ENGR 292 Fluids and Thermodynamics

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ENGR 292

- ***Notes of last week posted in***
  - *K Drive: Li\ENGR 292*
  - *Website: http://www.fireflylabs.com/disted/courses/e292(2017)/e292-index.html*
- ***D2L (under construction)***

Review of Last Class

- ***What is fluid?***
- ***Fluid vs Solid***
- ***Liquid vs Gas***

Review of Last Class

- ***Fluid Power: Hydraulics, Pneumatics***
- ***Fluid Mechanics***
  - *Fluid Statics*
  - *Fluid Dynamics*
- ***Fluid Properties***

Review of Last Class

- ***Primary Dimensions***
  - *Mass*
  - *Length*
  - *Time*
  - *Temperature*
- ***Units:***
  - *The international system of units (SI)*
  - *The U.S. Customary System (Imp)*

Review of Last Class

- ***There are many secondary dimensions***
  - *Force; Pressure*
  - *Area; Volume*
  - *Velocity; Acceleration*
  - *Density; Specific weight; Specific gravity; Specific volume*
  - *Energy; Power*
  - *Flow rate: Volume flow rate; Mass flow rate;*
  - *Viscosity: Absolute viscosity; Kinematic viscosity*
  - *Bulk Modulus*

6

Review of Last Class

- It is obvious that lots of the fluid properties are in Secondary Dimensions, such as:
  - Density (ρ);
  - Specific Weight (γ);
  - Specific Gravity (sg);
  - Specific Volume
  - Viscosity (μ):
    - Absolute viscosity (η);
    - Kinematic viscosity (ν)
  - Bulk Modulus (β)
  - More

7

Review of Last Class

- There are many important parameter in fluid mechanics are in also Secondary Dimensions, such as:
  - Pressure (P), Stress, Force
  - Flow Rate (Q) (mainly Volumetric flow rate)
  - Velocity, Acceleration
  - Area, Volume
  - Power, Energy

8

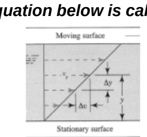
Review of Last Class

- Viscosity
  - Definition of Viscosity
  - Variation of Viscosity with Temperature
  - Viscosity Index

9

Review of Last Class

- Newtonian Fluid vs. Non-Newtonian Fluid
  - Any fluid that behaves in accordance with Fig and equation below is called Newtonian fluid.



$$\tau = \mu \frac{\Delta v}{\Delta y}$$

  - Most common fluids are classified as Newtonian fluids

10

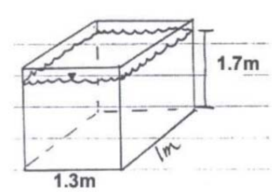
Examples

- We learnt lots of concepts
  - Fluid Properties
  - Bulk Modulus
  - Pressure
- To better understand the concepts, let's do some practices.

11

Example 1

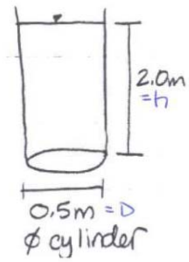
- A tank of water is open to the atmosphere, water is 4 ℃. Find:
  - Volume V
  - Density ρ
  - Mass m
  - Weight W
  - Pressure on the table p



12

Example 2

- Fluid is oil with sg of 0.92. Find
  - Volume V
  - Density ρ
  - Mass m
  - Weight W
  - Pressure on the table p



13

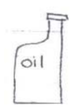
Example 3

- An unknown material has a mass of 342 g and a volume of $1.8X10^{-4}$ m^3. Find
  - Density ρ
  - Specific Gravity sg
  - Weight W
  - Specific Weight γ

14

Example 4

- Motor oil has an sg of 0.887, what volume would weight 12 N?



15

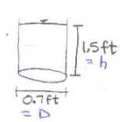
Example 5

- For mercury, γ=132,800 N/m^3. What is the volume of a 92.0g sample of mercury? What is the sg of mercury?

16

Example 6

What pressure is the bucket exerting on the table in psi? When no information is given about the fluid, assume it is water at 4 ℃.



17

Example 7

Compute the change in pressure that must be applied to water to change its volume by 1.0 %

Solution:

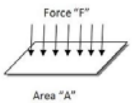
The 1.0% volume change indicates that $\frac{\Delta V}{V} = -0.01$

Then, the required change in pressure is

$E = \frac{-\Delta P}{\Delta V / V}$ → $\Delta P = -E\left(\frac{\Delta V}{V}\right) = -(316000psi)(-0.01)$
$= 3160\ psi$

18

Pressure



$$P = \frac{F}{A}$$

F: Force, A: Area, P: Pressure

SI unit of Pressure is Pascal (Pa) (N/m² Newton per square meter)
Imperial unit of Pressure is psi (lb/in² pounds per square inch)

19

Pascal's Law

Blaise Pascal
1623 - 1662

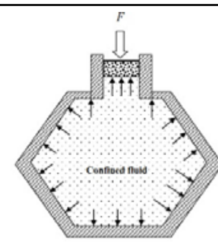


Illustration of Pascal's law

20

Powerful Hydraulic Equipment

https://www.youtube.com/watch?v=msLm4uPxTr0 ; https://en.wikipedia.org/wiki/Hydraulic_machinery

21

Pressure

F-A-P Triangle

$$F = A * P$$

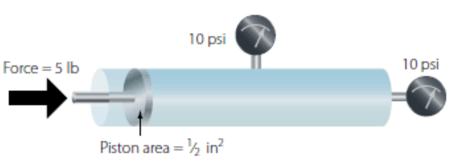
$$A = \frac{F}{P} \qquad P = \frac{F}{A}$$

F: Force, A: Area, P: Pressure

http://www.flight-mechanic.com/fluid-mechanics-pascals-law/

22

Pascal's Law



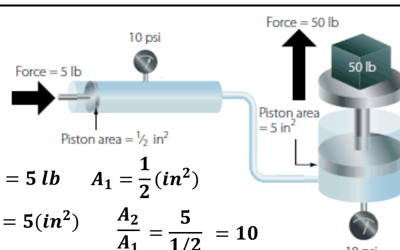
$$F = 5\ lb \qquad A = \frac{1}{2}(in^2)$$

$$P = \frac{F}{A} \rightarrow P = \frac{5\ lb}{\frac{1}{2}(in^2)} \rightarrow P = 10\ psi$$

http://www.flight-mechanic.com/fluid-mechanics-pascals-law/

23

Pascal's Law



$$F_1 = 5\ lb \qquad A_1 = \frac{1}{2}(in^2)$$

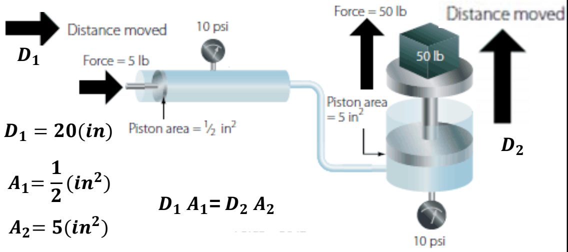
$$A_2 = 5(in^2) \qquad \frac{A_2}{A_1} = \frac{5}{1/2} = 10$$

$$P = \frac{F_1}{A_1} = \frac{F_2}{A_2} \rightarrow F_2 = \frac{A_2}{A_1}F_1 = 10F_1$$

http://www.flight-mechanic.com/fluid-mechanics-pascals-law/

24

Pascal's Law



D_1

$D_1 = 20(in)$

$A_1 = \frac{1}{2}(in^2)$

$A_2 = 5(in^2)$

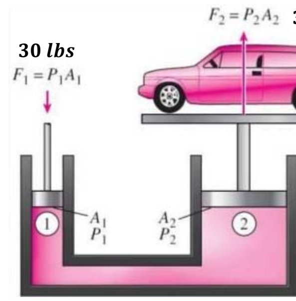
$D_1 A_1 = D_2 A_2$

D_2

$$D_2 = \frac{A_1}{A_2} D_1 = \frac{1/2}{5} D_1 = \frac{1}{10} D_1 = 2\ (in)$$

http://www.flight-mechanic.com/fluid-mechanics-pascals-law/

Example 8



$3000\ lbs$

$30\ lbs$

$A_2 = 100 A_1$

$A_1 = \pi r_1^2$

$A_2 = \pi r_2^2$

$\pi r_2^2 = 100 \pi r_1^2$

$r_2 = 10 r_1$

https://www.britannica.com/science/Pascals-principle

Summary

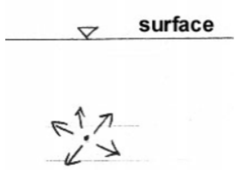
- ***By Definition:* Pressure is defined as the amount of force exerted on a unit area of a substance or on a surface.**
- ***Unit of Pressure:* Pascal (pa = N/m²) or psi (pounds per square inch)**

Summary

- ***Pascal's law / principle states that the pressure exerted anywhere in a mass of confined fluid is transmitted undiminished in all directions throughout the fluid***
- ***The working of hydraulic devices like hydraulic press and hydraulic jacks are based on this principle***

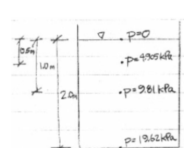
More on Fluid Pressure

- ***At any point, pressure is the same in all directions***



More on Fluid Pressure

- ***Pressure increases linearly with depth (for a fluid standing still)***



$$p = \frac{w}{A} = \frac{mg}{A}$$

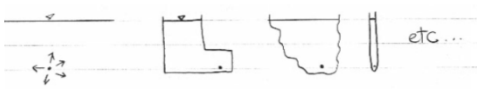
$$= \frac{\rho V g}{A} = \rho g \frac{V}{A}$$

$$= \rho g h = \gamma h$$

$p = \gamma h$

More on Fluid Pressure

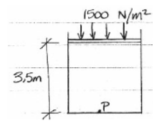
- ***Pressure is independent of the shape of the vessel or the shape of the water above the point.***



$$p = \gamma h$$

More on Fluid Pressure

- ***Any pressure on the surface of the water (other than the atmosphere) is directly added on the fluid pressure.***



Find the pressure at point P:

$p = \gamma\, h + 1500 N/m^2$

$= 9810\ N/m^3 \times 3.5m + 1500N/m^2$

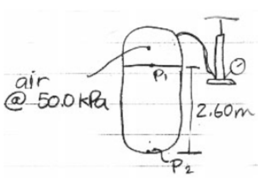
$= 34{,}355 + 1500$

$= 35{,}835\ N/m^2$ or Pa

$= 35.835$ kPa

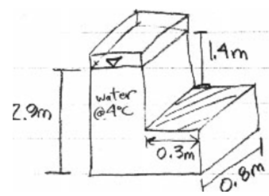
Example 9

The liquid is oil (sg=0.9), what is the pressure at P1 and P2?



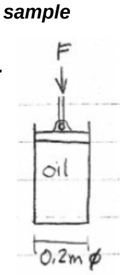
Example 10

Calculate the force on the shaded area from the water pressure.



Example 11

Before any force is applied the volume of the sample of oil is 1.000L. A force, F, is applied causing the pressure to rise to 4000 psi or 27,579 kpa. Calculate the new volume and the magnitude of force F. Perform your calcs in both metric and imperial.



What is next?

- ***Any Questions?***
- ***Due day of Assignment 1: TBD***
- ***Next class, we will continue on Fluid Statics***
- ***See you this Friday, Jan.20 at CBA 120***