Hydraulic Testing Apparatus

Hydraulic Testing Company (HTC)

Team Members

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Project Overview

Project Purpose

To design and construct a hydraulic testing apparatus that can demonstrate hydraulic principles to the Northern Arizona University engineering students.

Figure 1: Previous Water Resources Project

Project Stakeholders

- Client: Alarick “Lar” Reiboldt
- Technical Advisor: Mark Lamer
- Water Resources and Fluid Mechanics students and professors

Project Parameters

- Free-standing
- Allow for a minimum of 1 minute hydraulic testing time
- Structural materials must be steel
- Interchangeable hydraulic parts
- Allow for testing of free-falling head and constant head

Structural Design

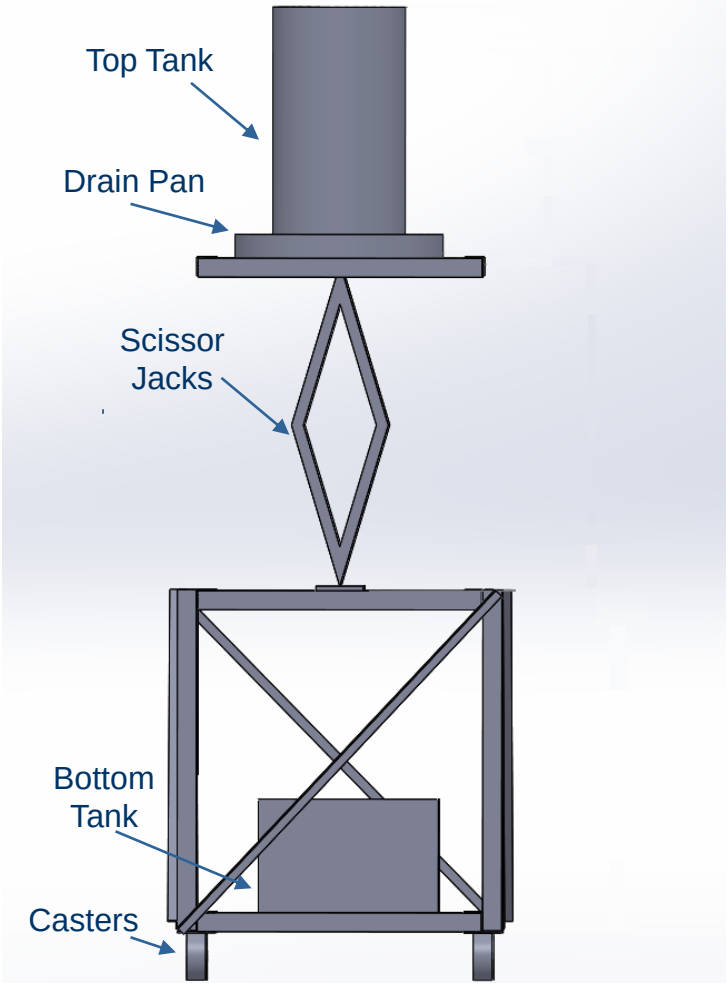

Figure 2: Structural Design on SOLIDWORKS

Structural Characteristics

- Scissor jacks to allow for varied hydraulic head
- Steel material for a durable structure
- Heavy duty wheels attached for easy transportation and holding in place
- Steel angles used to create the strongest structure
- Middle level allows for work area and storage
- Fully jacked height is 74.5 inches (6.2 feet)
- Width is 36 inches (3 feet) and length is 60 inches (5 feet)

Structural Analysis

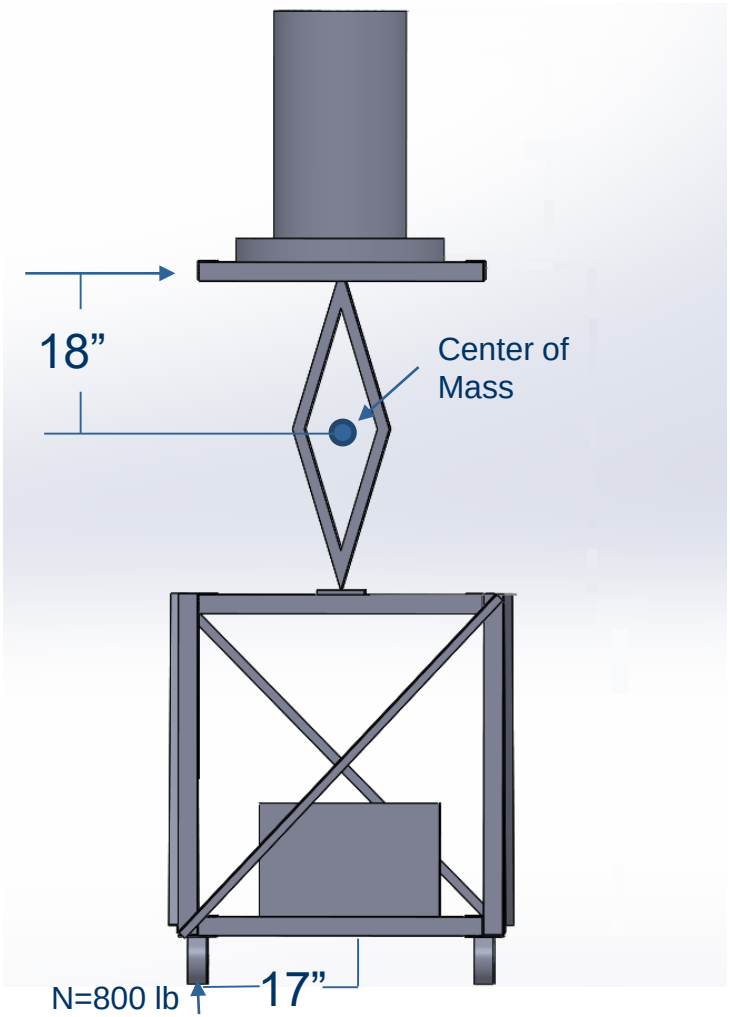

Figure 3: CAD Tipping Moment

Structural Calculations

$M_1=(F_T)(18”)$

$M_2=(800\ lb)(17”)$

Structure begins to tip when

$M_1=M_2$

$F_T=(800\ lb)(17”)/(18”)$

$F_T=756\ lb$

Structural Calculations

- Center of mass of the structure is **18 inches** from the top of the structure and **17 inches** from the side of the structure.
- Tipping force required to tip the structure is **756 lbs**.

Structural Design Views

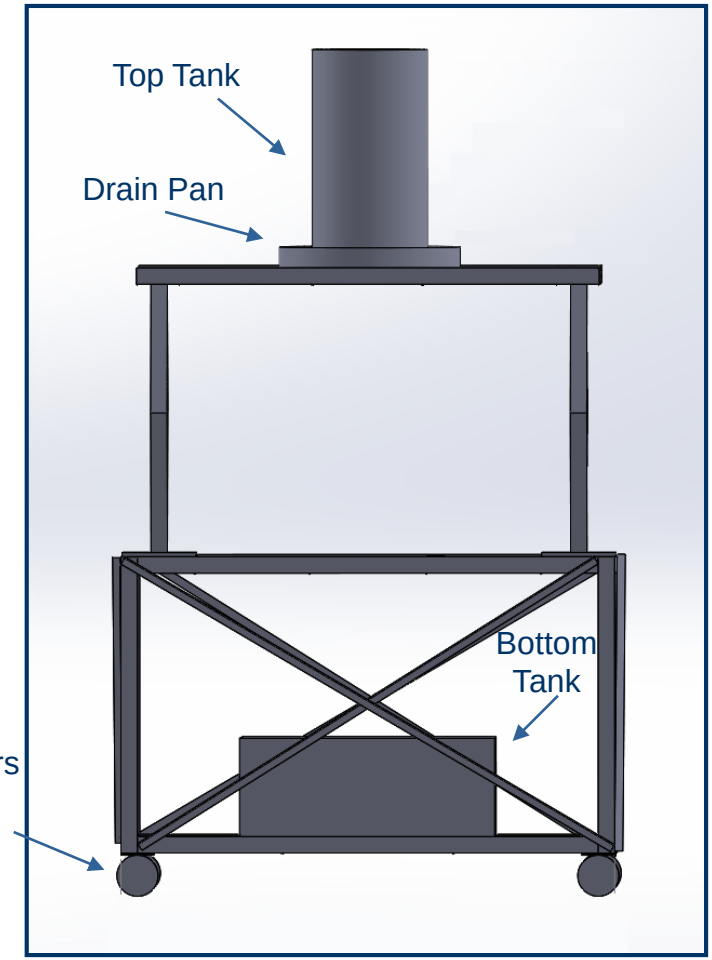

Figure 4: Front View of Structure Design using SOLIDWORKS

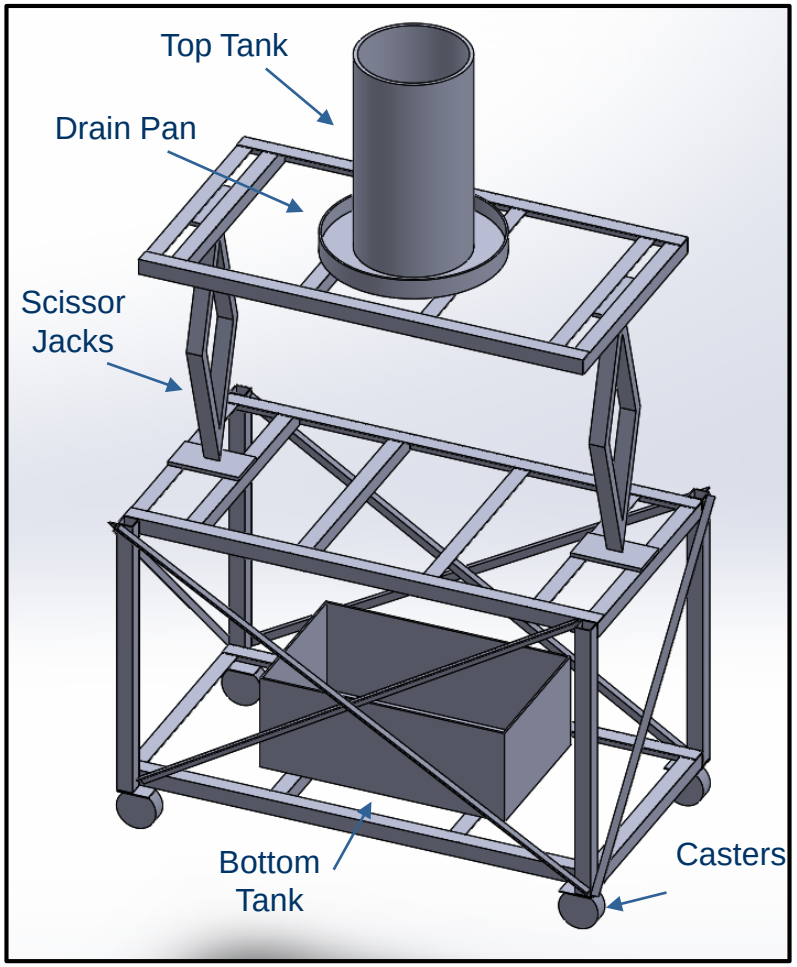

Figure 5: 3D Aerial View of Structure Design using SOLIDWORKS

Purchasing for Structure

Figure 6: Steel Angles and Steel Tubing

Item	Total Length (in)
2”x2” x 1/8” Steel Angles	824
1”x1” x 1/8” Steel Angles	187
2”x2” x 0.2” Square Tubing	36

Table 1: Steel Purchased from Mayorga’s Welding

Purchasing

- Purchased steel material from Mayorga’s Welding near downtown Flagstaff
- Purchased fasteners and tools from Home Depot
- Purchased scissor jacks and caster wheels online

Construction of the Structure

Figure 7: Structural Assembly

Figure 8: Welding of the Structure

Construction Phase 1

- Assembly of the steel angles and scissor jacks

Construction Phase 2

- Welding of the steel angles for added structural strength

Construction of the Structure (Continued)

Figure 9: Wheel Installation

Figure 10: Primer and Painting

Construction Phase 3

- Installation of the caster wheels for easy transportation

Construction Phase 4

- Primer and paint added to avoid rusting

Completion of the Structure

Figure 11: Final Structure

Flow Diagram of the System

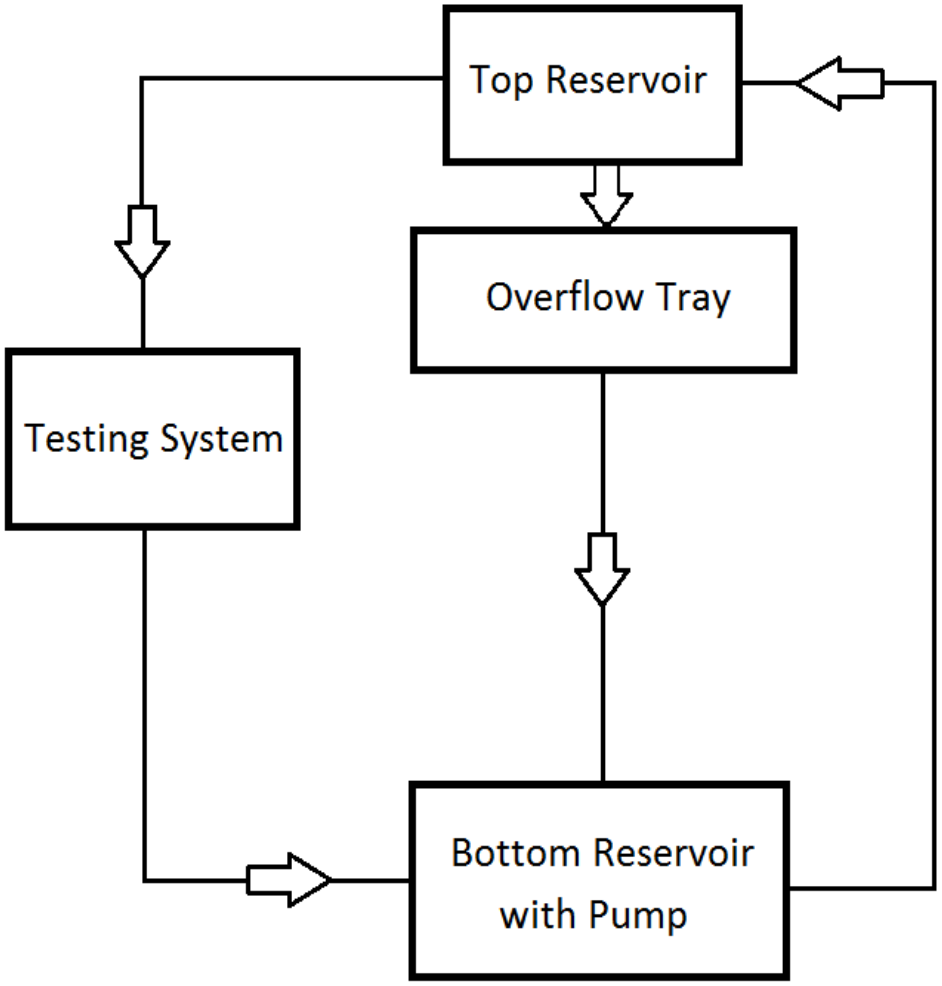

Figure 12: Flow diagram of the system

Hydraulic Analysis

Hydraulic Calculations

- 6.2 feet of head

Kinetic Energy = Potential Energy

$\frac{1}{2} mv^2 = mgh$

Velocity

$V = \sqrt{2gh}$

Area of Pipe

$A = (\pi / 4) d^2$

Discharge

$Q = VA$

Pressure

$P = 0.433 * h * SG$

Tank and Pump Sizing	
Pipe Area (in^2)	0.2
Pressure (psi)	2.7
Flowrate (gph)	**733.5**
Testing Time (s)	63.8
Pipe Diameter (in)	0.5
Height (ft)	6.2
Tank Volume (gallons)	**13.0**

Table 2: Tank and Pump Sizing Calculations

Free-Falling Head vs. Constant Head

Figure 13: Water System Tank

Free-Falling Head

- Water level in the tank decreases over time
- Decrease of system pressure
- Eventually emptying the tank

Constant Head

- Water elevation in the tank remains constant over time
- Constant system pressure

Pressure in Full Tank

- Head = 6.2 feet
- Pressure = 2.68 psi

Pressure in Near Empty Tank

- Head = 5.2 feet
- Pressure = 2.25 psi

Purchasing for Water System

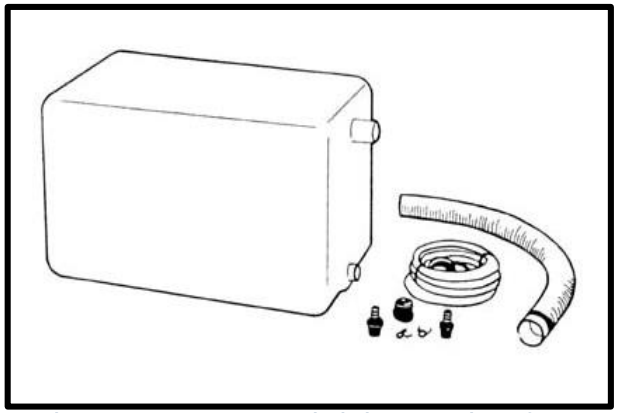

Figure 14: Water Tank (Picture taken from CampingWorld.com)

Figure 15: Washer Drain Pan (Picture taken from HomeDepot.com

Figure 16: Pond Pump (Picture taken from HomeDepot.com

Purchasing

Purchased

- Two water tanks from Camping World (Figure 14)
- Top reservoir with dimensions of 12” x 12” x 24” 15 gallon tank
- Bottom reservoir with dimensions of 14” x 20.75” x 22” 26 gallon tank
- 30” x 32” washing mashing drain pan under the top reservoir to allow for constant head to be tested (Figure 15)
- Pond pump with a maximum pumping height of 9 feet and 960 gph (Figure 16)

Construction of the Water System

Figure 17: Water System

Construction Phase 1

- Placement of the top tank and bottom tank

Construction Phase 2

- Installation of pond pump into bottom reservoir and connect to top reservoir

Construction Phase 3

- Connection of overflow pan to bottom reservoir using vinyl tubing.
- Drilled additional overflow holes on top tank

Construction Phase 4

- Installation of main connection from top tank to allow for interchangeability for other students

Project Material Cost

Category	Cost
Steel Material	$302.10
Water Tanks	$263.52
Scissor Jacks	$107.22
Caster Wheels	$180.84
Washer Draining Pan	$29.99
Screws, Bolts, and Nuts	$24.52
Pond Pump	$140.55
Fittings	$20.17
Tubing	$30.32
Tools and Equipment	$33.36
Extra Piping	$20.00
Plywood	$95.14

Table 3: Cost of Materials

Final Cost

- Projected cost of the project was $1,000
- Final cost of the project materials was $1,247.73
- Additional piping and fittings purchased for the students to use

Project Staffing Cost

Classification	Hours	Rates ($/hr)	Cost ($)
Senior Engineer	60	114	6,840.00
Engineer	90	58	5,220.00
Intern	95	21	1,995.00
Administrative Assistant	85	38	3,230.00
Total	**330**		**$17,285.00**

Table 4: Projected Staffing Cost

Classification	Hours	Rates ($/hr)	Cost ($)
Senior Engineer	50	114	5,700.00
Engineer	120	58	6,960.00
Intern	150	21	3,150.00
Administrative Assistant	90	38	3,420.00
Total	**410**		**$19,230.00**

Table 5: Final Staffing Cost

Water Resources 1 Course Testing

Questions?