

# Improving the Efficiency and Stability of a Spherical Robot in Water

## Introduction

- Professor Mitul Luhar is interested in studying turbulent fluid flows over complex surfaces.
- The Sphero SPRK+ is an amphibious robot with advantageous properties.
  - flexible mobility
  - Waterproof
- There are many real world applications such as under water surveillance and even deep ocean exploration.
- The goal was to create the most efficient and stable mobility in water for a Sphero SPRK+ robot through 3D printed belts to increase its speed and straight motion.



Sphero with a belt

## Experimental Setup

- We tested 3D printed belts with varying widths and thicknesses designed using Solidworks. The entire object was placed in a non flowing water channel driven from one end to the other.
- The velocity was calculated through two steps:
  - capture sphero motion with a video camera from a top to bottom view.
  - Calculate velocity through a MATLAB image analysis to find the pixel per frame and converting to meter per second.
  - Sphero motion was also tracked with a stopwatch and ruler, resulting in slightly greater variance and error than the image analysis results.

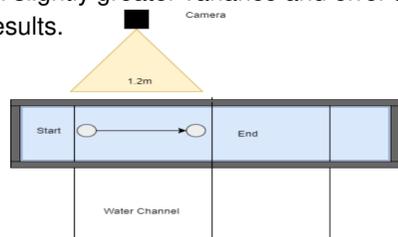


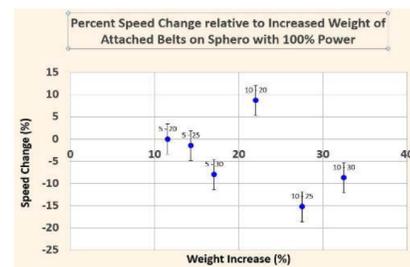
Diagram of Water Channel Setup.

We also captured sphero motion from a side view with the sphero approaching the camera. Based on the amplitude and frequency of sideways swaying motion, we determined its stability.

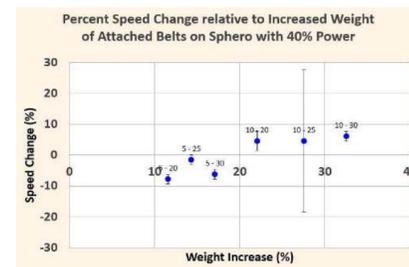
Six different belts were tested with thicknesses of 5mm or 10mm and widths of either 20, 25, or 30 mm. Three different power levels were tested for each of the six belts: 50, 100, and 255 (maximum power).

## Results and Analysis

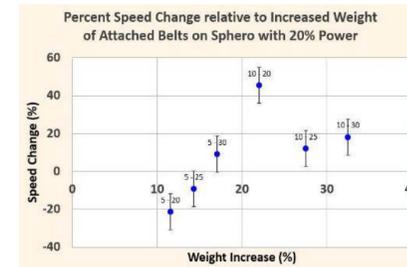
The sphero wearing a belt of 10 mm thickness and 20mm width resulted in the greatest increases in speed relative to a naked sphero. Spheros with 5mm thickness belts generally had the slowest speeds, with some resulting in speeds slower relative to a naked sphero.



Sphero with 10mm thickness and 20mm width has positive speed change



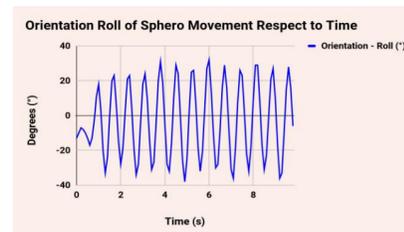
Sphero with 10mm thickness belts generally had most efficient speed increases.



Lowest power level had the greatest increase in speed for 10mm thickness and 20 mm width belt.

Non stable motion correlates to slower speeds as it would result in less efficient non linear motion that decreases kinetic energy. At the 50 power level, the 5 mm thicknesses belt had greatest instability and had slower speeds compared to the 10 mm thickness belts. Although belts with greater widths had greater stability and traction due to increased surface area, they were slower because the greater weight of the belt outweighed the benefits of increased stability, resulting in slower speeds for the 30mm width belts compared to 20 mm belts. In the end, the sphero wearing a belt of thickness 10 mm and width 20 mm had the greatest speeds at all power levels due to optimal stability, surface area, and weight.

Instability of sphero with a belt of 5 mm thickness and 10 mm width.



Very unstable as the sideways motion is consistently 70 degrees.

## How This Relates to Your STEM Coursework

Aerospace Engineering utilizes numerous concepts from high school physics courses. Laws of motion and derivative applications of velocity and acceleration were used frequently throughout the experiment. Concepts of drag forces and rotational motion supported my understanding of the results and how the sphero moves.

Conversion between different units was another skill utilized throughout the entirety of the program. Understanding dimensional analysis allowed for efficient data plotting and accurate results.

Much of the fluid dynamics I learned was new and had no mention in a standard high school classroom. Programming courses would also be a neat introduction to understanding the MATLAB applications used for experiments.

## Next Steps

- Test belts with the same widths and thicknesses but different weights.
- Test belts with the same weights but different widths and thicknesses.
- Test belts with different material.
- Use Particle Image Velocimetry to examine physical properties of each belt.
- Test fins that may further improve the efficiency of the sphero.

## Advice for Future SHINE Students

- Be proactive - You will be in a very independent environment. Make yourself busy, stay focused, and ask questions when you need help.
- Be open - You will be surrounded by talented and experienced individuals. Learn from them as much as you can.
- Be imaginative. Research stems from the creative questions people ask. If you're curious about a certain topic, suggest it to your mentor.
- Visit other labs. Everyone is doing something really interesting and different. You can expose yourself to more than just your specific engineering field.

## Acknowledgements

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