Rising 3D-printed quarter

Name(s):____

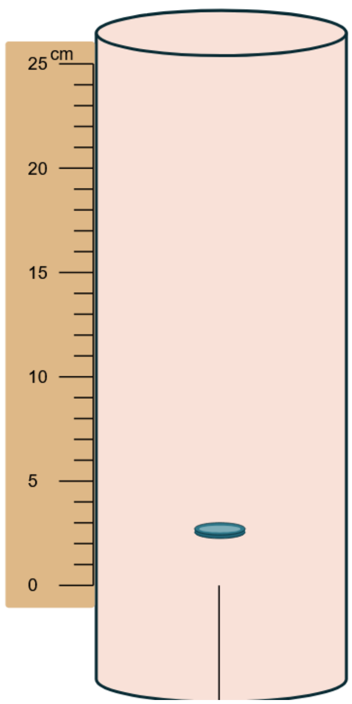
The experiment consists of releasing a 3D-printed solid polystyrene quarter either face-down or edge-on in a viscous liquid. The viscosity and the density of the fluid are calculated

from the rate of rise of the coin.

Student learning objectives

1. Explain terminal velocity.
2. Be able to measure terminal velocity experimentally.
3. Compare terminal velocity of a disk face-down versus edge-on.
4. Extract useful information from terminal velocity.

Equipment



Before starting the experiment.

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

2. The liquid density is greater than the solid polystyrene density. Would you release the coin from the top of the tank or the bottom of the tank to measure the terminal velocity if you did the experiment in water? Why?

3. How will you infer if viscous or inertial forces dominate the drag?

Running the experiment

1. Set the coin orientation to face-down and measure the elapsed time and distance for 6 or 7 distances. Record the values in Table 1.

Table 1 Face down

Elapsed time (s)	Distance (cm)

2. Repeat these measurements for edge-on orientation and record the values in Table 2.

Table 2 Edge on

Elapsed time (s)	Distance (cm)

After the experiment

1. Fit the distance versus time data to straight lines to determine terminal velocities:

   U_f (face-down velocity) ___________

   U_e (edge-on velocity) ___________

2. Do force balances on the coin, assuming viscous drag forces:

   $$F_{face-down} = 16\,\mu a U_f$$

   $$F_{edge-on} = \frac{32}{3}\mu a U_e$$

   where μ is the fluid viscosity and a is the coin radius.

   Express the answer in terms of the coin density ρ_c, the liquid density ρ, the coin radius a, the coin thickness t, the fluid viscosity μ, and the gravitational constant g.

3. Look up the density of polystyrene and search for the thickness and radius of a quarter coin. Calculate the density of the coin ρ_c.

4. From the two force balances, calculate the viscosity and the density of the liquid.

5. Show that the flow is viscous because $Re \ll 1$.