HYDROELECTRIC WAVE ENERGY SYSTEM

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ABSTRACT

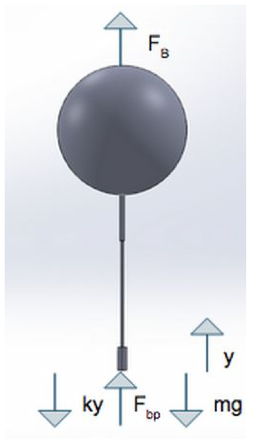
As the world turns towards renewable energies for future energy supplies, the question is which type of renewable energy will be the most dependable. This project is designed to harnesses the energy naturally present in ocean surface waves via a buoy and a spring loaded pump. Through non-dimensional analysis, a prototype spring loaded pump was developed and tested in a wave simulation tank. Experimental testing revealed that the spring loaded pump successfully elevated water at a rate of 0.09 gallons/min, proving the ability of the system to convert wave energy into stored potential energy. This stored potential energy would then theoretically be connected to a hydroelectric turbine in order to convert it into marketable electrical energy. The efficiency of the prototype pump was determined to be 14%, due to limitations in the manufacturing of the plunger within the pump. The full-scale system is designed so that an array of 20 buoy-pump systems will all pump water into a central, land based storage tank elevated to 75 feet above sea level. This storage tank will release the elevated water at 16.5 gal/s to a turbine with 90% efficiency, to produce 12.2 kilowatts during peak usage hours.

DESIGN GOALS

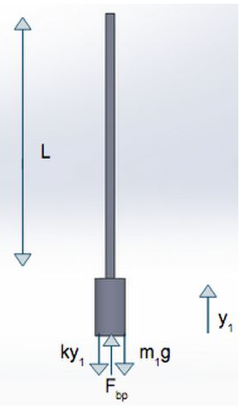
- Create a scaled model to prove concept of our design
- Develop wave simulation tank to accurately model ocean waves
- Transfer buoyancy force into mechanical force to pump water up 3 meters

DESIGN PROCESS

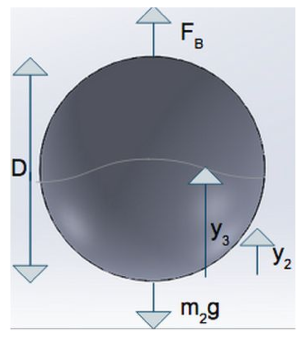
Free body diagrams for each component of the system were drawn to derive differential equations.



$$\frac{d^2y}{dt^2} = \frac{\varrho g[\frac{\pi}{3}(y_3-y_2)^2[1.5D-(y_3-y_2)]]}{m} - \frac{k}{m}y - \frac{A_cP}{m} - g$$

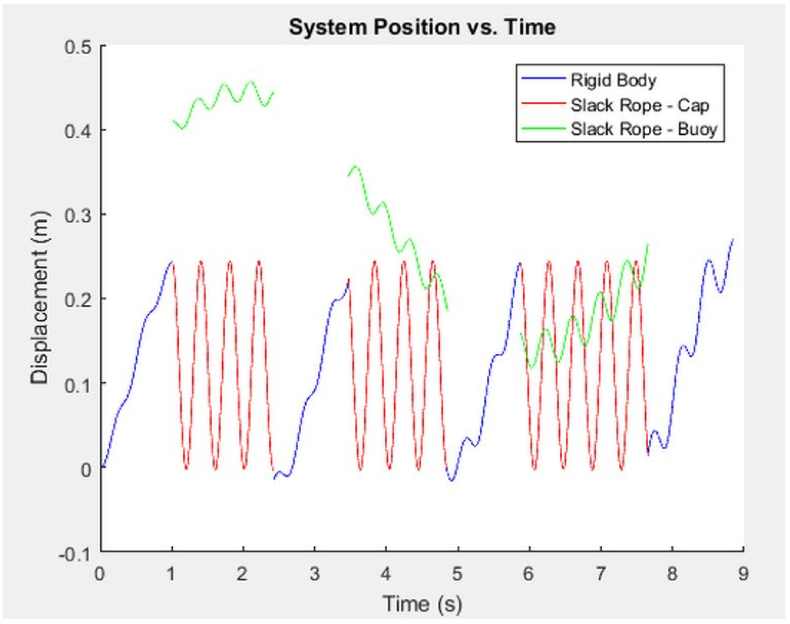


$$\frac{d^2y_1}{dt^2} = -\frac{k}{m_1}y_1 + \frac{A_cP}{m_1} - g$$

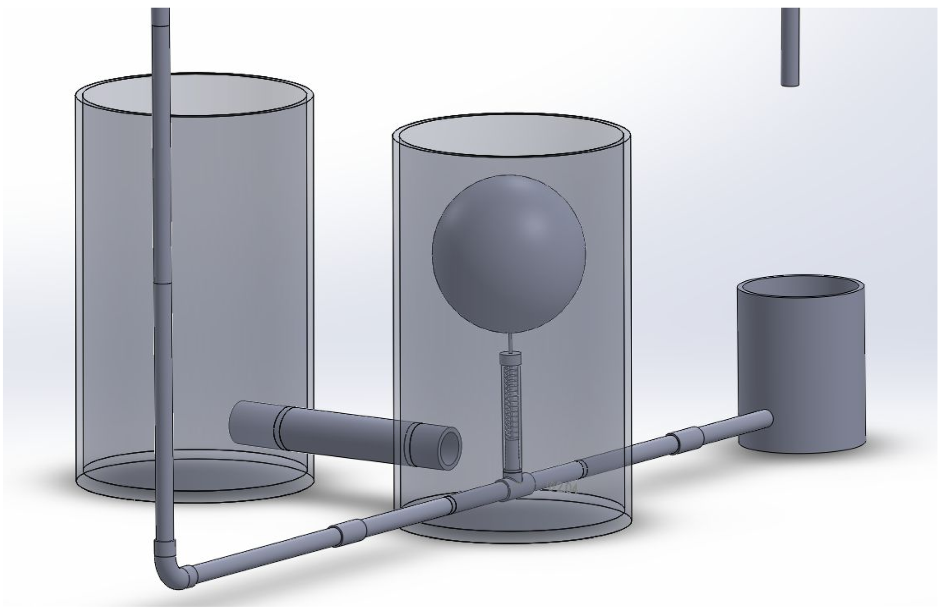


$$\frac{d^2y_2}{dt^2} = \frac{\varrho g[\frac{\pi}{3}(y_3-y_2)^2[1.5D-(y_3-y_2)]]}{m_2} - g$$

The equations were solved in MATLAB to predict the movement of the system.



The buoy and pump are enclosed within a 2 tank wave simulator. The water is pumped up to an elevated tank 3 meters high.



DIMENSIONAL ANALYSIS

The following dimensionless variables were derived from the three differential equations using the Buckingham π Theorem.

$$\frac{K}{a_1 h_1^2 \rho} \quad \frac{K}{a_1 h_2^2 \rho} \quad \frac{(m_1+m_2)}{\rho D^3}$$

$$\frac{A_c}{h_1^2} \quad \frac{m_1}{h_1^3 \rho} \quad \frac{A_c}{D^2}$$

Symbol	Variable
k	Spring constant
a_1	Peak spring displacement
h_1	Height of water level
h_2	Height of storage tank
ρ	Water density
A_c	Cross sectional area of piston
m_1	Mass of piston
m_2	Mass of buoy
D	Diameter of buoy

These equations were then implemented with a spring constant of 913 lb/in to scale up to a full size model.

FINAL DESIGN

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