Miami University

College of Liberal Arts and Applied Science

Department of Engineering Technology

ENT 497/498
Senior Design

Triple Falling-Ball Viscometer
Small-Scale Pipeline System
Final Report

(Lab Components for ENT 310)

Team Members: Ted Shirk, Thuc Nguyen, and Kyle Rufer

Academic Advisors: Prof. Robert Speckert and Dr. Zhiyuan Yu

Supporting Mentor: Dr. Murat Dinc

Supporting Company: Miami University

Date: April 27, 2021

Statement of purpose:

The purpose of this project is to design and build two lab components (The Flexible Triple Falling-Ball Viscometer and Small-Scale Pipeline) used in the fluid mechanics classes at Miami University. These components are being designed, built, and tested so they can be reproduced for both Miami campuses and regional locations. With this in mind we developed the following goals:

- To design and build lab components for Miami University's fluid mechanics classes.
- Provide components which will give the student an opportunity to learn and apply concepts and principles learned within the class.

This project will enhance our experience and understanding in our field of study, as well as provide others with components to enhance theirs also.

Contents

Scope and Methodology:

The scope and methodology used for this project had a dual aspect to it with the development and design of two separate lab components.

The first of the two lab components considered was that of the falling ball viscometer. The initial falling ball viscometer consisted of a single tube with three separate balls. This design limits the function and an improvement was sought. The design we settled on was a viscometer with three tubes, which could be operated a single tube at a time or all three together, with the ability to quickly change the fluid inside the tubes. The team developed the following set up which is shown in Figure 1 below.

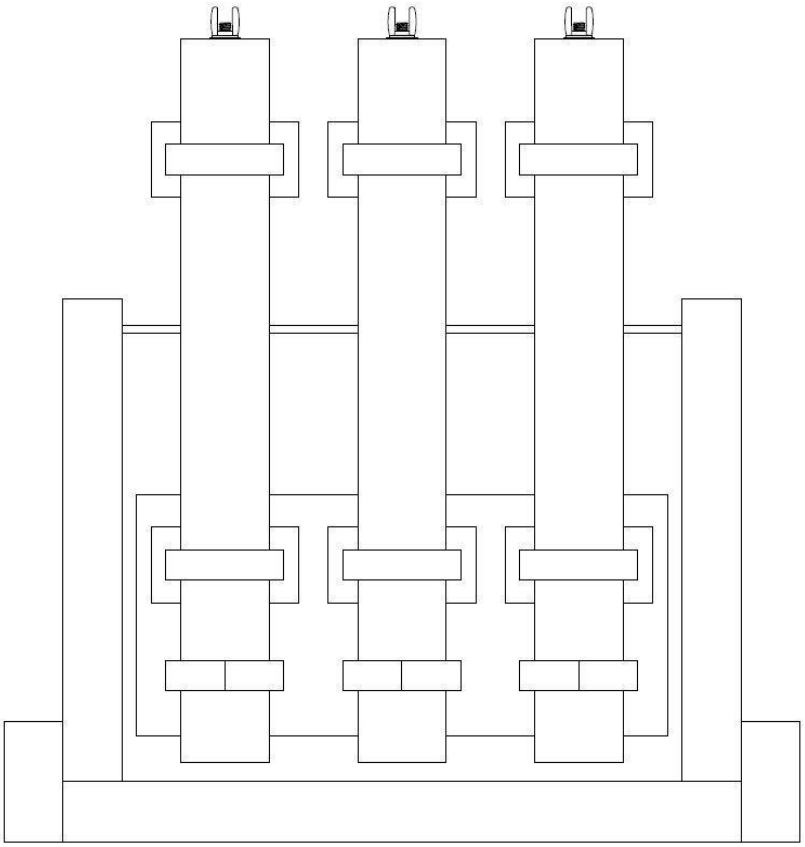


Figure 1: CAD Model of Flexible Triple Falling-Ball Viscometer

This set up allows for different fluids at the same time which serves to expand the opportunities for students to learn and experiment with the concepts taught in ENT310 and the textbook used in that course (The 7th edition Applied Fluid Mechanics chapter two).

The second of the Lab components designed was that of the Small Scale Pipe-Line. The team started out with a very basic design of a series pipe-line. After reviewing the textbook for ENT310 mentioned above, we added to the design in order to enhance the component. The addition would make it possible to carry out lab experiments on both series pipe-lines and parallel pipe-lines, as well as the pressure changes which can be caused by multiple elbows in a system. The design we settled on is shown in Figure 2 below.

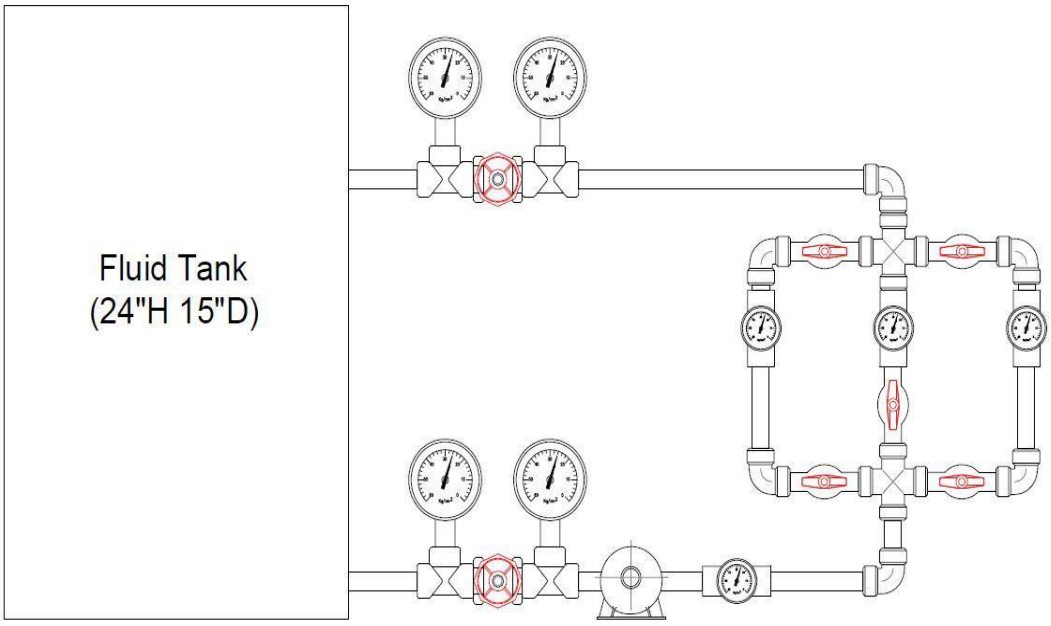


Figure 2: CAD Model of Small Scale Pipeline System

Once we decided on the design for both components we divided the tasks. Kyle pursued the CAD drawings, Ted developed the budget and pursued the costs of materials, and Thuc went to work on the pipeline simulation using PipeFlo software available on Miami University Regionals WebApp and to do some theoretical calculations using methods learned in the ENT-310 Fluid Mechanics.

Pipeline Analysis:

Our pipeline problem is considered a Class **I series pipeline** since the system is very much defined. Our goals were to compute the input power required by the pump and calculate the energy loss and pressure different between inlet and outlet points for all pipeline sections. Figure 3 below shows the PIPE-FLO model of the Small Scale Pipeline System.

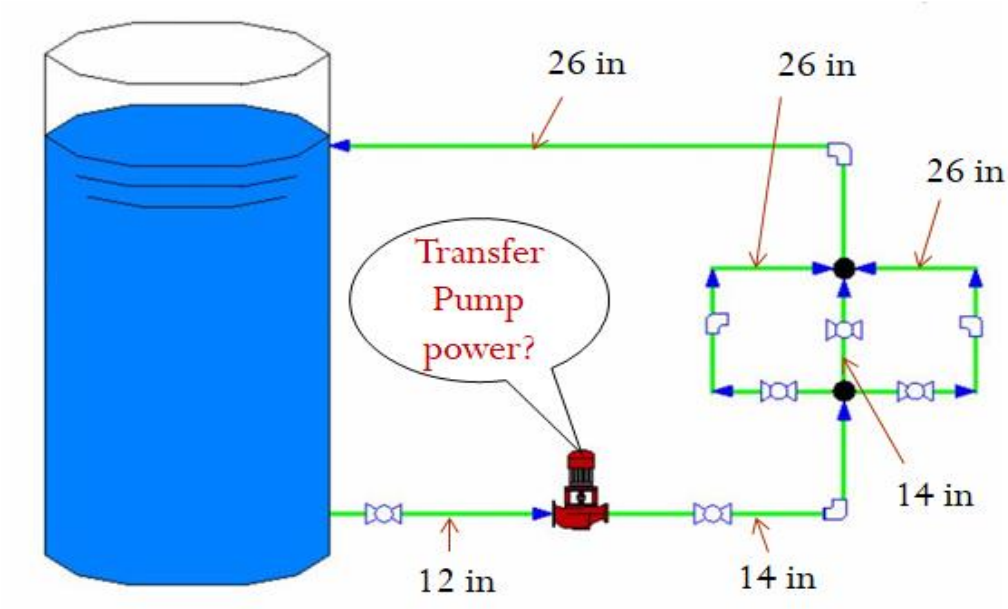


Figure 3: PIPE-FLO Model of Small Scale Pipeline System

For PIPE-FLO simulation, our group determined the following:

- Transparent cylindrical tube
- Height and diameter of the tank: 24” H and 15” D
- Pipe specs: PVC Plastic pipe, Sch 40, ¾- in diameter, 118 in (9.83 Ft) total length
- Design flow rate: 15 gal/min
- A number of Valves & Fittings that will be installed on the system

After working with PIPE-FLO calculations, the following simulation results were generated by the program (see Figure 4):

- It shows pressure drop between inlet and outlet points for all pipeline sections
- It also displays the powered required by the pump to deliver 15 gallon per minute as a designed value for this system
- 2.09 psi is the highest pressure fluid from the pump based on the flow rate of 15 gpm

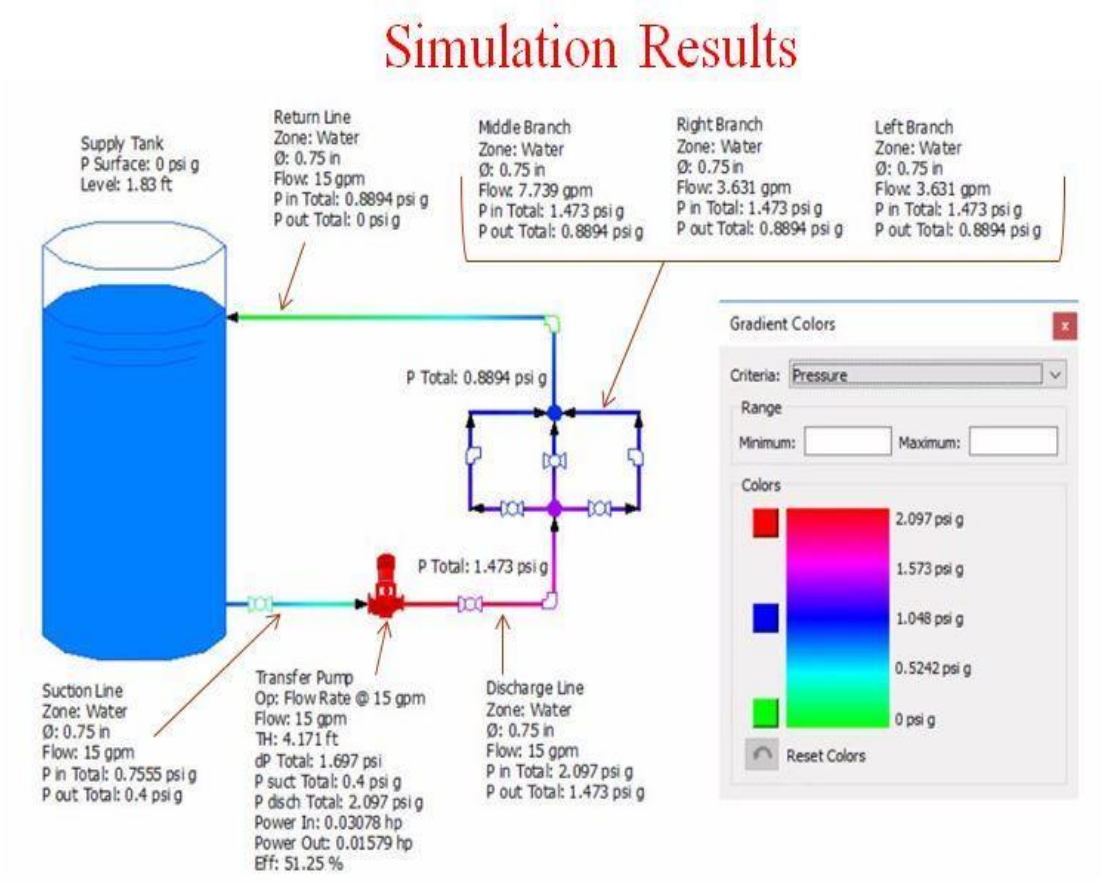


Figure 4: Simulation Results of Small Scale Pipeline System

Theoretical calculations and Excel calculations were completed in order to validate and compare with the simulation results.

Hand calculations for Suction line shown below were based on ¾ in pipe and design pipe length. These calculations also were based on the design flow rate of 15 gpm. First, we calculated pressure at the inlet point of the suction line based on our design values and water properties using a pressure-elevation equation. We need to know the pressure at this point in order to analyze the pressure difference between inlet and outlet points of this suction line. Next, we calculated the friction loss and minor losses for all valves and fittings that will be installed on this suction line. Finally, we applied an energy equation to find the pressure difference in this suction line. The results are the same as simulation results.

Expected Findings:

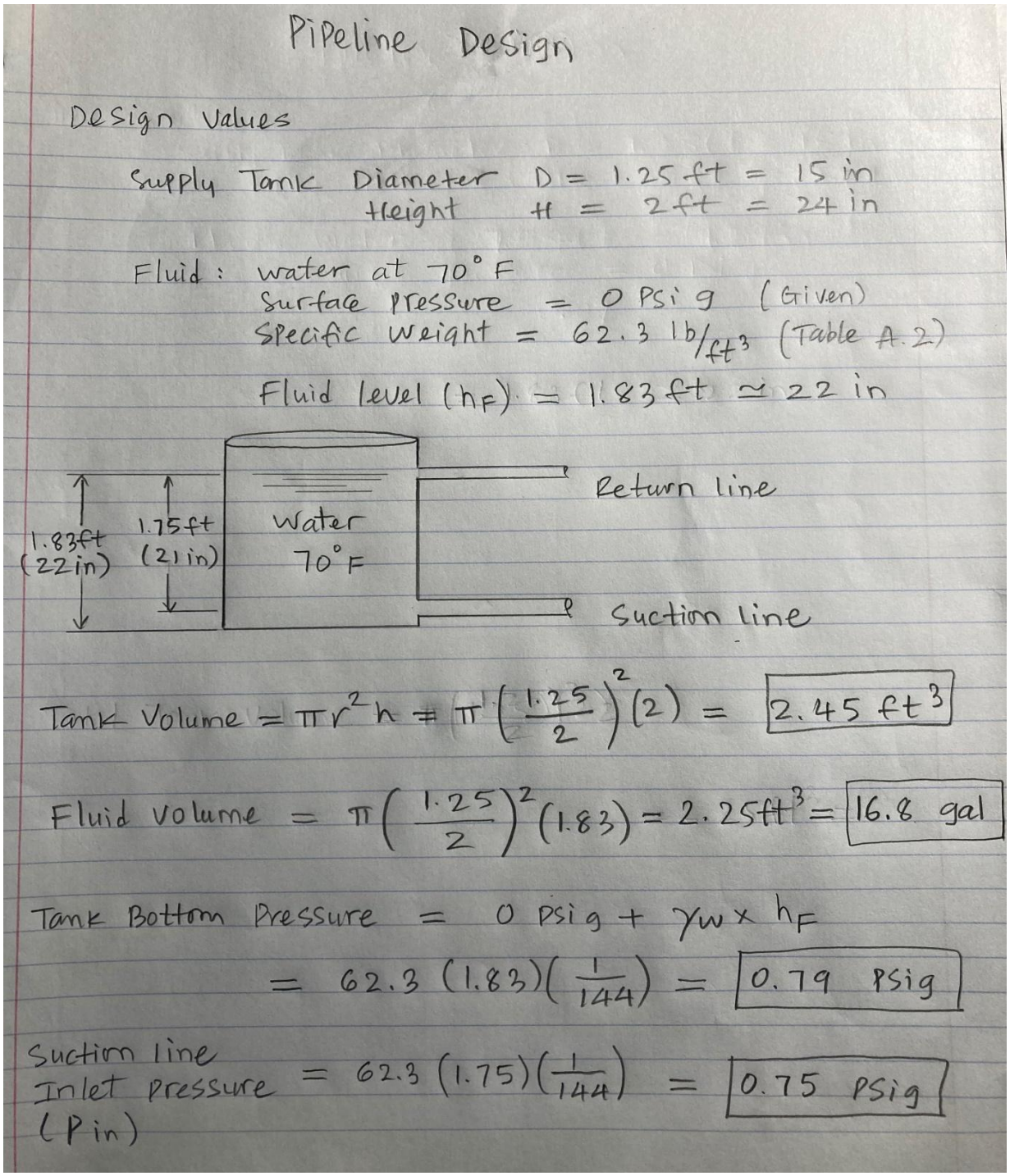


Figure 5: Tank Volume, Liquid volume, and Pressures calculations

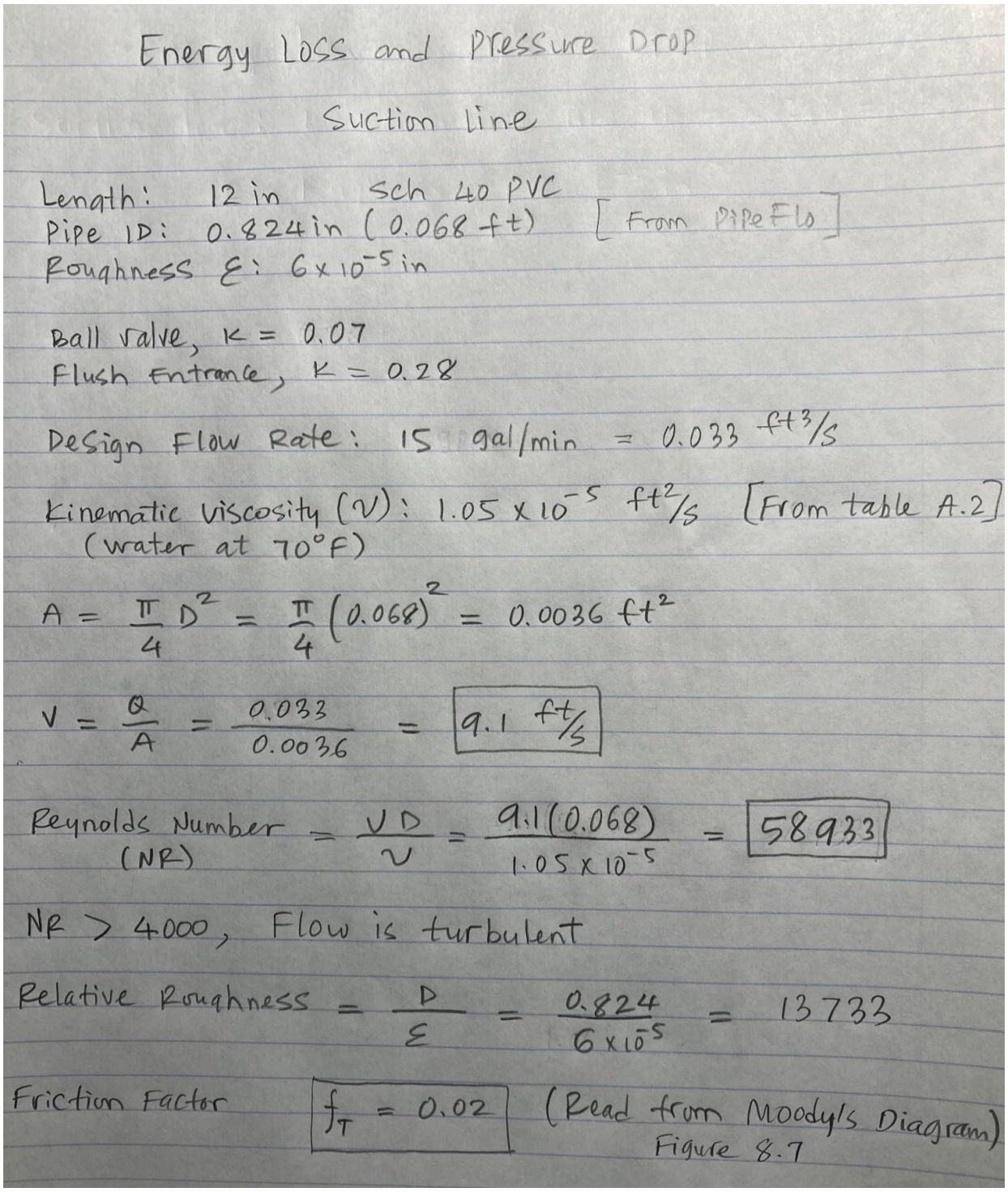


Figure 6: Reynolds Number and Friction Factor for Suction Line Calculations

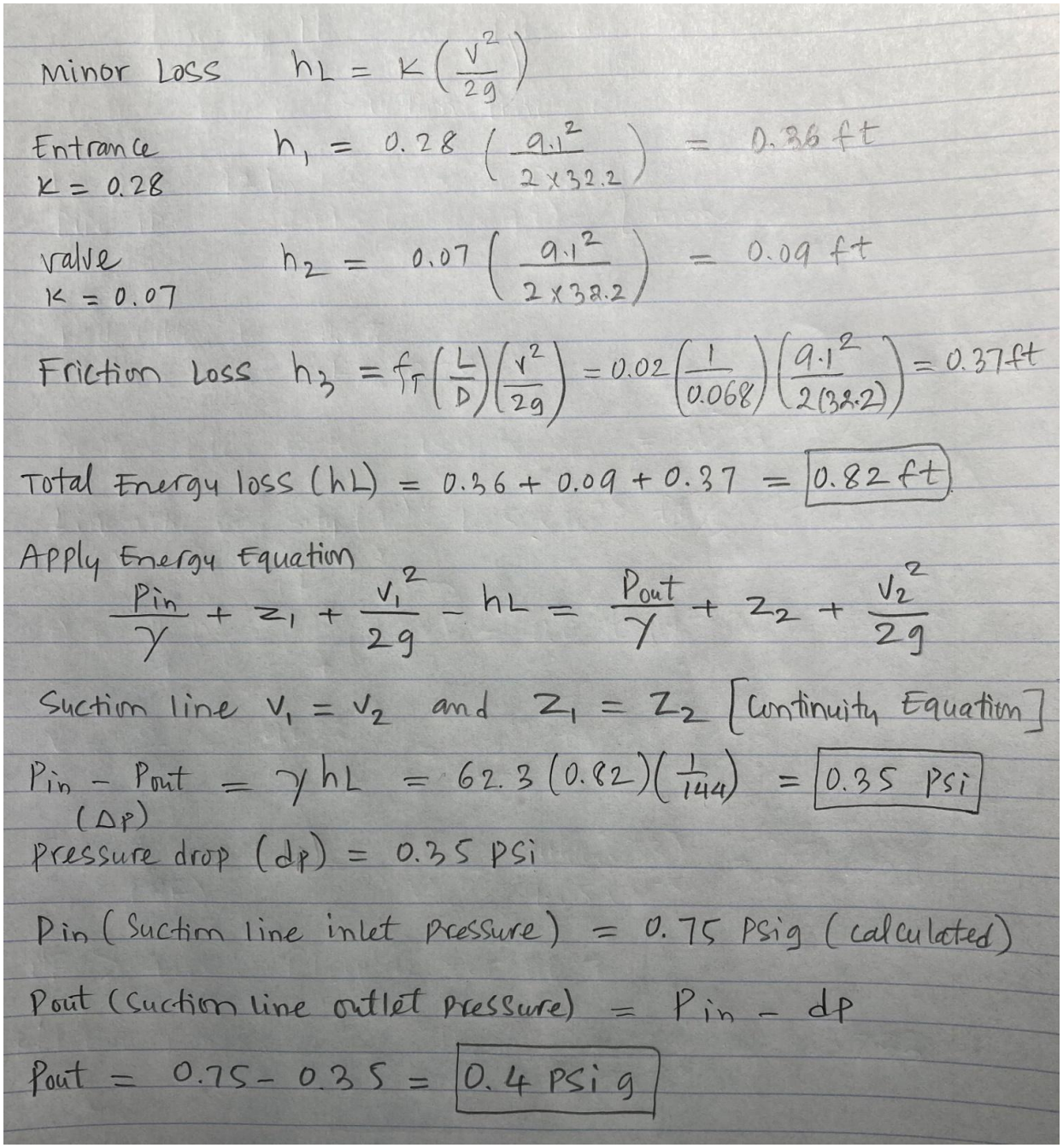


Figure 7: Fiction Loss, Minor Loss, and Pressure different for Suction Line Calculations

We also used Excel calculations to compare the simulation results for other pipeline sections. Dr. Murat Dinc provided our team some Excel spreadsheets that were based on some pipeline problems from the ENT 310 textbook; we modified them to fit our pipeline design and used the results to compare with PIPE-FLO results.

Excel calculations for the discharge line using Excel spreadsheet for Class I series is shown below (Figure 8). These calculations also were based on the design flow rate of 15 gpm, ¾ in. pipe diameter, and design pipe length.

ENT 497 - 498 Pipeline System: Engergy Loss and Pressure Drop						
Discharge Line		Point 1: At outlet of pump Point 2: At node 1 (three branches network)				
System Data:	US Customary Units					
Volume flow rate: Q =	*0.033*	*ft^3/s*	*Elevation at point 1 =*	*0.084*	*ft*	*Inlet Point*
Total Inlet Pressure =	*2.09*	*psig*	*Elevation at point 2 =*	*0.334*	*ft*	*Outlet Point*
Velocity at point 1 =	*9.20*	*ft/s*	Vel head at point 1 =	1.31	ft	
Velocity at point 2 =	*9.20*	*ft/s*	Vel head at point 2 =	1.31	ft	
Fluid Properties:	Water at 70 deg F					
Specific weight =	*62.3*	*lb/ft^3*	*Kinematic viscosity =*	*1.05E-05*	*ft^2/s*	*(Found in Table A.2)*
Pipe Spec: 3/4-in Sch. 40 PVC pipe						
Diameter: D =	*0.068*	*ft*				
Wall roughness: ε =	*5.00E-06*	*ft*	*(From PipeFlo)*			
Length: L =	*1.167*	*ft*				
Area: *A* =	3.63E-03	ft^2	[$A = \pi D^2/4$]			
D /ε =	13600		Relative roughness			
L /*D* =	17					
Flow Velocity =	9.20	ft/s	ft/s [v = Q/A]			
Velocity head =	1.314	ft	[v2/2g]			
Reynolds No. =	5.96E+04		[$N_R = vD/\nu$]			
Friction factor: *f* =	0.0203		Using Eq. 8-7	For Turbulent Flow		
Energy losses-Pipe	*K*	Qty.				
Pipe: $K_1 = f(L/D)$ =	0.35	1	Energy loss h_{L1} =	0.46	ft	Friction Loss
Ball valve: K_2 =	*0.07*	*1*	Energy loss h_{L2} =	0.09	ft	Minor Loss
90 Deg elbows: K_3 =	*0.72*	*1*	Energy loss h_{L3} =	0.95	ft	Minor Loss
			Total energy loss h_{Ltot} =	1.50	ft	Total Head Loss
	Results:		Total change in pressure (dP):	**-0.76**	psi	
			Total Outlet Pressure	**1.33**	**psig**	
Reference:	Spreadsheet for CLASS I SERIES SYSTEMS					
	Chapter 11, Applied Fluid Mechanics Textbook					

Figure 8: Pressure Drop Calculations of Discharge Line Using Excel

Similarly, the table below (Figure 9) shows the comparisons between Excel Calculation and Simulation results for Energy Loss and Pressure drop. They both show the same results

Pipeline Sections	Details	Calculations Results	Simulation Results	Unit
Left Branch Line	Total Engergy Loss	0.19	0.18	ft
	Pressure In	1.47	1.47	psi g
	Pressure Drop (dP)	0.59	0.58	psi
	Pressure Out	0.88	0.88	psi g
Middle Branch Line	Total Engergy Loss	0.19	0.18	ft
	Pressure In	1.47	1.47	psi g
	Pressure Drop (dP)	0.59	0.58	psi
	Pressure Out	0.88	0.88	psi g
Right Branch Line	Total Engergy Loss	0.19	0.18	ft
	Pressure In	1.47	1.47	psi g
	Pressure Drop (dP)	0.59	0.58	psi
	Pressure Out	0.88	0.88	psi g
Return Line	Total Engergy Loss	0.90	1.72	ft
	Pressure In	0.90	0.88	psi g
	Pressure Drop (dP)	0.90	0.88	psi
	Pressure Out	0	0	psi g

Figure 9: Pressure Drop Calculations of the Remaining Pipeline Sections Using Excel

To validate the pump power, we also used Excel calculations to find the power required by the pump with the flow rate of 15 gallons per minute. The results are the same as the simulation results (see Figure 10).

ENT 497 - 498 PIPELINE SYSTEM			Power US:		CLASS I SERIES SYSTEMS
Objective: *Pump power*			*Reference points for the energy equation:*		
Transfer Pump			Pt. 1: At Supply Tank (Suction Line)		
			Pt. 2: At Supply Tank (Return Line)		
System Data:	**U.S. Customary Units**				
Volume flow rate: Q =	*0.0334*	*ft^3/s*	*Elevation at point 1 =*	*0.084*	*ft*
Pressure at point 1 =	*0.75*	*psig*	*Elevation at point 2 =*	*1.83*	*ft*
Pressure at point 2 =	*0*	*psig*	*If Ref. pt. is in pipe: Set v_1 "= B20" OR Set v_2 "= E20"*		
Velocity at point 1 =	*9.20*	*ft/s -->*	Vel head at point 1 =	1.31	*ft*
Velocity at point 2 =	*9.01*	*ft/s -->*	Vel head at point 2 =	1.26	*ft*
Fluid Properties:	Water at 70 deg F				
Specific weight =	*62.30*	*lb/ft^3*	*Kinematic viscosity =*	*1.05E-05*	*ft^2/s*
Suction Pipe: 3/4-in Schedule 40 PVC pipe			***Discharge Pipe: 3/4-in Schedule 40 PVC pipe***		
Diameter: D =	*0.068*	*ft*	*Diameter: D =*	*0.068*	*ft*
Wall roughness: ε =	*5.00E-06*	*ft*	*Wall roughness: ε =*	*6.00E-05*	*ft [From PipeFlo]*
Length: L =	*1*	*ft*	*Length: L =*	*5.5*	*ft*
Area: *A* =	0.00363	ft^2	Area: *A* =	0.00363	ft^2 [$A = \pi D^2/4$]
D/ε =	13600		*D/ε* =	1133	Relative roughness
L/D =	15		*L/D* =	81	
Flow Velocity =	9.20	ft/s	Flow Velocity =	9.20	ft/s [$v = Q/A$]
Velocity head =	1.314	ft	Velocity head =	1.314	ft [$v^2/2g$]
Reynolds No. =	5.96E+04		Reynolds No. =	5.96E+04	[$N_R = vD/\nu$]
Friction factor: *f* =	0.0203		Friction factor: *f* =	0.0233	Using Eq. 8-7
Energy losses-Suction Line:	*K*	Qty.			
Pipe: K_1 =	0.30	1	Energy loss h_{L1} =	0.39	ft
Ball Valve : K_2 =	*0.07*	*1*	Energy loss h_{L2} =	0.09	ft
Flush Entrance: K_3 =	*0.28*	*1*	Energy loss h_{L3} =	0.37	ft
Energy losses-Discharge Line:	*K*	Qty.			
Pipe: K_1 =	1.88	1	Energy loss h_{L1} =	2.47	ft
90 Deg Elbow: K_2 =	*0.72*	*2*	Energy loss h_{L2} =	1.89	ft
Ball Valve: K_3 =	*0.07*	*2*	Energy loss h_{L3} =	0.18	ft
			Total energy loss h_{Lot} =	5.40	ft
	Results:		Total head on pump: h_A =	5.4	ft
			Power added to fluid: P_A =	0.02	hp
			Pump efficiency =	*60.00*	*%*
			Power input to pump: P_i =	0.03	hp

Reference: Chapter 11, Figure 11.3, Applied Fluid Mechanics Textbook

Figure 10: Pump Power Calculations Using Excel

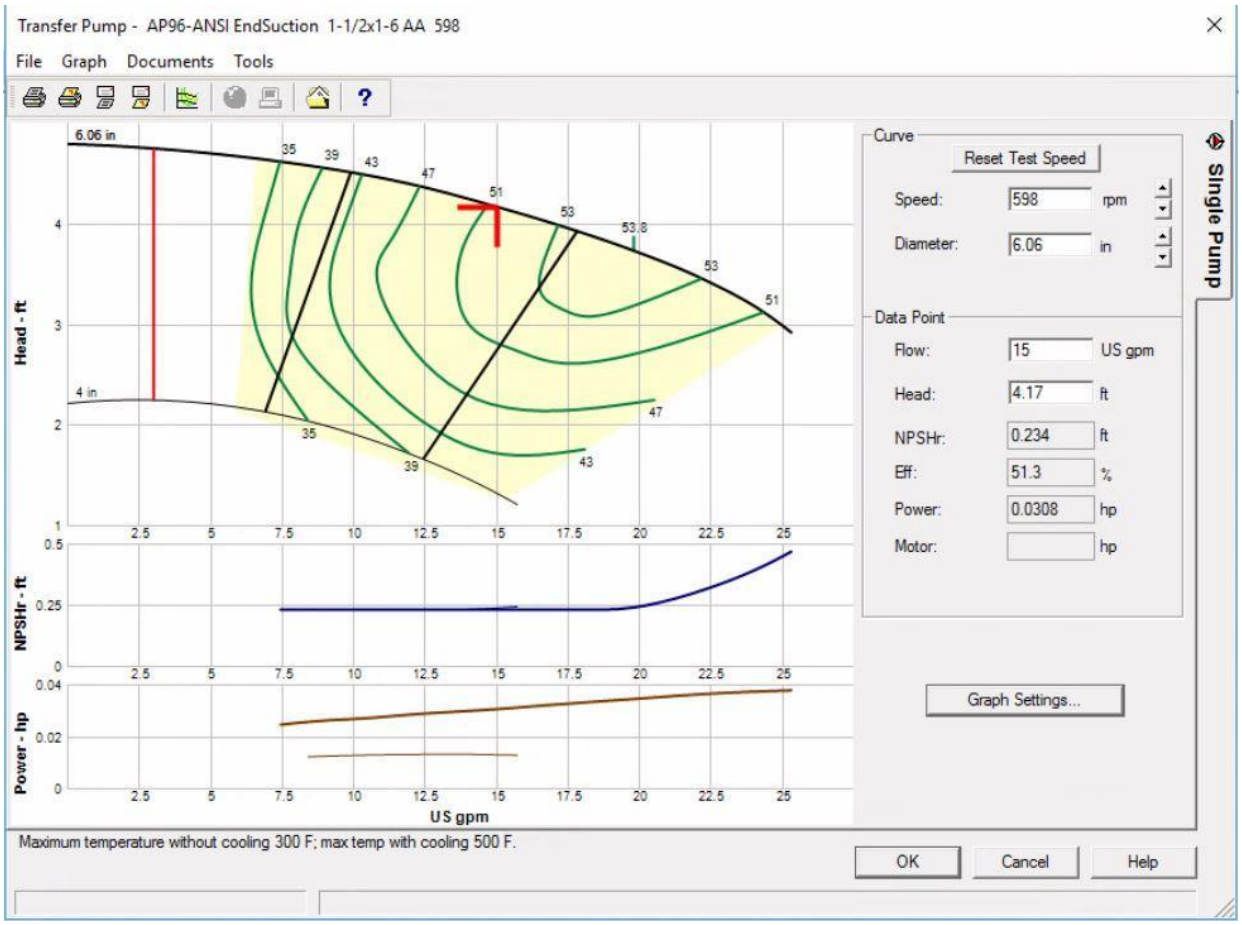


Figure 11: Pump Curve for 15gpm Flow Rate Generated from PIPE-FLO

Completed Components:

Figure 12: Completed Flexible Triple Falling-Ball Viscometer

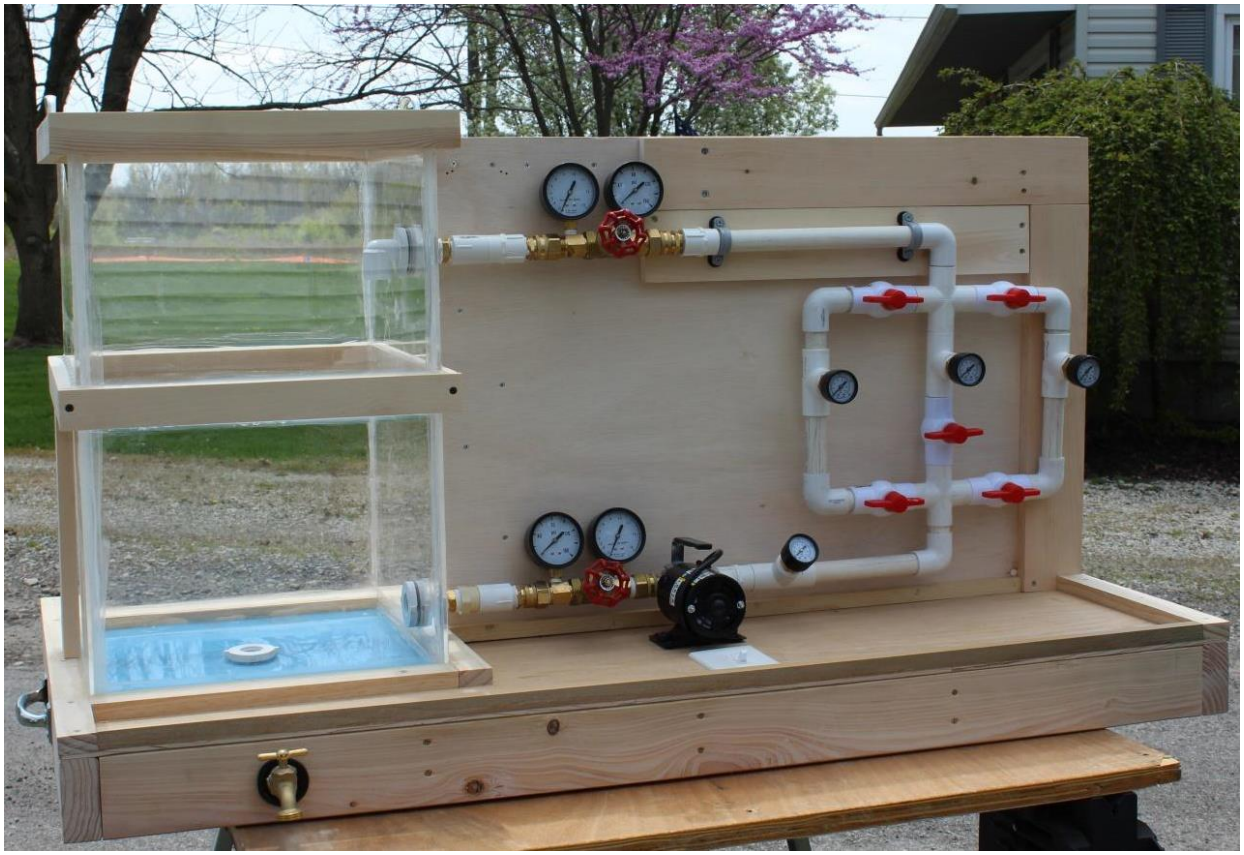


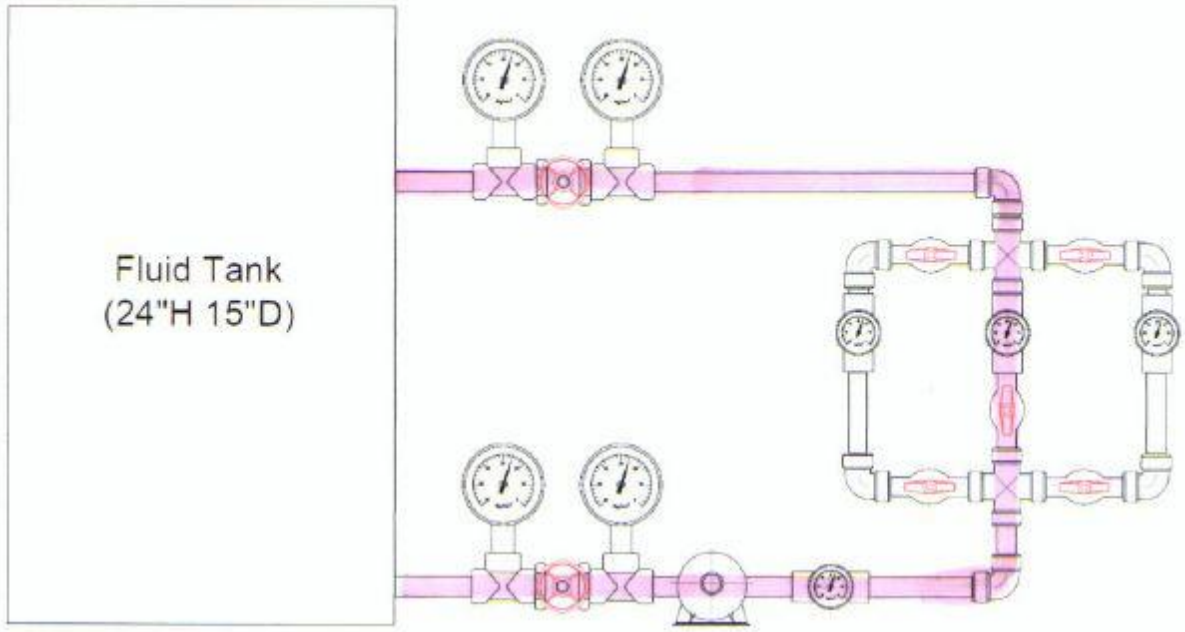
Figure 13: Completed Small Scale Pipeline System

Experimental Results:

We performed experiments 7 times for 3 series tests and 4 parallel tests with the following conditions:

- Filled the tank with 15” of water at 70 deg Fahrenheit
- Adjusted the last valve at ½” closed

Series 1 test:



1st pressure = 0

1st Flow = 0

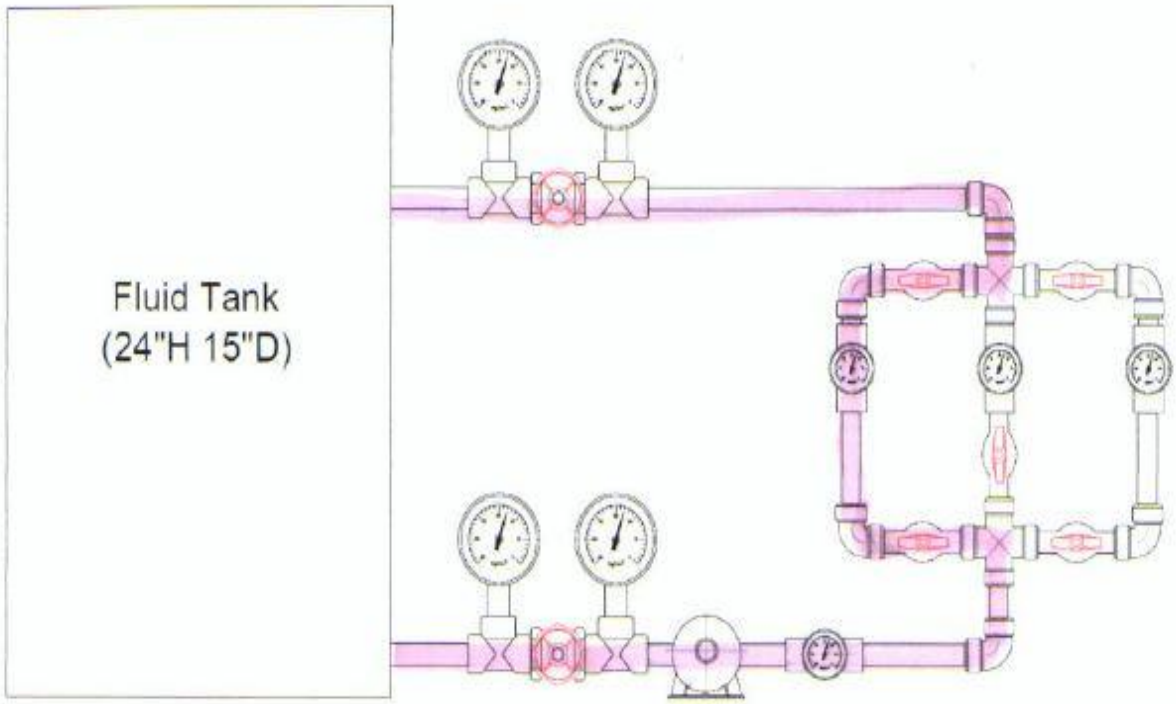
2nd pressure = 20lbs

3rd pressure = 20lbs

6th pressure = 20lbs

2nd Flow = 4gpm

Series 2 test:



1st pressure = 0

1st Flow = 0

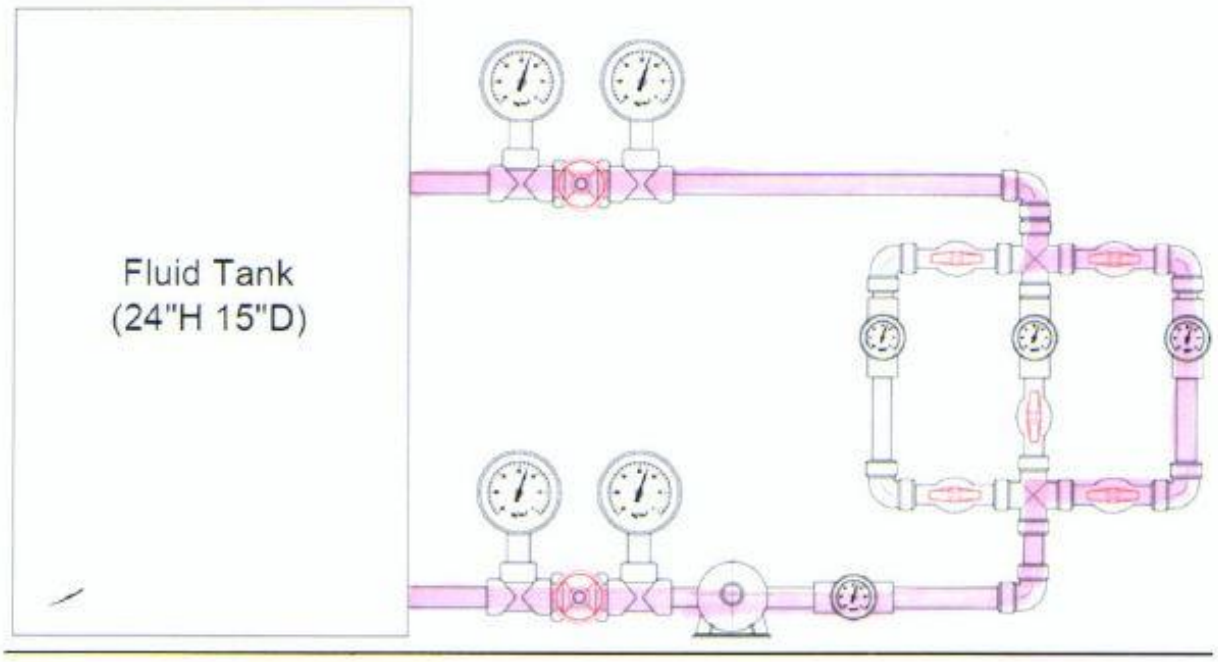
2nd pressure = 20lbs

4th pressure = 15lbs

6th pressure = 20lbs

2nd Flow = 4gpm

Series 3 test:



1st pressure = 0

1st Flow = 0

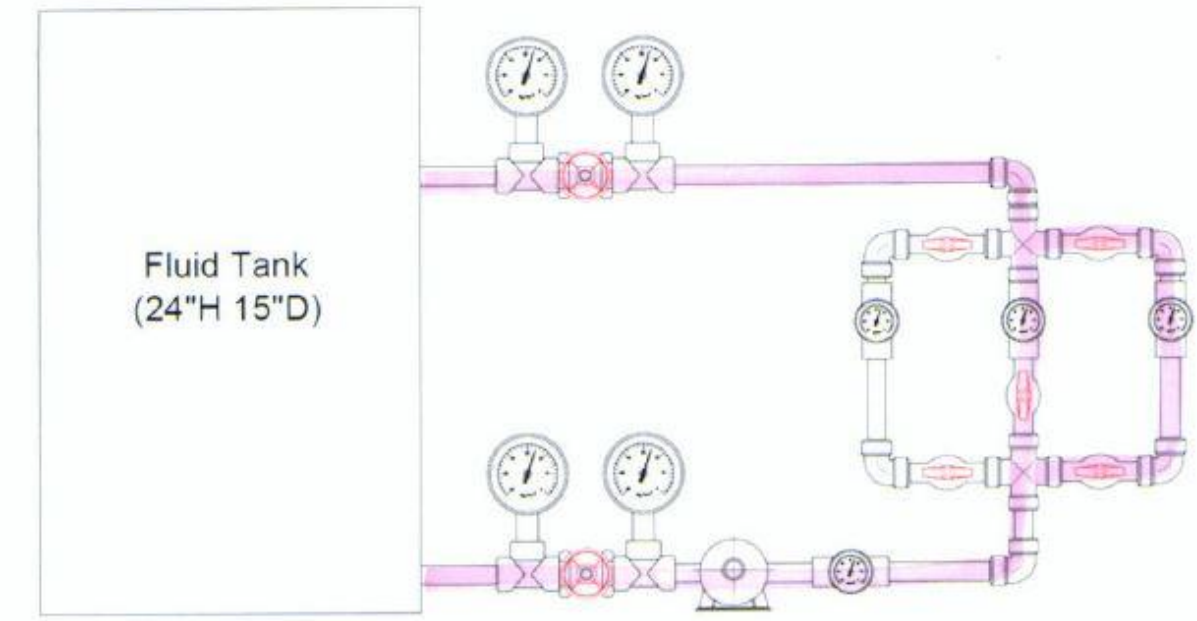
2nd pressure = 20lbs

5th pressure = 15lbs

6th pressure = 20lbs

2nd Flow = 3gpm

Parallel 1 test:



1st pressure = 0

1st Flow = 0

2nd pressure = 20lbs

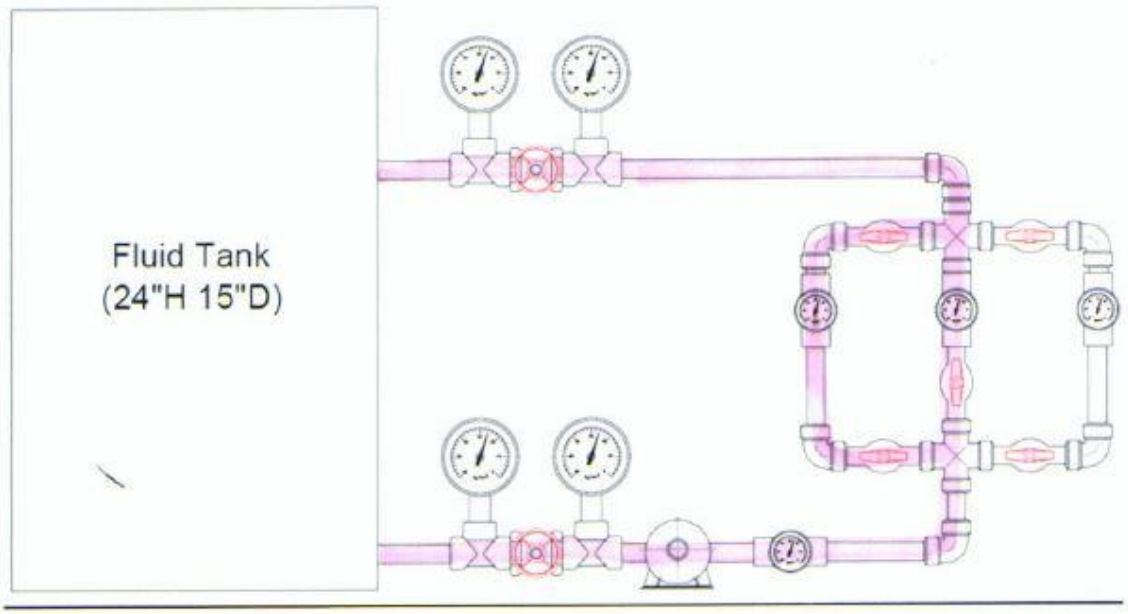
3rd pressure = 20lbs

5th pressure = 20lbs

6th pressure = 20lbs

2nd Flow = 3gpm

Parallel 2 test:



1st pressure = 0

1st Flow = 0

2nd pressure = 20lbs

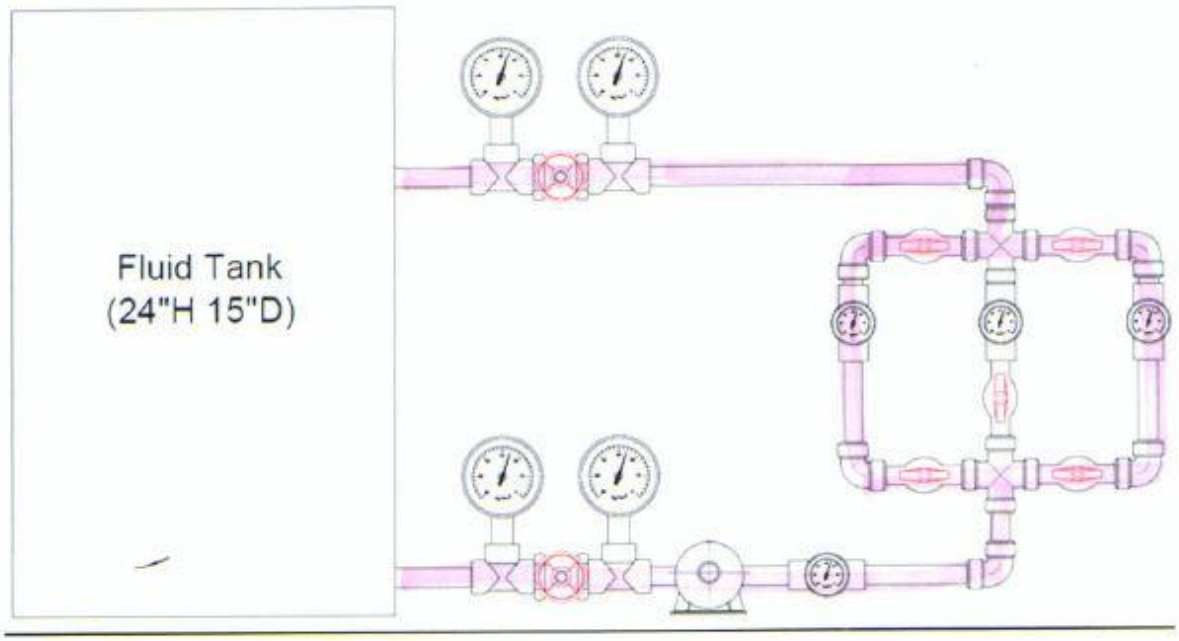
3rd pressure = 15lbs

4th pressure = 15lbs

6th pressure = 20lbs

2nd Flow = 3gpm

Parallel 3 test:



1st pressure = 0

1st Flow = 0

2nd pressure = 20lbs

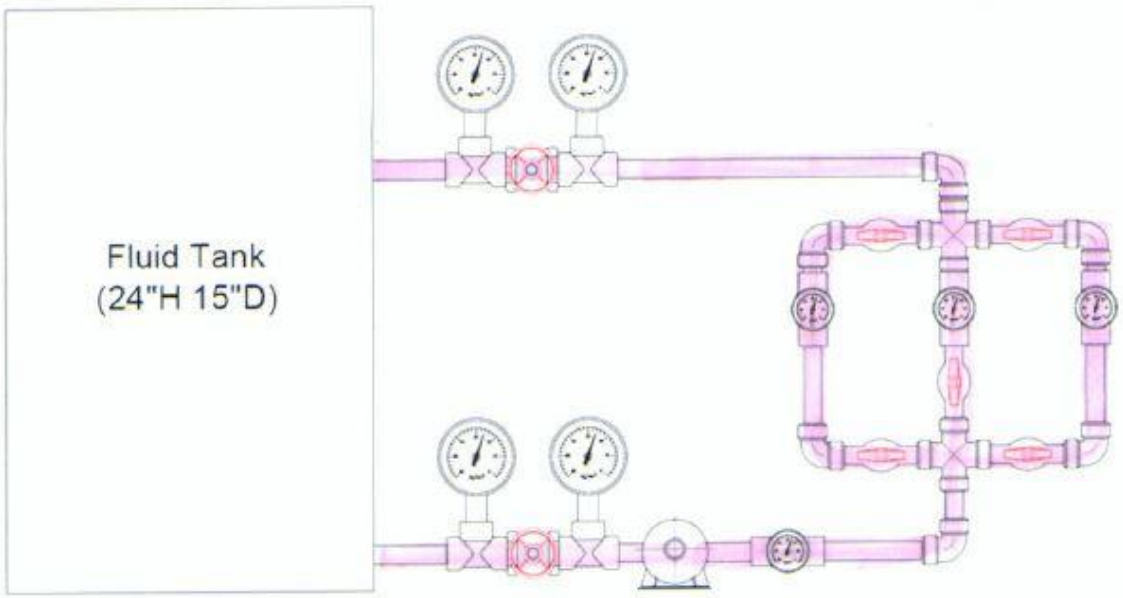
4th pressure = 15lbs

5th pressure = 15lbs

6th pressure = 20lbs

2nd Flow = 3gpm

Parallel 4 test:



1st pressure = 0

1st Flow = 0

2nd pressure = 20lbs

3rd pressure = 15lbs

4th pressure = 15lbs

5th pressure = 15lbs

6th pressure = 20lbs

2nd Flow = 3gpm

Cost of Production:

Estimated Cost:

With the CAD drawings complete and the simulation results/report from PipeFlo, as well as design values determined, the budget and cost of material estimate equaled the following:

Budget for Lab Componets Project				
Componet One: Falling Ball Viscosmeter		Qnty	Price	Total
USP Corp	#34109 3" Clear Rigid Schedule 40 PVC Pipe	3	$19.75/ft	$150.00
USP Corp	#34298 3" Clear Schedule 40 PVC Cap	3	$69.28 each	$208.00
USP Corp	#32250 Turn-Tite Expandable Rubber Plug 3" Dia. x 2" Height	3	$42.07 each	$127.00
E-Trailer	# QF50050 Quick Fist 3" Clamp - 2-3/4" to 3-1/4" Inner Diameter	3	$16.31 each	$49.00
Lowes	#1435821 Oatey 3-in Galvanized 2-hole Pipe Strap	6	$2.28 each	$14.00
Zoro	#G4581841 Oil Hard Drill Rod, 1/2inch x 36inch	1	$11.68	$12.00
Zoro	#G2316973 Pillow Block Bearing, Sleeve, 1/2" Bore	3	$17.81	$54.00
Lowes	#279178 1x3x10ft wood plank	1	$10.00	$10.00
Lowes	#175694 8-ft Board 1x2x8	1	$4.29	$5.00
Lowes	#27172 2x4x10 white wood lumber	1	$8.77	$9.00
Comoponet Total				**$638.00**
Small scale pipe-line				
	#26503 3/4" White PVC Schedule 40 Pipe	1	$0.93 per ft	$7.00
	#28534 3/4" Schedule 40 White PVC Socket 90° Elbow	6	$0.25 each	$2.00
	#28474 3/4" Schedule 40 White PVC Socket Cross	2	$1.69 each	$4.00
poolsupplyunlimited.	#V08491N White MIP Ball Valve 3/4" White PVC White SxS	8	$5.69 each	$46.00
Master-Carr	#6769k26 Easy-Maintenance Inline Circulation Pumps for Water	1	$679.79	$680.00
Master-Carr	#5020T72 Socket-Connect Flowmeter/Totalizers for Water	2	$344.80	$690.00
Coast Pneumatics	#50BAC-S1-06 50BAC-S1-06 quick connect	2	$3.57	$8.00
Coast Pneumatics	#10AC-5S-02 10AC-S2-02 Pack of (25)	1	$27.89	$28.00
Lowes	#154277 1/2-in Common Fir Sanded Plywood, Application as 2 x 4	1	$16.86	$17.00
Fishtanks direct	# AA015RC Clear for Life Acrylic15 Gallon - 24"L x 13"W x 12"H	1	$210.00	$210.00
Lowes	#27172 2-in x 4-in x 10-ft Whitewood Lumber	1	$8.77	$9.00
USP Corp	#: 26324 1" Gray PVC Schedule 80 Pipe	1	$1.53 per ft	$2.00
	#3515N41 Drinking Water Pressure Gauges	6	$19.04	$120.00
Componet Total				**$1,823.00**
TOTAL FOR BOTH LAB PROJECTS				
	Falling Ball			$638.00
	Small Scale Pipe-Line			$1,823.00
SUB TOTAL				**$2,461.00**
	Shipping and Handling			$$159.00
GRAND TOTAL				**$2,620.00**

Figure 14: Lab Component Estimated Cost

Final Cost:

As we progressed in the project some prices changed from the original estimate these are included below and compared to the estimated cost:

Budget for Lab Componets Project									
						Actual Cost			
Componet One: Falling Ball Viscosmeter		Qnty	Price	Total		Qnty	Total	Above Budget (+)	Below Budget (-)
USP Corp	#34109 3" Clear Rigid Schedule 40 PVC Pipe	3	$19.75/ft	$150.00		3	$173.60	(+) $23.60	
USP Corp	#34298 3" Clear Schedule 40 PVC Cap	3	$69.28 each	$208.00		3	$207.84		(-) $0.16
USP Corp	#32250 Turn-Tite Expandable Rubber Plug 3" Dia. x 2" Height	3	$42.07 each	$127.00		3	$7.89		(-) $119.11
E-Trailer	# QF50050 Quick Fist 3" Clamp - 2-3/4" to 3-1/4" Inner Diameter	3	$16.31 each	$49.00		3	$48.84		(-) $0.16
Lowes	#1435821 Oatey 3-in Galvanized 2-hole Pipe Strap	6	$2.28 each	$14.00		6	$36.96	(+) $22.96	
Zoro	#G4581841 Oil Hard Drill Rod, 1/2inch x 36inch	1	$11.68	$12.00		1	$11.68		(-) $0.32
Zoro	#G2316973 Pillow Block Bearing, Sleeve, 1/2" Bore	3	$17.81	$54.00		3	$56.19	(+) $2.19	
Lowes	#279178 1x3x10ft wood plank	1	$10.00	$10.00		1	$7.61		(-) $2.39
Lowes	#175694 8-ft Board 1x2x8	1	$4.29	$5.00		1	$6.15	(+) $1.86	
Lowes	#27172 2x4x10 white wood lumber	1	$8.77	$9.00		1	$8.77		(-) $0.23
Comoponet Total				**$638.00**				**(+) $60.61**	**(-) $123.37**
Small scale pipe-line									
	#26503 3/4" White PVC Schedule 40 Pipe	1	$0.93 per ft	$7.00		1(10')	$9.30	(+) $2.30	
	#28534 3/4" Schedule 40 White PVC Socket 90° Elbow	6	$0.25 each	$2.00		7	$1.61		(-) $0.39
	#28474 3/4" Schedule 40 White PVC Socket Cross	2	$1.69 each	$4.00		2	$2.76		(-) $1.24
poolsupplyunlimited.	#V08491N White MIP Ball Valve 3/4" White PVC White SxS	8	$5.69 each	$46.00		8	$9.92		(-) $36.08
Master-Carr	#6769k26 Easy-Maintenance Inline Circulation Pumps for Water	1	$679.79	$680.00		1	$139.99		(-) $540.01
Master-Carr	#5020T72 Socket-Connect Flowmeter/Totalizers for Water	2	$344.80	$690.00		2	$161.20		(-) $528.80
Coast Pneumatics	#50BAC-S1-06 50BAC-S1-06 quick connect	2	$3.57	$8.00		2	$13.94	(+) $5.94	
Coast Pneumatics	#10AC-SS-02 10AC-S2-02 Pack of (25)	1	$27.89	$28.00		1 Bag	$8.51		(-) $19.49
Lowes	#154277 1/2-in Common Fir Sanded Plywood, Application as 2 x 4	1	$16.86	$17.00		2	$12.64		(-) $4.36
Fishtanks direct	# AA015RC Clear for Life Acrylic 15 Gallon - 24"L x 13"W x 12"H	1	$210.00	$210.00		1	$95.42		(-) $114.58
Lowes	#27172 2-in x 4-in x 10-ft Whitewood Lumber	1	$8.77	$9.00		1	$8.77		(-) $0.23
USP Corp	#: 26324 1" Gray PVC Schedule 80 Pipe	1	$1.53 per ft	$2.00		not needed			
Master- Carr	#3515N41 Drinking Water Pressure Gauges	6	$19.04	$120.00		4	$176.34	(+) $56.34	
Componet Total				**$1,823.00**				**(+) $64.58**	**(-) $1245.18**
TOTAL FOR BOTH LAB PROJECTS								Actual Totals	
	Falling Ball			$638.00				$565.24	
	Small Scale Pipe-Line			$1,823.00				$642.40	
SUB TOTAL				**$2,461.00**					
	Shipping and Handling			$$159.00					
GRAND TOTAL				**$2,620.00**				**$1,207.64**	**(-) $1412.36**

Figure 15: Lab Component Final Cost

Conclusion/recommendations for further study:

In conclusion, with the lab components built, operational, and tested we are able to make recommendations for future units. One area we were aiming for was to make these two components affordable, so they could be reproduced for the various campuses, this has been challenging and we have been pursuing different avenues in an attempt to reduce the cost. During the construction of the components we were able to reduce the overall cost, and completed both units under budget. Further reductions in the cost of construction can be realized by several other tweaks to both components. These recommendations can be found in the section Recommendations.

Recommendations:

1) Flexible Triple Falling-Ball Viscometer

- Smaller tubes- we used tubes with 3” ID, reducing the size of the tubes would make construction easier, and cut a small amount of the cost.
- The style of bearings, or a system which does not require bearings could possibly further lower the cost.

2) Small-Scale Pipeline System

- The first stage pressure gauge needs to be changed out with a gauge with a smaller scale.
- The first stage flow meter either should be replaced with an alternative style, and possibly replaced at the discharge side of the pump.
- The pipe size from the discharge side of the pump and to the tank could be reduced to ⅝” ID or ½” ID.
- The ball valves could be exchanged for gate valves; this would reduce the cost and allow for greater freedom for the size of the piping structure.

References:

1) Mott, R. L., & Untener, J. A. (2016). *Applied fluid mechanics*. Harlow, Essex, England: Pearson Education Limited.

2) PipeFlo Software. (n.d.). Retrieved December 03, 2020, from https://pipe-flo.com/

Appendix A: Weekly Journals

Weekly Journals

Thursday, 4/22/21

Topics discussed:

- Talked about finishing up the project poster and project video
- Discussed performance experiment for the Flexible Triple Falling-Ball Viscometer and the pipeline system
- Talked about running leak test for the supply tank, as well as the pipeline system
- Talked about comparing the test results with simulation and hand calculation results for the pipeline system
- Discussed components used and expected findings (results) of the pipeline system for the final report
- Discussed project overview presentation on senior design day

Thursday, 4/15/21

Topics discussed:

- Discussed constructions progress for pipeline system as well as testing procedures for the completed Flexible Triple Falling-Ball Viscometer.
- Talked about the completed pipeline sections, valves, and fittings.
- Talked about testing the pipeline system and comparing the test results with simulation/ hand calculation results, especially for the pump input and output power.
- Our group will be focusing on finishing up the pipeline system as well as the oral presentation and project video this week.

Thursday, 4/8/21
Topics discussed:

- Reviewed and tested the new Flexible Triple Falling-Ball Viscometer
- Captured photos of the new Flexible Triple Falling-Ball Viscometer
- Talked about valves and fittings as well as reviewing a number of measuring devices that need to be installed on the pipeline system.
- Discussed the oral presentation, project video, and poster design progress.
- Assigned oral presentation as well as project video section for each team member
- Our group will be focusing on finishing up the pipeline system.
- Talked about testing the pipeline system and comparing the test results with simulation/ hand calculation results
- Our group will be also working on oral presentation and project video this week.

Thursday, 3/25/21

Topics discussed:

- Discussed the completed builds of the Flexible Triple Falling-Ball Viscometer
- Talked about painting option for the completed Flexible Triple Falling-Ball Viscometer
- Talked about taking equipment photos and construction progress photos
- Tracked the remaining parts deliveries for the pipeline system
- Talked about the project poster design and its contents as well as the final report

- Discussed date(s) and time(s) as well as the possible locations where our team will meet to finish the construction for the pipeline system once all parts have arrived.
- Our team is still planning for date and time to meet to assemble the pipeline system as well as run test sometime during the first week of April

Thursday, 3/18/21

Topics discussed:

- Talked about finishing up the support frame for the Flexible Triple Falling-Ball Viscometer
- Reviewed the completion of some pipeline sections, especially the 3-branch pipeline network
- Reviewed all arrived items and tracked the remaining parts deliveries
- Talked about the project poster design and its contents
- Discussed date(s) and time(s) as well as the possible locations where our team will meet to build the pipeline system

Action Items:

- Our team keeps working on the Flexible Triple Falling-Ball Viscometer.
- Once all items for the Pipeline system arrived (scheduled for delivery this week), we will meet to assemble and run tests sometime during the first week of April as planned.
- Our team will also start working on final report and poster design

Thursday, 3/4/21

Topics discussed:

- Talked about what sections of pipeline we can put together first
- Discussed how to connect the pipeline network to the pump and supply tank
- Discussed how to build the support frame for the Flexible Triple Falling-Ball Viscometer
- Reviewed the arrived items and talked about the plans to pick up the remaining items

Action Items:

- Ted will be meeting Frank, Technical Service Spec, at Hamilton Campus to pick up some supplies for our project.
- Ted and Kyle will be working on connecting partial pipeline sections together and building the support frame for the Flexible Triple Falling-Ball Viscometer
- Thuc will be reviewing and comparing the new pump specifications with PipeFlo simulation results.

Sunday, 2/28/21

Topics discussed:

- Talked about our group and project photos showing team members working on project.
- Discussed our project descriptions and prepared to show equipment and group photos as well as project descriptions
- Talked about building some pipeline sections and working on the supply tank for the pipeline system while we are waiting for the pump to arrives
- Discussed and reviewed the new pump ordered from Northern Tool.

Action Items:

- Ted and Thuc will be sending Kyle the working on the project photos, so Kyle can put all project photos together along with his working on the project photos.
- Our group will be also focusing on parts delivery and pickup dates.

Thursday, 2/25/21

Topics discussed:

- Talked about the replacement pump that is available and fits our pipeline system.
- Talked about our project descriptions and how to put our project photos as well as the group photos together.
- Reviewed all ordered items, tracked items deliveries, and talked about construction plans.
- Reviewed the overall dimensions of our pipeline system to see how to transport after the pipeline system is completed.
- Reviewed our step-by-step plan listed in the proposal

Action Items:

- Our group will be focusing on project descriptions, group photos, and tracking items deliveries.
- Our group will be making sure the delivered items meet our design specifications.
- All team members are also preparing for our project's construction and test plans.

Thursday, 2/11/21

Topics discussed:

- Reviewed the new simulation results from PipeFlo for our pipeline system
- Discussed new pump power and specifications after decreasing the design flow rate to 10 gpm
- Talked about selecting the supply tank material and shape for our pipeline system
- Discussed construction plans and reviewed all ordered forms and parts
- Reviewed our step-by-step plan listed in the proposal
- Talked about taking project photos and group photos

Action Items:

- Our group will be focusing on taking project photos that include our equipment and all team members
- Our group will be also making sure ordered materials arrive on time and meet our design specifications.

Thursday, 2/4/21

Topics discussed:

- Discussed our project's progress and construction plans
- Talked about changing the design flow rate for our pipeline system, so we can use economical pump in order to reduce the overall cost of our pipeline system.
- Reviewed the Bill of Materials and timeline of our project
- Talked about ordering parts and supplies for our design project.

Action Items:

- Ted will be filling out and submitting the parts and supplies order forms.
- Thuc will be updating the design flow rate to 10 gpm in PipeFlo simulation.
- Kyle will be working on drawings and construction plans.

Sunday, 11/08/20

Topics discussed:

● Talked about comparing and validating hand calculations results with the simulation results for pipeline analysis and design
● Reviewed progress of our design projects: Triple Falling-Ball Viscometer and the pipeline system
● Talked about creating the PowerPoint Slides for our group oral presentation
● Talked about gathering all input data and calculations results for the midterm report
● Discussed construction plans and reviewed the Bill of Materials and timeline of our project

Action Items:

● Ted will be gathering the final design dimensions and models for the oral presentation
● Thuc will be gathering hand calculations, Excel data, and simulations results of the pipeline system for the oral presentation
● Kyle will be reviewing and gathering the bill of materials, construction plans, and timeline for our oral presentation.

Sunday, 11/01/20

Topics discussed:

- Talked about selecting a case from the National Society of Professional Engineers' ethics resources web page for Ethics team assignment
- Discussed the credit for engineering work subject for Ethics team assignment
- Discussed test simulations of the pipeline system with and without measurement devices
- Discussed the design project's oral presentation and midterm report

Action Items:

- Our group will discuss more ethical cases on the National Society of Professional Engineers' website and prepare a summary of the case.
- Our group will also review all data values, calculation results, dimensions, and details of our design project.

Sunday, 10/25/20

Topics discussed:

- Discussed new PipeFlo results after increasing pipe lengths and fluid tank height.
- Discussed pipe material and specification for pipeline system
- Talked about adding new pipe lengths to the Bill of Materials
- Reviewed the Bill of Materials for both lab components
- Discussed clearance of all devices on the pipeline system and constructing method
- Talked about filling out and submitting the Fleck Scholarship application

Action Items

- Our group will review all input data, PipeFlo results, CAD drawings dimensions, and Bill of Materials for both lab components.
- Our group will also be working on the Fleck Scholarship application form, as well as submitting it for approval.

Sunday, 10/18/20

Topics discussed:

- Discussed actual footprint of pipeline system's devices
- Discussed existing CAD drawings dimensions of both lab components
- Reviewed the Bill of Materials for both lab components
- Talked about increasing the height of fluid tank and the pipe lengths in some discharge line sections
- Reviewed cost and budget of both lab components

Action Items

- Our group will be discussing more about new dimensions that work best for the pipeline system.
- Ted and Kyle will review the new pipe lengths that provide more clearance for pressure gages and valves.
- Thuc will update pipe lengths in PipeFlo to reflect the new pipe lengths.

Sunday, 10/11/20

Topics discussed:

- Talked about finishing up the proposal and reviewed the project's timeline
- Discussed what models, drawings, and tables will be included in the proposal
- Discussed preliminary results from PipeFlo simulations software
- Discussed cost and budget of both lab components' materials

Action Items:

- Kyle will be finishing up all details for the CAD drawings
- Ted will be working on cost/budget for both ENT 310 lab components.
- Thuc will review examples in the ENT 310 textbook regarding parallel pipeline system calculations in order to compare with PipeFlo results.

Sunday, 10/4/20

Topics discussed:

- Discussed dimensions of CAD drawings for both ENT 310 lab components
- Discussed initial assumed pipe lengths and volume flow rate for the pipeline systems
- Talked about the Bill of Materials for both ENT 310 lab component projects
- Discussed what spreadsheets and calculations will be needed in order to compare with PipeFlo results.
- Talked about the remaining items of the proposal that need to be completed.

Action Items:

- Kyle keeps working on CAD drawings and will compare CAD drawings dimensions with PipeFlo simulation.
- Ted will be working on the Bill of Materials for both ENT 310 lab components.
- Thuc will reach out to Dr. Dinc for assistance on how to get some spreadsheet example problems for pipeline systems from the ENT 310 textbook.

Sunday, 9/27/20

Topics discussed:

- Talked about selecting pipe lengths and pump power for the pipeline system
- Discussed CAD drawings for both lab components
- Discussed selecting volume flow rate for our pipeline systems
- Discussed what calculations will be needed for pipeline and pump selection.
- Talked about reviewing tutorial demonstrations videos for PipeFlo
- Talked about cost, parts list, and timeline

Action Items:

- Our team will be reviewing general suggestions about pipe design and pump selection that Dr. Dinc sent out to our group.
- Kyle keeps working on CAD drawings
- Ted will be focusing on cost and creating Bill of Materials
- Thuc keeps working on data spreadsheets and PipeFlo simulation.

Sunday, 9/20/20

Topics discussed:

- Talked about selecting pipe and pump sizes for the pipeline system
- Discussed CAD drawings for both lab components
- Discussed support frame and quick disconnect fitting for pipline system
- Started using PipeFlo simulation software to calculate pump size
- Discussed step by step plan, cost, and timeline

Action Items:

- Our team will be focusing on selecting pipe lengths in order to enter them into PipeFlo simulation software, as well as start creating CAD drawings.
- We also keep working on the proposal and creating parts lists for manufacturing.

Sunday, 9/13/20

Topics discussed:

- Created a Jira account for our group and added all members to Jira in order to assign tasks and monitor our project progress.
- All team members will be working on the proposal; each member will be responsible for particular sections.
- Talked about the applicability of these two lap components.
- Talked about acquiring more data and specifications for the project.
- Discussed step by step plan for both lab components projects: Triple Falling-Ball Viscometer and Small-Scale pipeline
- Discussed Gantt Chart/Timeline and Cost estimations

Action Items:

- Ted is working on sketches and will reach out to Dr. Dinc to acquire more data and specifications required for these lab components.
- Thuc will be working on step by step plan and gathering data for theoretical calculations
- Kyle will be working on Gannet Chart and Cost for these lap components projects.

Tuesday, 9/8/20

Topics discussed:

- Started using WebEx meetings tool for our weekly group meeting
- Reviewed information and sketches of two lab components that Dr. Murat Dinc sent out to our team.
- Discussed dimensions and materials' requirements for both systems
- Team was wondering if the pipeline system will be used for different kinds of fluid.
- Talked about the proposal and simulation software for pipeline system
- Talked about sharing projects' information via google docs and creating timeline on Jira software

Action Items:

- Ted will start working on sketches for the Triple Falling – Ball Viscometer and pipeline system.
- Thuc will start looking to see if there is any simulation software available that can be used to analyze pipeline system.
- Kyle will start working on research for hardware and components that fits our small-scale design.

Appendix B: PIPE-FLO Specifications and results

Pipe Specifications:

Pipeline Report

File Name: ENT498 PIPELINE.pipe
Lineup: <Design Case>
Program Name: PIPE-FLO Advantage Student
Version: 17.2.51801
Calculation Method: Darcy-Weisbach

Laminar cutoff Re: 2100
Max Iterations: 1000
Deviation Tolerance: 0.01
Atmospheric Pressure: 14.7 psi a

Company:MIAMI UNIVERSITY
Project:Kyle_Ted_Thuc_Pipeline
by:Thuc Nguyen
Date:Saturday, April 10, 2021 10:48 PM

Discharge Line

Pipe Details

Pipe Name: Discharge Line
Length: 1.167 ft
Nominal Size: 0.75 in
Inside Diameter: 0.824 in
Inlet Elevation: 0.334 ft
Outlet Elevation: 0.334 ft
Device at Inlet: Transfer Pump
Device at Outlet: Node 1

Pipe Specification Details

Specification Name: PVC
Specification Standard: PVC Plastic Pipe
Schedule: 40
Absolute Roughness: 6E-05 in
Hazen-Williams C Factor: 140
Sizing Criteria: 4.0 ft/s
Design Limits: Velocity: to ft/s
Pressure: to psi g
Reynolds Number: to
Mach Number: to

Valve and Fitting Details

V&F Friction Factor (fft): 0.02398

Installed Valves and Fittings	Resistance Coefficient (K)
1 x Elbow - Standard 90°	0.72
1 x Ball	0.07
Total Valve and Fitting K:	0.79

Fluid Zone Details

Fluid Zone Name: Water
Fluid: Water
Fluid State: Liquid
Temperature: 70 °F
Pressure: 0 psi g
Density: 62.31 lb/ft³
Viscosity: 0.9695 cP
Vapor Pressure: 0.3633 psi a
Critical Pressure: 3199 psi a
Specific Heat Ratio: –
Relative Molecular Mass: 18
Specific Heat Capacity: 1.013BTU/lb°F

Left Branch

Pipe Details

Pipe Name: Left Branch
Length: 2.167 ft
Nominal Size: 0.75 in
Inside Diameter: 0.824 in
Inlet Elevation: 0.334 ft
Outlet Elevation: 1.5 ft
Device at Inlet: Node 1
Device at Outlet: Node 2

Pipe Specification Details

Specification Name: PVC
Specification Standard: PVC Plastic Pipe
Schedule: 40
Absolute Roughness: 6E-05 in
Hazen-Williams C Factor: 140
Sizing Criteria: 4.0 ft/s
Design Limits: Velocity: to ft/s
Pressure: to psi g
Reynolds Number: to
Mach Number: to

Valve and Fitting Details

V&F Friction Factor (fft): 0.02398

Installed Valves and Fittings	Resistance Coefficient (K)
2 x Elbow - Standard 90°	1.44
2 x Ball	0.14
Total Valve and Fitting K:	1.58

Fluid Zone Details

Fluid Zone Name: Water
Fluid: Water
Fluid State: Liquid
Temperature: 70 °F
Pressure: 0 psi g
Density: 62.31 lb/ft³
Viscosity: 0.9695 cP
Vapor Pressure: 0.3633 psi a
Critical Pressure: 3199 psi a
Specific Heat Ratio: –
Relative Molecular Mass: 18
Specific Heat Capacity: 1.013BTU/lb°F

Middle Branch

Pipe Details

Pipe Name: Middle Branch
Length: 1.167 ft
Nominal Size: 0.75 in
Inside Diameter: 0.824 in
Inlet Elevation: 0.334 ft
Outlet Elevation: 1.5 ft
Device at Inlet: Node 1
Device at Outlet: Node 2

Valve and Fitting Details

V&F Friction Factor (fft): 0.02398

Installed Valves and Fittings	Resistance Coefficient (K)
2 x Ball	0.14
Total Valve and Fitting K:	0.14

Pipe Specification Details

Specification Name: PVC
Specification Standard: PVC Plastic Pipe
Schedule: 40
Absolute Roughness: 6E-05 in
Hazen-Williams C Factor: 140
Sizing Criteria: 4.0 ft/s
Design Limits: Velocity: to ft/s
Pressure: to psi g
Reynolds Number: to
Mach Number: to

Fluid Zone Details

Fluid Zone Name: Water
Fluid: Water
Fluid State: Liquid
Temperature: 70 °F
Pressure: 0 psi g
Vapor Pressure: 0.3633 psi a
Critical Pressure: 3199 psi a
Specific Heat Ratio: –
Specific Heat Capacity: 1.013BTU/lb°F
Density: 62.31 lb/ft³
Viscosity: 0.9695 cP
Relative Molecular Mass: 18

Return Line

Pipe Details

Pipe Name: Return Line
Length: 2.167 ft
Nominal Size: 0.75 in
Inside Diameter: 0.824 in
Inlet Elevation: 1.5 ft
Outlet Elevation: 1.83 ft
Device at Inlet: Node 2
Device at Outlet: Supply Tank

Valve and Fitting Details

V&F Friction Factor (fft): 0.02398

Installed Valves and Fittings	Resistance Coefficient (K)
1 x Elbow - Standard 90°	0.72
Total Valve and Fitting K:	0.72

Pipe Specification Details

Specification Name: PVC
Specification Standard: PVC Plastic Pipe
Schedule: 40
Absolute Roughness: 6E-05 in
Hazen-Williams C Factor: 140
Sizing Criteria: 4.0 ft/s
Design Limits: Velocity: to ft/s
Pressure: to psi g
Reynolds Number: to
Mach Number: to

Fluid Zone Details

Fluid Zone Name: Water
Fluid: Water
Fluid State: Liquid
Temperature: 70 °F
Pressure: 0 psi g
Vapor Pressure: 0.3633 psi a
Critical Pressure: 3199 psi a
Specific Heat Ratio: –
Specific Heat Capacity: 1.013BTU/lb°F
Density: 62.31 lb/ft³
Viscosity: 0.9695 cP
Relative Molecular Mass: 18

Right Branch

Pipe Details

Pipe Name: Right Branch
Length: 2.167 ft
Nominal Size: 0.75 in
Inside Diameter: 0.824 in
Inlet Elevation: 0.334 ft
Outlet Elevation: 1.5 ft
Device at Inlet: Node 1
Device at Outlet: Node 2

Pipe Specification Details

Specification Name: PVC
Specification Standard: PVC Plastic Pipe
Schedule: 40
Absolute Roughness: 6E-05 in
Hazen-Williams C Factor: 140
Sizing Criteria: 4.0 ft/s
Design Limits: Velocity: to ft/s
Pressure: to psi g
Reynolds Number: to
Mach Number: to

Valve and Fitting Details

V&F Friction Factor (fft): 0.02398
Installed Valves and Fittings

	Resistance Coefficient (K)
2 x Elbow - Standard 90°	1.44
2 x Ball	0.14
Total Valve and Fitting K:	1.58

Fluid Zone Details

Fluid Zone Name: Water
Fluid: Water
Fluid State: Liquid
Temperature: 70 °F
Density: 62.31 lb/ft³
Pressure: 0 psi g
Viscosity: 0.9695 cP
Vapor Pressure: 0.3633 psi a
Critical Pressure: 3199 psi a
Specific Heat Ratio: –
Relative Molecular Mass: 18
Specific Heat Capacity: 1.013BTU/lb°F

Suction Line

Pipe Details

Pipe Name: Suction Line
Length: 1 ft
Nominal Size: 0.75 in
Inside Diameter: 0.824 in
Inlet Elevation: 0.084 ft
Outlet Elevation: 0.084 ft
Device at Inlet: Supply Tank
Device at Outlet: Transfer Pump

Pipe Specification Details

Specification Name: PVC
Specification Standard: PVC Plastic Pipe
Schedule: 40
Absolute Roughness: 6E-05 in
Hazen-Williams C Factor: 140
Sizing Criteria: 4.0 ft/s
Design Limits: Velocity: to ft/s
Pressure: to psi g
Reynolds Number: to
Mach Number: to

Valve and Fitting Details

V&F Friction Factor (fft): 0.02398
Installed Valves and Fittings

	Resistance Coefficient (K)
1 x Entrance - Flush, r/d .02	0.28
1 x Ball	0.07
Total Valve and Fitting K:	0.35

Fluid Zone Details

Fluid Zone Name: Water
Fluid: Water
Fluid State: Liquid
Temperature: 70 °F
Density: 62.31 lb/ft³
Pressure: 0 psi g
Viscosity: 0.9695 cP
Vapor Pressure: 0.3633 psi a
Critical Pressure: 3199 psi a
Specific Heat Ratio: –
Relative Molecular Mass: 18
Specific Heat Capacity: 1.013BTU/lb°F

Simulation Results:

List Report

File Name: ENT498 PIPELINE.pipe
Lineup: <Design Case>
Progam Name: PIPE-FLO Advantage Student Edition
Version: 17.2.51801

Calculation Method: Darcy-Weisbach
Laminar Cutoff Re: 2100
Max Iterations: 1000
Percent Tolerance: 0.01
Allowable Deviation: 1 %

Company: MIAMI UNIVERSITY
Project: Kyle_Ted_Thuc_Pipeline
by: Thuc Nguyen
Date: Saturday, April 10, 2021 10:46 PM
Atmospheric Pressure: 14.7 psi a

Pipe Specifications

Specification Name / Valve Table	Material / Schedule	Absolute Roughness / Hazen Williams C Factor	Sizing Criteria / Sizing Criteria Value		Design Limits: Velocity	Pressure	Re Number	Mach
PVC	PVC Plastic Pipe	6E-05 in	Velocity = 4 ft/s	Min:	ft/s	psi g		
standard	Schedule: 40	140	4.0 ft/s	Max:	ft/s	psi g		

Fluid Zones

Fluid Zone Name / Table Name	Temperature / Pressure	Fluid State / Relative Molecular Mass	Density / Viscosity	Vapor Pressure / Critical Pressure	Specific Heat Capacity (cp) / Specific Heat Ratio (k)
Water	70 °F	Liquid	62.31 lb/ft³	0.3633 psi a	1.013 BTU/lb°F
Water	0 psi g	18	0.9695 cP	3199 psi a	–

Centrifugal Pumps

Pump Name / Operational Mode and Set Point	Test Speed / Operating Speed	Suction Elevation / Suction Pressure	Discharge Elevation / Discharge Pressure	Total Head / dP	Flow Rate / Power	Efficiency / BEP Efficiency	NPSHa / NPSHr	Design NPSH Margin Ratio
Transfer Pump	1750	0.084 ft	0.334 ft	4.171 ft	15 gpm	51.25 %	34.05 ft	--
Flow Rate @ 15 gpm		0.4 psi g	2.097 psi g	1.697 psi	0.03078 hp	53.8 %	0.2335 ft	

Company: AnsiPro Pump Company
Curve: Catalog Pump
Type: AP96-ANSI EndSuction

Size: 1-1/2x1-6 AA
Diameter: 6.06 in
POR: from 50% to 90%

Pipelines

Pipeline Name / Specification / Fluid Zone	Size / Inside Diameter / Length	Inlet Device / Inlet Elevation / Outlet Device / Outlet Elevation	Flow Rate / Fluid Velocity / Reynolds Number / Pipe Friction Factor	Inlet Total Pressure / Inlet Static Pressure / Inlet Energy Grade / Inlet Hydraulic Grade	Total dP / Total Head Loss	Outlet Total Pressure / Outlet Static Pressure / Outlet Energy Grade / Outlet Hydraulic Grade	V&F Friction Factor / V&F Resistance K / V&F dP / V&F Head Loss
Discharge Line	0.75 in	Transfer Pump	15 gpm	2.097 psi g	0.6233 psi	1.473 psi g	0.02398
PVC	0.824 in	0.334 ft	9.025 ft/s	1.549 psi g		0.9257 psi g	0.79
Water	1.167 ft	Node 1	59268	5.18 ft	1.44 ft	3.739 ft	0.4334 psi
		0.334 ft	0.02041	3.914 ft		2.473 ft	1.002 ft
Left Branch	0.75 in	Node 1	3.631 gpm	1.473 psi g	0.5839 psi	0.8894 psi g	0.02398
PVC	0.824 in	0.334 ft	2.184 ft/s	1.441 psi g		0.8574 psi g	1.58
Water	2.167 ft	Node 2	14345	3.739 ft	0.1835 ft	3.556 ft	0.05078 psi
		1.5 ft	0.02826	3.665 ft		3.481 ft	0.1173 ft
Middle Branch	0.75 in	Node 1	7.739 gpm	1.473 psi g	0.5839 psi	0.8894 psi g	0.02398
PVC	0.824 in	0.334 ft	4.656 ft/s	1.328 psi g		0.7437 psi g	0.14
Water	1.167 ft	Node 2	30578	3.739 ft	0.1835 ft	3.556 ft	0.02097 psi
		1.5 ft	0.02358	3.402 ft		3.219 ft	0.04847 ft
Return Line	0.75 in	Node 2	15 gpm	0.8894 psi g	0.8894 psi	0 psi g	0.02398
PVC	0.824 in	1.5 ft	9.025 ft/s	0.3418 psi g		-0.5477 psi g	0.72
Water	2.167 ft	Supply Tank	59268	3.556 ft	1.726 ft	1.83 ft	0.394 psi
		1.83 ft	0.02041	2.29 ft		0.5643 ft	0.9105 ft

Pipelines

Pipeline Name Specification Fluid Zone	Size Inside Diameter Length	Inlet Device Inlet Elevation Outlet Device Outlet Elevation	Flow Rate Fluid Velocity Reynolds Number Pipe Friction Factor	Inlet Total Pressure Inlet Static Pressure Inlet Energy Grade Inlet Hydraulic Grade	Total dP Total Head Loss	Outlet Total Pressure Outlet Static Pressure Outlet Energy Grade Outlet Hydraulic Grade	V&F Friction Factor V&F Resistance K V&F dP V&F Head Loss
Right Branch	0.75 in	Node 1	3.631 gpm	1.473 psi g	0.5839 psi	0.8894 psi g	0.02398
PVC	0.824 in	0.334 ft	2.184 ft/s	1.441 psi g		0.8574 psi g	1.58
Water	2.167 ft	Node 2	14345	3.739 ft	0.1835 ft	3.556 ft	0.05078 psi
		1.5 ft	0.02826	3.665 ft		3.481 ft	0.1173 ft
Suction Line	0.75 in	Supply Tank	15 gpm	0.7555 psi g	0.3555 psi	0.4 psi g	0.02398
PVC	0.824 in	0.084 ft	9.025 ft/s	0.2078 psi g		-0.1476 psi g	0.35
Water	1 ft	Transfer Pump	59268	1.83 ft	0.8216 ft	1.008 ft	0.1927 psi
		0.084 ft	0.02041	0.5643 ft		-0.2572 ft	0.4454 ft

Tanks

Tank Name Fluid Zone Tank Geometry	Bottom Elevation Liquid Level Liquid Volume	Surface Pressure Bottom Pressure Total Tank Volume	Hydraulic Grade Net Flow Rate	Connecting Pipelines Pipeline Name	Penetration Height	Pipeline Flow Rate	Pressure at Penetration
Supply Tank	0 ft	0 psi g	1.83 ft				
Water	1.83 ft	0.7918 psi g	0 gpm				
Cylindrical Vertical with Volume = 2.454 ft³	2.246 ft³	2.454 ft³					
				Return Line	1.83 ft	15 gpm	0 psi g
				Suction Line	0.084 ft	15 gpm	0.7555 psi g

Nodes

Node Name	Elevation	Pressure	Hydraulic Grade
Node 1	0.334 ft	1.473 psi g	3.301 ft
Node 2	1.5 ft	0.8894 psi g	3.118 ft

Pump Data:

Pump Data Sheet - AnsiPro Pump Company

Company: ENT 498
Name:
Date: 4/10/2021

AnsiPro Pump Company

Pump:

Size: 1-1/2x1-6 AA
Type: AP96-ANSI EndSuction
Synch Speed: 1800 rpm
Speed: 598 rpm
Dia: 6.06 in
Curve: AP96-1801
Impeller: AP96-ST
Specific Speeds:
Ns: ---
Nss: ---
Dimensions:
Suction: 1.5 in
Discharge: 1 in

Operating Point:

Flow: 15 US gpm
Head: 4.17109 ft
Preferred Operating Region: 50% - 90% BEP

Fluid:

Water
Density: 62.3091 lb/ft³
Viscosity: 0.9695 cP
Temperature: 70 °F
Vapor Pressure: 0.3633 psi a
Atm Pressure: 14.7 psi a
NPSHa: 34.0479 ft

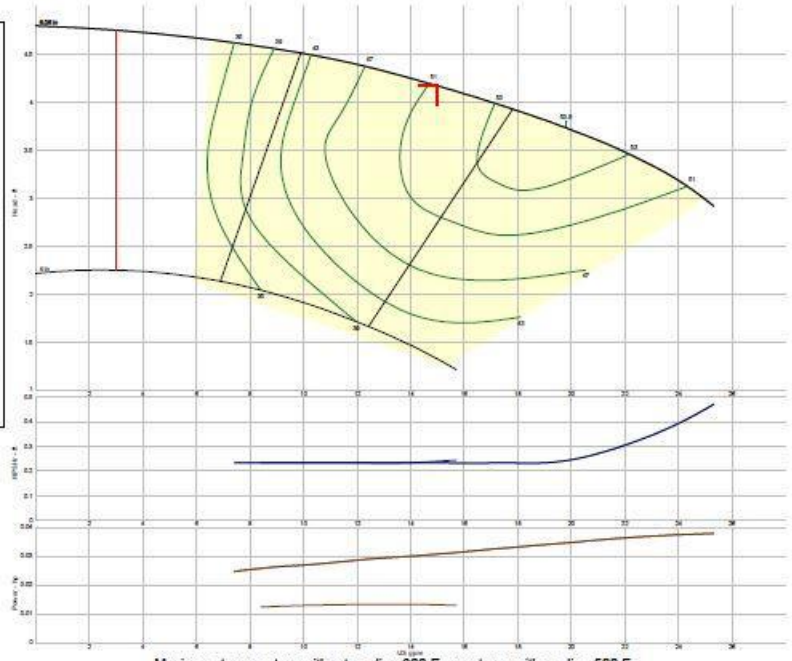
Pump Limits:

Temperature: ---
Pressure: ---
Sphere Size: 0.344 in
Power: ---
Eye Area: 3.1 in²

Motor:

Consult AnsiPro Pump Company to select a motor for this pump.

---- Duty Point ----	
Flow:	15 US gpm
Head:	4.17 ft
Eff:	51.3%
Power:	0.0308 hp
NPSHr:	0.234 ft
---- Design Curve ----	
Shutoff Head:	4.8 ft
Shutoff dP:	2.08 psi
Min Flow:	3 US gpm
BEP:	53.8% @ 19.8 US gpm
NOL Power:	0.038 hp @ 25.3 US gpm
-- Max Curve --	
Max Power:	0.038 hp @ 25.3 US gpm



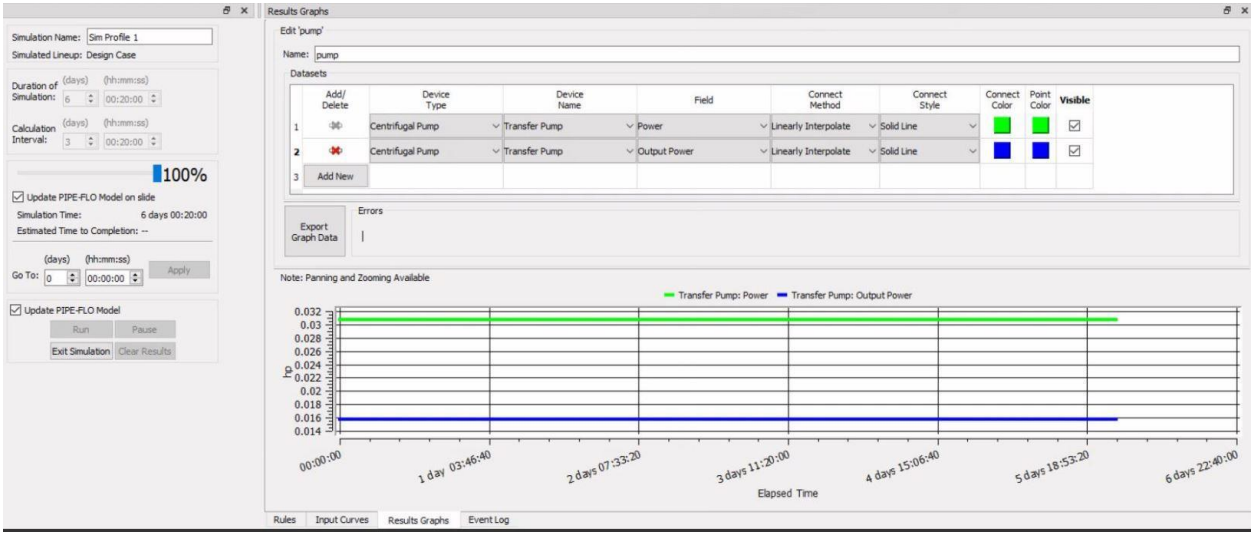
Maximum temperature without cooling 300 F; max temp with cooling 500 F.

Performance Evaluation:

Flow US gpm	Speed rpm	Head ft	Efficiency %	Power hp	NPSHr ft
18	598	3.91	53.3	0.0333	0.236
15	598	4.17	51.3	0.0308	0.234
12	598	4.4	46.4	0.0287	0.234
9	598	4.56	39.3	0.0263	0.234
6	598	4.66	31.2	0.0232	0.234

Selected from catalog: AnsiPro Pump Company.60 Vers: 1.1

Test Simulation Result:



System Summary Report:

System Summary Report

File Name:	ENT498 PIPELINE.pipe	**Calculation Method:**	Darcy-Weisbach	**Company:**	MIAMI UNIVERSITY
Lineup:	<Design Case>	**Laminar Cutoff Re:**	2100	**Project:**	Kyle_Ted_Thuc_Pipeline
Progam Name:	PIPE-FLO Advantage Student Edition	**Max Iterations:**	1000	**by:**	Thuc Nguyen
Version:	17.2.51801	**Percent Tolerance:**	0.01	**Date:**	Saturday, April 10, 2021 02:03 PM
		Allowable Deviation:	1 %	**Atmospheric Pressure:**	14.7 psi a

Number of Piping System Devices

Fluid Zones:	1	**Centrifugal Pumps:**	1	**Tanks:**	1	**Fixed dP Devices:**	0	**Control Valves:**	0	**Balancing Orifices:**	0
Pipe Specs:	1	**Fans:**	0	**Pressure Boundaries:**	0	**Curve dP Devices:**	0	**Pressure Relief Valves**	0	**Orifice Meters:**	0
Pipelines:	6	**Blowers:**	0	**Flow Demands:**	0	**Heat Source / Sinks:**	0	**Pressure Gain Devices:**	0	**Nozzle Meters:**	0
Reducers:	0	**Compressors:**	0	**Nodes:**	2	**Heat Exchangers (2-Pipe):**	0	**Compressible Pipelines:**	0	**Venturi Meters:**	0

System Liquid Volume

NOTE: model must be calculated to populate Tank Liquid Volume

Total Pipeline Liquid Volume:	0.27 gal	0.04 ft^3	0.001 m^3	1.0 liters	0.01 bbl	62.9 in^3	1031.3 cm^3
Total Tank Liquid Volume:	16.80 gal	2.25 ft^3	0.064 m^3	63.6 liters	0.40 bbl	3880.7 in^3	63592.5 cm^3
Total System Liquid Volume:	17.07 gal	2.28 ft 3	0.065 m 3	64.6 liters	0.41 bbl	3943.6 in 3	64623.8 cm3

Total System Volumes

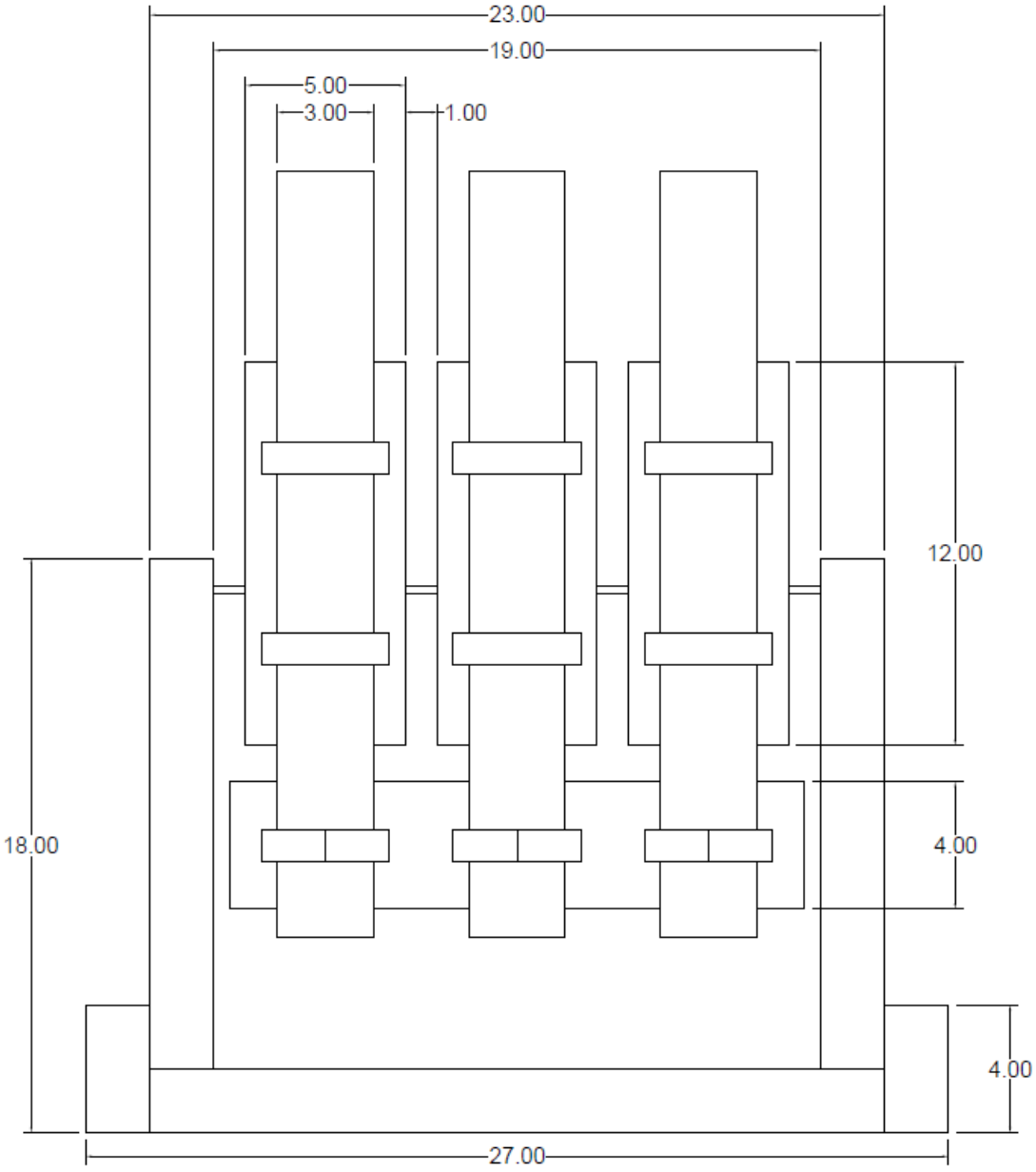
NOTE: model must be calculated to populate Total Tank Volume

Total Pipe Volume:	0.27 gal	0.04 ft^3	0.001 m^3	1.0 liters	0.01 bbl	62.9 in^3	1031.3 cm^3
Total Tank Volume:	18.36 gal	2.45 ft^3	0.069 m^3	69.5 liters	0.44 bbl	4241.2 in^3	69500.0 cm^3
Total System Volume:	18.63 gal	2.49 ft 3	0.071 m 3	70.5 liters	0.44 bbl	4304.1 in 3	70531.3 cm3

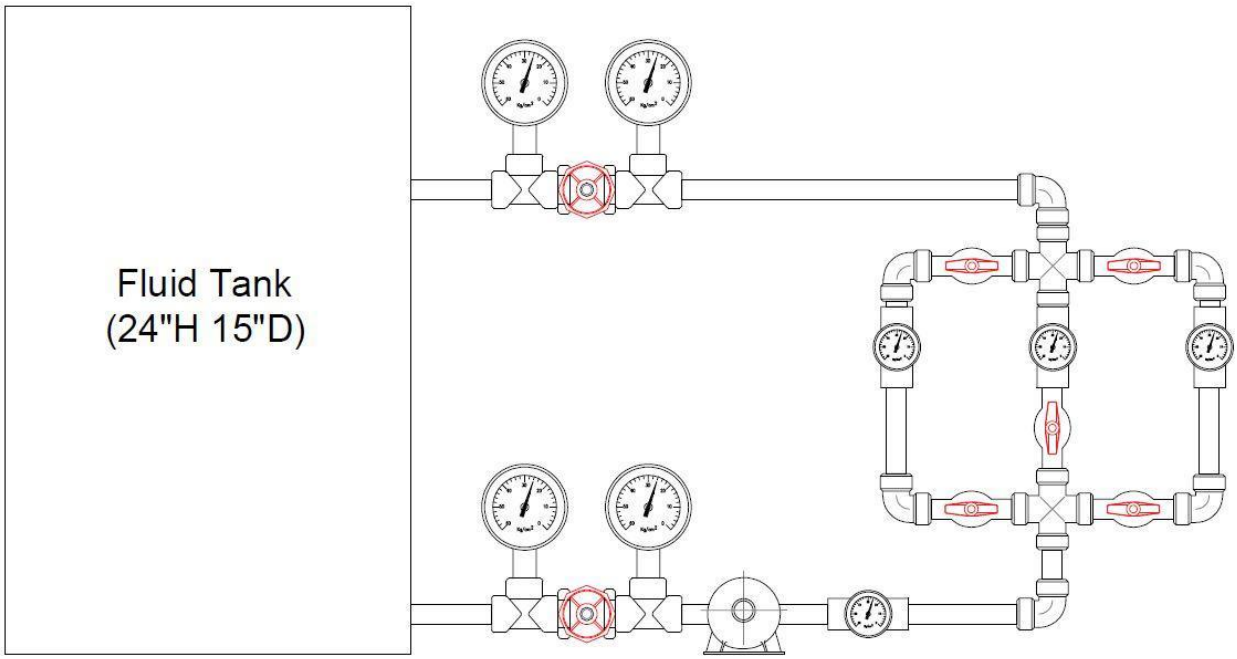
Appendix C: Computer Aided Drawings

CAD Drawings

Flexible Triple Falling-Ball Viscometer



Small-Scale Pipeline System



Appendix D: Budget:

Estimated Cost:

Budget for Lab Componets Project				
Componet One: Falling Ball Viscosmeter		Qnty	Price	Total
USP Corp	#34109 3" Clear Rigid Schedule 40 PVC Pipe	3	$19.75/ft	$150.00
USP Corp	#34298 3" Clear Schedule 40 PVC Cap	3	$69.28 each	$208.00
USP Corp	#32250 Turn-Tite Expandable Rubber Plug 3" Dia. x 2" Height	3	$42.07 each	$127.00
E-Trailer	# QF50050 Quick Fist 3" Clamp - 2-3/4" to 3-1/4" Inner Diameter	3	$16.31 each	$49.00
Lowes	#1435821 Oatey 3-in Galvanized 2-hole Pipe Strap	6	$2.28 each	$14.00
Zoro	#G4581841 Oil Hard Drill Rod, 1/2inch x 36inch	1	$11.68	$12.00
Zoro	#G2316973 Pillow Block Bearing, Sleeve, 1/2" Bore	3	$17.81	$54.00
Lowes	#279178 1x3x10ft wood plank	1	$10.00	$10.00
Lowes	#175694 8-ft Board 1x2x8	1	$4.29	$5.00
Lowes	#27172 2x4x10 white wood lumber	1	$8.77	$9.00
Comoponet Total				**$638.00**
Small scale pipe-line				
	#26503 3/4" White PVC Schedule 40 Pipe	1	$0.93 per ft	$7.00
	#28534 3/4" Schedule 40 White PVC Socket 90° Elbow	6	$0.25 each	$2.00
	#28474 3/4" Schedule 40 White PVC Socket Cross	2	$1.69 each	$4.00
poolsupplyunlimited.	#V08491N White MIP Ball Valve 3/4" White PVC White SxS	8	$5.69 each	$46.00
Master-Carr	#6769k26 Easy-Maintenance Inline Circulation Pumps for Water	1	$679.79	$680.00
Master-Carr	#5020T72 Socket-Connect Flowmeter/Totalizers for Water	2	$344.80	$690.00
Coast Pneumatics	#50BAC-S1-06 50BAC-S1-06 quick connect	2	$3.57	$8.00
Coast Pneumatics	#10AC-5S-02 10AC-S2-02 Pack of (25)	1	$27.89	$28.00
Lowes	#154277 1/2-in Common Fir Sanded Plywood, Application as 2 x 4	1	$16.86	$17.00
Fishtanks direct	# AA015RC Clear for Life Acrylic15 Gallon - 24"L x 13"W x 12"H	1	$210.00	$210.00
Lowes	#27172 2-in x 4-in x 10-ft Whitewood Lumber	1	$8.77	$9.00
USP Corp	#: 26324 1" Gray PVC Schedule 80 Pipe	1	$1.53 per ft	$2.00
	#3515N41 Drinking Water Pressure Gauges	6	$19.04	$120.00
Componet Total				**$1,823.00**
TOTAL FOR BOTH LAB PROJECTS				
	Falling Ball			$638.00
	Small Scale Pipe-Line			$1,823.00
SUB TOTAL				**$2,461.00**
	Shipping and Handling			$$159.00
GRAND TOTAL				**$2,620.00**

Side by Side Comparison:

Budget for Lab Componets Project									
						Actual Cost			
Componet One: Falling Ball Viscosmeter		Qnty	Price	Total		Qnty	Total	Above Budget (+)	Below Budget (-)
USP Corp	#34109 3" Clear Rigid Schedule 40 PVC Pipe	3	$19.75/ft	$150.00		3	$173.60	(+) $23.60	
USP Corp	#34298 3" Clear Schedule 40 PVC Cap	3	$69.28 each	$208.00		3	$207.84		(-) $0.16
USP Corp	#32250 Turn-Tite Expandable Rubber Plug 3" Dia. x 2" Height	3	$42.07 each	$127.00		3	$7.89		(-) $119.11
E-Trailer	# QF50050 Quick Fist 3" Clamp - 2-3/4" to 3-1/4" Inner Diameter	3	$16.31 each	$49.00		3	$48.84		(-) $0.16
Lowes	#1435821 Oatey 3-in Galvanized 2-hole Pipe Strap	6	$2.28 each	$14.00		6	$36.96	(+) $22.96	
Zoro	#G4581841 Oil Hard Drill Rod, 1/2inch x 36inch	1	$11.68	$12.00		1	$11.68		(-) $0.32
Zoro	#G2316973 Pillow Block Bearing, Sleeve, 1/2" Bore	3	$17.81	$54.00		3	$56.19	(+) $2.19	
Lowes	#279178 1x3x10ft wood plank	1	$10.00	$10.00		1	$7.61		(-) $2.39
Lowes	#175694 8-ft Board 1x2x8	1	$4.29	$5.00		1	$6.15	(+) $1.86	
Lowes	#27172 2x4x10 white wood lumber	1	$8.77	$9.00		1	$8.77		(-) $0.23
Componet Total				**$638.00**				**(+) $50.61**	**(-) $123.37**
Small scale pipe-line									
	#26503 3/4" White PVC Schedule 40 Pipe	1	$0.93 per ft	$7.00		1(10')	$9.30	(+) $2.30	
	#28534 3/4" Schedule 40 White PVC Socket 90° Elbow	6	$0.25 each	$2.00		7	$1.61		(-) $0.39
	#28474 3/4" Schedule 40 White PVC Socket Cross	2	$1.69 each	$4.00		2	$2.76		(-) $1.24
poolsupplyunlimited.	#V08491N White MIP Ball Valve 3/4" White PVC White SxS	8	$5.69 each	$46.00		8	$9.92		(-) $36.08
Master-Carr	#6769k26 Easy-Maintenance Inline Circulation Pumps for Water	1	$679.79	$680.00		1	$139.99		(-) $540.01
Master-Carr	#5020T72 Socket-Connect Flowmeter/Totalizers for Water	2	$344.80	$690.00		2	$161.20		(-) $528.80
Coast Pneumatics	#50BAC-S1-06 50BAC-S1-06 quick connect	2	$3.57	$8.00		2	$13.94	(+) $5.94	
Coast Pneumatics	#10AC-SS-02 10AC-S2-02 Pack of (25)	1	$27.89	$28.00		1 Bag	$8.51		(-) $19.49
Lowes	#154277 1/2-in Common Fir Sanded Plywood, Application as 2 x 4	1	$16.86	$17.00		2	$12.64		(-) $4.36
Fishtanks direct	# AA015RC Clear for Life Acrylic 15 Gallon - 24"L x 13"W x 12"H	1	$210.00	$210.00		1	$95.42		(-) $114.58
Lowes	#27172 2-in x 4-in x 10-ft Whitewood Lumber	1	$8.77	$9.00		1	$8.77		(-) $0.23
USP Corp	#: 26324 1" Gray PVC Schedule 80 Pipe	1	$1.53 per ft	$2.00		not needed			
Master- Carr	#3515N41 Drinking Water Pressure Gauges	6	$19.04	$120.00		4	$176.34	(+) $56.34	
Componet Total				**$1,823.00**				**(+) $64.58**	**(-) $1245.18**
TOTAL FOR BOTH LAB PROJECTS								Actual Totals	
	Falling Ball			$638.00				$565.24	
	Small Scale Pipe-Line			$1,823.00				$642.40	
SUB TOTAL				**$2,461.00**					
	Shipping and Handling			$$159.00					
GRAND TOTAL				**$2,620.00**				**$1,207.64**	**(-) $1412.36**