The Lift and Drag of Hemispheres Experiencing Flow

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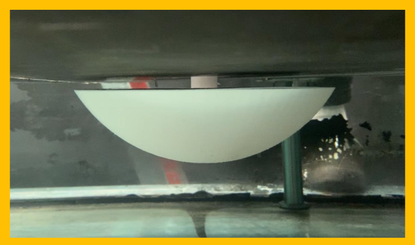
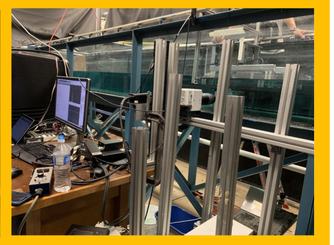
Introduction

In my lab, we are studying how we can control flow with different shapes and surfaces. This summer specifically, we studied the different forces that the flow generated around hemispheres of varying sizes.



3D print of a 1.73 hemisphere – PC Jackie Oldoerp



Our lab set up – PC Noah Shen

Objective

The objective of our lab is to find the optimal shape of an object in order to most efficiently attach to a surface when in flowing fluid. My mentor Mark Hermes tested with starfish shaped prints because of the downforce that they create.

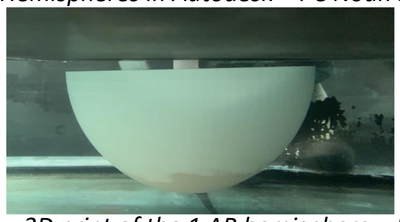
Acknowledgements

Thank you to Ph. D students Mark Hermes and Shilpa Vijay for guiding through the research and experiments, Professor Luhar for allowing me to work in his lab, Dr. Mills, Dr. Herrold and the other SHINE staff for running this program, and last but certainly not least, my parents for supporting me throughout this worthwhile experience.

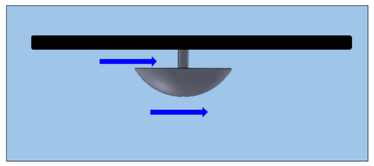
Methods and Results of Research

- First we used Autodesk to create hemispheres with different aspect ratios. Each one needed to have the same diameter but different heights.
- Next we attached each hemisphere to a plate with a sensor that we put in a water channel. We used a servo motor to control the hemispheres distance from the plate.
- We used MATLAB to create an offset, basically to "zero" the forces before we tested. Then we turned on the water channel and tested each hemisphere with a high and low speed and 5 and 30 mm from the plate. Then we used MATLAB to create graphs of the data

Hemispheres in Autodesk – PC Noah Shen



3D print of the 1 AR hemisphere – PC Jackie Oldoerp



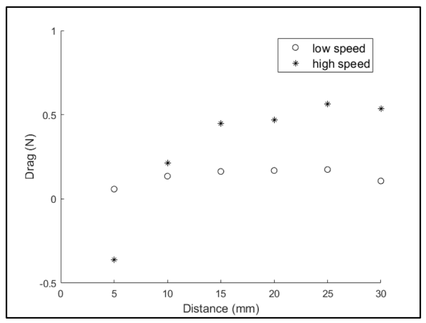


Figure 1: Graph of velocity vs drag at different distances for the 1.73 AR

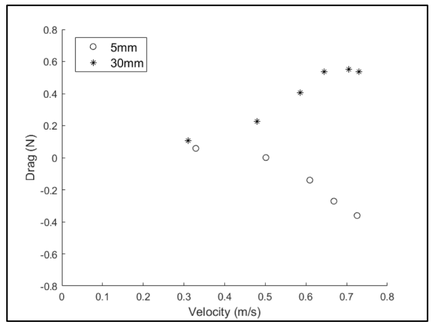


Figure 3: Graph of distance vs drag at different speeds for the 1.73 AR

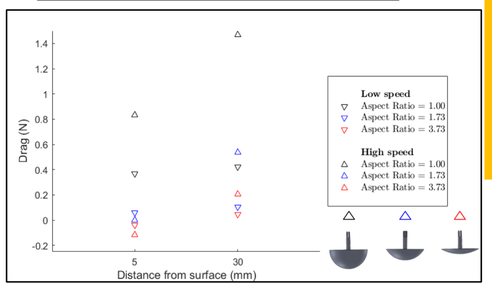


Figure 5: Graph of distance vs drag at different with each hemisphere

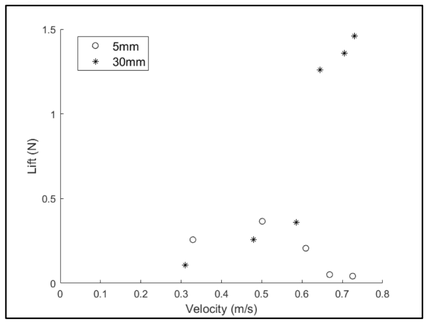


Figure 2: Graph of velocity vs lift at different distances for the 1.73 AR

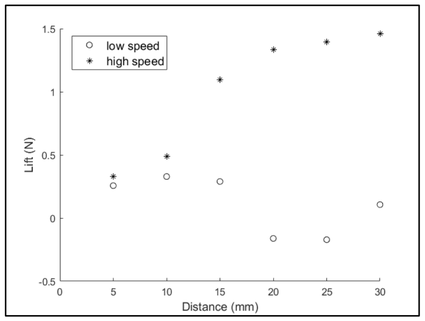


Figure 4: Graph of distance vs lift at different distances for the 1.73 AR

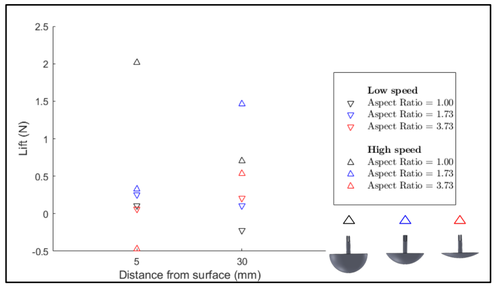


Figure 6: Graph of distance vs lift at different with each hemisphere

Skills Learned

AUTODESK® INVENTOR®

MATLAB

ARDUINO

3D print of the 3.73 AR hemisphere – PC Jackie Oldoerp

When at high speeds, the lift and drag increased with as the distance from the plate increased. However, sometimes at low speeds the lift and drag stayed the same or even decreased as the distance increased. We found intriguing results when the distance was at 5 mm. Often, the 1.73 and 3.71 aspect ratio hemispheres experienced negative drag, which means forward force against the flow of the water.