University of Wisconsin ZeroG Team

Ben Conrad

Sophomore, Engineering Mechanics-Astronautics

Eric Liegel

Junior, Engineering Mechanics-Astronautics

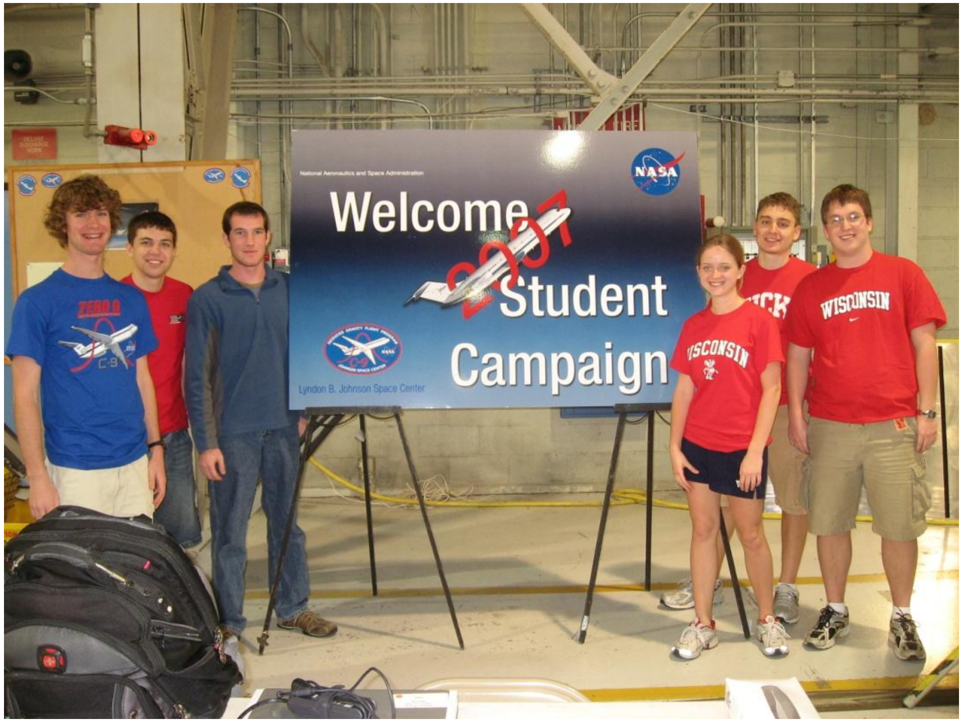
Professor Jake Blanchard

Department of Engineering Physics

University of Wisconsin-Madison

The team

- The ZeroG team is a student organization
- Members are typically engineers, though all are welcome
- Common interest in the Aerospace Industry
- Team members:
  - Mai Lee Chang
  - Lisa McGill
  - John Springmann
  - Ben Conrad
  - Eric Liegel
  - Curtis LaLuzerne
  - Stephen Bonney
  - Alyssa Skulborstad
  - Andrew Elizondo
  - Alex Robinson
  - Keith Rein
  - William Yang



Reduced Gravity Student Flight Opportunities Program

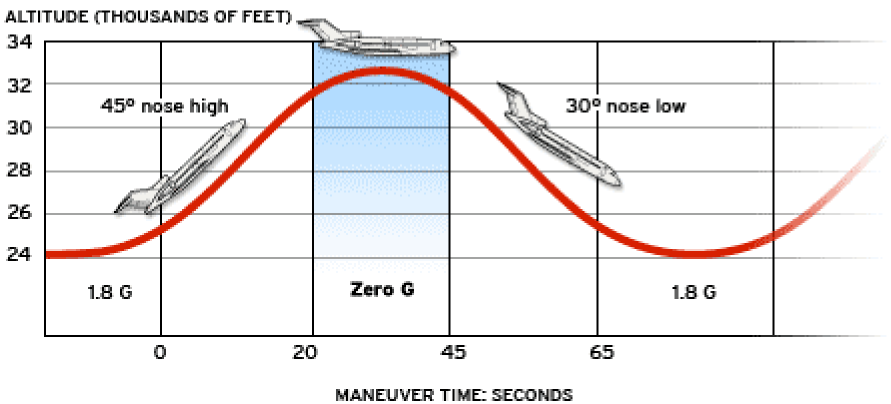
- A NASA Program that provides a unique academic experience for undergraduate students
- Student teams propose, design, fabricate, fly, and evaluate a microgravity experiment
- 60 proposals submitted last October
- 34 teams were chosen to fly

The Aircraft

- The DC-9B Weightless Wonder
  - Padded interior
  - Experiments secured to the floor
  - Flies 30 microgravity parabolas
  - 2 at Lunar gravity, 2 at Martian

Escaping Gravity

- Following a parabolic trajectory
- Microgravity lasts for ~20 seconds
- We are accelerating upward at $9.8 m/s^2$
- Gravity is pulling downward at $-9.8 m/s^2$
- Net effect is zero gravity

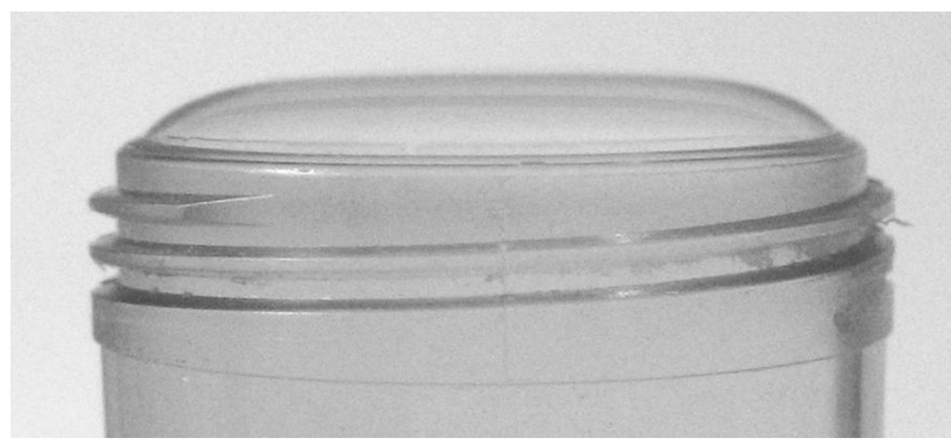


Microgravity allows us to…

…and investigate the effects of gravity on physical phenomena

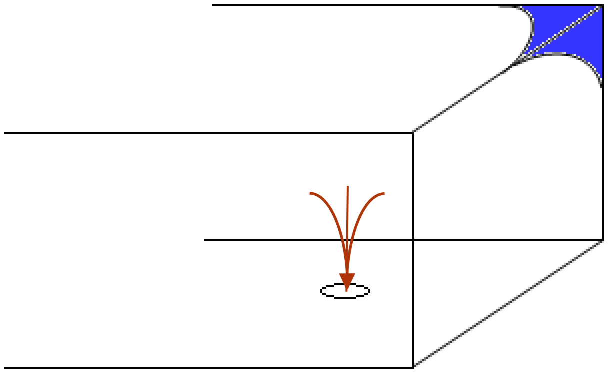
Dynamic Fluid Flow due to Capillary Forces

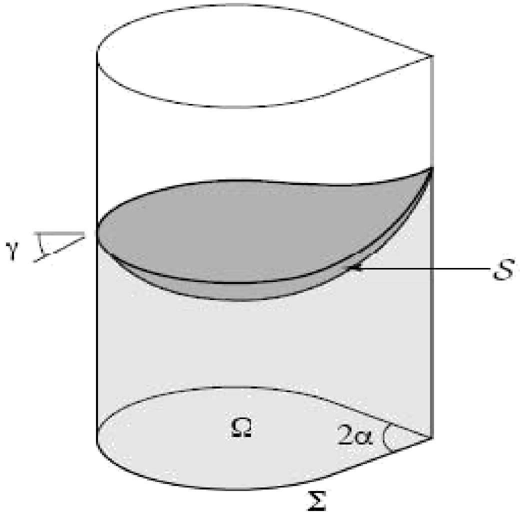
- All liquids ‘want’ to minimize their surface tension
- This causes them to creep up the sides of their containers, usually held back by gravity
- Known as Capillary Action
- Caused by surface tension - the intermolecular attraction between molecules in a liquid and molecules on the surface of a solid



Geometry on Capillary Forces

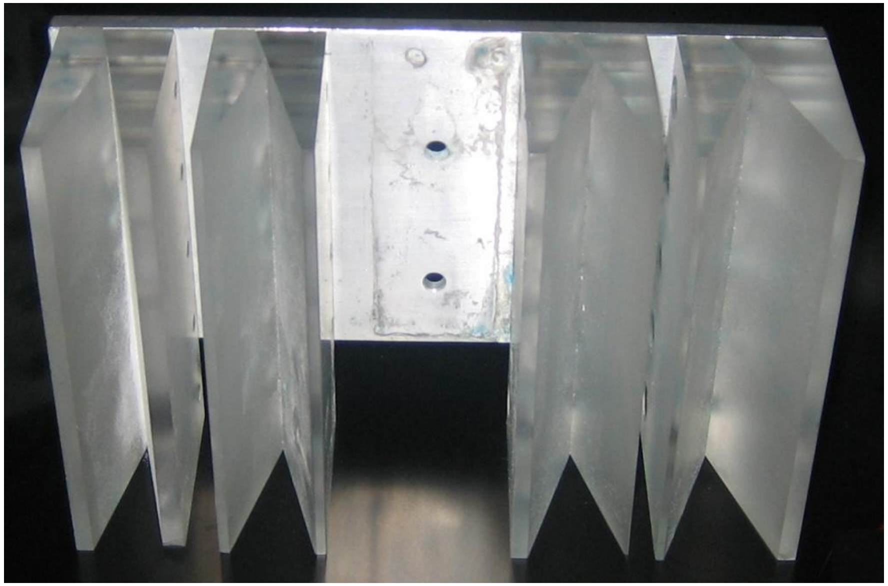
- Surface tension is enhanced by inside corners due to the higher ratio of solid surface area to liquid volume
- Liquids rise higher near a surface and even higher in a corner (where there are multiple surfaces.
- Understanding capillary forces allows for more accurate predictions of a fluid's location when in zero gravity
- If a tank is incorrectly designed, some liquid will be inaccessible; researching capillary action helps to prevent this waste





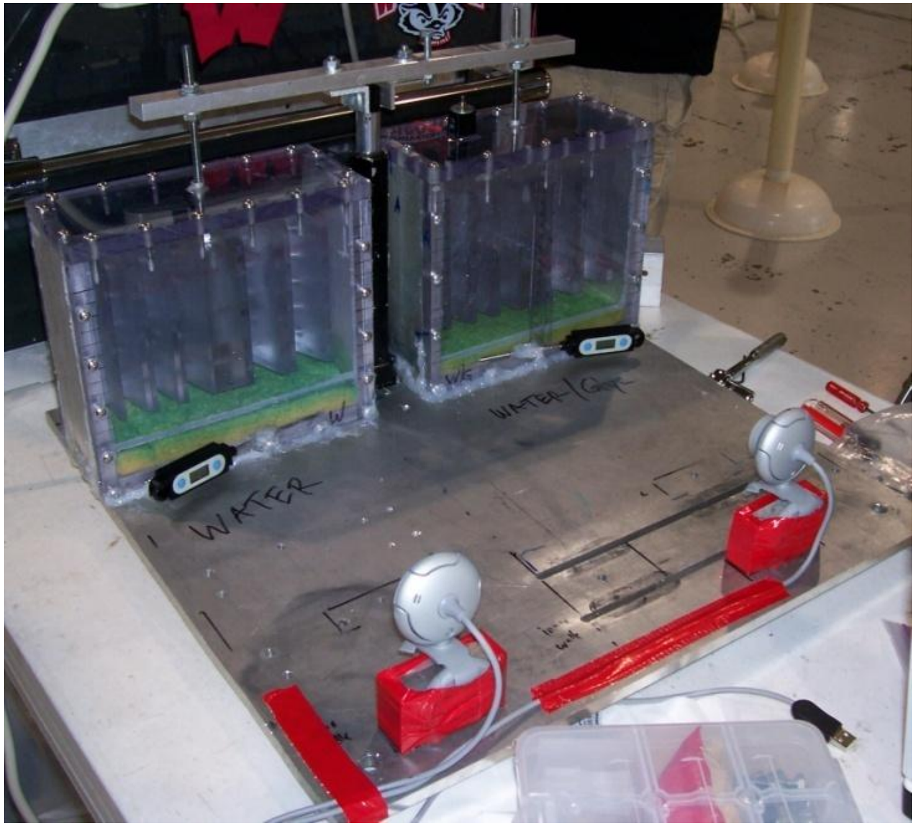
To better understand Capillary Action,

- We investigated the effect of contact angle, surface quality, and viscosity on flow velocity
- Two sealed boxes containing water and a water/glycerin mix
- 5 wedges consisting of 25, 30, 35, and 40 degree angles
- One 25° wedge is finished with 1000 grit sandpaper
- All others are finished with 2000 grit

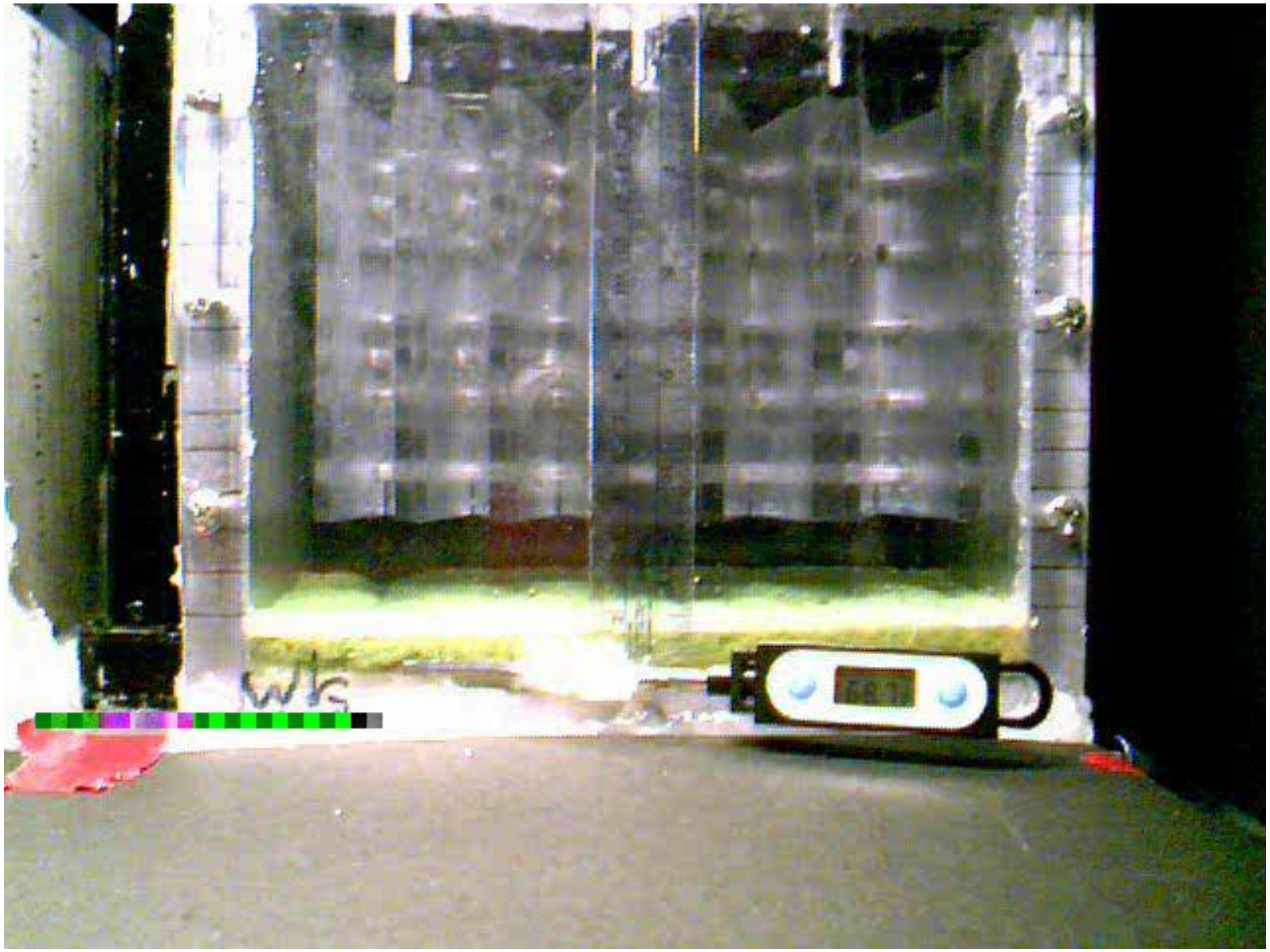


Experiment Design

- Electric actuator to raise and lower the wedges, controlled by a toggle switch
- 2 webcams and 2 laptops to record the fluid flow



Flight Video



Look for movement in the reflections as the liquid climbs the wedges.

Data Analysis

- Analysis proved difficult
- Poor video quality and liquid/wedge contrast (as was just seen)
- Velocities calculated as the time difference between the first contact of the wedge with the liquid and the first occurrence of the reflection at the top of the wedge

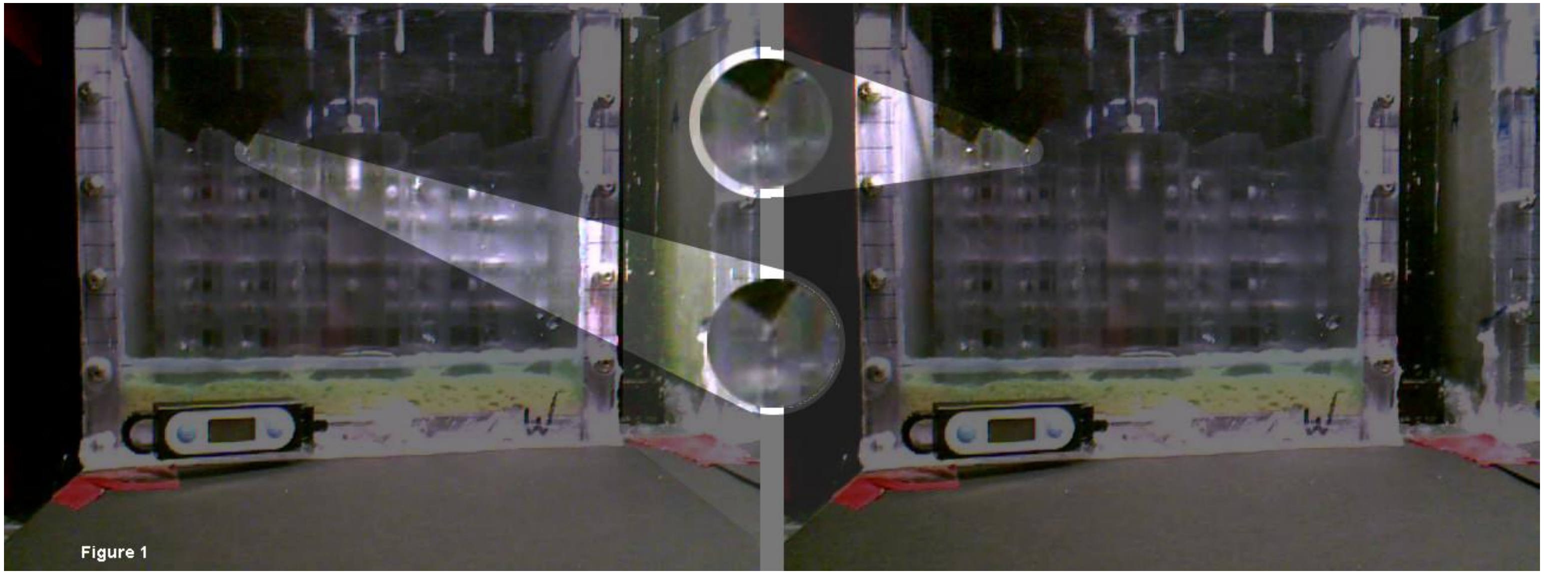
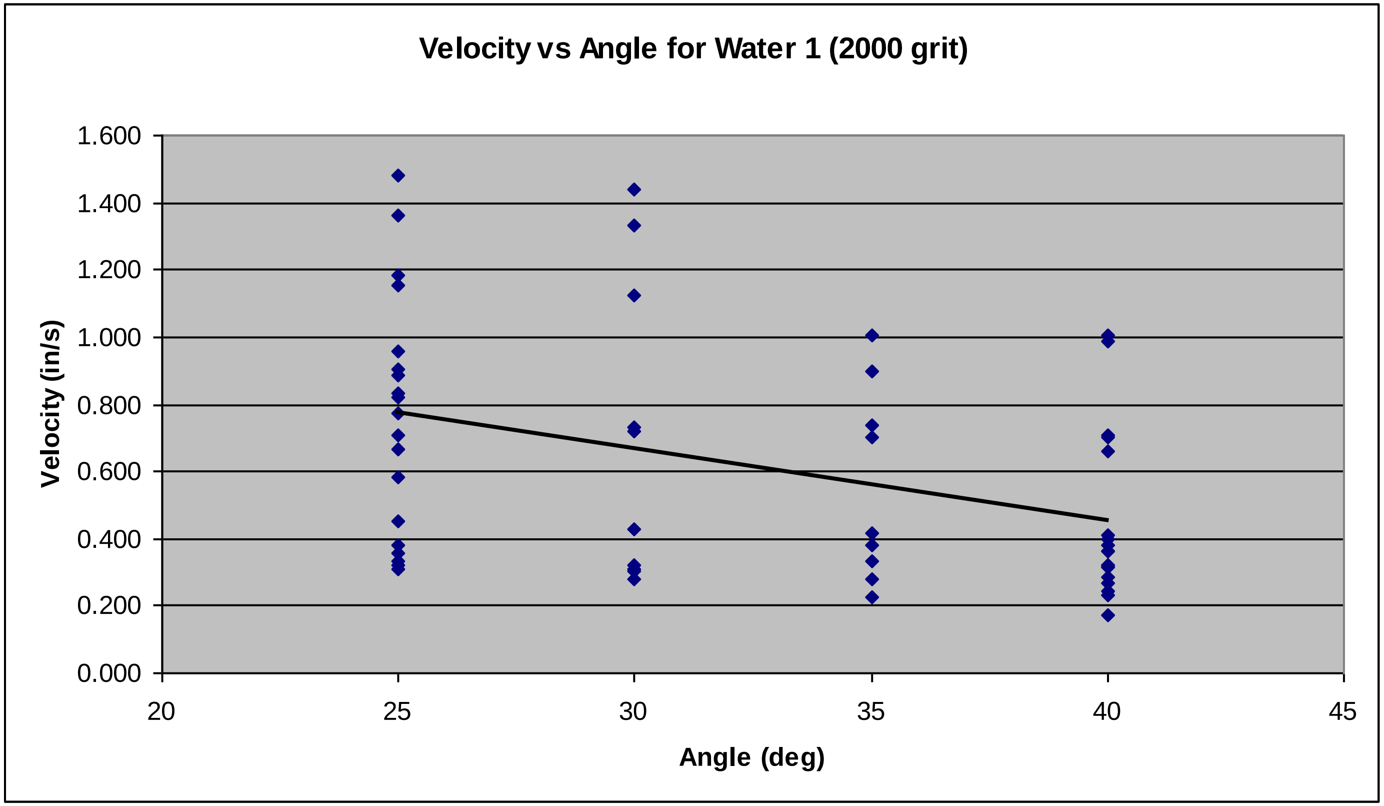


Figure 1

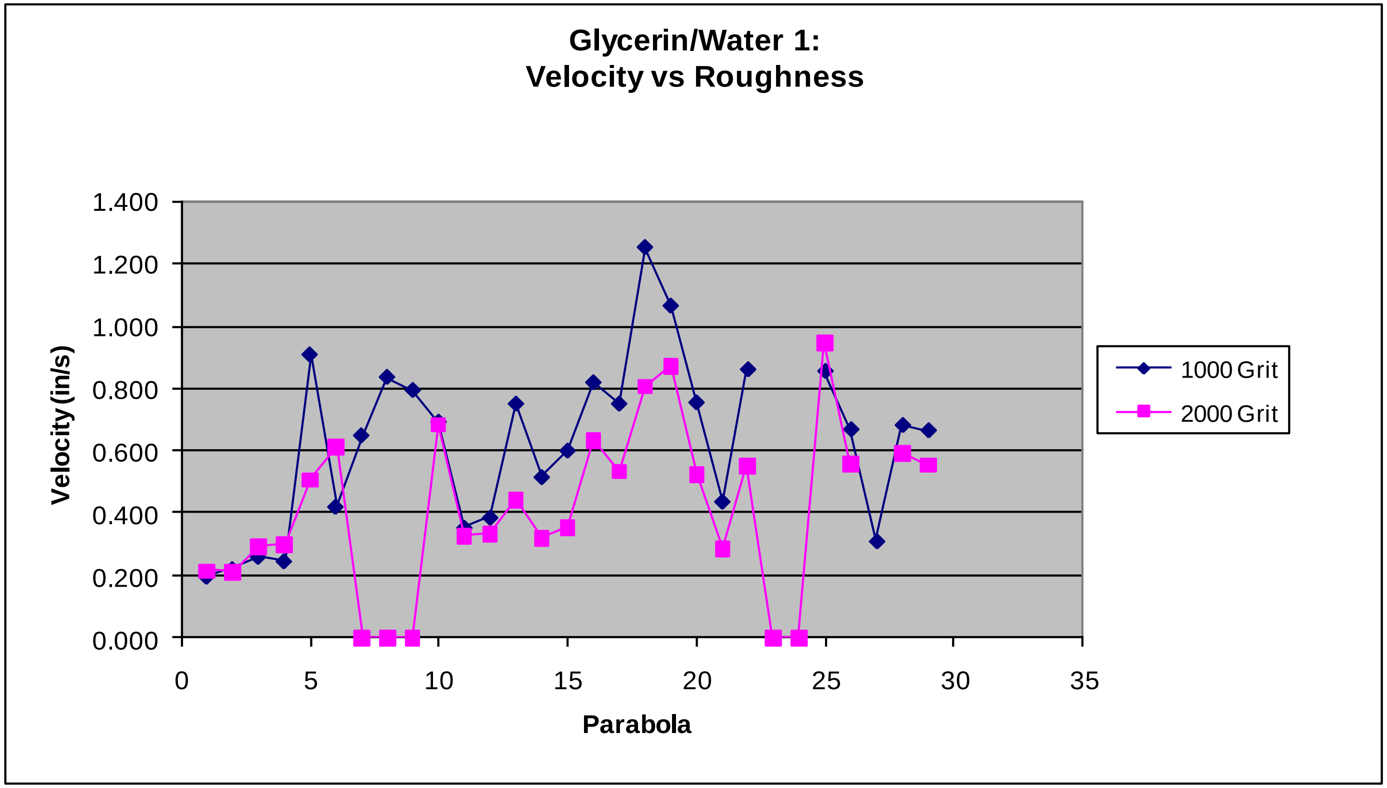
Results:
Velocity versus Angle

- Smaller angles had higher velocities than the large angles



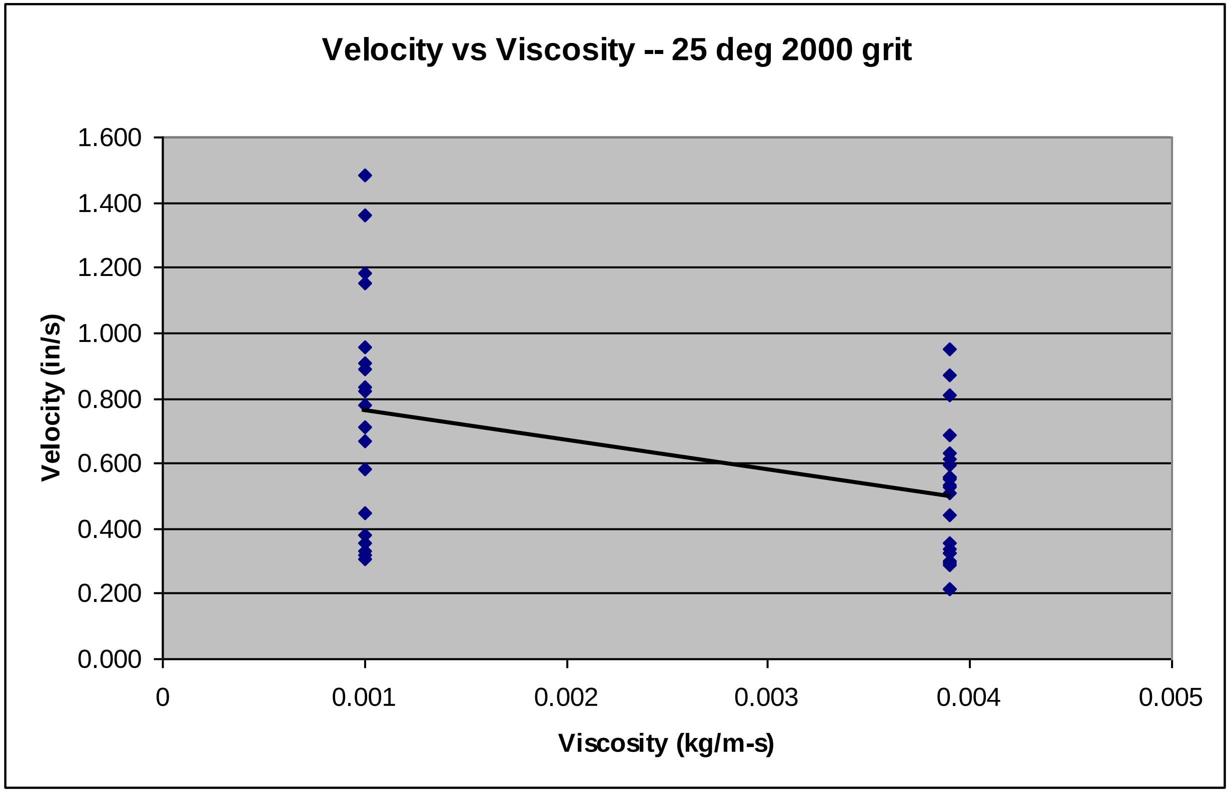
Results:
Velocity versus Roughness

- The 2000 grit surface was slower than the 1000 grit



Velocity versus Viscosity

- Higher viscosity led to lower velocities



Conclusions

- Our initial hypotheses are supported by our data
- Wedge angle, surface quality, and liquid viscosity all have an effect on fluid velocity
- Poor video quality, lack of contrast between the liquid and wedge, inconsistent gravity, and splashing contributed to error in our data
- We would have liked to derive an equation that predicts the flow rate but that was beyond the capabilities of our data
- We will develop a new experiment for next year, possibly relating to capillary action as a further application of what we learned this year

Thanks to:

The Wisconsin Space Grant Consortium
UW-Madison Department of Engineering Physics
UW-Madison Space Science and Engineering Center

Questions?