ME-446 Liquid-Gas Interfacial Heat and Mass Transfer

Homework 1

Presentation by Group 1 on Thursday 18th September 2025

Problem 1: Sessile Droplet

A sessile droplet refers to a droplet that rests on a surface without spreading out completely. Consider such a droplet of water on a substrate, taking the shape of a spherical cap.

Given:

- the ambient air pressure P_{atm}
- the liquid-air surface tension γ
- the radius of the footprint of the droplet r
- the angle between the spherical cap and substrate θ

Determine the liquid pressure in the droplet.

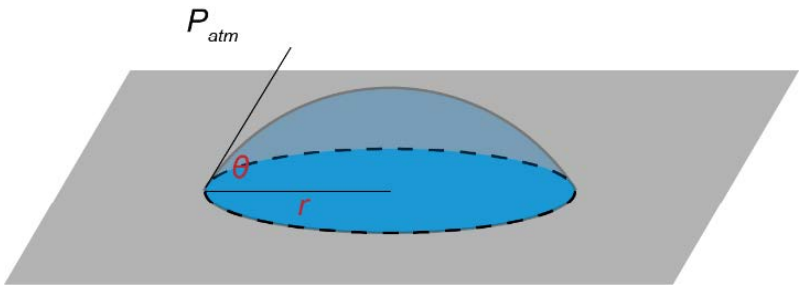

Figure 1: Schematic of a sessile droplet.

Problem 2: Water Jet

Now, consider the case of a cylindrical water jet.

Given:

- the ambient air pressure P_{atm}
- the liquid-air surface tension γ
- the radius of the jet r

Determine the liquid pressure inside the cylindrical water jet.

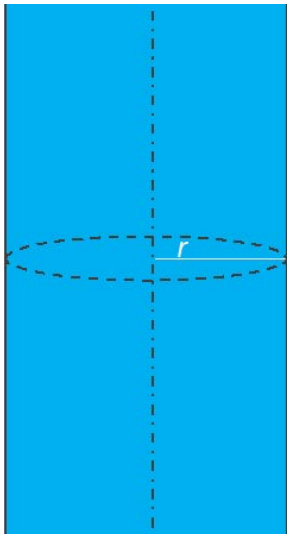

Figure 2: Schematic representation of a vertical water jet of radius r.

Problem 3: Capillary Adhesion

Two wetted surfaces can stick together with great strength if the liquid wets them with an angle $\theta < 90°$. Imagine that we mash a large drop between two plates separated by a distance H. The drop forms what is called a capillary bridge characterized by a radius R and a surface area $A = \pi R^2$.

Assuming $H \ll R$, and that we know the liquid surface tension γ, determine the force F we need to separate the two plates.

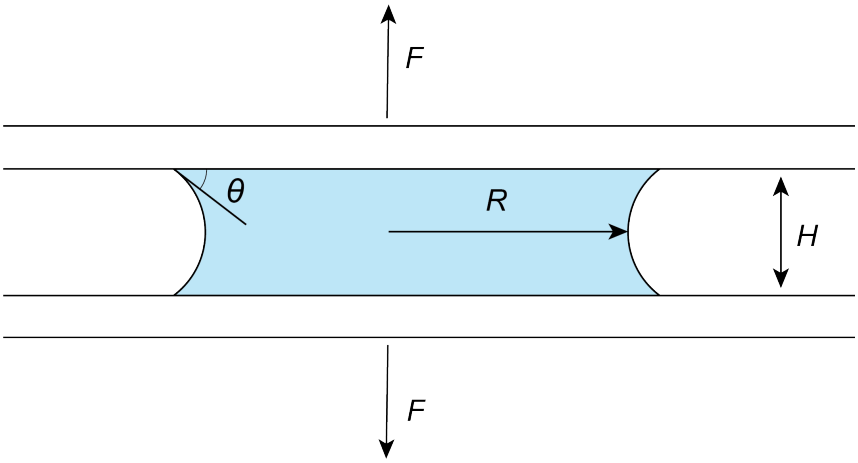

Figure 3: Capillary adhesion

Problem 4: Pendant Drop Method

The pendant drop method measures liquid surface tension. In the figure below, we are looking at a liquid drop suspended from a needle in air. The shape of the drop results from the relationship between the liquid-air surface tension and gravity.

Given (cf. figure below):

- the liquid density ρ
- the surface mean curvature at point 1, κ_1
- the surface mean curvature at point 2, κ_2
- and the height difference between point 1 and point 2, H

Determine the surface tension of the liquid.

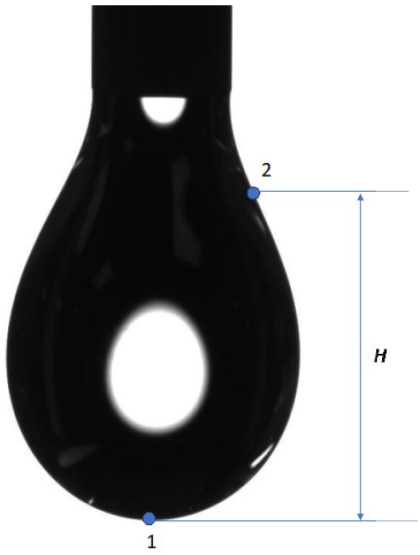

Figure 4: Pendant Drop Method