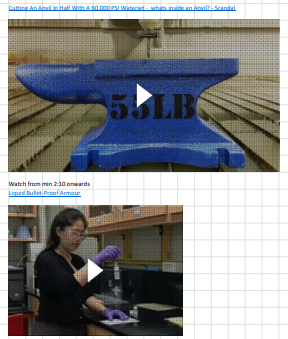
First Lecture

Who is stronger a solid or a fluid?



Our Goals for Today (lect. 2)

1. Understand shear stress in liquids
2. Viscosity & its temperature and pressure dependance

Before we start... What are we after in Studying Fluid Dynamics?

1. Pressure field/values
2. Velocity Field
   1. Work
   2. Forces
   3. Power
   4. Losses
      1. Pressure
      2. Drag/resistive force

What is the main difference between a solid and a liquid?

* Fluids do not keep their shape under any stress
* Stems from ability of liquid molecules to move around

Aside: the terms Fluid Dynamics and Fluid Mechanics are used interchangeably in this course and mean largely the same thing

Solid vs Fluid

A solid can resist a shear stress (τ) by a static deformation, but a fluid cannot!

What happens when a fluid experiences a shear stress?

It flows!

Diagram

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At a given time, δt, The larger the τ, the larger will be δθ, so

A constant shear stress, causes a strain (δθ) that is changing with time, at a rate of .

Eq (1) à Newton’s law for viscosity

Where is the viscosity (proportionality constant)

Viscosity is the resistance of a fluid to motion.

à unit is or

or 1 cP (centi-poise)

Viscosity is a thermodynamic property, so:

Where T = temperature and P = Pressure

changes significantly with temperature.

For gases,

Known at (273K)

n is a constant (for air 0.7)

But for liquids, decreases with temperature

a and b are constants that depend on the type of liquid

why different between gas & liquid?

, and P↑ so does for all fluids.

If is divided by fluid density (ρ), it is called kinematic viscosity (v).

)

For water v = 1c or

In fluid mechanics, we’re not interested in strain rate (unlike solid mechanics), but care about velocity distribution with in the fluid. Let’s see how we can match strain to velocity.

A picture containing line chart

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à (for small strains & elements)

à

From Eqs. (2 & 3):

Diagram

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Example: Skating on ICE!

Let’s assume ice between skate and surface is melted. What is the relative profile within the liquid film?

Diagram

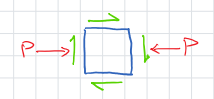
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Assumption:

1 – The flow is one dimensional in x-direction, i.e. u(x) = u(z) = 0, u(y) ≠ 0

2 – no pressure variation in x direction

Let’s consider force balance over a fluid element



From force balance

If the person is not accelerating, then is a constant, is a constant (water), then the integral can be solved as:

B.C.

at y = 0 🡪 u = 0 🡺 a = 0

at y = h à u = v  v = 0 + è

(linear velocity profile)

Summary for today’s lecture

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1. Viscosity charge with T&P
2. Intermolecular forces is the origin if viscosity
3. Difference between solid & liquid in terms of strain
4. Proportionality between velocity & shear stress

Our Goals for Today (lect. 3)

1. Non-Newtonian Fluids
2. Various ways to study fluid dynamics

Newtonian vs Non-Newtonian Fluid