1. SELF-PROPELLING DROP

An asymmetric capillary device may prompt spontaneous drop propulsion. An example of such motion is illustrated below. A drop of silicone oil is deposited on a conical copper wire (mean radius of 250 µm), whose radius increases from the right to the left with a gradient dr/dz of the order of 1 %. Note that silicone oil totally wets copper. Four successive photographs are taken. The interval between two snapshots is about 1 second.

a) In which direction does the drop move? Why?

b) Why is the interval between two drops not constant?

2. LIQUID SLUG

A fluid drop is placed in a tube and forced along the tube by air. The liquid totally wets the tube, so that a film (of thickness \( h \)) is deposited on the wall in the wake of the drop. When the forcing is stopped, the pressure is atmospheric on both sides of the drop.

Does the drop then move? Calculate the force acting on it.
3. TEARS OF WINE

We discussed in class the tears of wine, for which we’ll now develop a mathematical model. Consider a film of thickness $d$ along a sloping plane tilted at an angle $\beta$ with respect to the vertical. The film is driven upwards by a surface stress $\tau$, and downwards by gravity.

a) Deduce an exact solution for the parallel flow in the film.

b) Describe and sketch the dependence of the form of the flow on the dimensionless parameter.

c) Calculate the volume flux up the plane, the rate of work done by the surface stress, the rate of work done against gravity, and the total dissipation per unit area in the system.

d) By estimating relevant parameters in a wine glass, estimate the number of tears that you expect to fall per minute in your average wine glass.

NIBBLING WINE TEARS. Consider now the dynamics of the tears, which consist of drops (depleted in alcohol) descending through a film of wine.

d) Rationalize the integrity of the tears. What determines their size? Describe the flow within the tears.

e) Rationalize the recoil observed as the tears impinge on the wine reservoir.
4. RETRACTION OF A FLUID THREAD

Consider a fluid thread of viscosity \( \nu \) and density \( \rho \) with an interfacial tension \( \gamma \). Initially, it assumes the form of a cylinder of radius \( a \) with hemispherical caps. Neglect the influence of gravity.

a) In the limit where viscosity is negligible, how do you expect its shape to evolve? Why?

b) In this same limit, deduce the rate of retraction of the thread.

c) By comparing the retraction rate with the growth rate of the Rayleigh-Plateau instability, estimate under what circumstances the thread will retract into a single droplet.

d) How will this physical picture change when the retraction and pinch-off are dominated by the influence of viscosity.