

Physics 101

Lecture 31.

Friday March 21, 2003.

Topics Covered:

Bernoulli's Equation

Viscosity

Surface Tension

Ref: 15-9

- Bernoulli's Equation

$$P + \rho g y + \frac{1}{2} \rho v^2 = \text{const.}$$

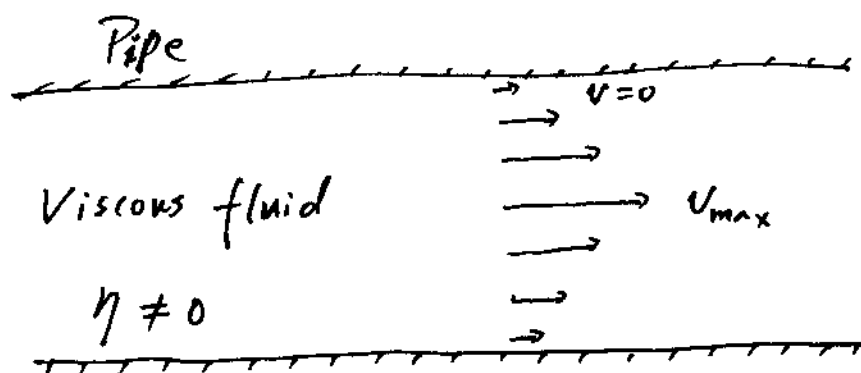
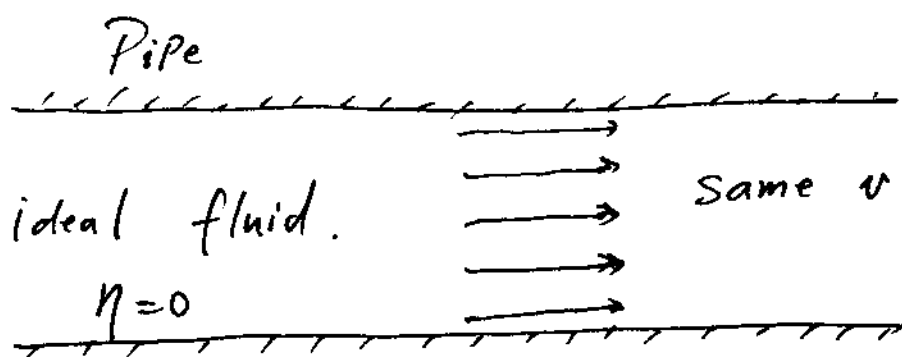
(The same everywhere).

e.g.: Last semester's final exam. Q# 21.

• Viscosity (η) — Drag.

Up till now, we have been dealing with
ideal fluids — No viscosity (i.e., No friction.
No drag).

No interaction between the molecules
in the fluid.

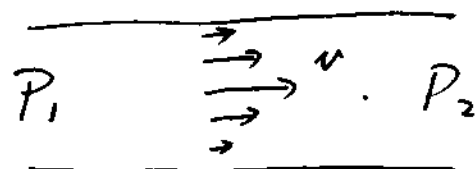


$\eta \neq 0$ because of interactions { between pipe and fluid
among molecules in the fluid.

- Pressure difference can cause the flow of viscous fluid

$$P_1 - P_2 \propto v.$$

v — average speed.



more ~~specifically~~ specifically:

$$P_1 - P_2 = 8\pi\eta \frac{vL}{A}.$$

L — length of pipe.

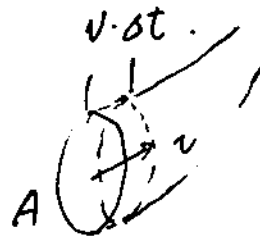
A — cross section area.

η — viscosity in $[N \cdot s / m^2]$.

another unit: Poise = $0.1 N \cdot s / m^2$.

- Volume flow rate.
(Volume per unit time).

$$Q = \frac{\Delta V}{\Delta t} = \frac{A v \cdot \Delta t}{\Delta t} = A v.$$



$$\therefore Q = \frac{(P_1 - P_2) A^2}{8 \pi \eta L}$$

for a cylindrical tube :

$$Q = \frac{(P_1 - P_2) \pi r^4}{8 \eta L} \quad (\text{Poiseuille's equation})$$

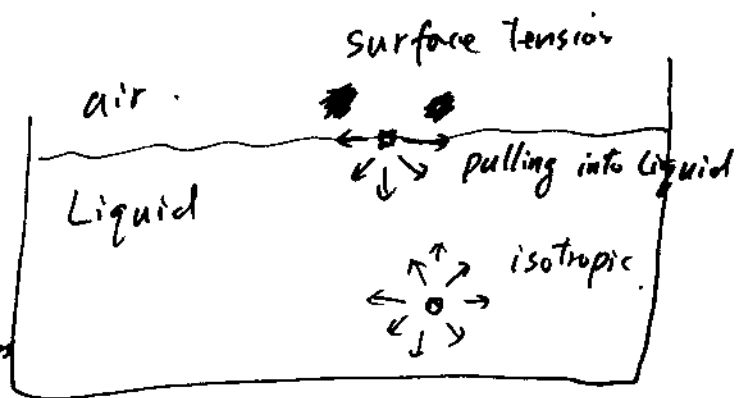
$$\therefore Q \propto r^4.$$

In an artery, reducing r (due to fat, for example) will cause increasing blood pressure dramatically to maintain certain blood flow rate Q .

e.g.: last semester's final exam. #15.

• Surface Tension* (just for fun)

The molecules in the middle of liquid experience no net force from its neighbours



but, A molecule on the surface experiences a net pulling force into the liquid.

i.e. One would need to do work to move a molecule from inside the liquid to the surface.

Therefore, the molecules on the surface have higher energy than the ones deeply in the liquid.

e.g.: A droplet of water — tends to form a spherical shape to minimize its energy.

as if there were a layer of plastic film on surface.

air 100
water

air 20
~~air~~
Soap.

demo:

~~peper~~
peper.

