ME 351A: Inviscid Fluid Mechanics Notes

James Clements

Fall 2012

Contents

Chapter 1

What is a fluid? - 9/25/2012

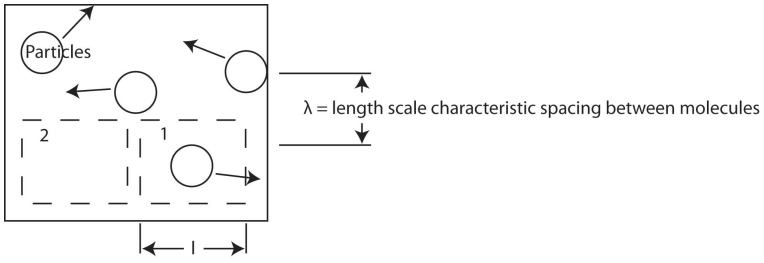
- Commonsense definition: fluids "fill their container", fluids "takes shape of container
- Studying fluid mechanics requires more mathematical precision.

1.1 Mathematically precise definition of fluid

(1) A fluid is a substance that deforms* continuously under the action of any shear* stress.

We will use continuum assumption to describe fluid flows. Namely, fluid/flow properties are continous and can be defined pointwise in space.

Consider: A microscopic view of actual fluids



- Individual particles undergo random motion in a fluid

Suppose You want to quantify the fluid density, ρ: $\rho(\bar{x}, t)$ which is a function of space and time.

If I use sampling windows spanning lxl:

- $\rho \neq 0$ in window 1
- $\rho = 0$ in window 2

Result: To study fluids at the macro level, assume that sampling windows span size l such that:

$$\lambda << l << \eta$$

where η represents the smallest important scale of the flow system. This will keep my system continuous.

- Note that η is set by flow geometry
- η_{Gas} is between 10^{-7} and 10^{-8} meters
- We need a $\lambda << l$ so properties vary continuously
- $l << \eta$ is sued so we can discriminate variations in properties.

In practice: do not need to actually define l for most engineering problems. Usually can be confident that such a scale exists.

!Warning Might not be able to apply continuum assumption under the following cases:

- Microfluidics can be problematic if η is very small
- Rarified systems (ie: in space), intermolecualar spacing, λ, might get very large. This can be a problem too.
- Study of fluid at molecular scale is field on its own called Kinetic Theory or Physical Fluid Dynamics

1.2 Fluid Properties

Scalars:

- Zero order tensor
- no directional information
- time, t; pressure, p; density, ρ; kinematic viscosity ν