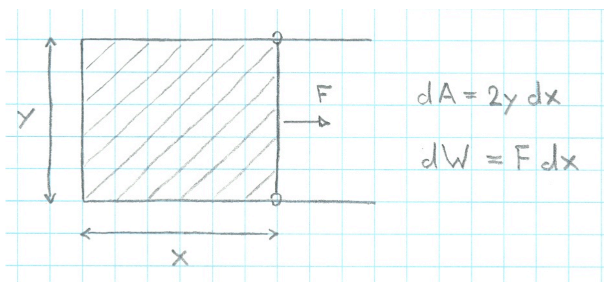
Surface Tension and Interfacial Tension [pln60]

The key attribute that makes surfactants effective detergents (see [psl13]) is that they reduce surface tension and interfacial tensions.

Surface tension:

Cohesive forces between molecules become anisotropic at liquid-gas interface (liquid surface) due to sharp rise in intermolecular distance. Surface tension is defined as the surface free energy per unit surface area.

Application: stretching a soap film (with two sides) on a rectangular frame.



$$\begin{aligned}\text{surface tension} &= \text{excess energy per unit area } [\mathrm{J/m^2}] \\ &= \text{force per unit length } [\mathrm{N/m}]\end{aligned}$$

$$\gamma = \frac{dW}{dA} = \frac{F}{2y}$$

Interfacial tension:

Consider two immiscible liquids a and b with surface tensions γ_a and γ_b, respectively, and interfacial tension γ_{ab}.

Removing a contact of area A between liquids a and b eliminates an interface and creates two surfaces. It costs work of *adhesion* $W_{ab} = Aw_{ab}$.

Separating two parts of liquid a creates two surfaces of area A. It costs work of *cohesion* $W_{aa} = Aw_{aa}$.

$$w_{ab} = \gamma_a + \gamma_b - \gamma_{ab}, \quad w_{aa} = 2\gamma_a.$$

Consider a drop of minority liquid a hitting the flat surface of a majority liquid b. The *spreading coefficient* S determines whether the interface tends to maximize ($S > 0$) and form a thin film of a or tends to minimize ($S < 0$) and form a compact lense of a.

$$S = w_{ab} - w_{aa} = \gamma_b - \gamma_a - \gamma_{ab}.$$

[gleaned from Hamley 2008]