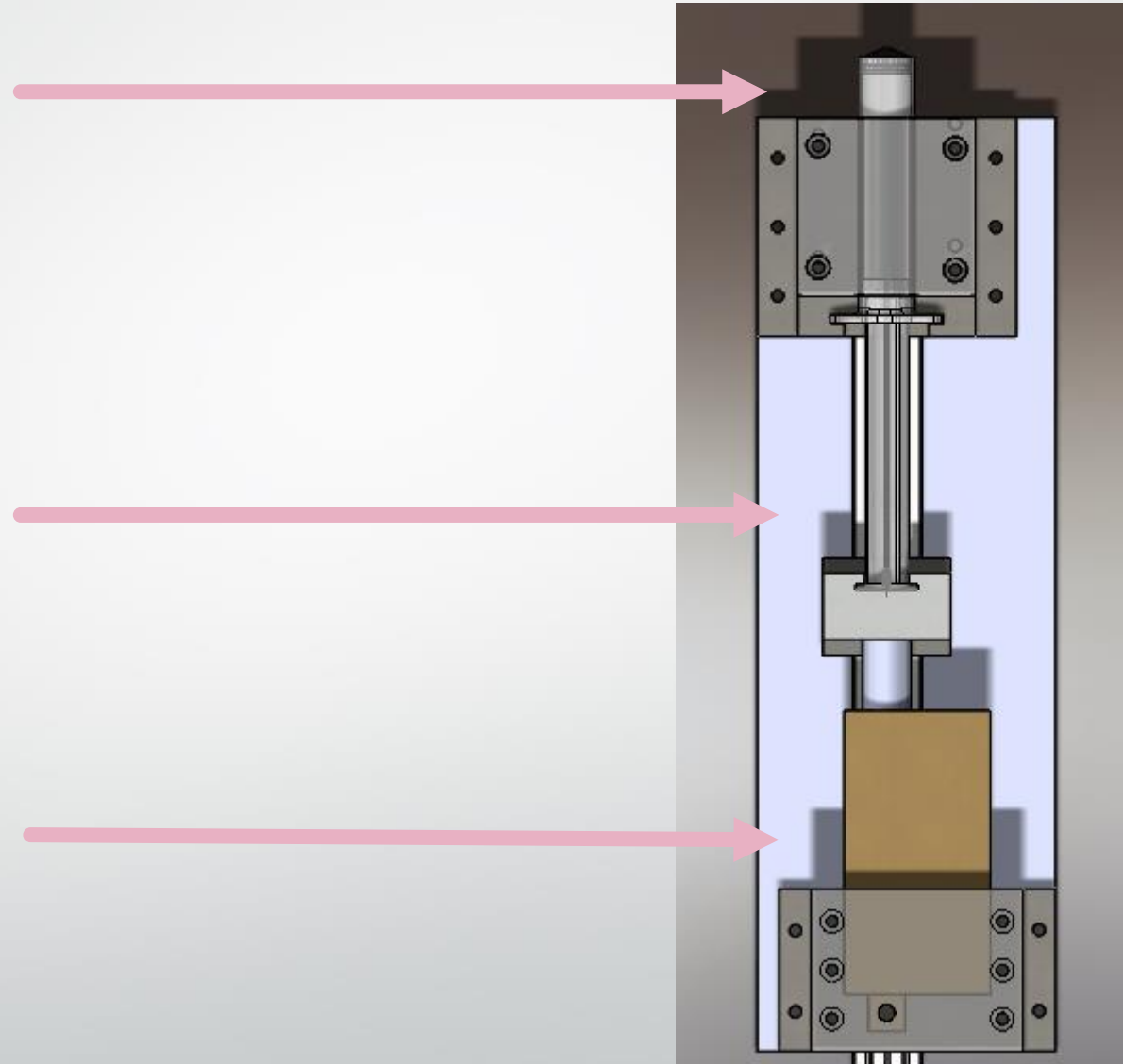
- 5 ml PLASTIC SYRINGE



- SLEEVE BEARING CARRIAGES AND GUIDE RAIL



- LINEAR ACTUATOR (50 mm length stroke)

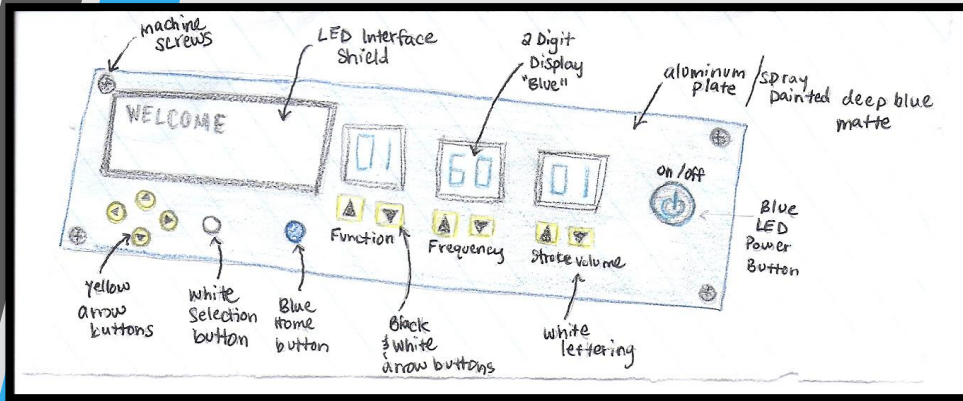


9 inch

1.3 inch in height

2.9 inch

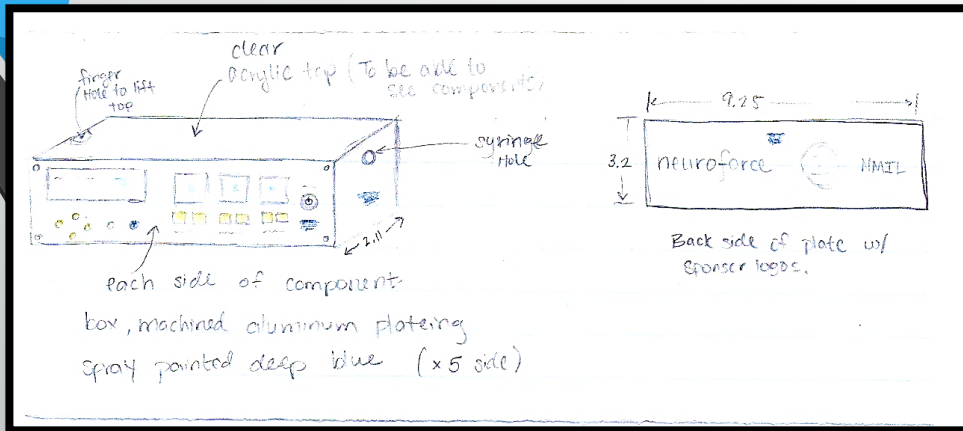
Interface Design



Prototype 1

- **Design Goals:**

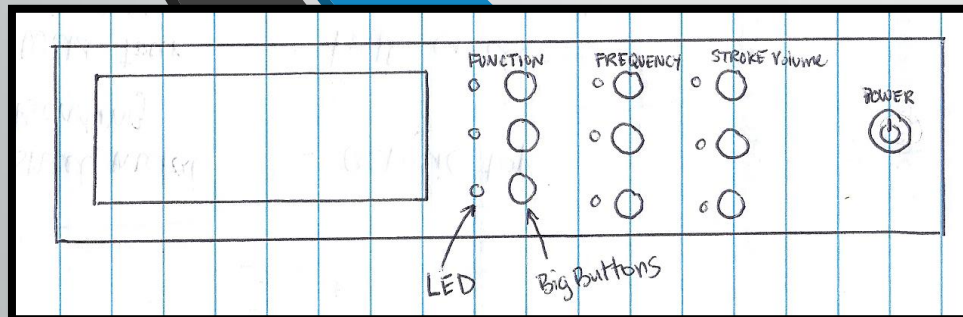
- Light
- Easy for non technical users
- Sleek
- Efficient



Prototype 2

- **Other Components:**

- Machine Screws
- Hole for Syringe Output
- Easy Access Acrylic Top
- Power Supply



Prototype 3

Interface Design

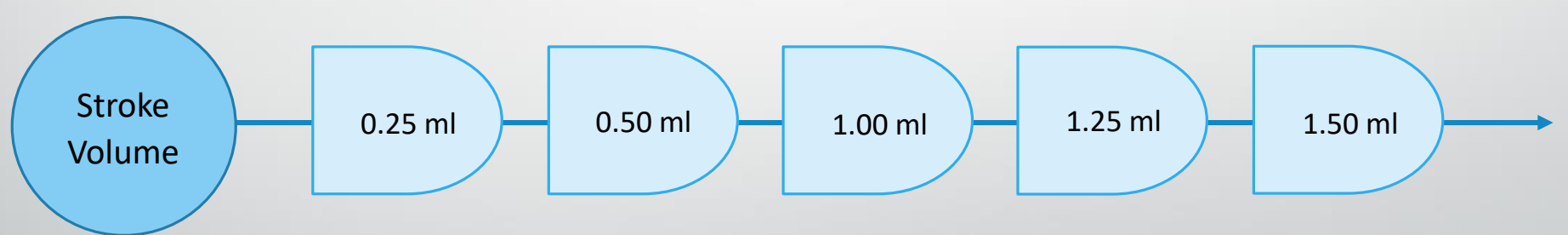
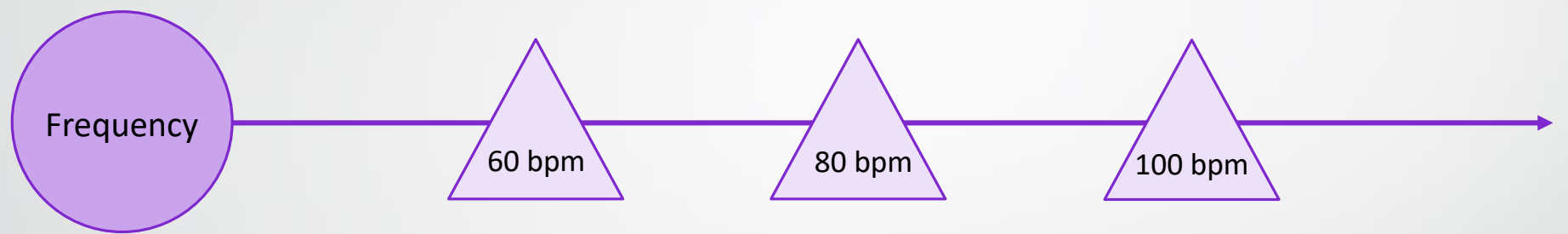
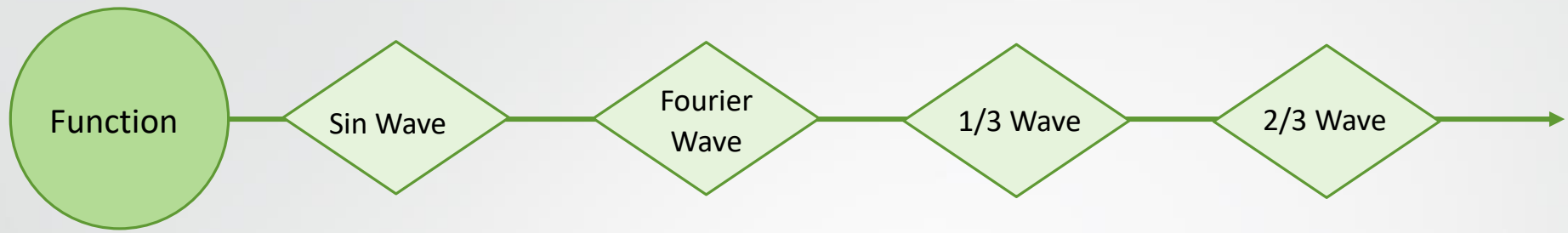
Directional Buttons



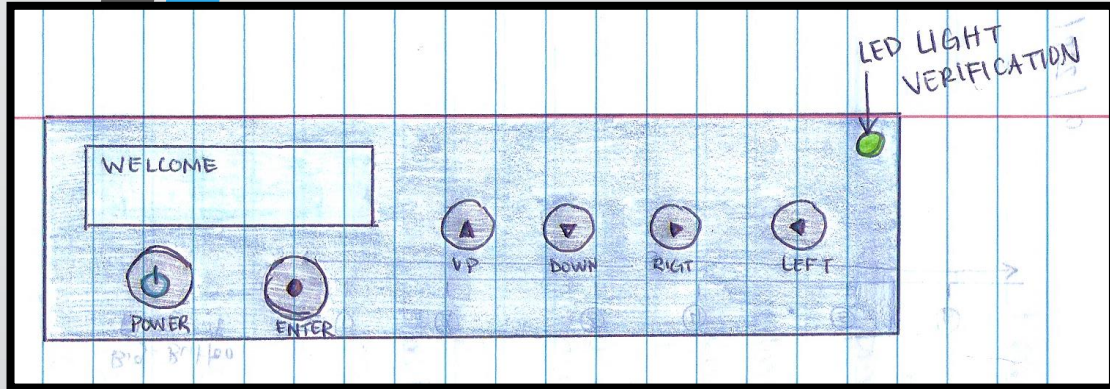
Power Button



- **Button System:**
 - Code: Counting Loop
 - 12 mm Right and Left Directional Arrows
 - LED Blinking Verification
 - 6 mm Power Button
 - Reset Button



Interface Design



Final Design - Rough Sketch



Final Design - 3D Solidworks Model

- **Final Design:**

- **Physical Features:**

- Dimensions: L x W x H
 - Sheet Metal Bending, Welded Corners
 - Light Weight Aluminum
 - Acrylic Top w/ Easy Syringe Access
 - Syringe and Power output holes

- **Technical Features:**

- LCD Screen w/ Text Verification
 - LED Light Verification
 - 4 Directional Buttons (Up, Down, Left, Right)
 - Power Button
 - Reset Button (Pin Hole)
 - Select Button



Proof of Concept

Complete – Focused data with relevant interpretations and conclusions

Oscilloscope Testing



Implementation

Well Planned – Specific vendors and model numbers ready for order; tooling and fixture needs well understood; complete set of design docs and mfg plans drafted and reviewed by shop manager



Conclusion



Questions?

- Comments/Questions on design concepts?