Lab 6, Drag in high and low Re flow.

Today you will investigate the drag experienced by bodies in different flows.

**Station 1.** Choose 6 clay models 2 spheres and four phytoplankton analogues as two pairs of similar phytoplankton; select the clay balls such that they weigh the same or slightly less than the phytoplankton analogues.

In two graduated cylinders, one with Glycerin and the other with water, measure the settling velocity of your models (one sphere and two phytoplankton similar analogues in two different orientations) using a stop watch and a ruler. Can you get the non-spherical objects to settle slower than the spheres (even though they may be larger)? In what orientation are they slowest?

Compute the Reynolds number of the models in water and in Glycerin using:
\[ \mu_{\text{glycerin}} = 0.0155 \text{ Pa s}, \ \rho_{\text{glycerin}} = 1.173 \text{ g/ml}, \ \mu_{\text{water}} = 0.001, \ \rho_{\text{water}} = 0.998 \text{ g/ml}. \]
How do they compare to phytoplankton in the ocean (assume a phytoplankton of about 10μm settling at about 50m/day):

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<th>Model 1</th>
<th>Model 2</th>
<th>Phytoplankton</th>
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<td>Velocity</td>
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<td>Size</td>
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<td>Reynolds number in water</td>
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<td>Reynolds number in Glycerin</td>
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*Figure 1. Hope and Elizabeth (left panel) and Sonja and Ruth (right panel) observe how shape and orientation affects sinking speed of phytoplankton like models in glycerin. The larger the surface area perpendicular to the vertical the slower the sinking speeds.*
Station 2. Sinking in stratified fluid. You have a cylinder stratified with normal Karo on the bottom and Karo-light at the top. Observe the settling of several spheres released within a small time interval in the fluid. Is the settling (and spacing between balls) affected by the change of density and viscosity of the fluid? Can you think of oceanic/limnological (lake) conditions for which this demonstration may be relevant?

![Figure 2. Jen, Dominique and Chris (left panel) and Sonja (right panel) observe how beads sinking through a stratified fluid slow down after crossing the interface and get closer together, much like cars on an interstate ramp.](image)

Station 3. Sedimentation tube: simulate a nephloid (bottom) storm by reversing the tube and letting the particles settle. Watch the settling as function of time as well as the water turbidity. Describe to your team member what is going on.

![Figure 3. Matt observe how particle stratify by size as they fall down. Since settling speed at high Re # increase as diameter square large particles sink much faster than small one resulting in a stratified sediment.](image)
Station 4. Swimming at low and high Re:
You have two bath toys. Take one and have it swim in water. Measure its velocity. Now put it in Glycerin. How fast does it swim? Why are the differences?

Figure 4. Jeremy and Matt, Alyssa, Chris and Jen, observe how different swimming strategies work in different fluids. In a very viscous fluid the flagellated robot works well while the dolphin does not. Both work in water.

Station 5. Feeding at low Re:
Try to catch balls in glycerin using a spoon a fork and knife. Which utensil can get closest to the particle? What does it teach us about filter feeding on particle at low Re?

Figure 5. Carlie and Ryan (left panel), Dominique and Alyssa (right panel) attempt to filter glass particles in glycerin. At low Reynolds number particles tend to fall around the spoon rather than land on it.

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