Fluid Mechanics

Fluid Statics
(or Hydrostatics)

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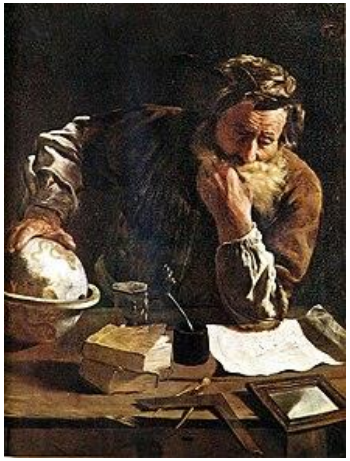
Outline / Terminology

- Pressure
- Unit
- Barometer/manometer
- Pascal's principle
- Hydrostatics – planar surfaces
- Center of pressure
- Area moment of inertia
- Hydrostatics – curved surface
- Buoyancy
- Archimedes' principle
- Immersed and floating bodies
- Free fall of fluid bodies
- Accelerating systems



Recitation: 12:30pm~1:30pm Friday,
Office Hour: 10:00am~11:30am Monday
link announce @ NTU COOL

The Basic Equations of Fluid Statics

✓ Pressure-Height Relation $\frac{dp}{dz} = -\rho g \equiv -\gamma$

Restrictions:

1. Static fluid.
2. Gravity is the only body force.
3. The z axis is vertical and upward.

The Basic Equations of Fluid Statics

Pressure values must be stated with respect to a reference level.
If the reference level is a vacuum, pressures are termed absolute

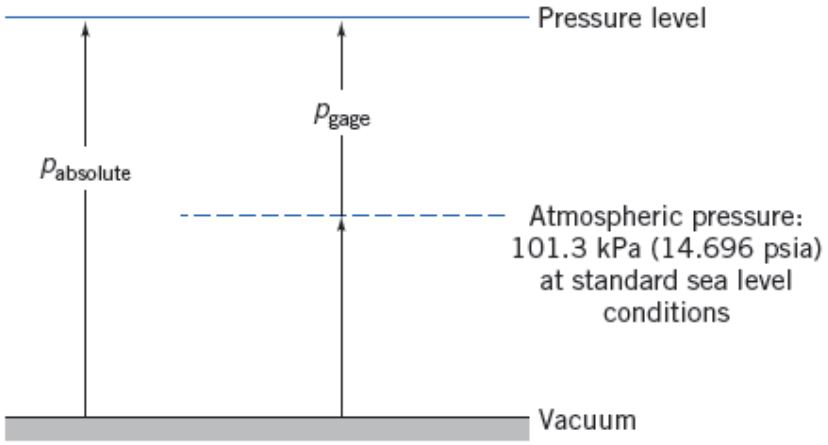


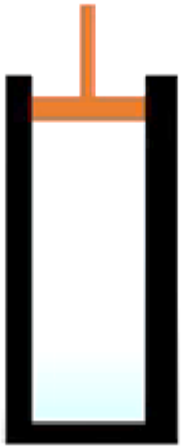
Fig. 3.2 Absolute and gage pressures, showing reference levels.

Most pressure gages indicate a pressure difference - the difference between the measured pressure and the ambient level (usually atmospheric pressure).

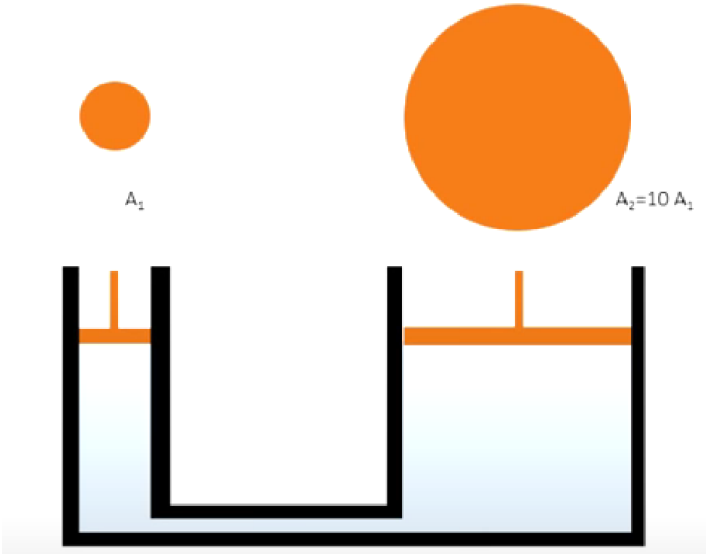
Hydrostatic Pressure in Stagnant Fluid

Pascal's Principle

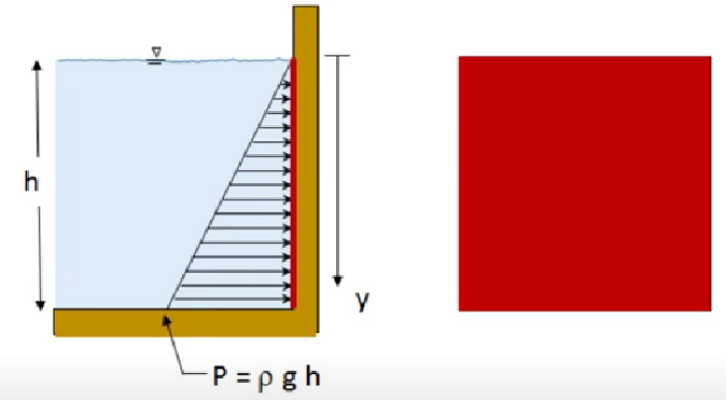
For a confined fluid at rest, if its pressure is increased in one part, there is an equal pressure increase everywhere in the fluid.



Hydraulic pressure &
Mechanical advantage

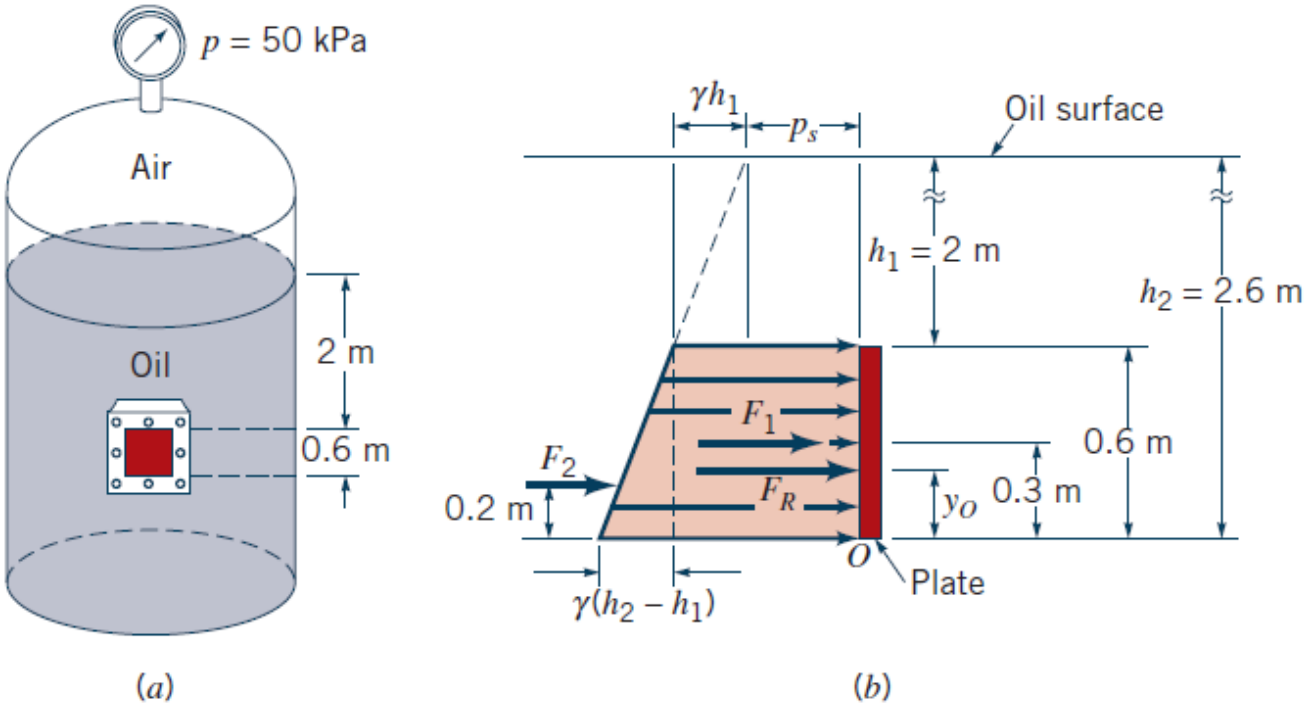


Vertical Surface



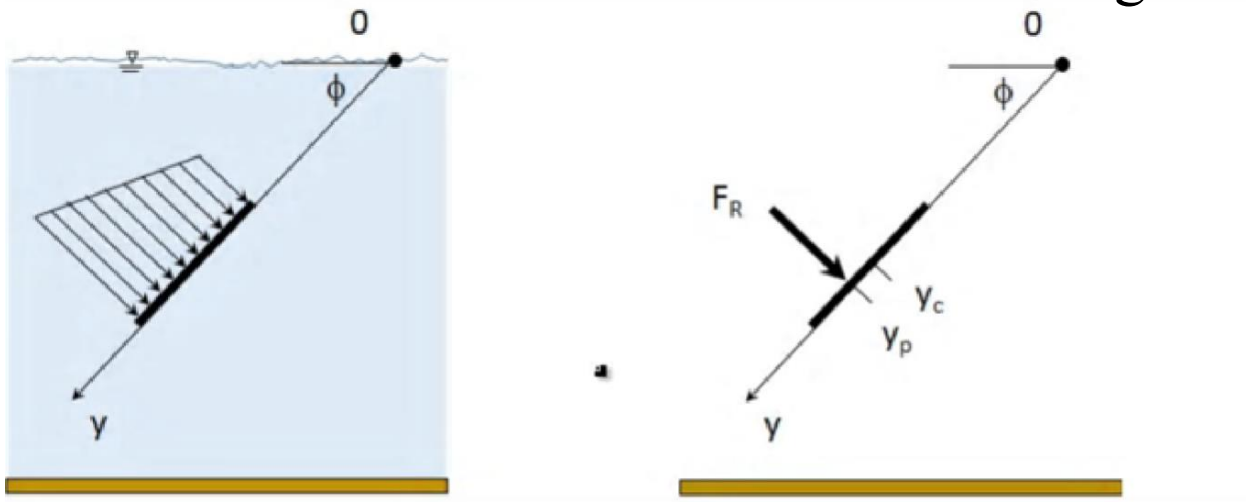
Example 2.8

Calculate the force that the “stop” must exert on the bottom of the gate to hold the water back



Submerged Planar Surfaces

Let's examine the force on a surface submerged in a liquid.

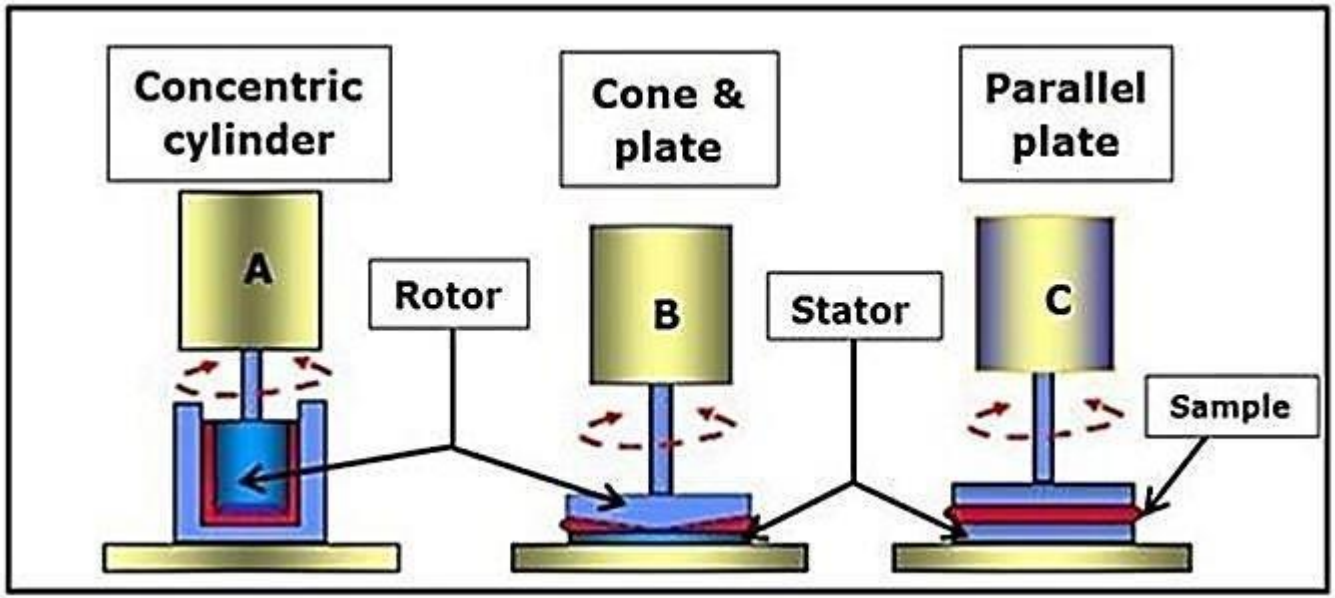


$P_c = \rho g y_c \sin(\phi)$

$F_R = P_c A$

$y_p = y_c + I_c/(y_c A)$

- Rheometer
  - Parallel plate: https://www.youtube.com/watch?v=QBD4Fj11q5c
  - Concentric cylinder https://www.youtube.com/watch?v=G0_HYiIT9vA



Oreology

- Oreo + Rheology

Physics of Fluids ARTICLE scitation.org/journal/phf

On Oreology, the fracture and flow of "milk's favorite cookie®"

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Note: This paper is part of the special topic, Kitchen Flows.
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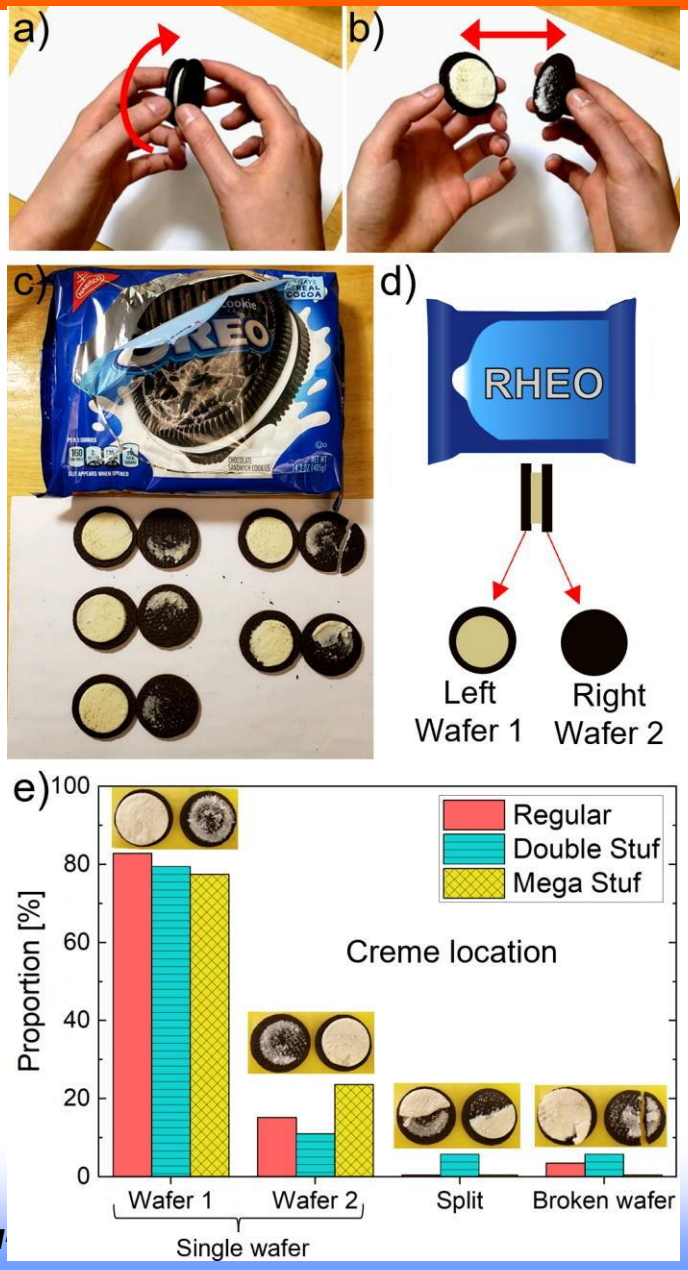
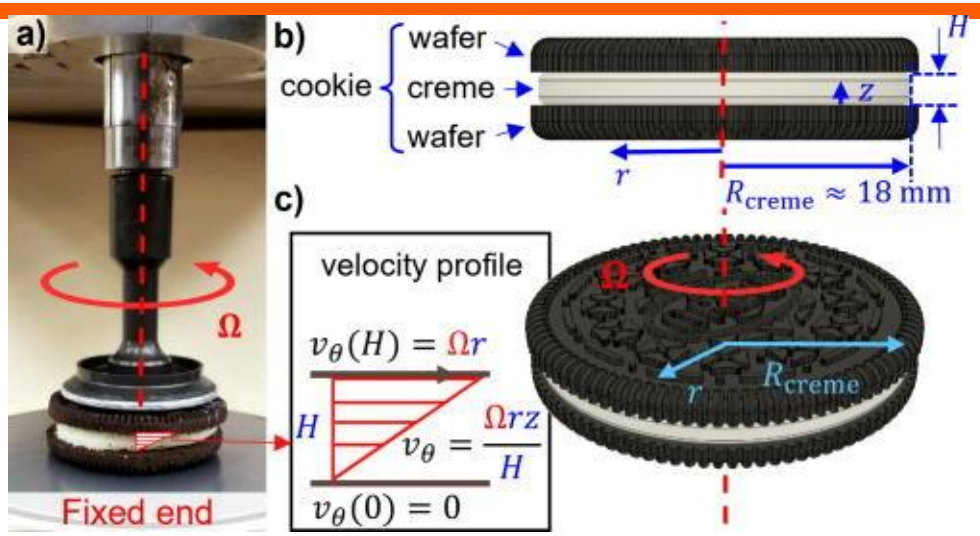
Oreology


a)
b)
c)
d)
RHEO
Left
Wafer 1
Right
Wafer 2
e)
Regular
Double Stuf
Mega Stuf
Creme location
Proportion [%]
100
80
60
40
20
0
Wafer 1
Wafer 2
Split
Broken wafer
Single wafer


a)
Ω
Fixed end
b)
cookie
wafer
creme
wafer
H
z
r
$R_{creme} \approx 18$ mm
c)
velocity profile
$v_\theta(H) = \Omega r$
H
$v_\theta = \frac{\Omega r z}{H}$
$v_\theta(0) = 0$
Ω
r
R_{creme}