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Capillary Attraction of Floating Particles
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Particles floating on the interface of two fluids, typically water and air, deform the interface. In a static situation, the interface deforms in order to meet the particle at a contact angle, which depends on the three materials involved. The line of contact will also balance the gravitational, buoyant and surface tension forces. Away from the particles, the interface obeys the Young-Laplace equation,

$$\Delta p = -\sigma \nabla \cdot \hat{n}$$

where Δp is the pressure difference, σ is the surface tension and \hat{n} is the unit normal vector. When multiple particles are present, the horizontal components of the surface tension forces will not balance and there will be a net force on the particles. This force typically decays exponentially as the distance between the particles increases, with the characteristic length being the capillary length of the interface, which is 2.7mm for water and air. For identical particles, or particles with similar wetting properties, the force will be attractive. This is sometimes called the cheerios effect, as it causes cheerios floating in milk to attract to each other, forming clumps.

One goal was to experimentally verify the theoretical attractive force between two parallel floating cylinders. Contact angles for rods of various materials were measured, using both water-air and glycerol-air interfaces. These rods were then placed on the interface in a parallel configuration, and allowed to attract. Since the capillary force is stronger at short distances, the parallel configuration is unstable. While we hoped that approximately parallel attraction could be achieved for a long enough time to test the model, analysis later showed this was not the case, as the drag coefficients were not known and the accelerations were.

Experiments with spheres were also performed, which are much easier to work with due to their rotational symmetry. By using the theoretical capillary force between floating spheres, which has already been verified, we determined the drag coefficient for various glycerol-water mix ratios. As glycerol has a viscosity roughly three orders of magnitude larger than water, the drag coefficient was measured over a large range of viscosities. For Stokes' drag, which occurs for fully submerged particles when the inertial forces are negligible compared to the viscous forces, the drag coefficient is linear with viscosity. We measured the drag coefficient to be larger than Stokes' drag for low viscosities, and smaller for higher viscosities. The drag coefficient was approximately linear in viscosity for higher viscosities.