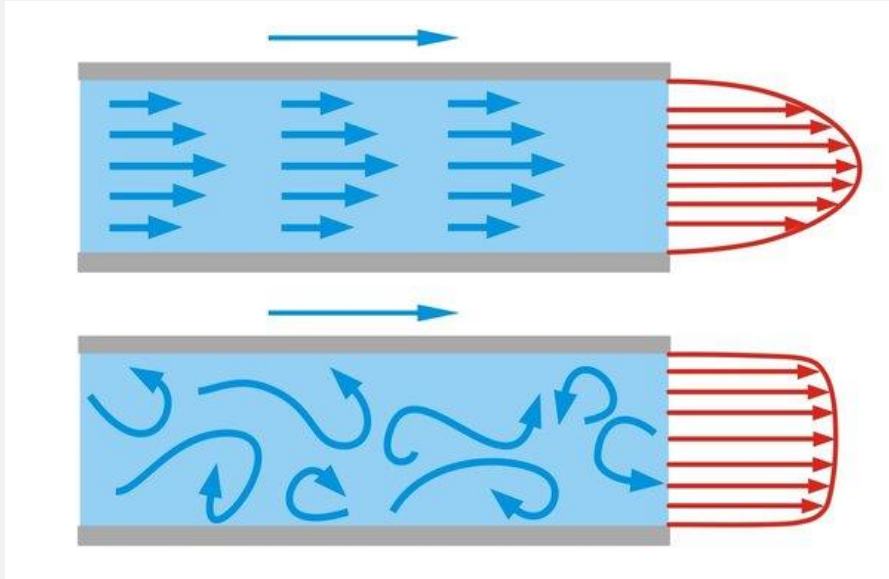


REAL FLUIDS

DYNAMICS OF REAL FLUIDS

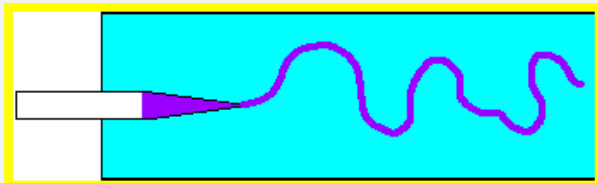
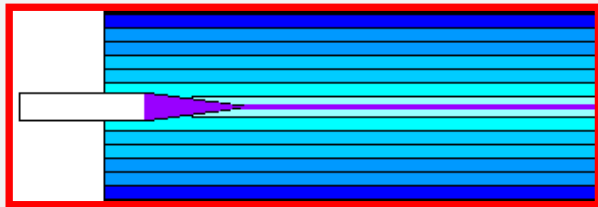
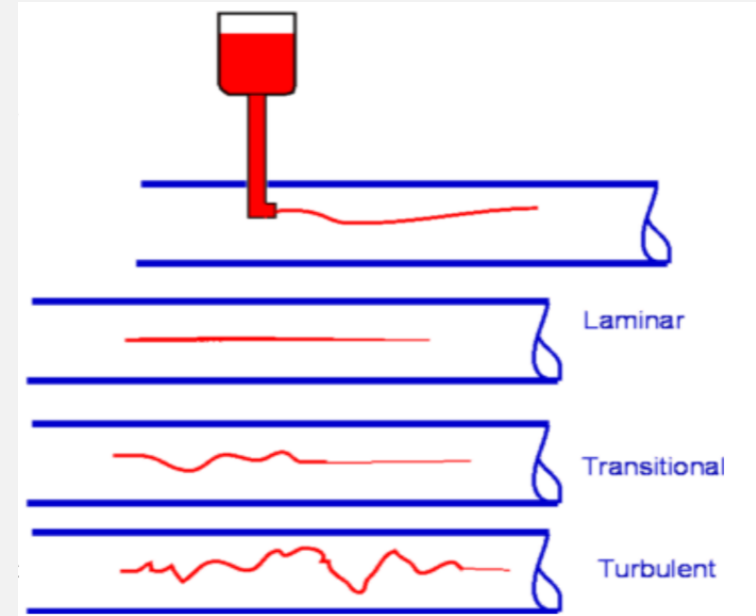
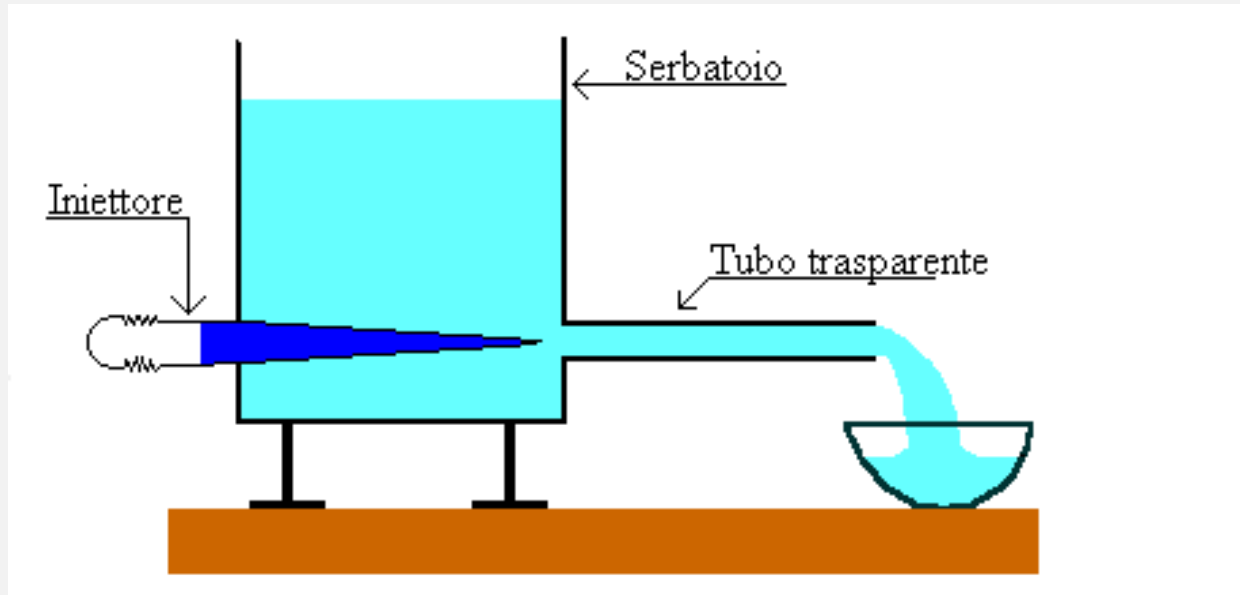


a) laminar flow (higher velocity at the centre)

b) turbulent flow (the velocity near the walls is comparable to that at the centre)

c) unstable flow (the fluid randomly alternates between turbulent and laminar regimes during its motion)

REYNOLDS EXPERIMENT



During his experiment, Reynolds found that four quantities governed the fluid motion:

1.FLOW VELOCITY

2.TUBE CROSS-SECTION

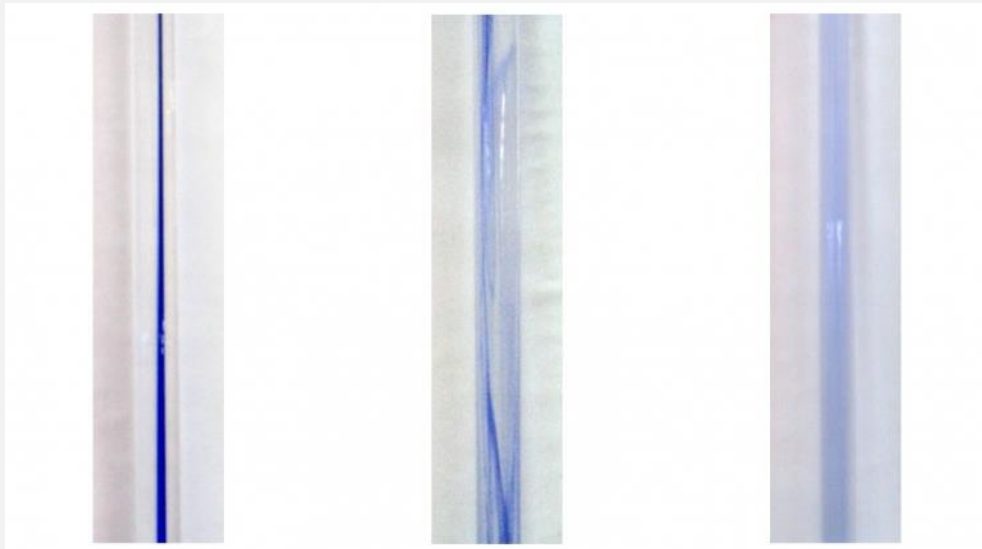
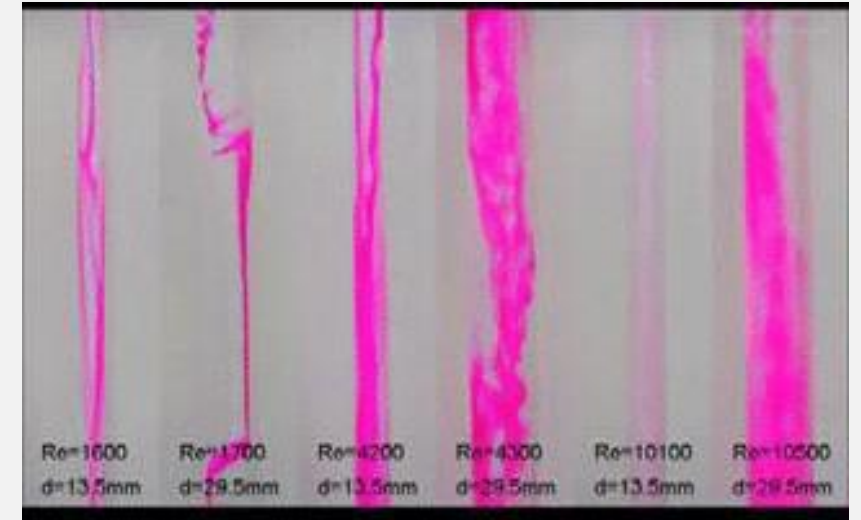
3.FLUID DENSITY

4. DYNAMIC VISCOSITY OF THE FLUID

REYNOLDS EXPERIMENT

ρ = density
 η = viscosity
 v = velocity
 d = diameter

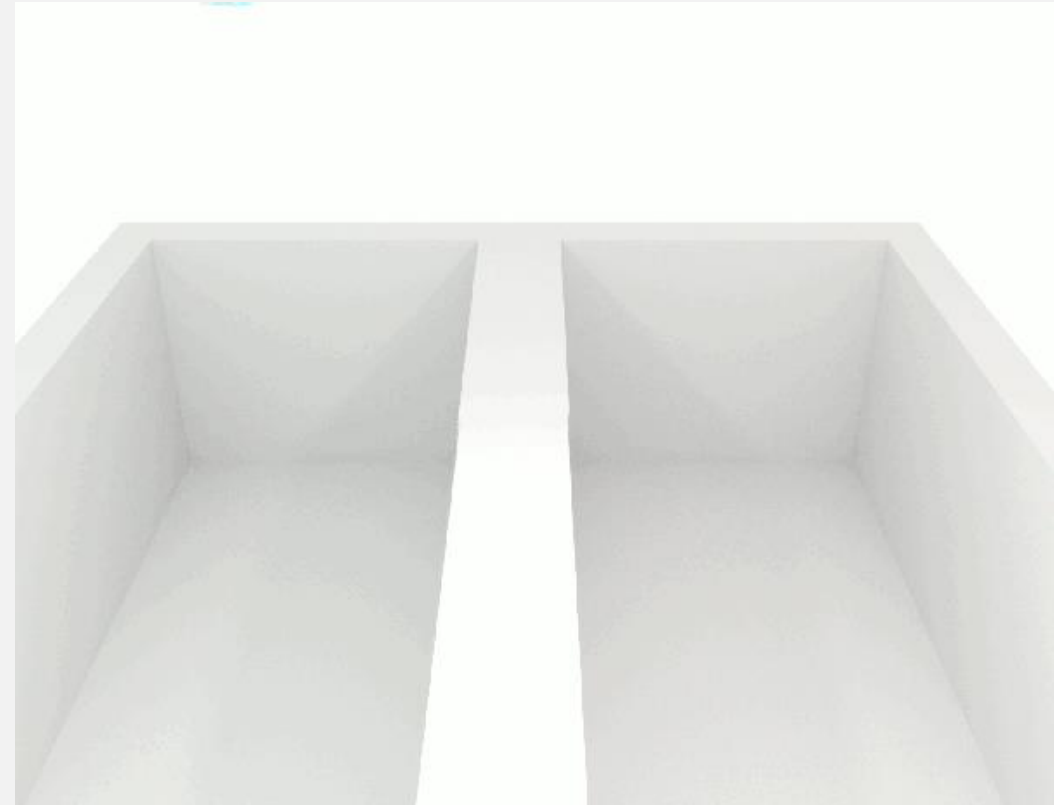
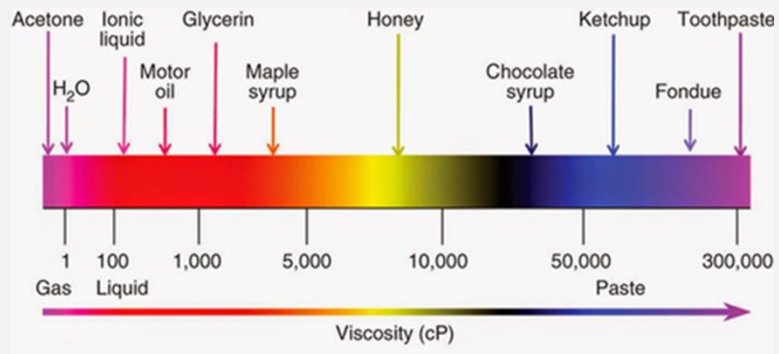
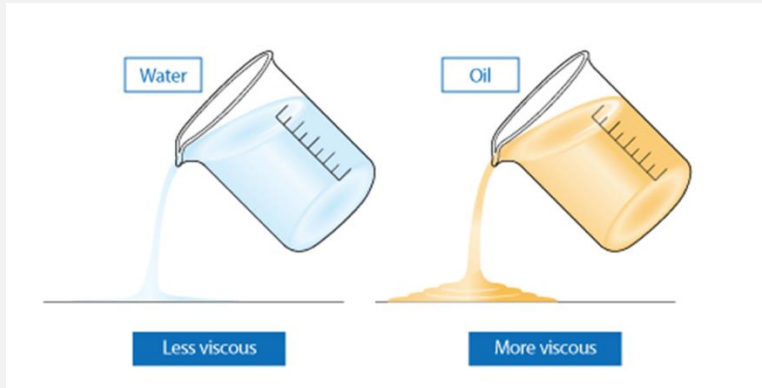
$$Re = \frac{\rho \cdot v \cdot d}{\eta}$$



- if $Re < 2100$ the flow is laminar; if $Re > 4300$ the flow is turbulent;
- $2100 < Re < 4300$ either laminar or turbulent flow may occur;
- $2500 < Re < 3500$ the flow regime is unstable

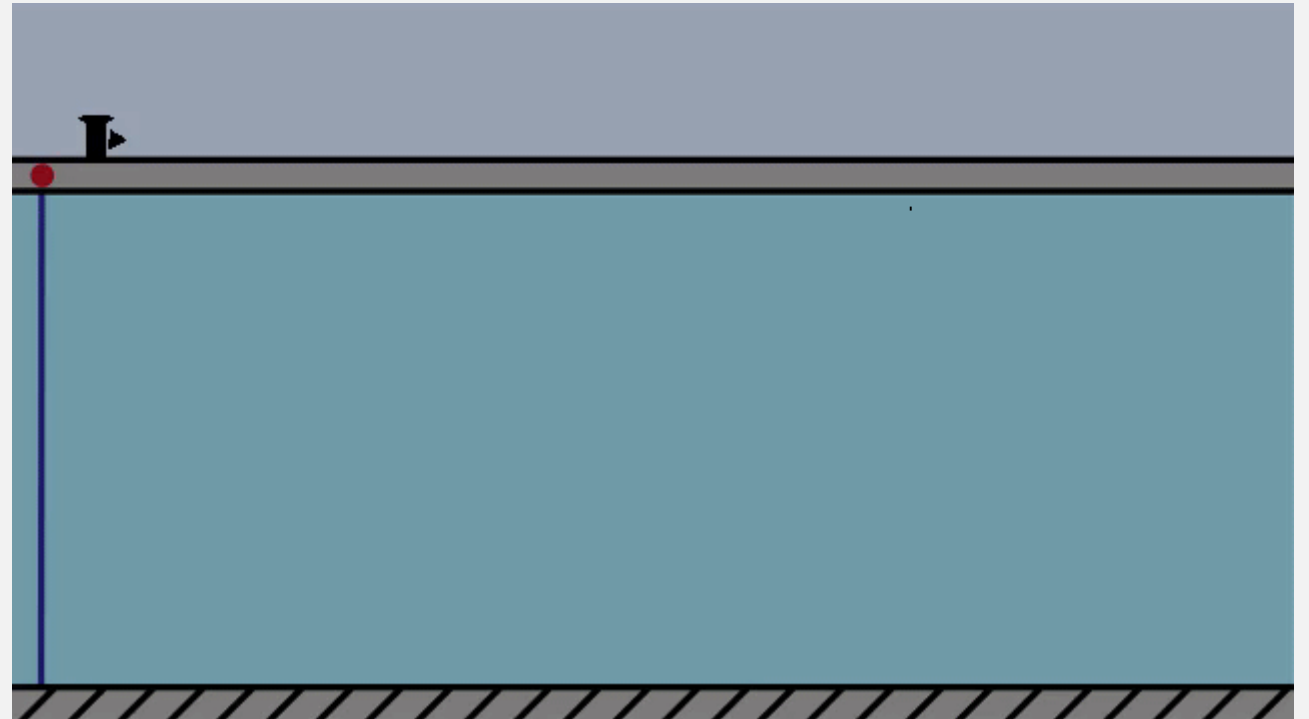
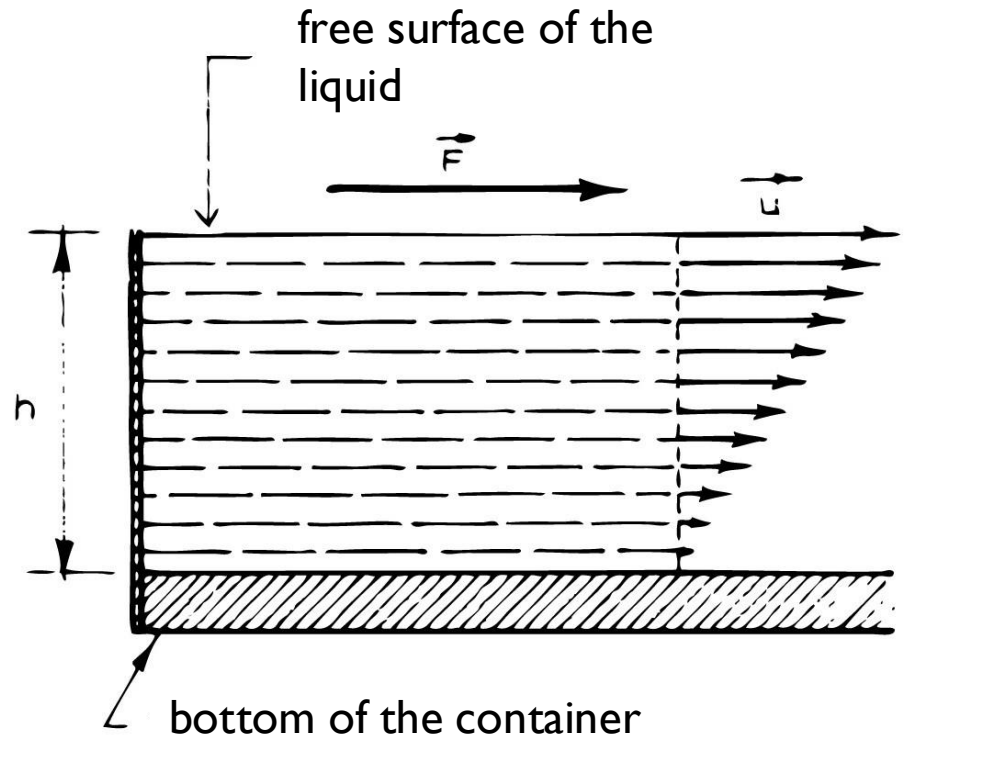
ρ = density in Kg/m^3 , v = velocity in m/s , d = diameter in m , η = viscosity in $\text{N} \cdot \text{s} / \text{m}^2$.

VISCOSITY



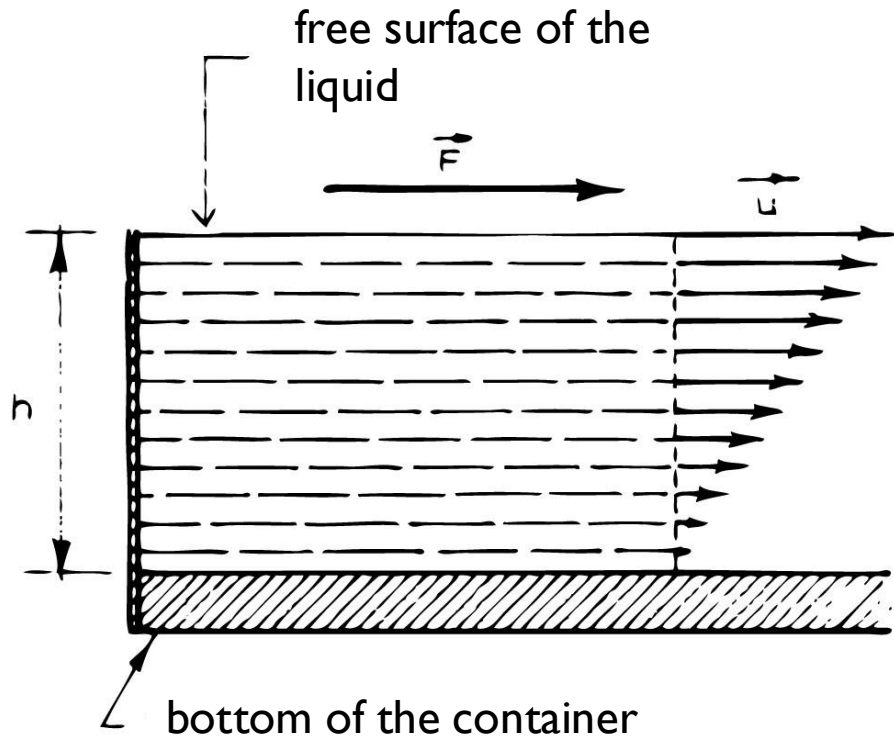
Internal friction → the greater or lesser ease with which one liquid layer slides relative to an adjacent layer

VISCOSITY



To express viscosity quantitatively, consider a liquid at rest contained within a vessel and suppose a force F is applied tangentially to the free surface of the liquid: the surface layer of the liquid will begin to move with a certain velocity (denoted by u), transmitting its motion to the underlying layers, which will begin to move with progressively decreasing velocities.

VISCOSITY



$$\eta = \frac{Fh}{uA} \quad \frac{F}{A} \cdot \frac{h}{u}$$

- F = magnitude of the force applied tangentially to the liquid (N);
- A = area of the surface layer of the liquid (m^2);
- u = velocity of the surface layer of the liquid (m/s);
- h = distance between the surface layer and the layer adhering to the bottom of the container (m)

VISCOSITY can be depicted as that force that would be necessary for a thin layer of fluid belonging to the fixed plane to reach the velocity of the fluid layer located at a precise distance (h).

A fluid flowing through a tube exhibits a non-uniform velocity profile: the minimum velocity occurs at the wall (due to friction), while the maximum velocity is found at the centre.

VISCOSITY is the pressure that, when exerted on the wall, permits a constant velocity along the whole section.

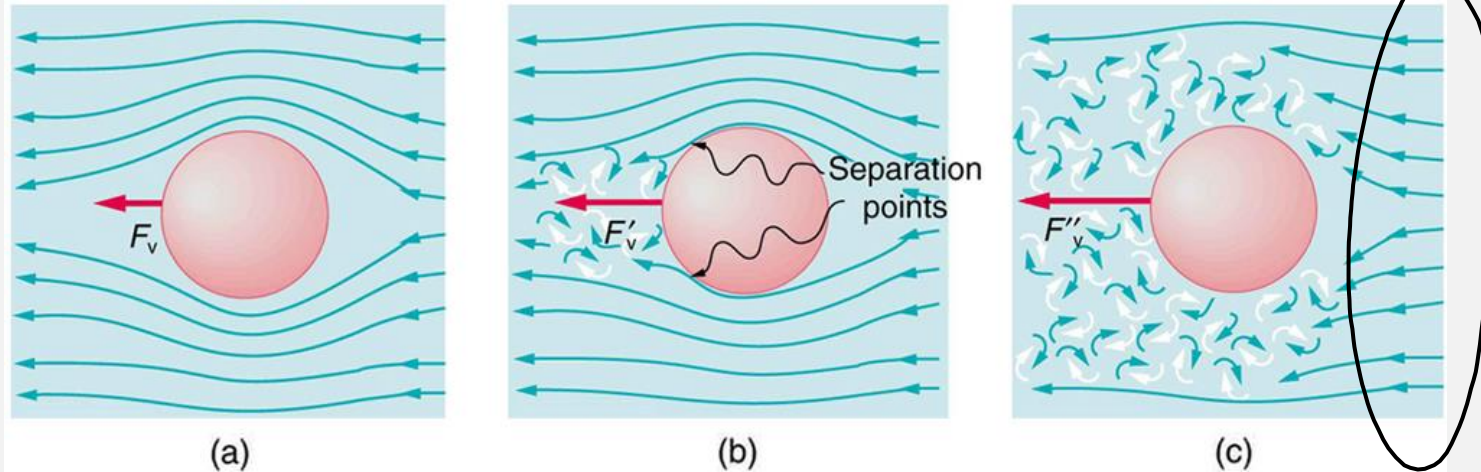
VISCOUS RESISTANCE

When a body moves through a fluid, the fluid exerts a resistive force upon it.

If the relative velocity between the body and the fluid is sufficiently low that the fluid flow around the body can be considered laminar, the resistive force is a consequence of viscosity and is termed **viscous resistance**.

Viscous resistance is proportional to the velocity of the object ($F_D \propto v$).

At higher relative velocities, the flow becomes turbulent and the drag force becomes proportional to the square of the object's velocity ($F_D \propto v^2$).



Stoke's Law:

$$F_v = 6\pi\eta r v$$

where r is the radius of the sphere, η is the viscosity of the fluid and v is the relative velocity of the body with respect to the fluid

SURFACE TENSION



The surface tension of a liquid represents the **work required to increase its free surface area**.

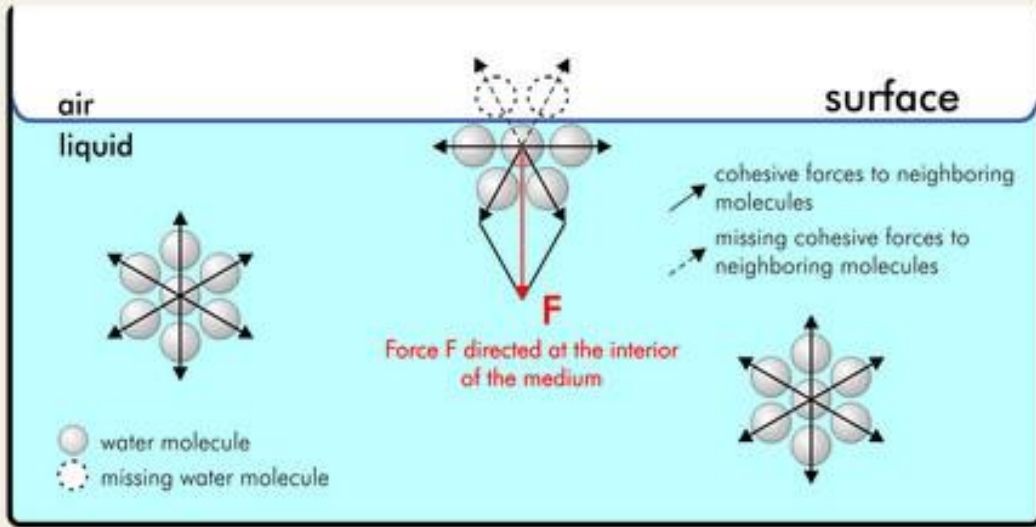
This work can be expressed in terms of the contraction force exerted on a hypothetical line of length L placed on the surface:

$$\tau = F/2L$$

In SI units, τ is measured in N/m or J/m²



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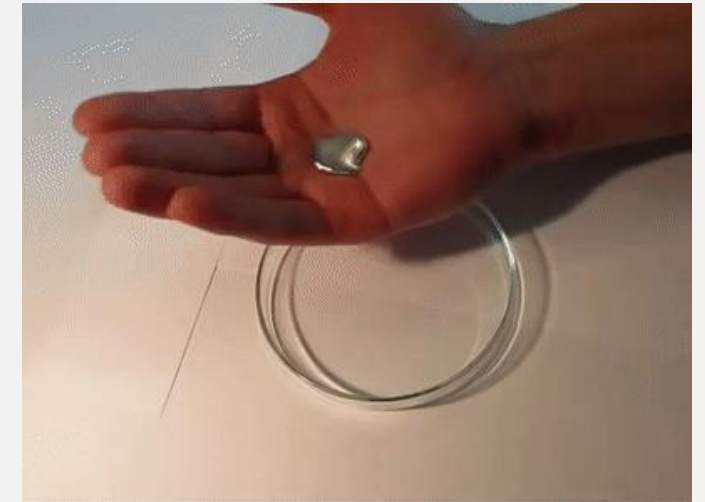
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Liquid	Temperature (°C)	Surface tension (N/m)
Water	0	0.076
	20	0.073
	50	0.068
	100	0.059
Olive oil	18	0.032
Mercury	20	0.436
Whole blood	37	0.058
Blood plasma	37	0.073



CAPILLARITY

