Worksheet: 3D Printed Quarter: Face-Down vs. Edge-On Rising

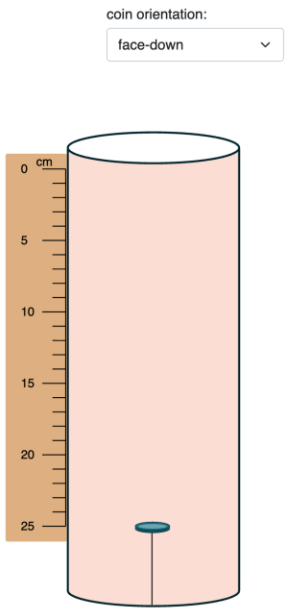
Name(s):_____

Fill in all sections – These are today's notes

Student learning objectives

1. What is terminal velocity? How to measure terminal velocity experimentally?
2. What is the terminal velocity of a disk face-down vs edge-on?
3. What useful information can one extract from terminal velocity?

Dimensions and details of the experiment



The experiment consists of a 3D printed polystyrene quarter being released either face-down or edge-on in a viscous liquid. Select a coin orientation and then use the release button and start a stopwatch. Measure the distance from the release height versus time and estimate the terminal velocity for the two orientations. Based on the measurements, estimate the viscosity of the liquid.

Before starting the experiment.

1. Which direction do you think will rise faster: face-down or edge-on? Why?

2. The current experiment is being done in a liquid with a density greater than that of polystyrene. If the same experiment were done in water, do you think the terminal velocity and direction would be the same? Why/why not?

3. How will you infer if the drag is dominated by viscous or inertial forces?

During the experiment.

1. Set the orientation to "face-down" and measure the distance from release versus time. Report the values.

2. Repeat 1 for "edge-on" orientation. Report the values.

After the experiment.

1. Calculate the velocity from the data obtained for the face-down or edge-on orientations.

2. Do a force balance on the object, assuming viscous drag force $F_{face-down} = 16\,\mu a U$ and $F_{edge-on} = \frac{32}{3}\mu a U$, where μ is the viscosity of the fluid, a is the radius of the coin, and U is the velocity of the disk. Find the two terminal velocities. Express the answer in terms of the density of the coin ρ_c, density of the liquid ρ, the radius of the coin a, the thickness of the coin t, viscosity of the liquid μ, and gravitational constant g.

3. Find the density of polystyrene, and search for the thickness and radius of a quarter coin.

4. Calculate the values of ρ_c and μ.

5. Based on the calculations, show that the flow is viscous such that $Re \ll 1$.