

21. Particles 1: trajectories

Friday, November 11, 2022 3:55 PM

Admin:

YES CLICKERS TODAY

Today:

One last critique: Ryan Wells?

Particles:

Interaction with flow

Generation

II Particles

Heavy seeding

Number density high enough to look like a dye

Similar considerations to dyes:

1) Particles must track with the flow

Dyes are molecules, track with the flow just fine.

Big difference from dyes

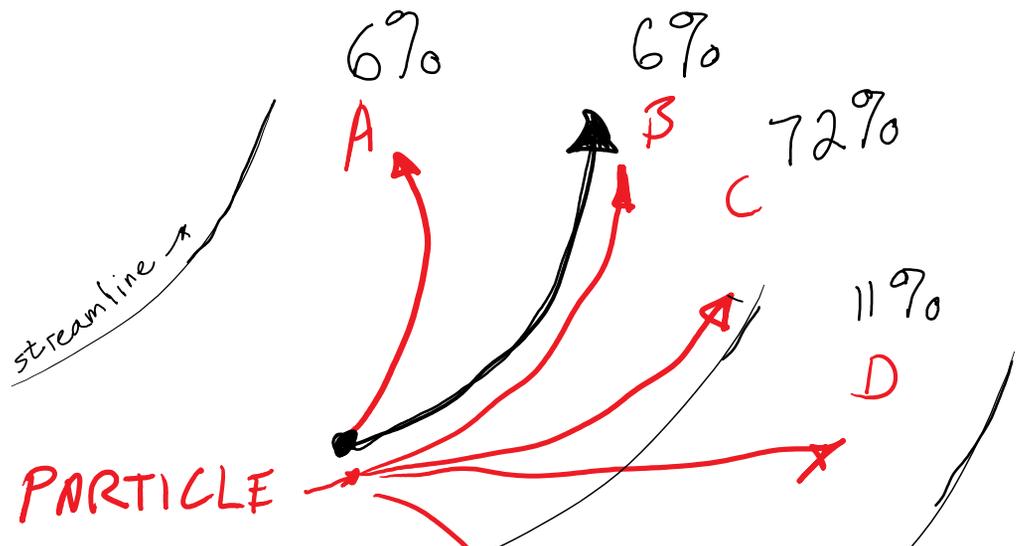
2) Want particles to NOT disturb flow

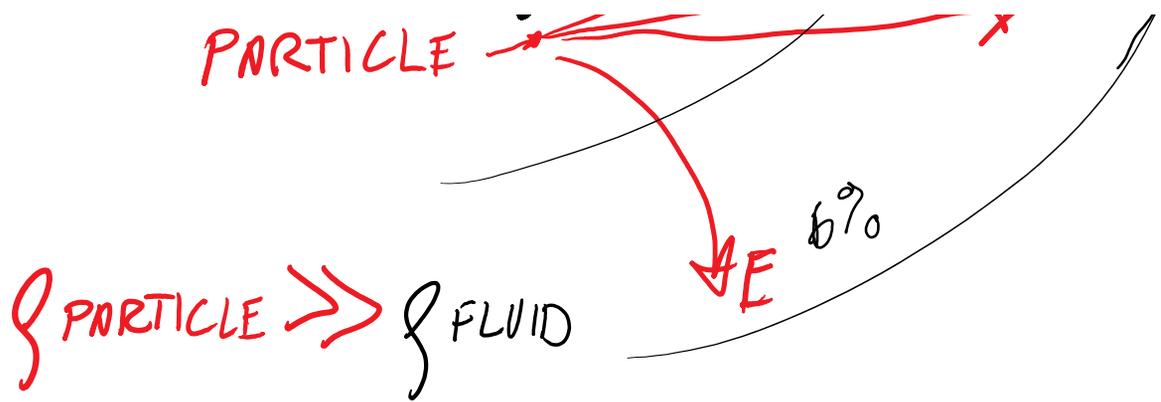
3) Want particles to show up - HIGH VISIBILITY

1) When will particles track well, be good tracers?

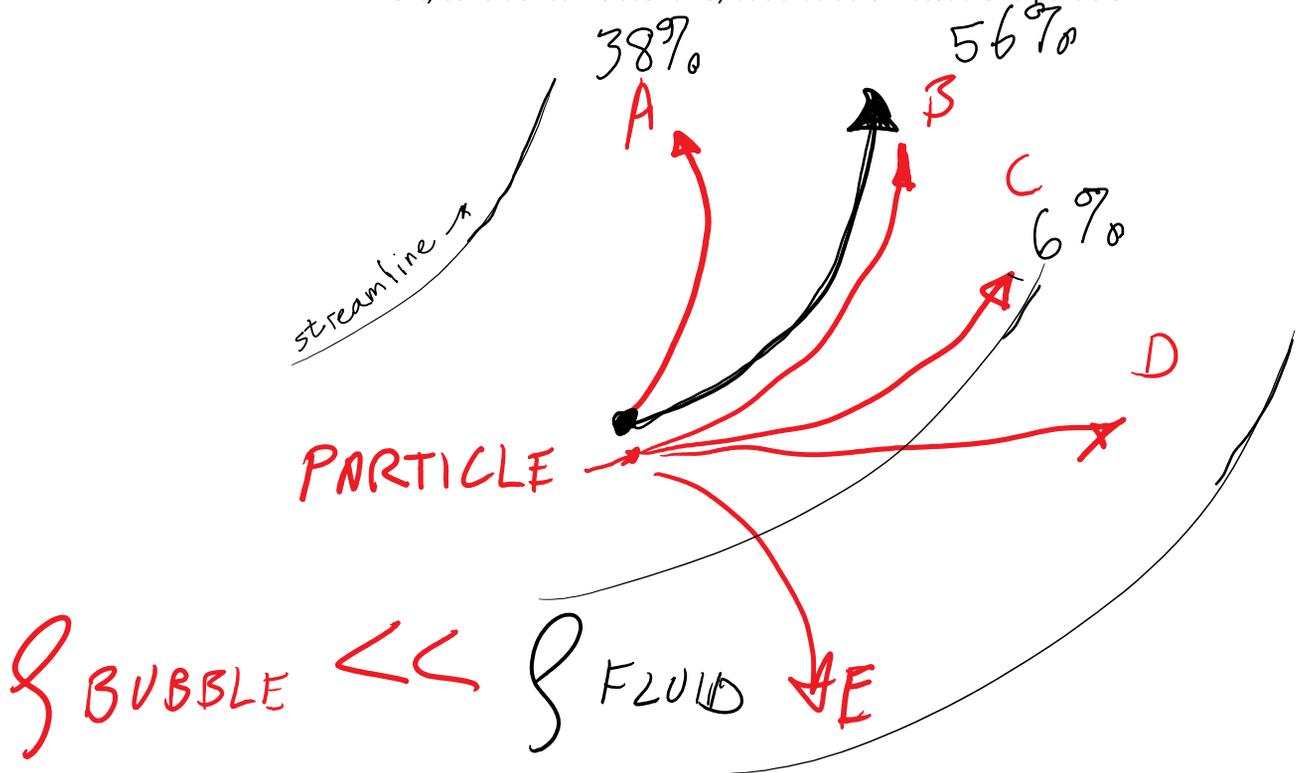
Clicker: Consider a curved streamline in a **horizontal plane**. Consider a small particle, much denser than the fluid. We are looking down on the trajectories; don't worry about gravity; it will just cause a slow drift out of the plane

What will the particle path look like compared to the fluid path?





Next, consider same scenario, but a bubble instead of a particle.



Discussion in groups: Why does it do that???

Ever been hit in the back of the head by a balloon when you are accelerating in a car?
<http://www.youtube.com/watch?v=XXpURFYgR2E>

For particles (or bubbles) to track with the surrounding fluid, they must accelerate the same as the neighboring fluid

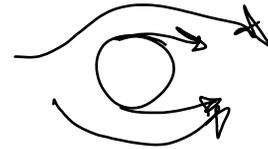
What are the forces **on particle**?

Body: gravity, neglect.

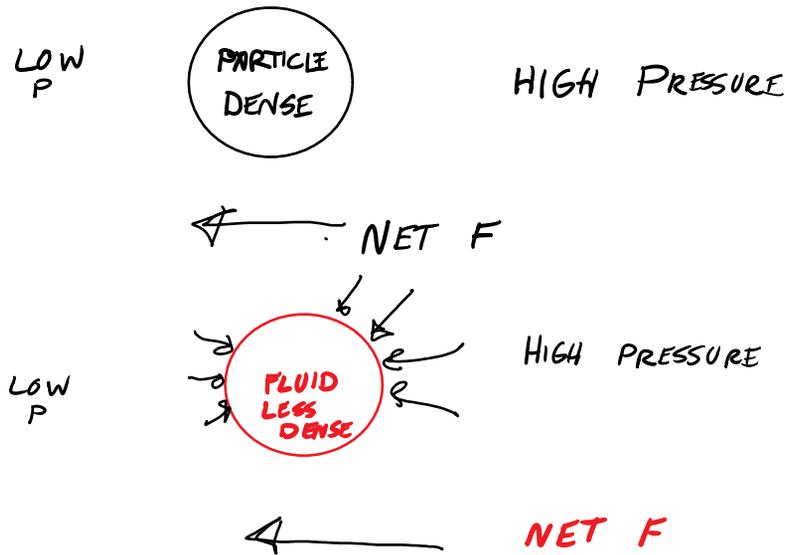
Surface:	normal = pressure parallel = shear
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from fluid



First, **assume** a pressure gradient acting on a spherical particle and fluid blob, same size:



- 83%
17%
- A) The net forces on the particle and fluid are the same
 - B) The net force on the particle is greater than on the fluid
 - C) The net force on the fluid is greater than on the particle
- BUBBLE

Thing

Which particle will accelerate more in this pressure gradient?

- 11% A) They will accelerate the same
22% B) The particle will accelerate more
67% C) The fluid will accelerate more
- BUBBLE

Why???? Because Newton's Second Law: $\sum F = ma$

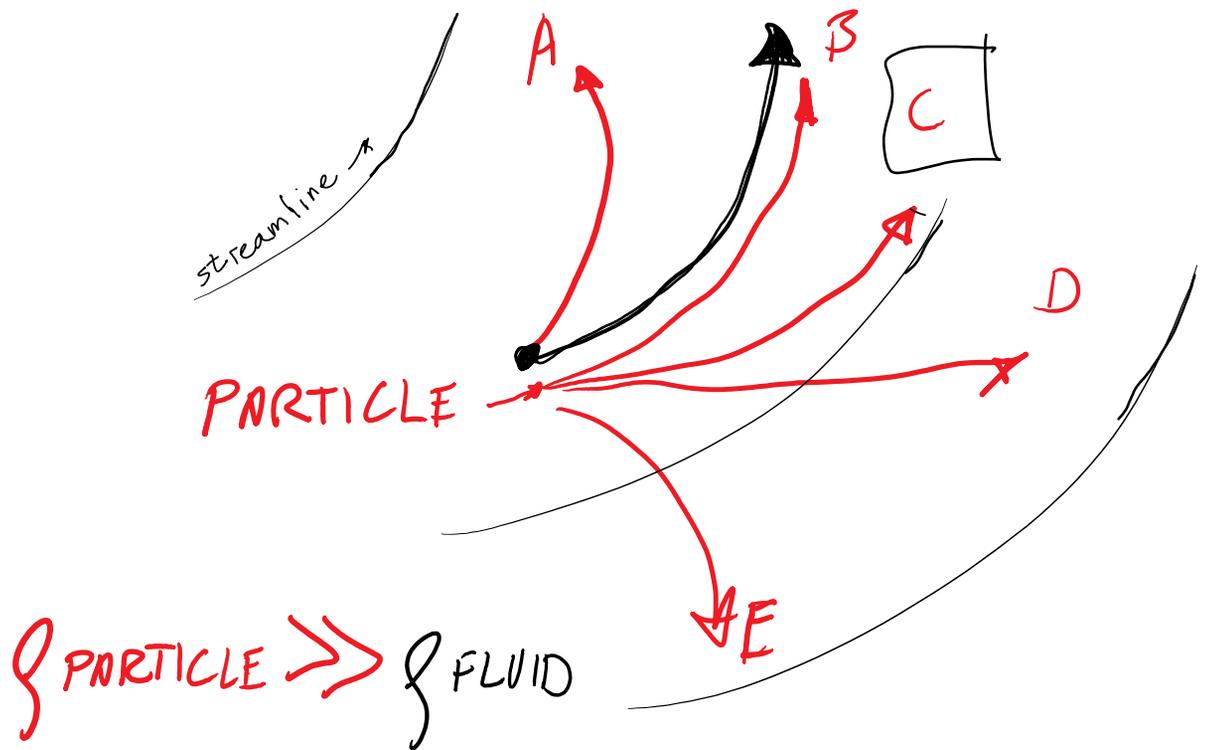
NSL: $F = ma$

What makes streamlines curve?

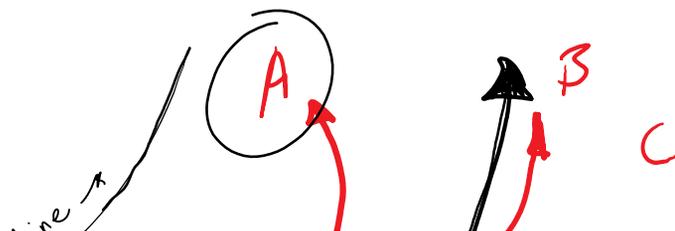
(what is a streamline?)

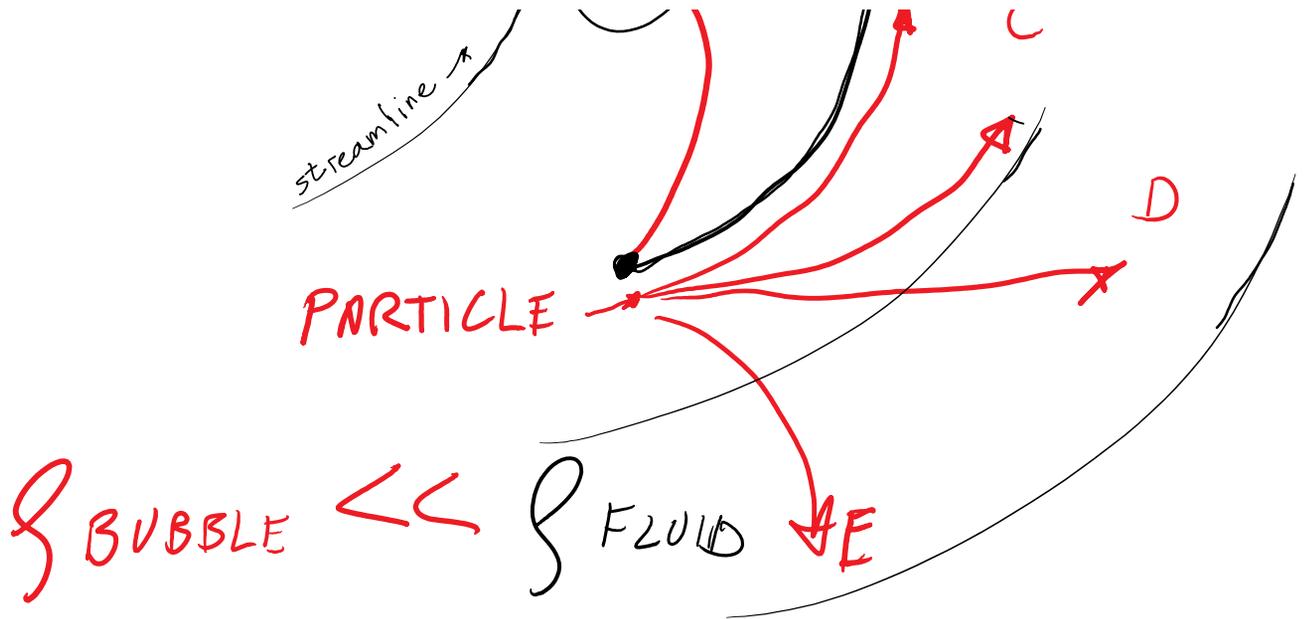


Streamlines curve because of pressure gradient. Low P is inside curve



Next, consider same scenario, but a bubble instead of a particle.





For particles to accurately track the fluid we have

Rules of thumb:

- In water or other liquids, particles of 100 μm diameter or less, any density, will track most flows.
- In air, particles of 1 μm diameter or less, any density, will track most flows.

Similar considerations to dyes:

- 1) Particles must track with the flow
- 2) Want particles to NOT disturb flow
- 3) Want particles to show up - HIGH VISIBILITY

2) Want particles to NOT disturb flow

- As with dyes, minimize injection differential velocity; inject at local flow speed.
- Want particles to not introduce new forces or effects. Avoid:
 - soluble particles
 - surface tension
 - chemical reactions
 - significant change of density
 - particle-particle interaction

Heavy Seeding

- Number density of particles = # of particles / unit volume. (Contrast to mass/volume of solid alone). Keep low enough to avoid interactions.
- Particle-particle interaction (collisions, drag) lead to non-Newtonian effects. Slurries, oobleck, blood, shampoo, silly putty, other polymers. Gets into 'complex fluid' categories. Interesting field.

3) High visibility

Particles only scatter light. Interaction depends on size (d) compared to λ .
Scattering = Σ of reflection, refraction, diffraction & absorption

λ = wavelength of light
 d or ϕ = diameter of particle

$d \sim O(\lambda)$: Mie scattering regime.

e.g. visible light = 0.4 - 0.7 μm , so diameters of 1 μm to 0.1 μm (100 nm, 1000 Å).

- Scattering efficiency drops as particles get smaller. Better tracking, but less light.
- Independent of wavelength; no colors from particles this small. Makes clouds white.
- Particles large enough to have color are too big to track well.



NASA Wake Vortex Study at Wallops Island
NASA Langley Research Center 5/4/1990 Image # EL-1996-00130

"NASA wing tip vortex. Information for ID # EL-1996-00130," n.d.,

<http://lisar.larc.nasa.gov/UTILS/info.cgi?id=EL-1996-00130>.

