Fluids 2.0

Diving deeper into the world of Fluids

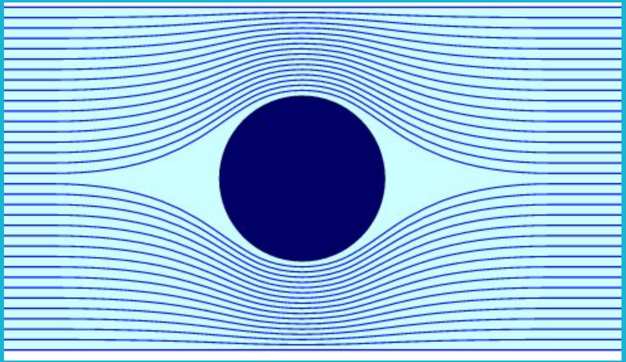
Types of Flow

Laminar Flow

Let's look at a video!

Laminar Flow, when water travels in parallel sheets

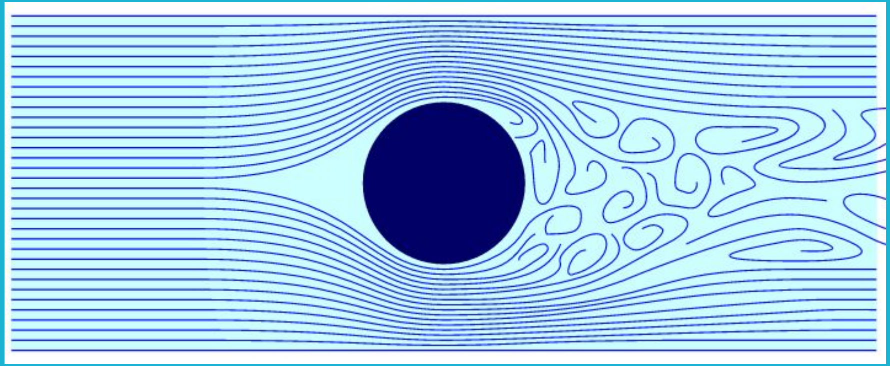
Orderly



Turbulent Flow

The opposite of Laminar flow, unorderly

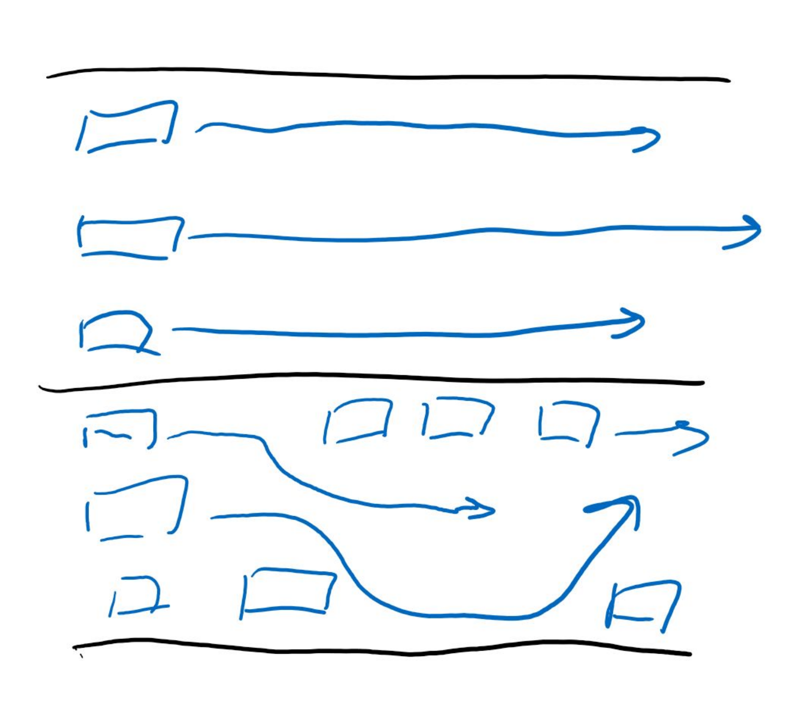
Eddies, the loops, are formed



Compared to traffic

Laminar flow: no traffic, everyone booling

Turbulent flow: lots of traffic



Reynold’s Number

What is Reynold’s Number?

It tells us when flow is laminar and when flow is turbulent

Labeled as Re

Formula $$\mathrm{Re} = \frac{\rho u L}{\mu}$$

Essentially you put numbers in, you get a number out and whatever that number is tells you what type of flow it is

Below 2000: Laminar

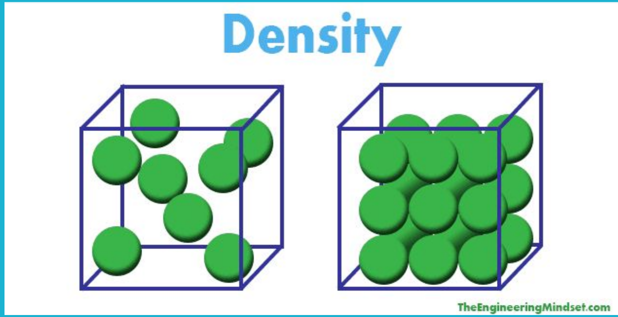
Above 2000: Turbulent

“Heaviness” and “lightness”

$$\mathrm{Re} = \frac{\rho u L}{\mu}$$

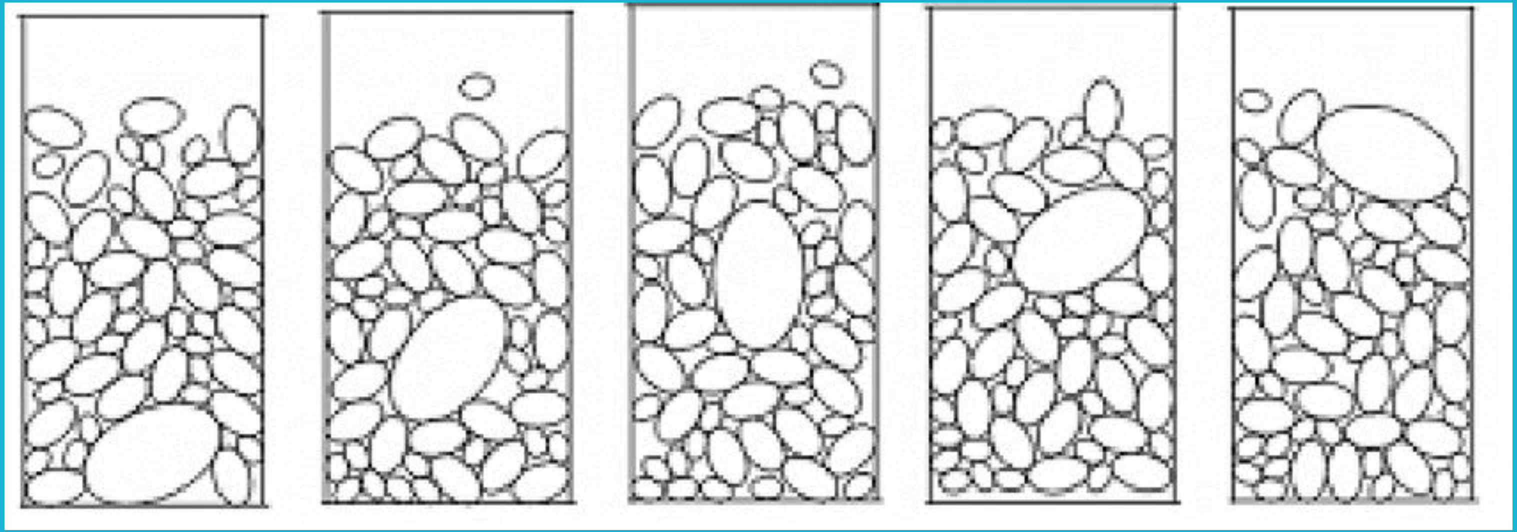
Density (ρ): Mass over volume

- Fluids can float in others (oil on water; air on water; helium on air)
- The less “dense” something is:
  - Less mass for same volume
  - “Lighter”
- Less dense objects float in more dense objects



Cereal bowl (Brazil Nut Effect)

If I have a box of cereal that has really large flakes and really small flakes, and I start to shake the bag, do you expect the small or large flakes to rise up?

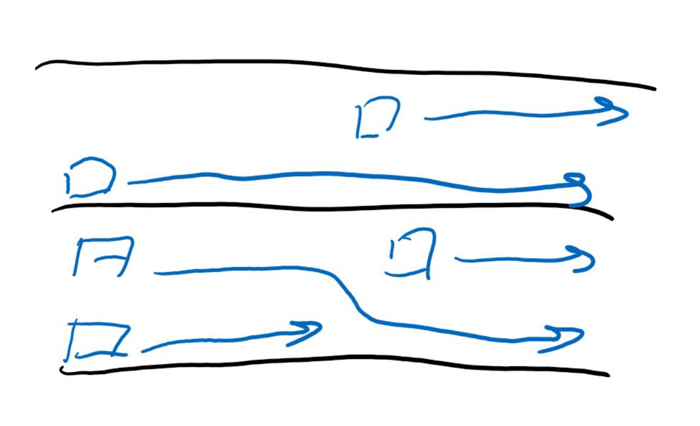


Density's role

$$\mathrm{Re} = \frac{\rho u L}{\mu}$$

Density tell us how much "stuff" is near other "stuff"

The more stuff there is that is closer together, the more likely you are going to hit something

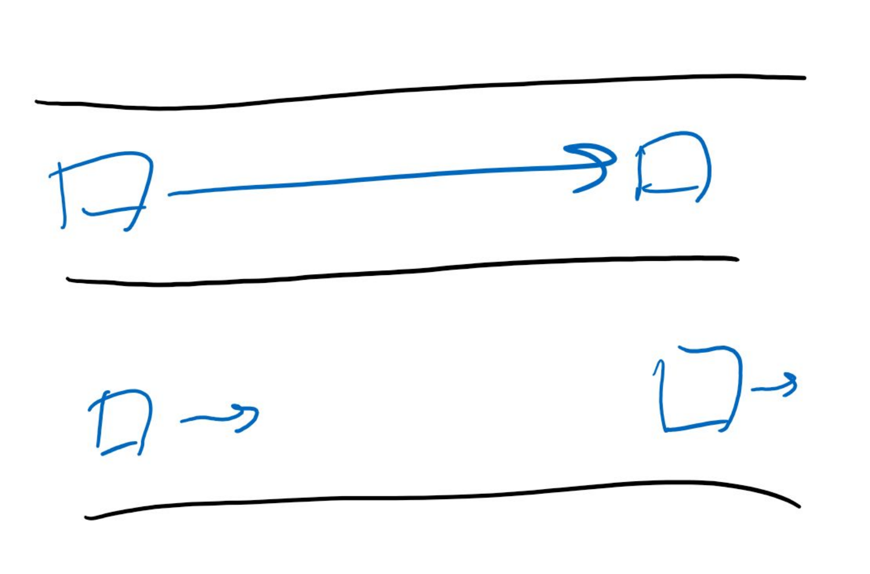


Speed of flow

$$\mathrm{Re} = \frac{\rho u L}{\mu}$$

Flow Speed (u):

- The Faster something goes, the more likely you are going to run into other particles
- Traffic

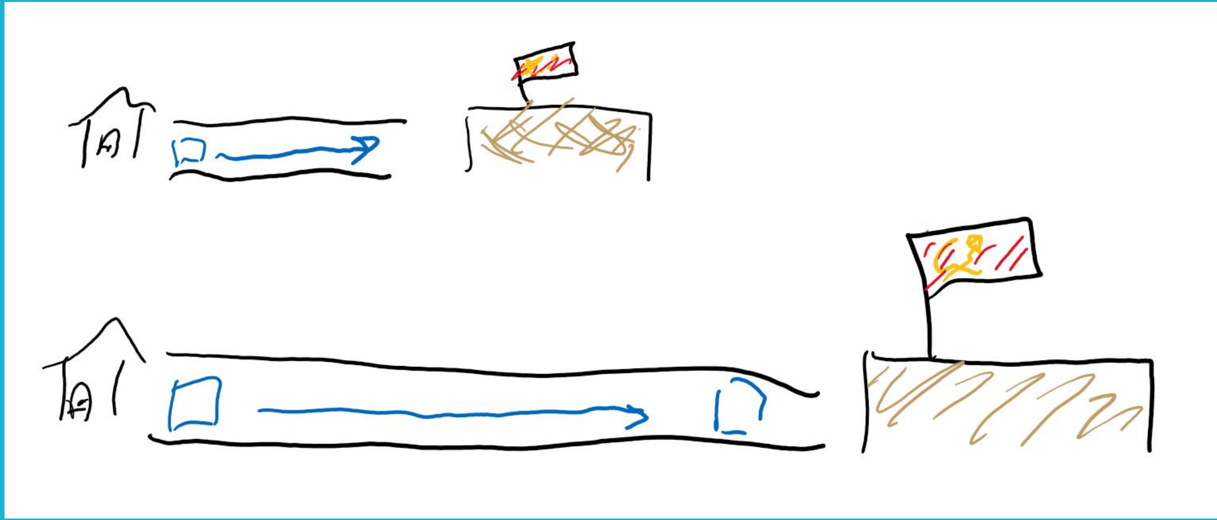


Length. . .

$$\mathrm{Re} = \frac{\rho u L}{\mu}$$

Length (L)

- The farther you must go, the more likely you are to run into something

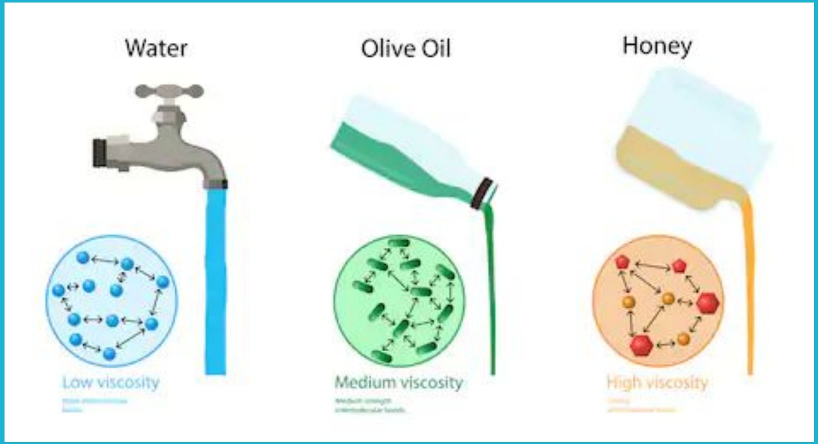


You're goin too fast pls slow down

$$Re = \frac{\rho u L}{\mu}$$

Viscosity (μ): Resistance to flow

- Fluids that flow slower are more "viscous"
- Ketchup is more viscous than water since water flows more easily than Ketchup
- THIIIIIIIIIIICK



Viscosity's role

$$Re = \frac{\rho u L}{\mu}$$

More viscosity forces particles to have a lot more energy to become unorderly

Resistance to non laminar flow

Maximizing Laminar Flow

$$\mathrm{Re} = \frac{\rho u L}{\mu}$$

How would you do so?

- Minimize numerator:
  - Slow moving fluids
  - Small length
  - Less Density
- Maximize denominator:
  - High Viscosity

Turbulent flow is the opposite

Dimensions of Reynold’s number?

$$\mathrm{Re} = \frac{\rho u L}{\mu}$$

ρ: Density, kg/m^3

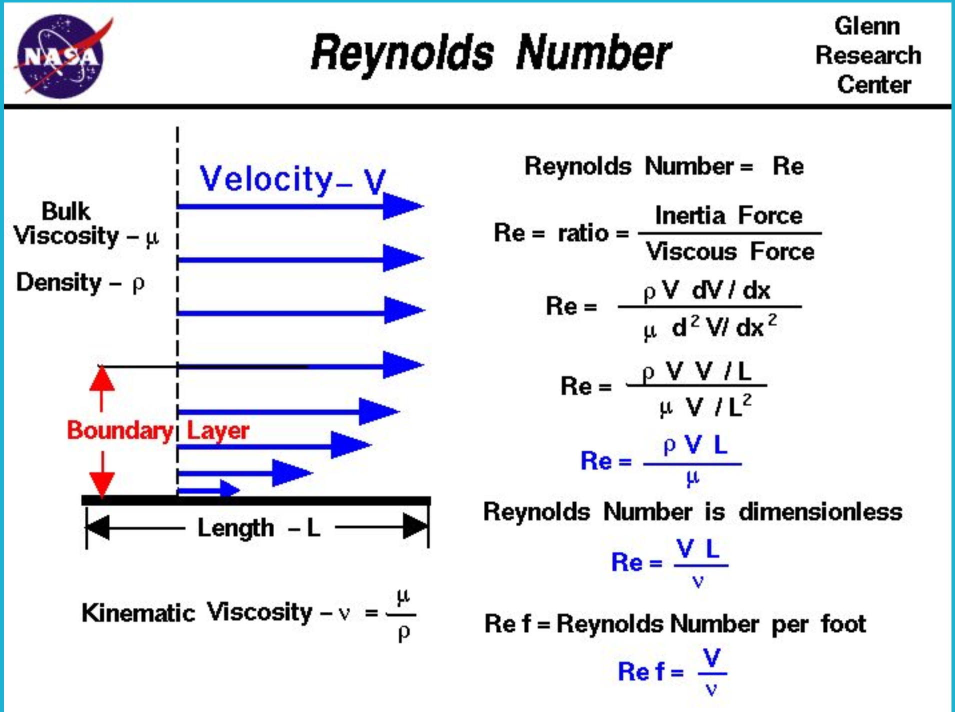
u: Flow Speed, m/s

L: Length, m

μ: Viscosity, N·s/m^2=kg/(m*s)

ρ*u*L=kg/m^3*m/s*m=kg/(m*s)

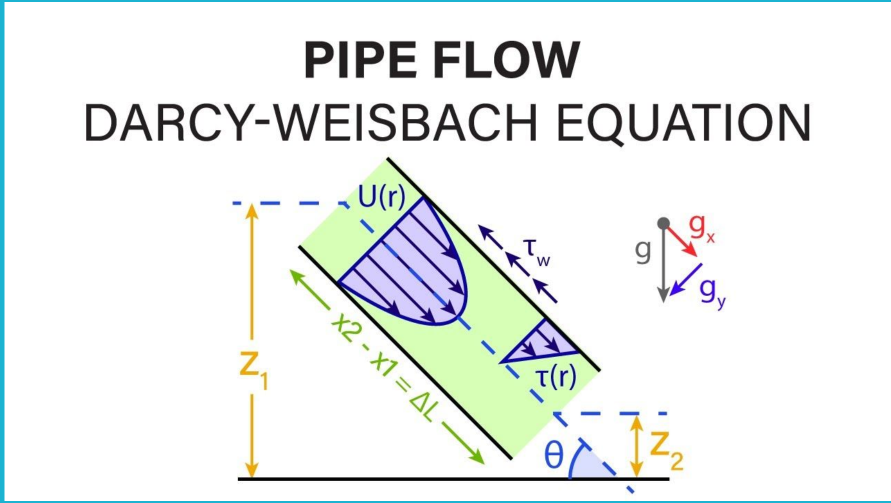
Unitless



Other equations

$$\mathrm{Re} = \frac{\rho u D_{\mathrm{H}}}{\mu}$$

If we're in a pipe, we have to worry about how wide the pipe is, or the friction the pipe exerts on the fluid, or. . . a bunch of other factors



Review

What are the two types of flow?

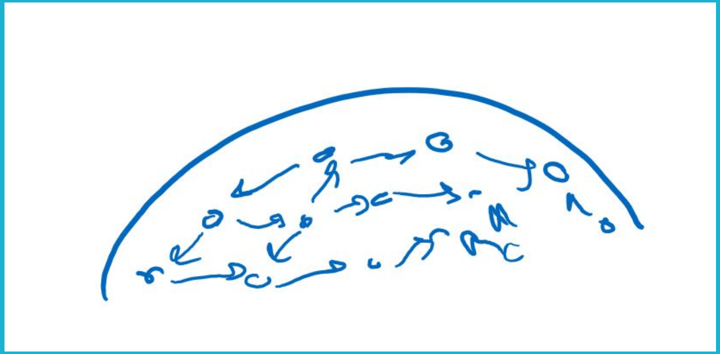
What does the Reynold's number help us determine?

What are a few things that affect the Reynold's number?

Fluid forces

More terms

- Surface tension: Attraction between molecules allows for the water to create a film
    - Only works for molecules that are attracted to each other, polar.



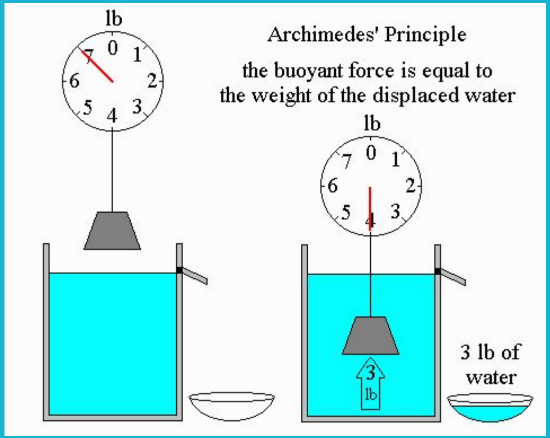
Archimedes Principle

How do objects float?

- Less dense object float, but why?

Archimedes Principle!

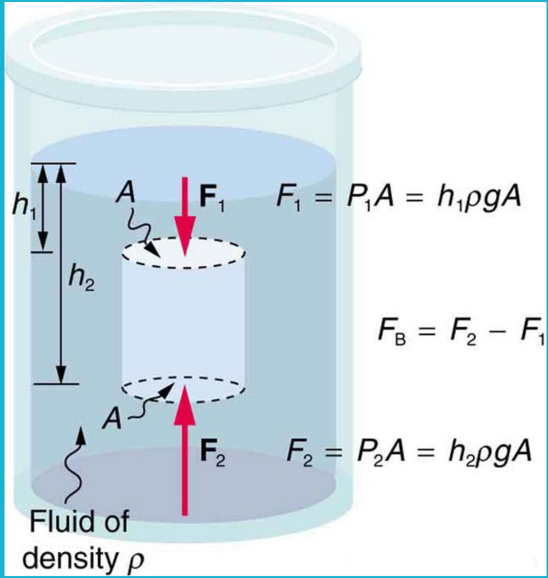
- Buoyant force is equivalent to weight of the water displaced!
- Displaced water, wants to take the place, but the object here has taken its place, so the water exerts a force on the object.
- Force is the same not matter how deep.



Derivations

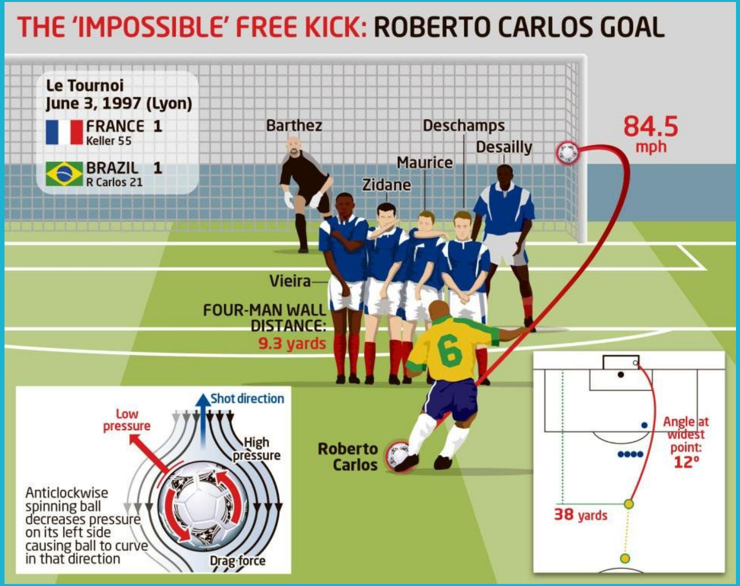
The Math:

- Force is area times pressure
- Pressure is the density time height times gravity
- Force is then hρgA on both the bottom and top
- The total force is the difference between the heights times ρgA
- hA is the volume, ρ times volume is mass, mass times g is weight



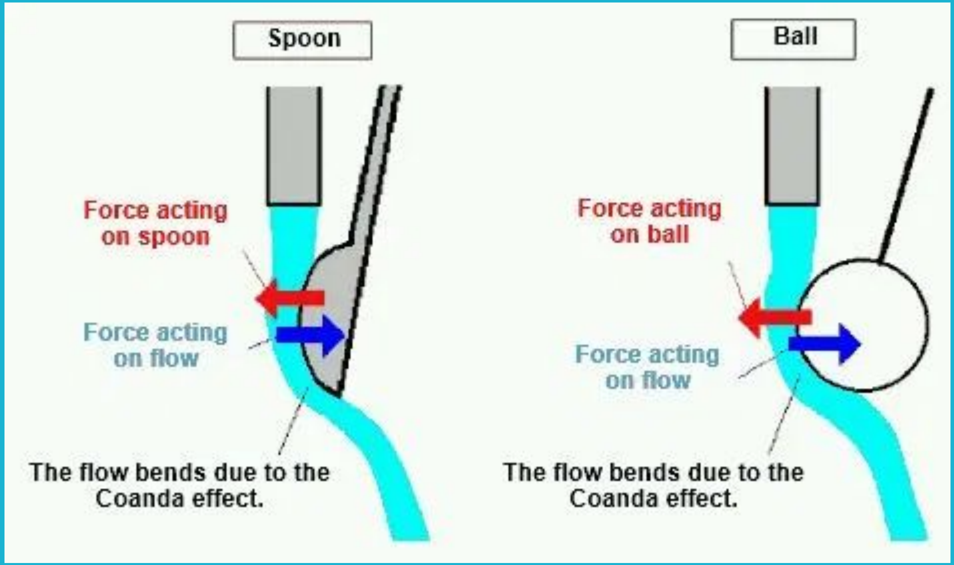
Magnus Force

A force that pulls a spinning object a direction in the air



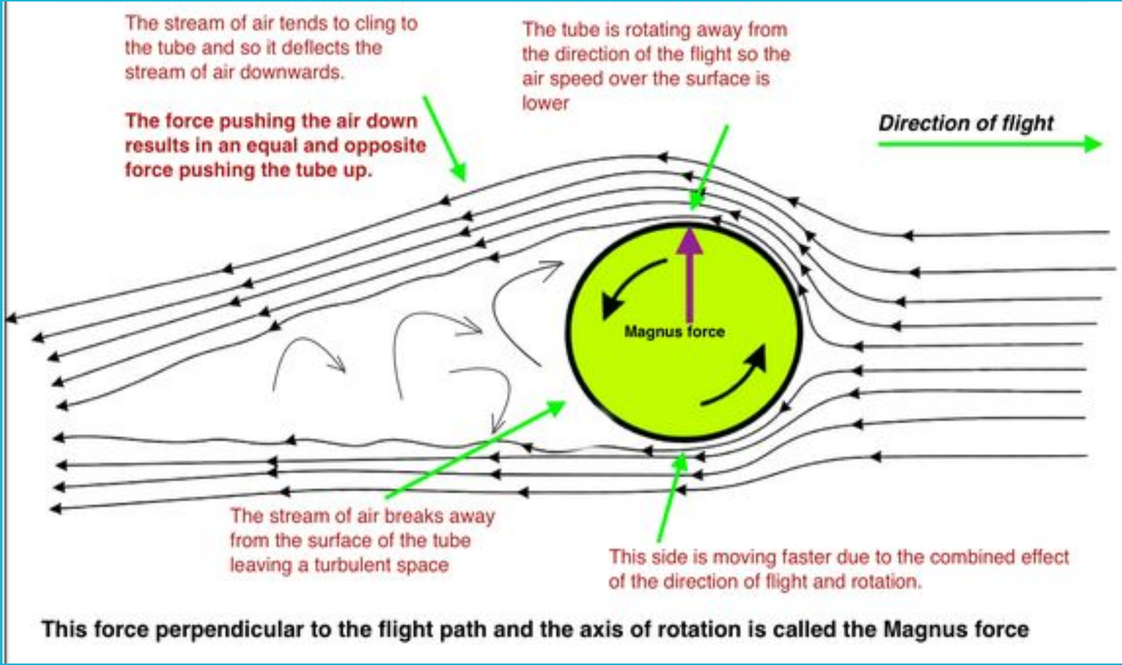
Coanda effect

Fluids like to stick to objects. . . that's pretty much it



Why?

- A ball is rotating in the air
- Top half is rotating with wind, other half is going against wind
- Top air is deflected downward
- Newton's third law

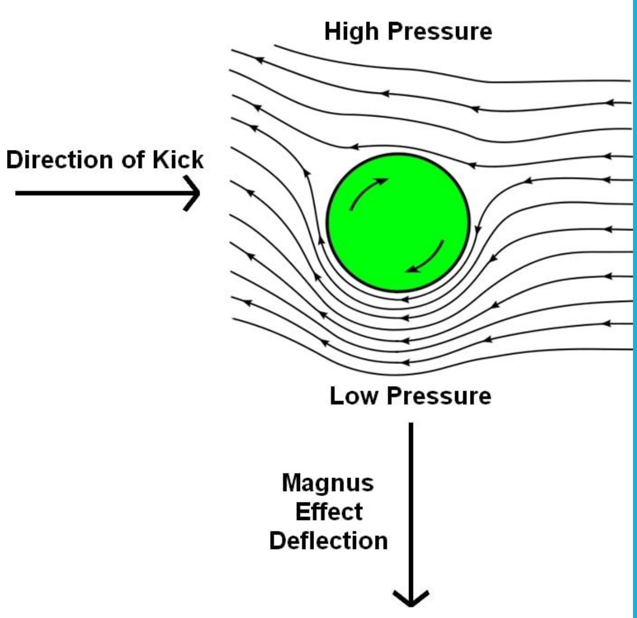


Bernoulli’s principle explanation

Air going “along with the spin” will be faster than that going “against” it

This creates a low pressure area

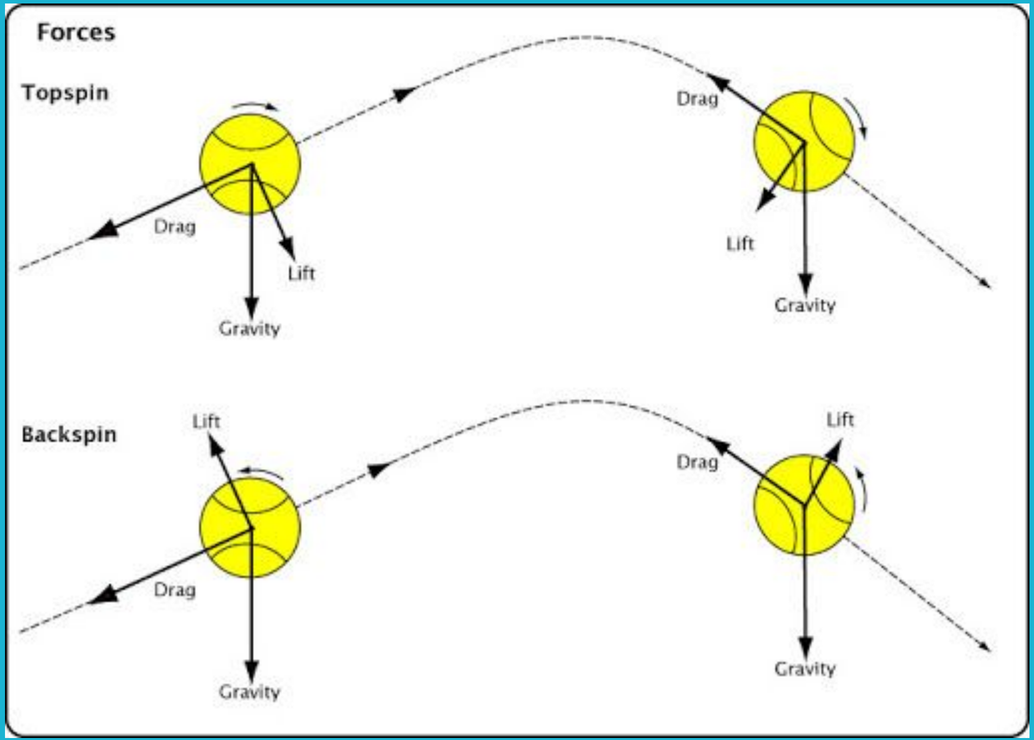
Low pressure areas “pull” an object toward it



Uses?

Tennis players
- Front Spin
  - Ball goes downward faster
- Back Spin
  - Ball goes upward

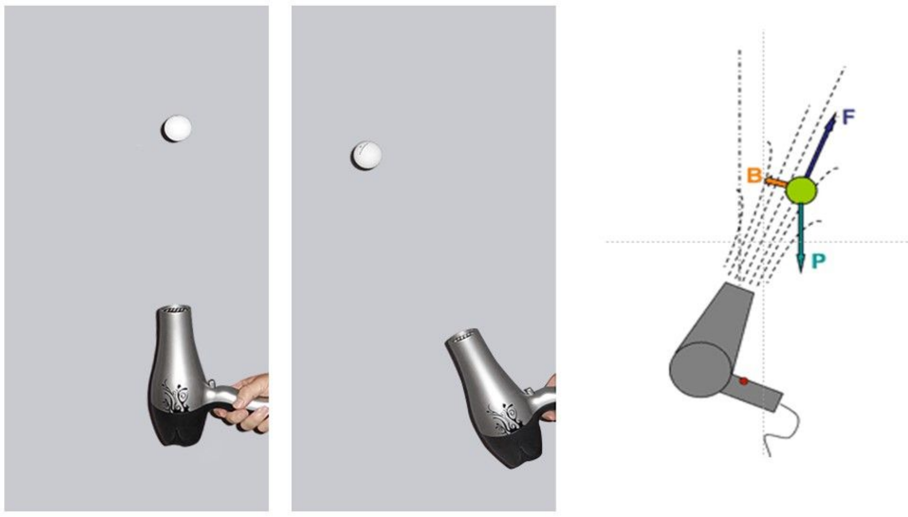
Baseball!
- Curve balls
- Screwballs



Do this at home or you get an f

Lots of backspin = Floating balls?

- Floating ping pong ball also floats because of this!



Review

Name a few “forces” that act on a fluid.

What does Archimedes’ principle tell us?

What causes the Magnus force?