WISCONSIN

UNIVERSITY OF WISCONSIN–MADISON

BME Design 200/300

Reusable Hydrometer for Human Specific Gravity Measurements

Matt Walker – Team Leader

Xiyu (Steve) Wang – Communicator

Jack Goss – BSAC

Yue (Jerry) Yin – BWIG

Reusable Hydrometer for Human Specific Gravity Measurements

- Introduction
  - Objective, PDS, Problem Statement, Hydrometer Physics.
- Data and Testing
  - Prototype Designs, Design Matrix, Data Analysis.
- Discussion
  - Timeline, Conclusion, Future Works, Acknowledgements, References.

Introduction

- Objective
- Problem Statement
- PDS
- Hydrometers
- Hydrometer Physics

Objective

- Design and fabricate a prototype adapter to mount onto a commercially available hydrometer for the purpose of measuring the specific gravity of human urine.

Problem Statement

- Kidney stones are an increasing problem in American culture. Approximately 10% of all Americans will have kidney stones that will result in $2.1 billion dollars in medical expenses. A possible preventative measure is to increase daily urine outflow, however it is hard for an individual to track urine output at home. Dr. Roy Jhagroo, a nephrologist at the University of Wisconsin-Madison hospital, has discovered an approachable method to test daily urine output by measuring the specific gravity of urine. Our team will be designing and implementing a portable, reusable hydrometer prototype to test the specific gravity of urine.

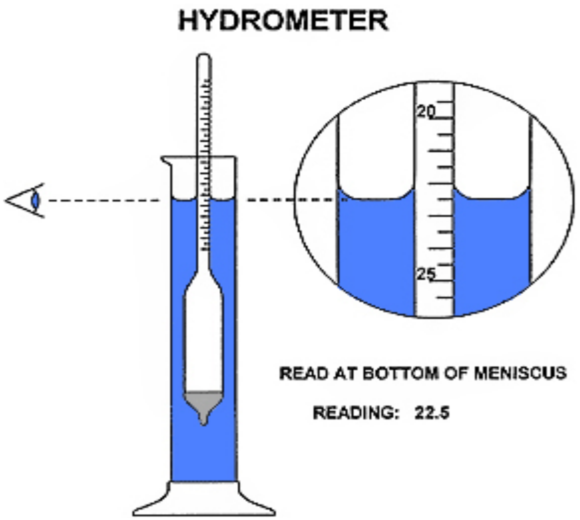
Project Design Specifications

- 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
  - 100 mL of urine for testing
- Adapter
  - Prevents bubble formation
  - Easy flow/stop of urine
  - 6 in length, 3 in diameter (funnel), 1 in diameter (tubing)

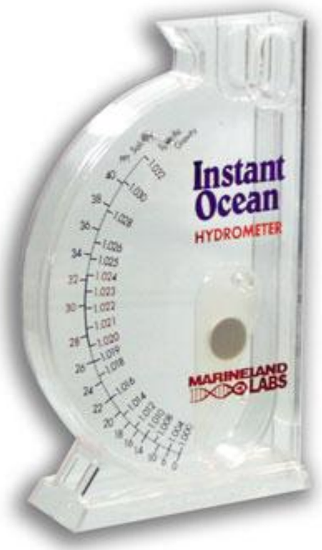
Hydrometers

- Hydrometer: measures specific gravity
  - Specific gravity : $\rho_{sample} / \rho_{ref}$
- Two models:

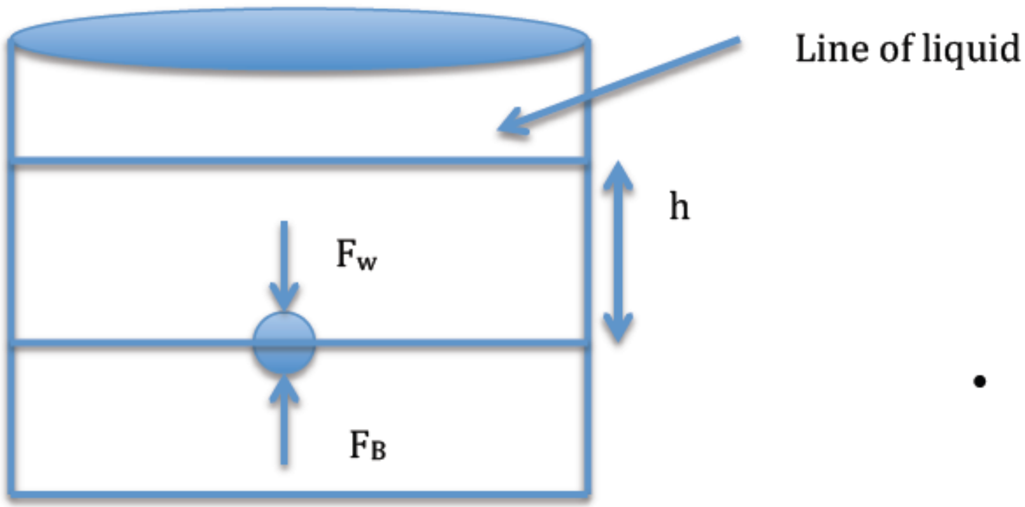
Standard:



Swing Arm:



Hydrometer Physics (1)

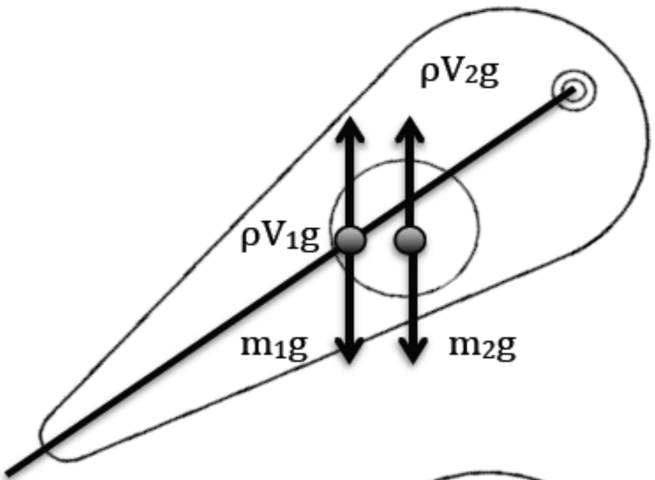


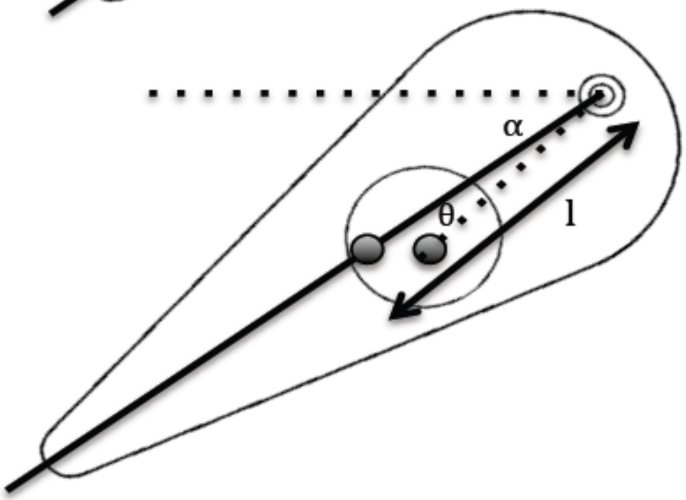
F_B / SA= Pressure = ρ_{sol} x h x g
F_B = F_w = ρ_{sol} x h x g x (SA) =mg
h=m/ (ρ_{sol} x SA)

SA = surface area of object

- Pressure is defined by the buoyant force over the surface area of the object
- Height is inversely related to the density of the solution

Hydrometer Physics (2)



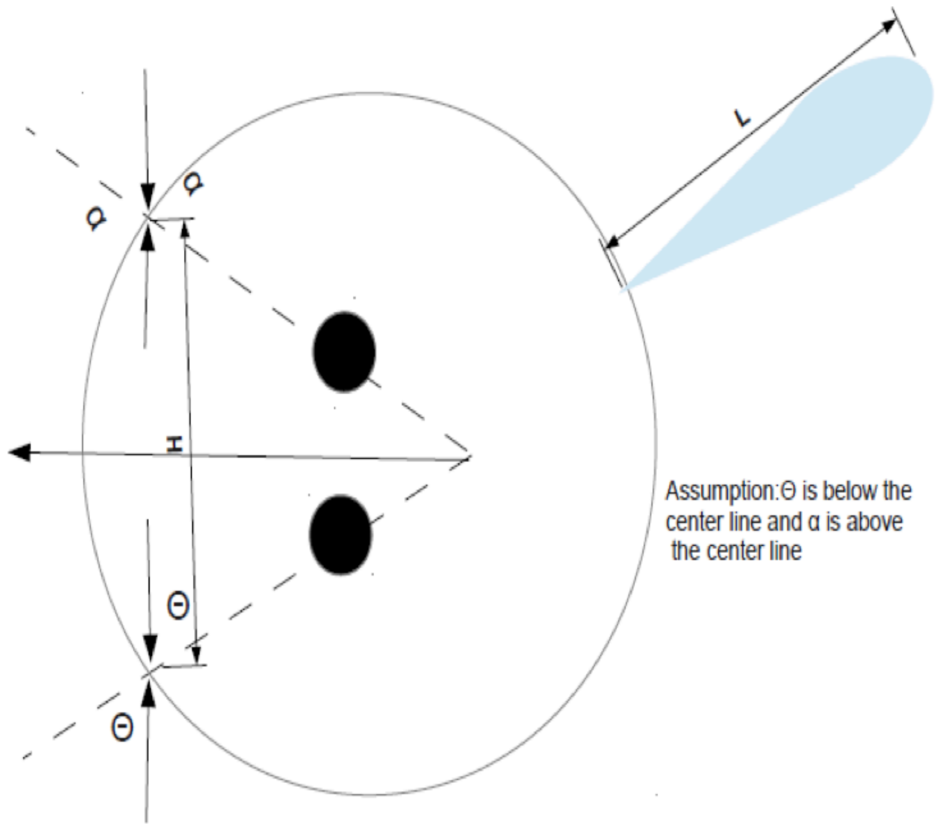


$\Sigma\text{Moment} = \rho V_1 g \times l\cos(\alpha + \theta) + \rho V_2 g \times l\cos(\alpha) - m_1 g \times l\cos(\alpha + \theta) - m_2 g \times l\cos(\alpha) = 0$

$\rho = (m_1\cos(\alpha + \theta) + m_2 g\cos(\alpha)) / (V_1 g\cos(\alpha + \theta) + V_2\cos(\alpha))$

- At equilibrium position, moment with respect to the fixed point cancels out.
- If solution has high density, angle alpha will be small.

Hydrometer Physics (3)



Assumption: Θ is below the center line and α is above the center line

$$H=\sqrt{(2L^2 x(1-\cos[(90-\Theta)+(\alpha-90)])}$$

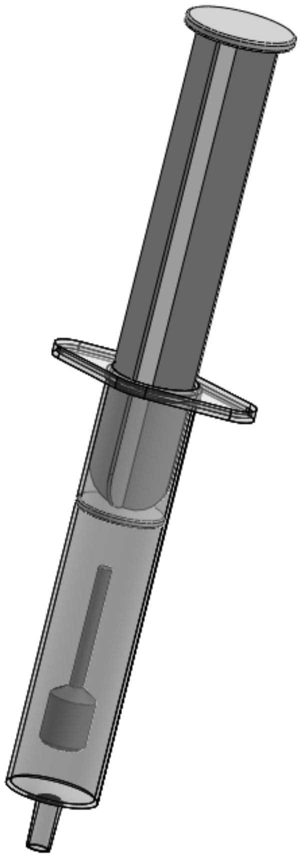
Data and Testing

- Prototype Designs
- Design Matrix
- Data Analysis

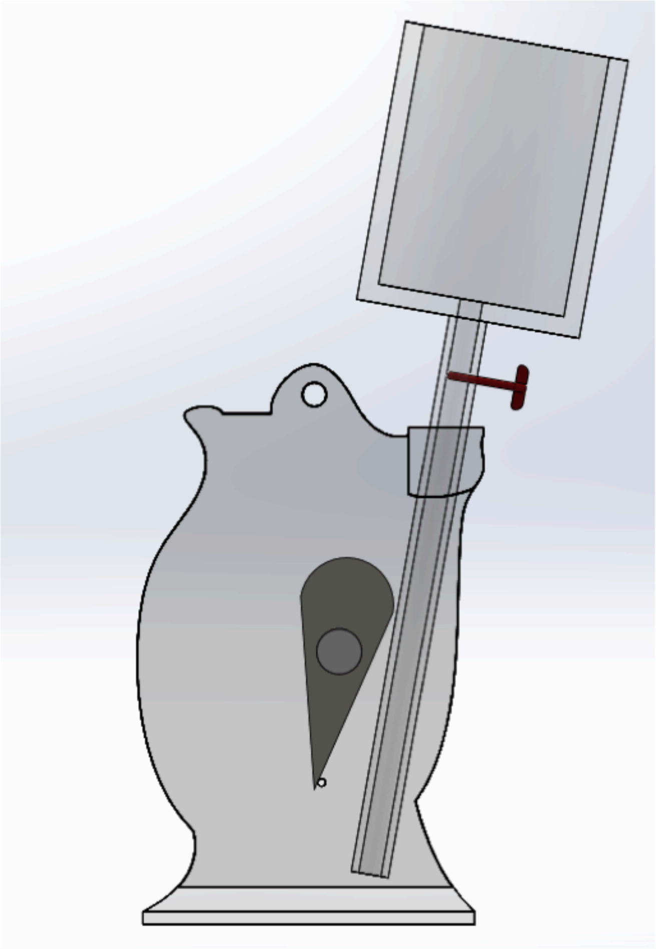
Prototype Designs

- Syringe
- Tube (Swing Arm)
- Funnel (Swing Arm)

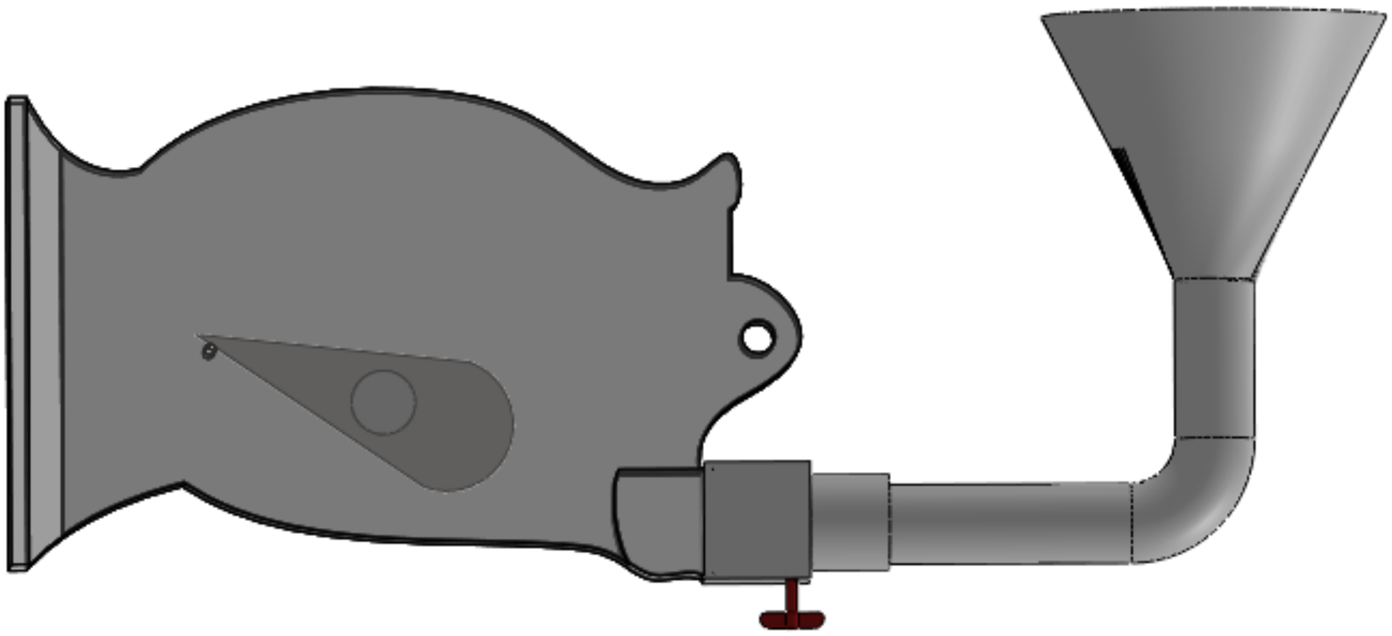
Prototype Designs: Hydrometers



Prototype Designs: Hydrometers (2)



Prototype Designs: Hydrometers (3)



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**

Data Analysis

- Effect of temperature on specific gravity
  - Tested with H_2O
  - Room: 1.003
  - Boiling: 1.001
  - Near freezing: <1.000
    - Source of error: physical properties of water

Discussion

- Timeline
- Conclusion
- Future Works
- Acknowledgements
- References

Timeline

Timeline (Tentative):

Task	September				October				November					December
	7	14	21	28	5	12	19	26	2	9	16	23	30	7
Project R&D														
Lit. Research	X	X	X	X										
Cost Estimation					X	X	X							
Manufacturing														
Prototyping														
Deliverables														
Progress Reports	X	X	X	X	X	X	X							
PDS		X	X	X	X	X	X							
Midsemester							X							
Final Poster														
Meeting														
Client		X		X										
Team	X	X	X	X	X	X	X							
Advisor	X	X	X	X	X	X	X							
Website														
Update	X	X	X	X	X	X	X							

Conclusion

- Monitor to prevent kidney stones
- Approachable design
- The hydrometer with adapter is preferred

Future Work

- Fabricating prototype
- Testing on prototypes
- Expected pitfalls
  - Gathering materials
  - Deciding on final prototype
  - Proper time management

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  - Dr. Ashton
  - The BME department

References

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