Fluid Dynamics Learning Set

Mech 3610 D223
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What is a Hydraulic System?

- A Hydraulic System transfers energy through a pump to achieve motion.

- Figure 1 is an example of how a hydraulic cylinder moves when pressure is applied to the inlet.

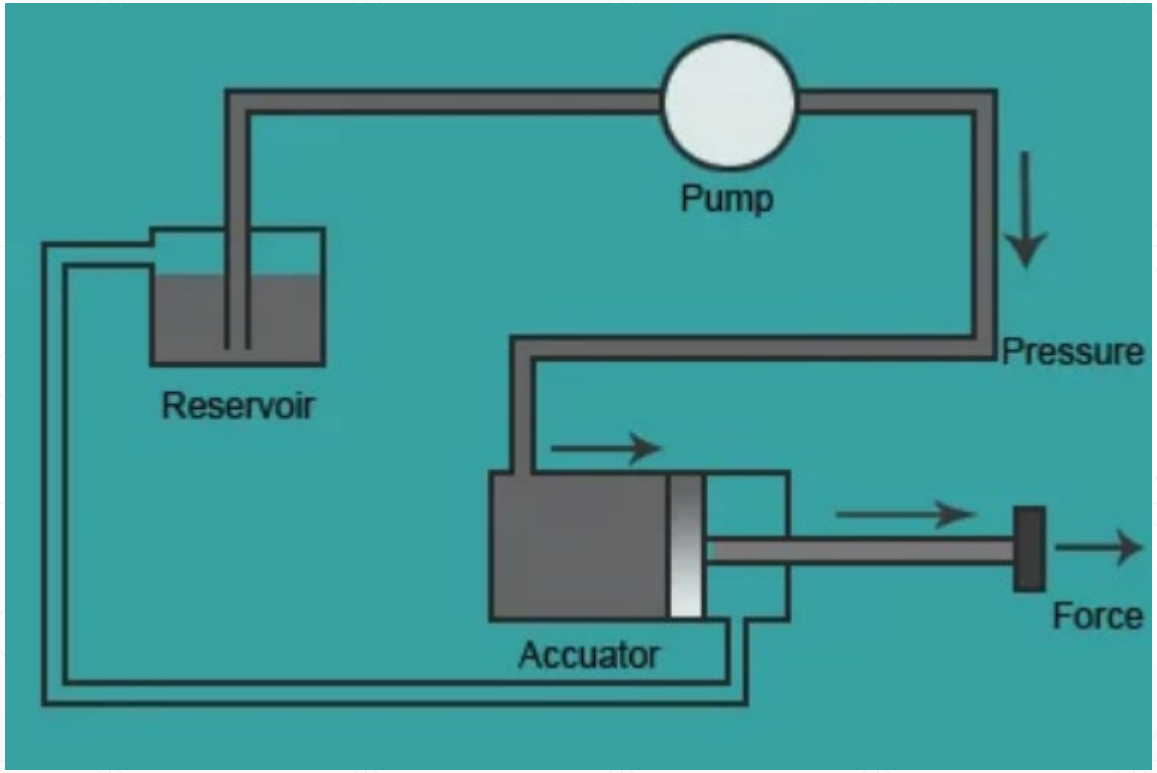


Figure 1 – Hydraulic Cylinder Movement Concept

Mission Statement

- A miniature hydraulic system intended to educate.
- Provide a hands on experience for college students.
- Demonstrates the physical interactions of fluids and associated forces.

Charter

- Designed to demonstrate core principles
- Describe concepts in fluid dynamics, in short, the way liquids transfer energy.
- Our kit will predominantly be used in an educational setting.
- Schools, colleges, and maker spaces need a practical, affordable way to communicate properly defined, complex ideas visually.

Opportunities Generation Process

- Lever Model
- Inclined Plane Model
- Pulley Model
- Screw Model
- Wedge Model
- Wheel & Axle Model
- Power Plant Scaled Models
- Manufacturing and Education Product
- Engineering Principles for Kids

Previously Existing Similar Products

Figure 2 – Simple Hydraulic System

Figure 3 – 3 in 1 Hydraulic System

Figure 4 – Expensive Hydraulic System

Figure 5 – Complex Hydraulic System

Opportunity Selection

- To fulfill a need for visual learning in hydraulics
- Mid-level learning resource to fill a void in the market
- Compact and portable lab

Customer Needs

- Grasp the essentials of fluid dynamics.
- A midrange educational product
- Modular for multiple concepts
- Easy to assemble, low mess.
- Hands on practice of principles of fluids.
- Visual gauges for measurements of demonstration

Need-Metric Relation

- Primary: Visual ways of measuring the force output and input, both by experiment and with a gauges. An interactive learning experience and a way to test principles of fluid dynamics and energy transfer.
- Secondary: The physical size, and weight of the system. Transportable.

No.	Metric	Spec.	Unit	Level
1	Max Output Force	15	Psi	1
2	Tube Diameter	1/8	in	3
3	Viscosity of Liquid (70°F)	2.034e-5	lb s/ft^2	3
4	Tank Volume	330	in^3	2
5	Total Mass of System	< 20	lbs	2
6	Input Energy	6	Joules	1
7	Pump Capacity	2	gal/hr	2
8	Min. Output Force	0	Psi	1
9	Length of Tube	36	in.	2
10	Output Configurations	3	Unitless	2

Table 4 - Metrics

House of Quality

Project:	Hydraulic Engineering Kit
Date:	11/18/2019

Relative Weight	Customer Importance	Customer Requirements	Maximum Output Force	Minimum Output Force	Configurations	Fluid Viscocity	Tank Volume	Total Mass of System	Input Energy	Pump Capacity	Diameter of Tube	Length of Tube	Our Product	Competitor 1	Competitor 2	Competitor 3
			Functional Requirements										Customer Competitive Assessment			
		Direction of Improvement	▲	▫	▫	▲	▫	▼	▼	▲	▼	▲				
8%	6	Modularity & Expandibility	▽	▽	•	▽	▽	▽	▽	▫	▫	▫	2	3	5	2
10%	7	Quick Setup Time	▽	▽	•	▽	▫	▽	▽	▽	▽	▽	3	4	1	3
6%	4	Neat & Contained Project Area	▽	▽	•	•	▽	▽	▽	▽	▽	▽	1	2	1	1
14%	10	Fundamental Properties of Fluids	•	•	•	•	▽	•	▫	•	•	•				
11%	8	Understanding of Nozzles	•	•	•	•	▽	•	•	•	•	•				
13%	9	Understanding of Pressure	•	•	•	•	▽	•	•	•	•	•				
13%	9	Understanding of Flowrate	•	•	•	•	▽	•	•	•	•	•				
8%	6	Example - Syringe (Displacment)	•	•	•	•	▽	•	•	•	•	•				
8%	6	Example - Electric Pump (GPM)	•	•	•	•	▽	•	•	•	•	•				
8%	6	Example - Water Tower (Elevated Tanks)	•	•	•	•	•	•	•	•	•	•				
		Importance Rating Sum (Importance x Rela	708.5	708	900	754	187	708	624	725	725	725				
		Relative Weight	10%	10%	13%	11%	3%	10%	9%	11%	11%	11%				
		Our Product	1	2	3	4										
		Competitor 1	3	0	1	2										
		Competitor 2	1	4	2	1										
		Competitor 3	5	1	0	1										
		Technical Competitive Assessment														

Correlations	
Positive	+
Negative	-
No Correlation	

Relationships		Weight
Strong	•	9
Medium	▫	3
Weak	▽	1

Direction of Improvement	
Maximize	▲
Target	▫
Minimize	▼

Table 5 – QFD

Concept Generation

- Clarify the Problem:
  - Modular- Systems for multiple concepts
- Decompose:
  - Tank, Valves, Tube, Syringes, Pump, Nozzles, Pressure Gauge, Rule.
- Critical Problems:
  - A reasonably sized systems for easy setup and clean up.

Input Energy	Transferring Energy	Output Energy
Syringe	Water	Pressure Gauge
Pump	Tubes	Nozzle
Tank	Valves	Distance

Table 6 – Concept Table

Concept Generation

Concept A :Syringe Water Tower

Input Energy: Manual Syringe
Output Energy: Elevated Tank

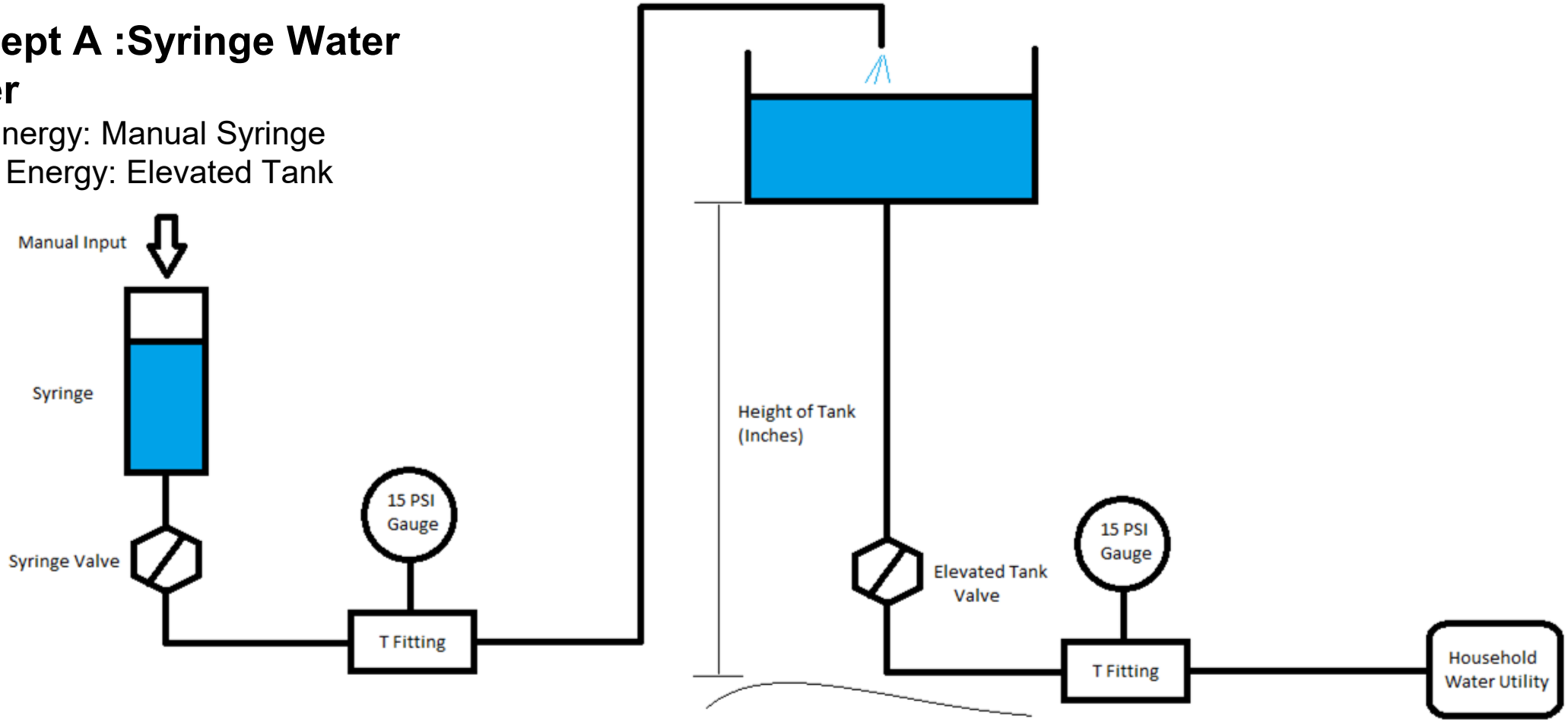


Figure 6 – Concept Generation A

Concept Generation

Concept B : Pump Water Tower

Input Energy: Electric Pump
Output Energy: Elevated Tank

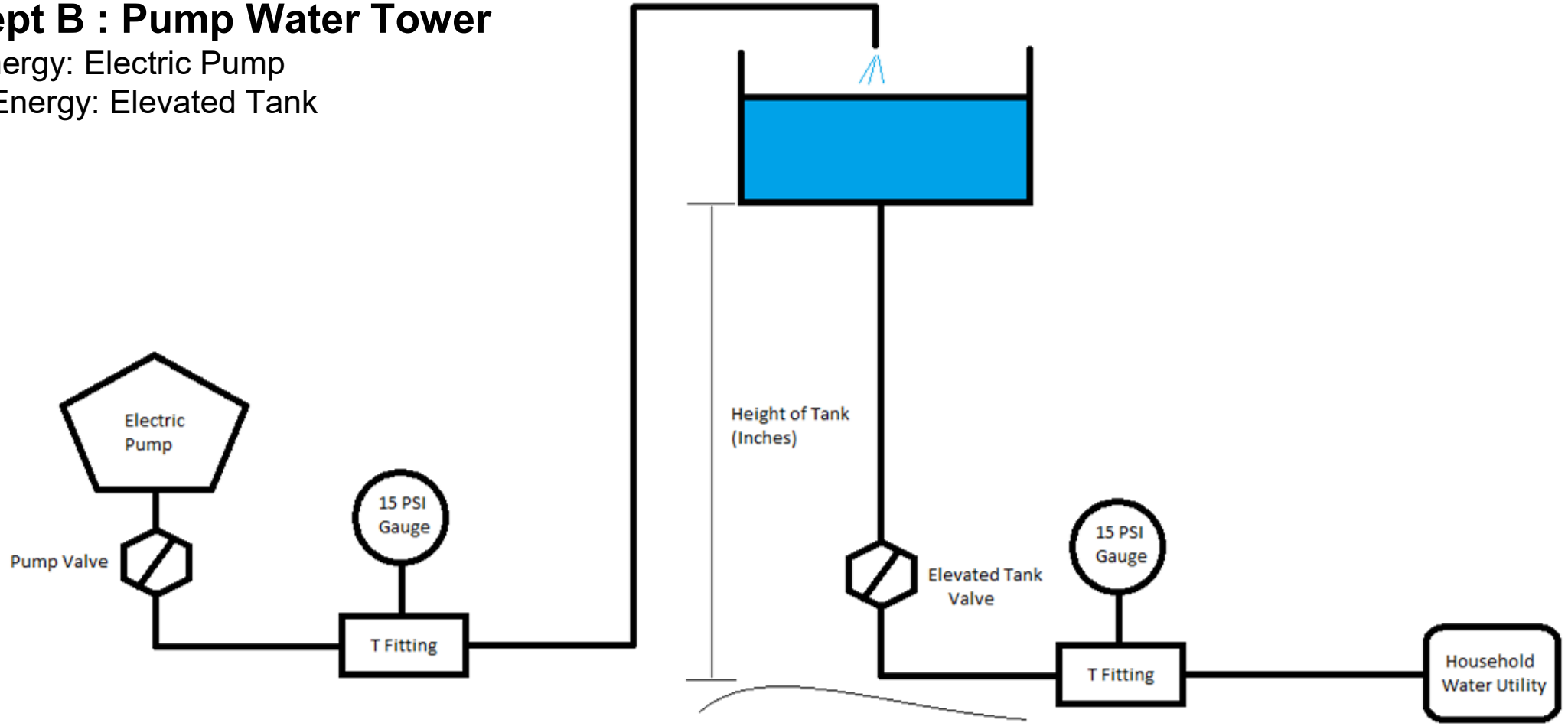


Figure 7 – Concept Generation B

Concept Generation

Concept C : Flow Vs. Displacement

Input Energy: Electric Pump
Output Energy: Jet Stream

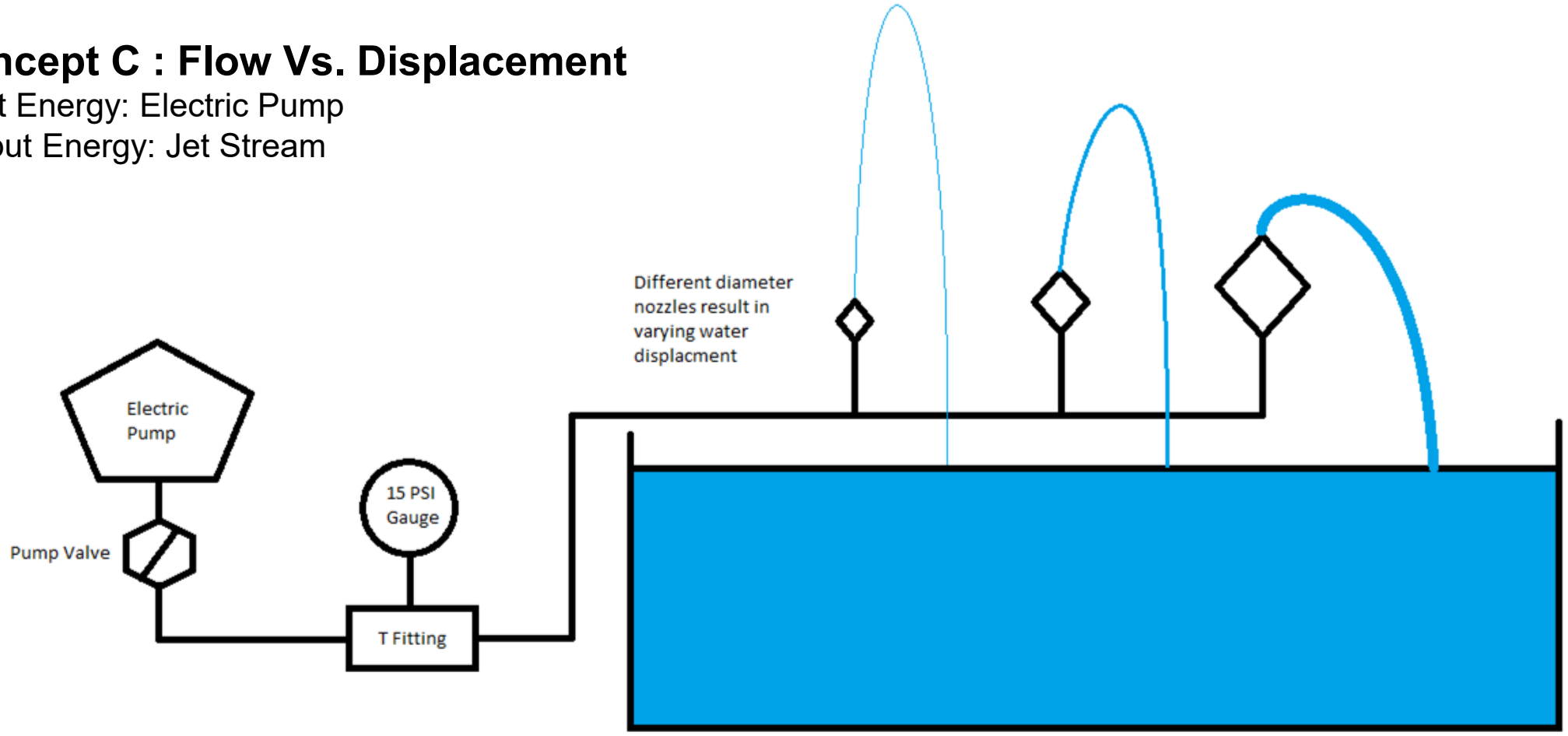


Figure 8 – Concept Generation C

Concept Selection

Based on Figures 2-5 in previous slides

A: Syringe Water Tower

B: Pump Water Tower

C:Flow Vs. Displacement

Selection Criteria	Concept Variants			REF
	A	B	C	
Ease of Handling	+	+	0	0
Ease of use	+	+	0	0
Modular	0	+	-	0
Easy to assemble	+	+	-	0
Low mess	-	0	+	0
Manufacturing Ease	+	+	-	0
Portability	+	+	-	0
Pluses	5	6	1	
Minuses	1	0	4	
Sames	1	1	2	
Net	4	6	-3	
Rank	2	1	4	
Continue	Yes	Yes	No	

Concept Scoring

R = Rating
WS = Weighted Score

A: Syringe Water Tower

B: Pump Water Tower

C:Flow Vs. Displacement

Selection Criteria | Weight		Concept Variants					
		A		B		C	
		R	WS	R	WS	R	WS
Material Cost	| 10%	8	0.8	9	0.9	4	0.4
Ease of use	| 20%	8	1.6	10	2	7	1.4
Modular	| 15%	8	1.2	8	1.2	2	0.3
Easy assembly	| 20%	10	2	8	1.6	4	0.8
Low mess	| 5%	3	0.15	7	0.35	9	0.45
Manufacturing Ease	| 15%	10	1.5	8	1.2	6	0.9
Portability	| 15%	10	1.5	10	1.2	4	0.6
Net		8.75		8.75		4.85	
Rank		2		1		3	
Continue		Yes		Yes		No	

Table 2 – Concept Scoring

Product Target Specifications

PARTS LIST				
Kit #	**Part Name**	**QTY**	**Per Item Price**	**Subtotal**
1	Pressure Syringe	2	$ 6.11	$ 12.22
2	Luer On/Off Valve	2	$ 1.38	$ 2.76
3	1/8 Barb On/Off Valve	2	$ 1.38	$ 2.76
4	Luer to 1/8 Barb Adapter	1 Pack of 10	$ 3.78	$ 3.78
5	0-15 PSI Guage	2	$ 11.90	$ 23.80
6	1/8" Tubing by the ft	12	$ 0.16	$ 1.92
7	1/8 NPT - T Fitting	2	$ 3.24	$ 6.48
8	1/8 NPT to 1/8 Barb Adapter	4	$ 4.51	$ 18.04
9	2 QT Tank with Pump	1	$ 24.58	$ 24.58
10	3/16 Barb Pump	1	$ 7.98	$ 7.98
11	1.5 Qt. Tank	1	$ 14.97	$ 14.97
TOTAL				$ 119.29

Table 3 – Product Target Specifications

Final Design

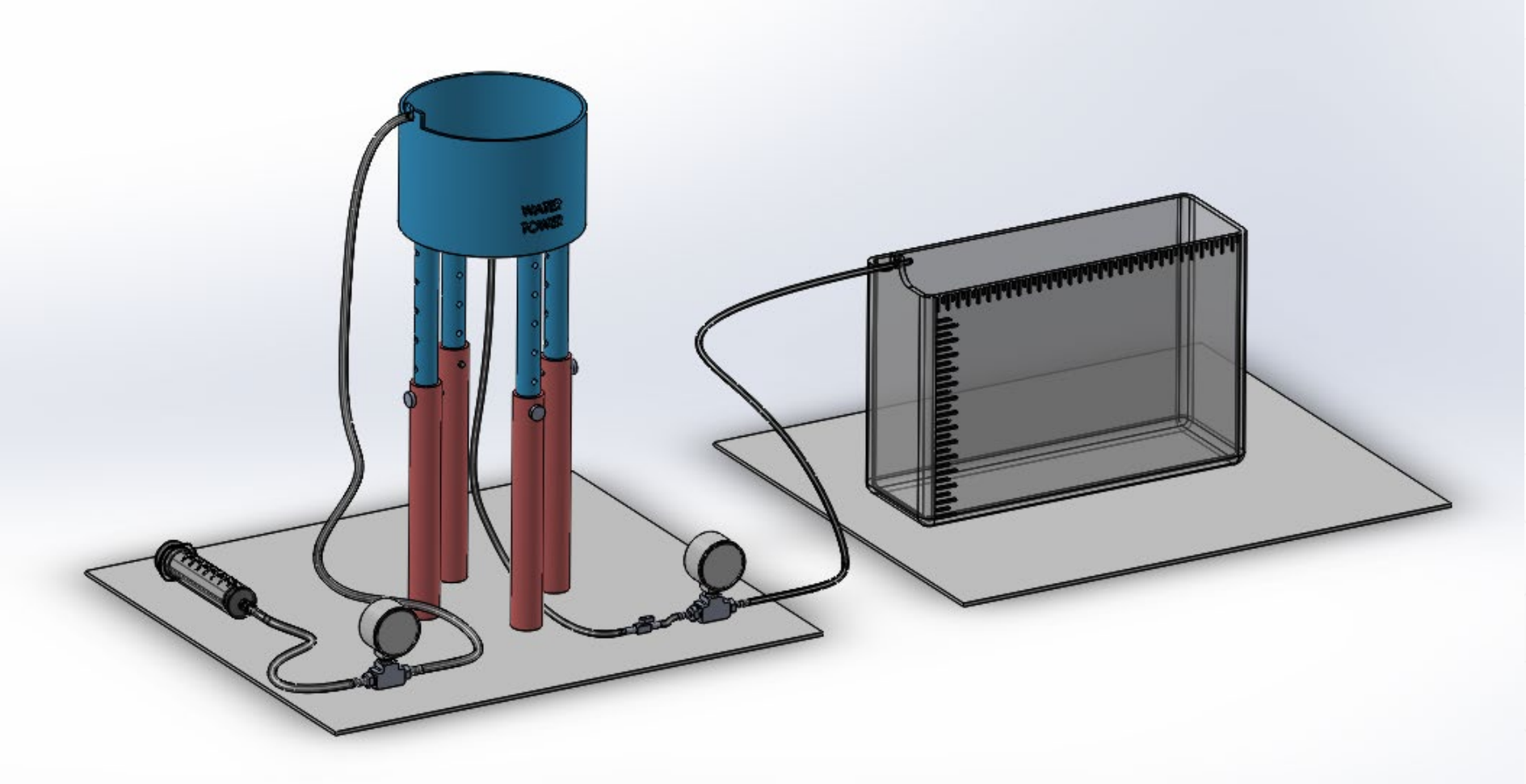
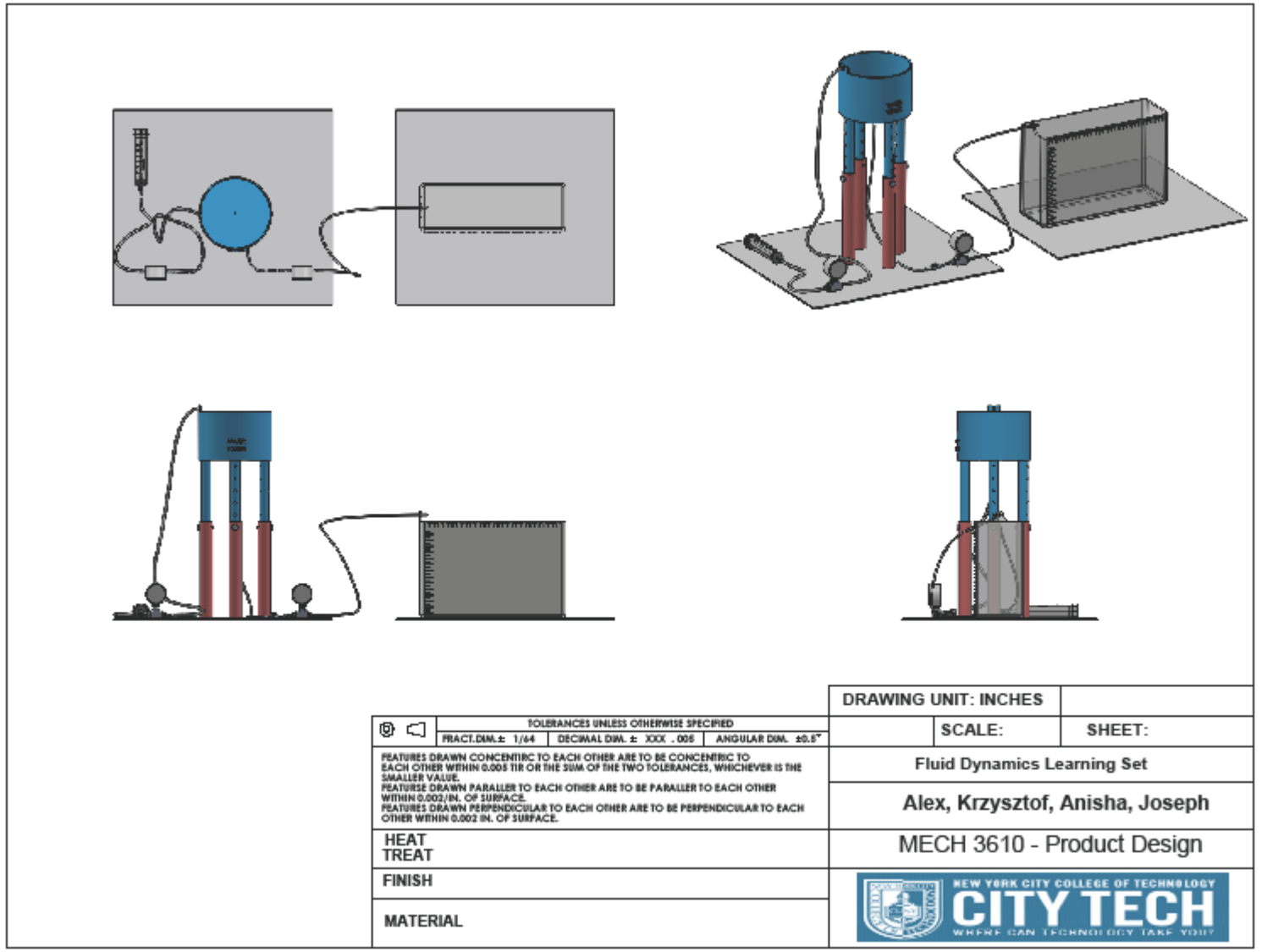


Figure – Final Design

Conclusion


DRAWING UNIT: INCHES
TOLERANCES UNLESS OTHERWISE SPECIFIED
FRACT.DIM.± 1/64
DECIMAL DIM. ± .XXX .005
ANGULAR DIM. ±0.5°
SCALE:
SHEET:
FEATURES DRAWN CONCENTRIC TO EACH OTHER ARE TO BE CONCENTRIC TO EACH OTHER WITHIN 0.005 TIR OR THE SUM OF THE TWO TOLERANCES, WHICHEVER IS THE SMALLER VALUE.
FEATURES DRAWN PARALLER TO EACH OTHER ARE TO BE PARALLER TO EACH OTHER WITHIN 0.002/IN. OF SURFACE.
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HEAT TREAT
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MATERIAL
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WHERE CAN TECHNOLOGY TAKE YOU?

References

- https://www.fsenergy.com/technology/hydraulic-system/