PROPERTIES OF FLUIDS

1. Density : Symbol ρ (Greek rho)

Dimensions $\frac{M}{L^3}$

SI Units. kg/m^3

Definition : mass per unit volume

Application : Given a (possibly non-uniform) density field $\rho(\underline{x},t)$ the mass (M) of fluid inside a given volume Ω is

$$\boxed{M = \int_\Omega \rho(\underline{x},t)\, dV}$$

Incompressible if $\rho(\underline{x},t) = \text{const.}$

Sample values : $\rho_{air} \approx 1.2\ kg/m^3$, $\rho_{water} = 10^3\ kg/m^3$.

2. Pressure : Symbol p

Dimensions $\frac{M}{LT^2} = \frac{F}{L^2}$

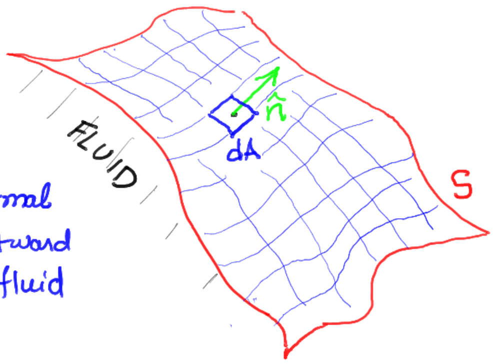
SI Units : $Pa = N/m^2 = kg/ms^2$

Definition: force per unit area normal to a surface

Application : Given a surface S, the force ($\underline{F}$) exerted by the fluid pressure on S is

$$\boxed{\underline{F} = \int_S p\,\hat{n}\, dA}$$

$\hat{n}$ = unit normal pointing outward from the fluid



3. Dynamic viscosity : Symbol μ (mu)

Dimensions : $\frac{M}{LT} = \frac{FT}{L^2}$

SI Units : $\frac{kg}{ms} = Pa{\cdot}s$

Definition : the proportionality constant between shear stress (σ) and shear rate ($\dot{\gamma}$).

$$\sigma = \mu\dot{\gamma}$$

Application : later in this chapter.

Sample values :

$\mu_{air} = 10^{-5}\ Pa{\cdot}s$, $\mu_{water} = 10^{-3}\ Pa{\cdot}s$

4. Kinematic viscosity : Symbol ν (nu) Definition : $\nu = \mu/\rho$.

Dimensions : $\frac{L^2}{T}$

SI units : m^2/s.

Application : to be explained in Chapters 3 and 7.

5. Surface tension : Symbol σ (sigma) Definition : tension in the liquid interface expressed as force per unit length.

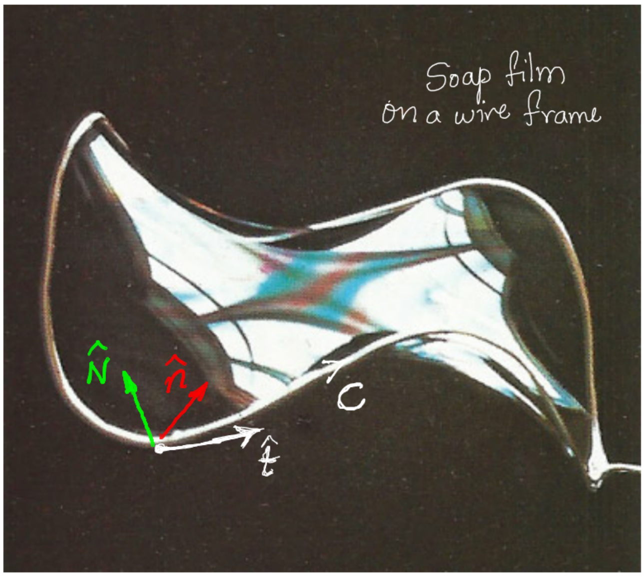
Dimensions : $\frac{M}{T^2} = \frac{F}{L}$

SI units : $\frac{N}{m} = \frac{kg}{s^2} = \frac{J}{m^2}$

Application : force ($\underline{F}$) exerted by the interface on its boundary is given by

$$\boxed{\underline{F} = \int_C \sigma \, \hat{n} \, dl}$$

$$\hat{n} = \hat{N} \times \hat{t}$$



$\hat{n}$ = normal to boundary & tangent to soap film

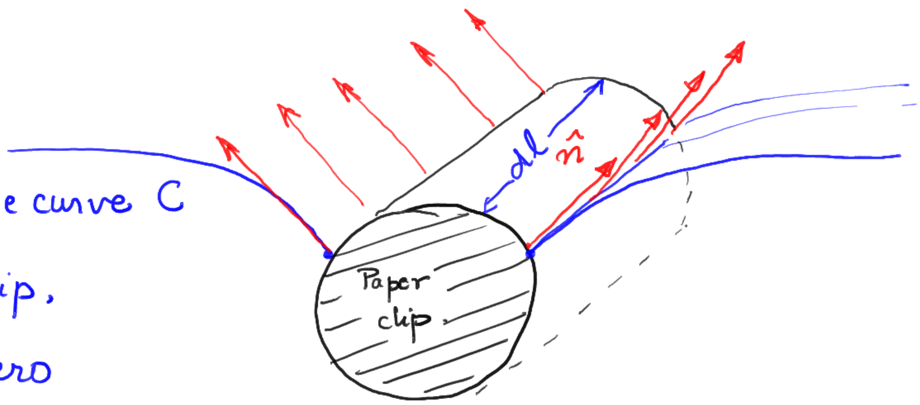
$\hat{t}$ = tangent to boundary

$\hat{N}$ = normal to soap film.

$$\sigma_{water} = 72 \times 10^{-3} \ N/m$$

The floating paper clip :

The interface exerts a force $\underline{F} = \int_C \sigma \hat{n} \, dl$ on the curve C where it meets the paper clip. This force $\underline{F}$ has a non-zero vertical component that balances part of the weight.



Force of surface tension on the floating paper clip.