



Reusable Hydrometer for Human Specific Gravity Measurements



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Abstract

Specific gravity is an approachable method to monitor daily outflow of urine for the purpose of preventing kidney stone formation. However, most specific gravity measurement devices are clinical research grade equipment and are not commercially available due to cost and technical experience to operate. Here described is our method for adapting a commercially available fish tank hydrometer to be utilized for human urine specific gravity measurements by fabricating an adapter attachment that not only increases the ease of use for our device but also increases the accuracy of it.

Motivation and Background

Kidney stone formation has become a prevalent problem facing the onset of the obesity epidemic. There are four major types of kidney stones: calcium stones, struvite stones, uric acid stones, and cystine stones. And among all four, calcium stones are the most common type.

A simple preventative to kidney stone formation is increased fluid intake. It has been found that the adequacy of a single 24-hour urine sample for evaluating patients for medical renal stone prevention. However, the results found that single 24-hour sample is not sufficient for evaluating patients before metabolic treatment for stone prevention. Our client, Dr. Jhagroo, a nephrologist at the University of Wisconsin – Madison Hospital and Clinic, has found a methodical way to approximate a patient's previous 24-hour urine volume output by measuring the specific gravity of the patient's urine. From this information, Dr. Jhagroo can diagnose a potential formation of renal stones

Design Specifications

Hydrometer

- Measures SG accurately
- Reusable (with no major effects on accuracy)
- Portable
- 3 in x 3/4 in x 5 in
- No more than 1.5 pounds

Adapter

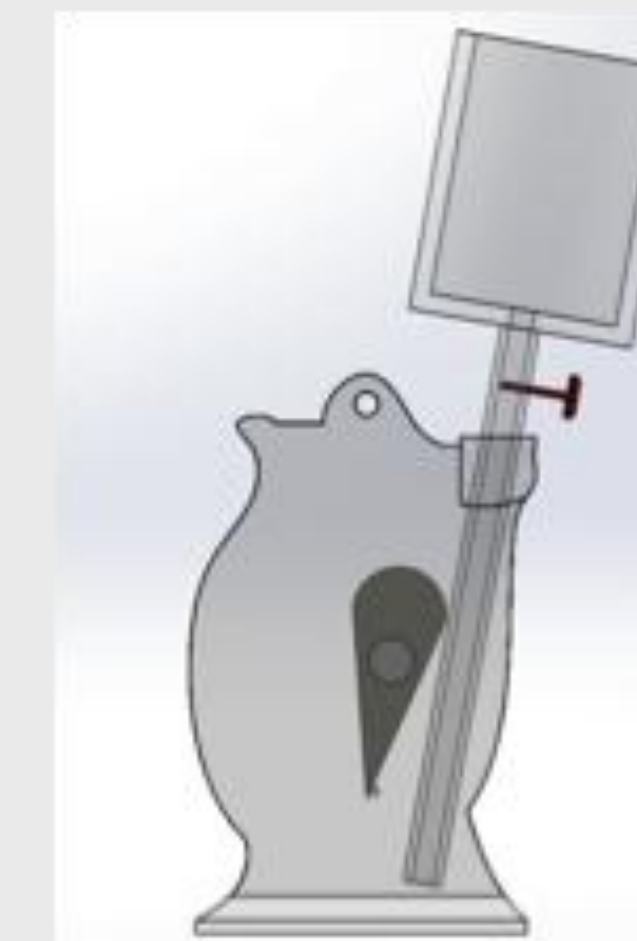
- Prevents bubble formation
- Easy flow/stop of urine
- 12 in length, 3 in diameter (funnel), 1 in diameter (tubing)

Preliminary Designs

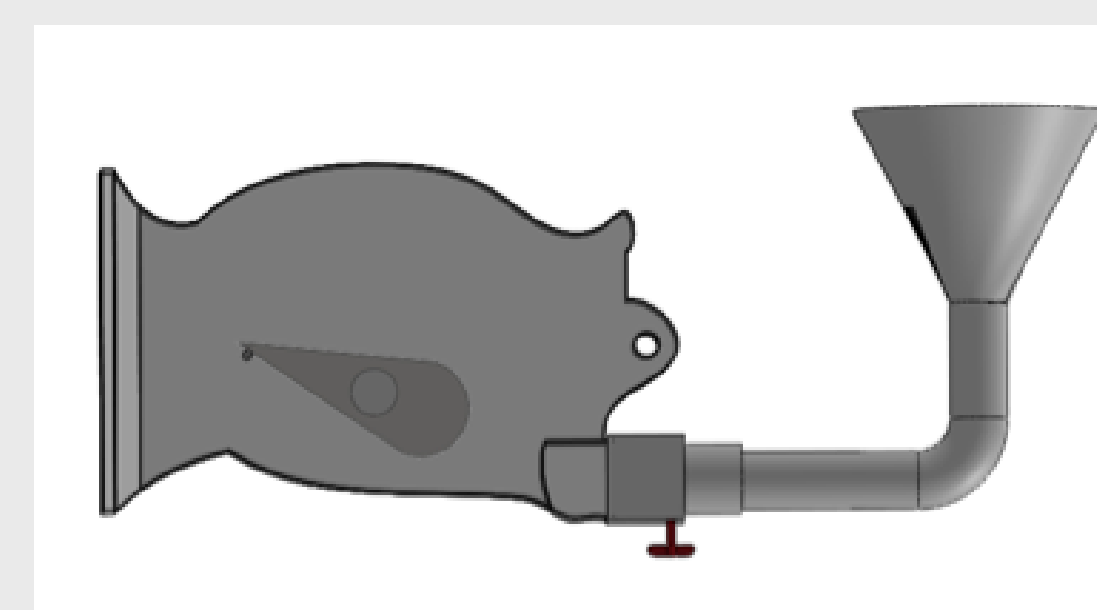
Syringe Hydrometer



Tube-adapter Hydrometer



Funnel Adapter Hydrometer

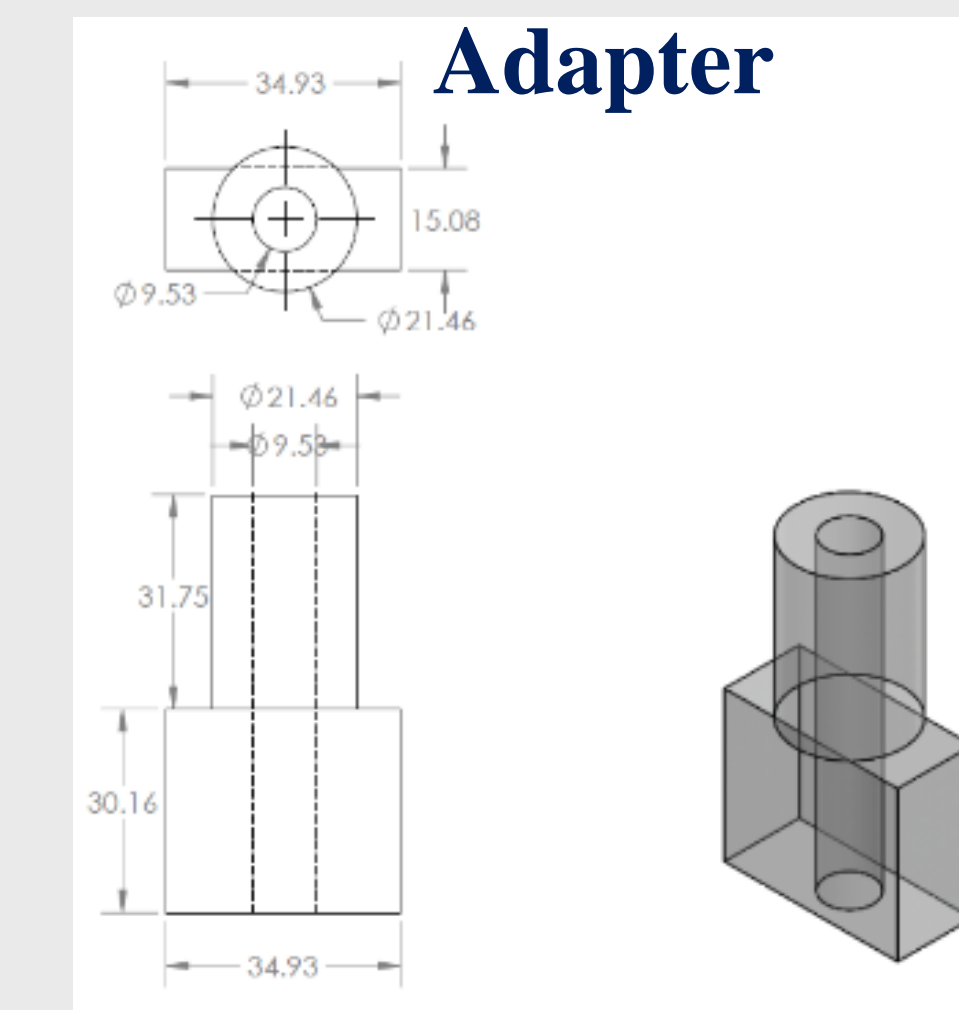
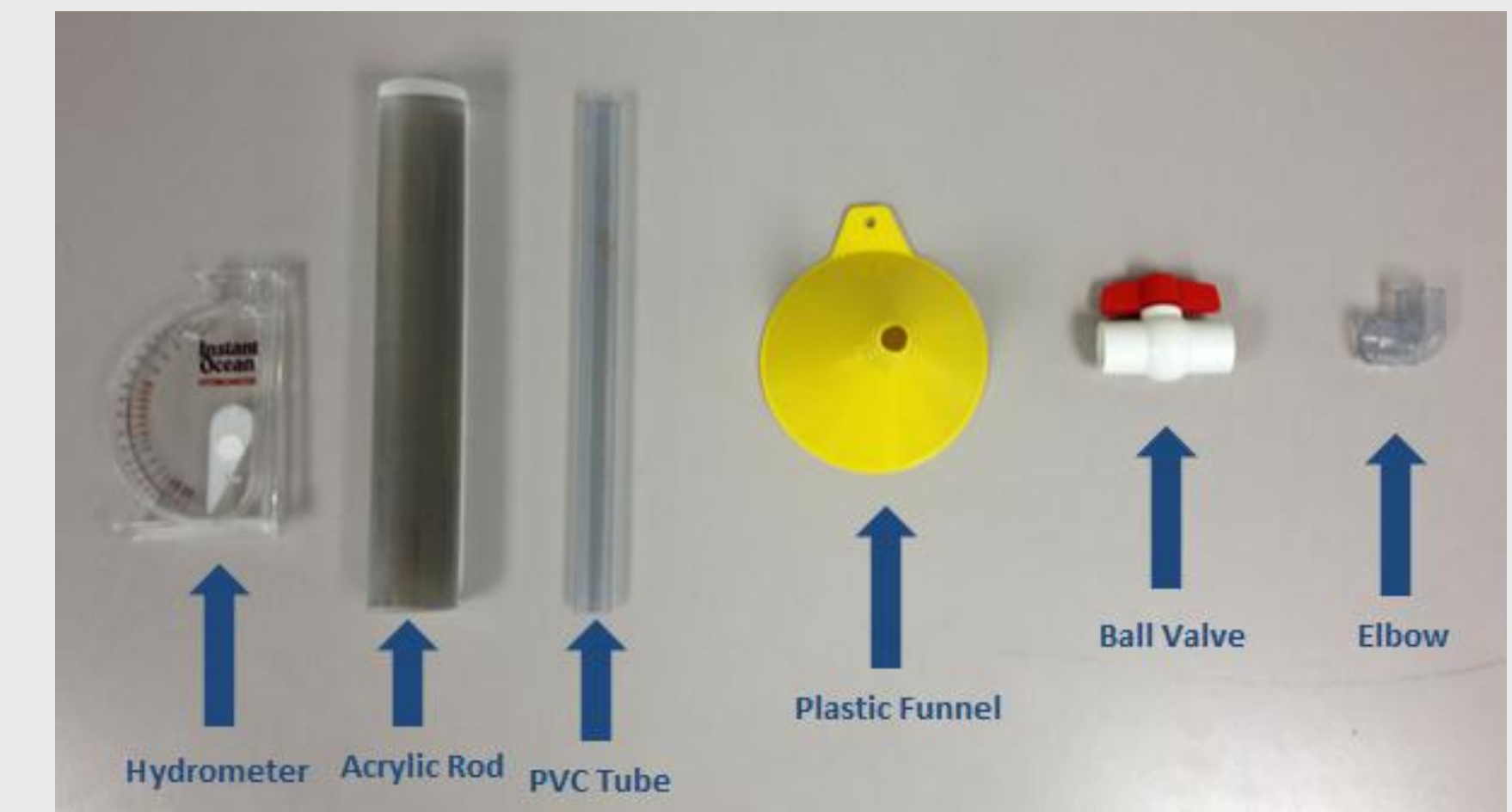


Design Matrix

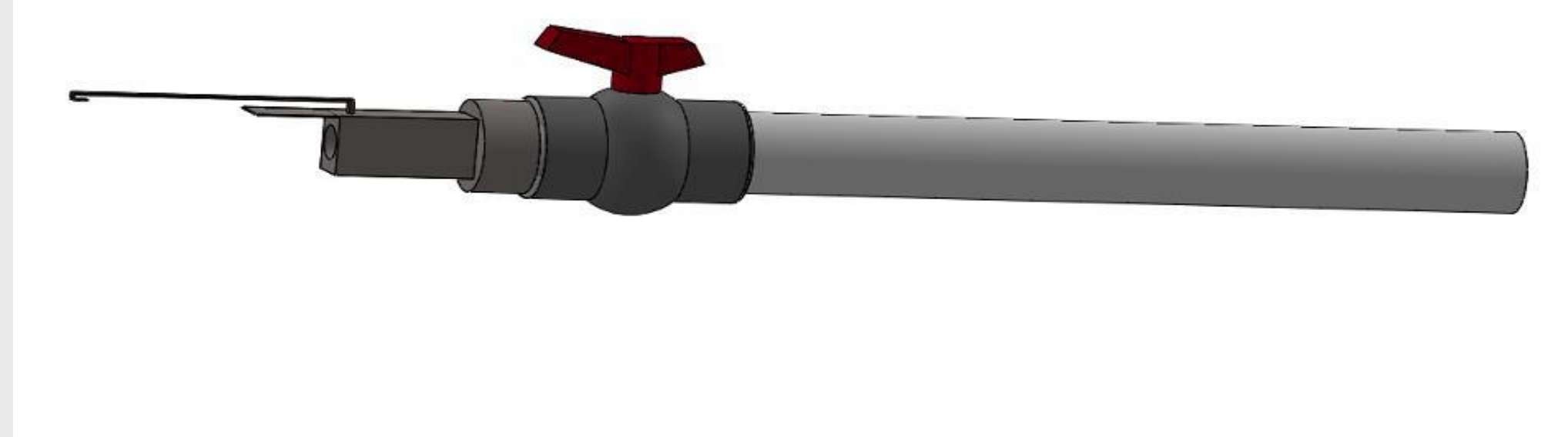
	Fish-tank hydrometer design I (Adapter)	Fish-tank hydrometer design II (tube)	Syringe hydrometer
Cost (20%)	5	5	5
Accuracy (20%)	5	5	4
Portability (15%)	4	3	5
Durability (15%)	5	5	3
Ease of use (15%)	5	3	4
Fabrication (10%)	4	4	5
Safety (5%)	5	5	5
Total score (out of 100)	95	86	87

Final Design

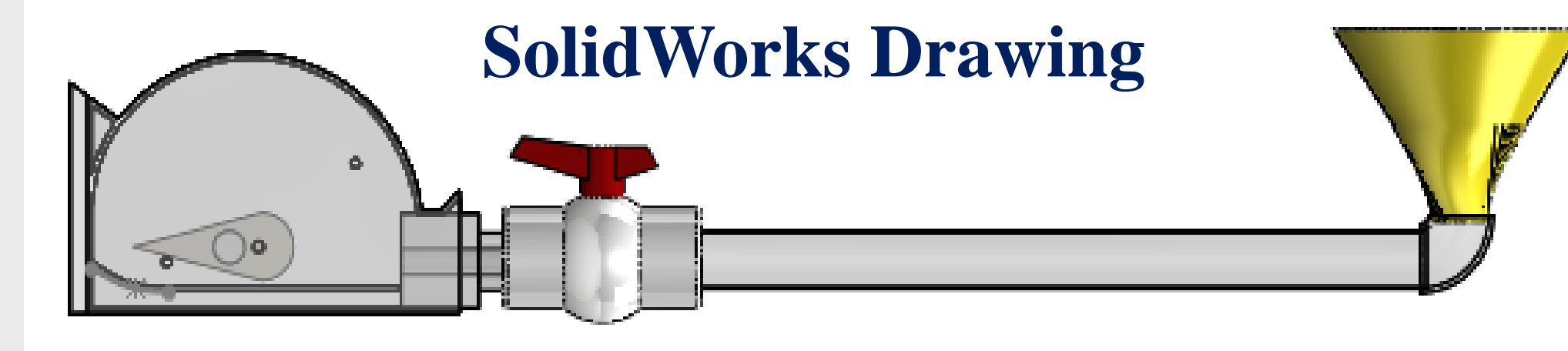
Material



Adapter with ball valve and tube



SolidWorks Drawing



Experimental Testing

Temperature	Trial 1	Trial 2	Trial 3	Average
21 Celsius	1.003	1.004	1.003	1.003
90 Celsius	1.000	1.001	1.001	1.001
1 Celsius	1.000	1.000	1.000	1.000

Hydrometer	Trial 1	Trial 2	Trial 3	Average
Used	1.0225	1.0230	1.0225	1.0227
New	1.0245	1.0245	1.0240	1.0243

Situation	No adapter	Adapter
Trial 1	1.000	1.000
Trial 2	1.000	1.000
Trial 3	1.000	1.000
Averages	1.000	1.000



Future Work

- There could be enhancements of fish-tank hydrometer adapter.
- A small and light ball valve with same inlet and outlet diameter would fit the design better.
- A prototype of syringe hydrometer could be fabricated to compare with the current adapter design in terms of the accuracy of measuring the specific gravity.

Conclusion

- Kidney stones are a prevalent problem in American culture, and the only real means of preventative measure is to increase daily urine outflow.
- Measuring the specific gravity of an individual's urine can be extrapolated to measure if daily urine outflow needs to be increased.
- This fish tank hydrometer has the required scale to measure human urine specific gravity but application of urine into the device can result in bubble formation around the needle, skewing data.
- Our team has consequently designed an adapter that will reduce bubble formation and thus give more accurate data.

Reference

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