ENGR 292 Fluids and Thermodynamics

Scott Li, Ph.D., P.Eng.
Mechanical Engineering Technology
Camosun College

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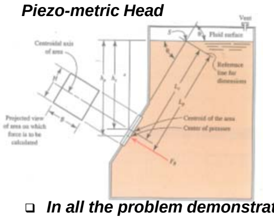
ENGR 292

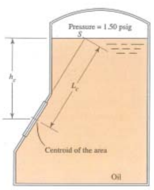
- **Course Schedule (see attached revised course schedule for details)**
  - *Fluid Statics*
  - *Fluid Dynamics*
  - *Midterm (Feb.28)*
  - *Thermodynamics*
  - *Others (pending)*
  - *Final (Apr.18, Tentative)*

Review of Last Class

Piezo-metric Head

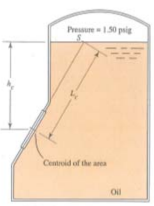


Vs.

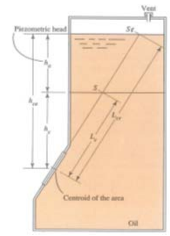


- *In all the problem demonstrated so far, the free surface of the fluid was exposed to the ambient pressure, where p=0 (gage).*
- *A change is required in our procedure if the pressure above the free surface of the fluid is different from the ambient pressure outside the area.*

Review of Last Class



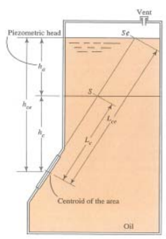
$$h_a = \frac{p_a}{\gamma}$$



Showing piezometric head equivlent to pressure above oil

Review of Last Class

- *The convenient method would be to use the concept of piezo-metric head, in which the actual pressure above fluid p_a, is converted into an equivalent depth of the fluid, h_a, that would create the same pressure.*



Review of Last Class

- **Buoyancy Material**
- **Buoyancy Material Desired Properties**

Review of Last Class

- **Stability**
  - *Completed Submerged Bodies*
  - *Floating Bodies*

A body in a fluid is considered stable if it will return to its original position after being rotated a small amount about a horizontal axis.

Review of Last Class

- **Important Concepts:**
  - *Center of Gravity (cg)*
  - *Center of Buoyancy (cb)*

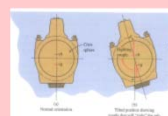
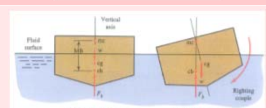
Review of Last Class

- **Important Concepts:**
  - *Metacenter (mc): the intersection of the vertical axis of a body when in its equilibrium position and a vertical line through the new position of the center of buoyancy (cb) when the body is rotated slightly.*
  - *MB: the distance from the center of buoyancy (cb) to the metacenter (mc)*

$$MB = \frac{I}{V_d}$$

Review of Last Class

- **Criteria of Stability**

Bodies	Criteria of Stability	
Completely Submerged	The center of gravity (cg) is below the center of buoyancy (cb)	
Floating	The center of gravity (cg) is below the metacenter (mc)	

Review of Last Class

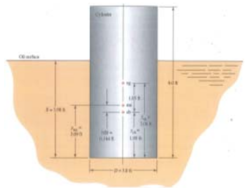
- **Procedure for Evaluating the Stability of Floating Bodies**
  - *Determine the position of the floating body, using the principles of buoyancy*
  - *Locate the center of buoyancy, cb; compute the distance from some reference axis to cb, called y_{cb}. Usually, the bottom of the object is taken as the reference axis.*
  - *Locate the center of gravity, cg; compute y_{cg} measured from the same reference axis.*

Review of Last Class

- **Procedure for Evaluating the Stability of Floating Bodies**
  - *Determine the shape of the area at the fluid surface and compute the smallest moment of inertia I for that shapes.*
  - *Compute the displaced volume V_d*
  - *Compute MB = I/V_d*
  - *Compute $y_{mc} = y_{cb} + MB$*
  - *If $y_{mc} > y_{cb}$, the body is stable*
  - *If $y_{mc} < y_{cb}$, the body is unstable*

Example 19

- *A solid cylinder is 3.0ft in diameter, 6.0 ft high, and weighs 1550 lb. If the cylinder is placed in oil (sg=0.9) with its axis vertical, would it be stable?*



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Review of Fluid Statics

- **Key Equations:**
  - Pressure:

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

  - Weight-Mass Relationship:

$$W = mg$$

  - Bulk Modulus:

$$E = \frac{-\Delta P}{\frac{\Delta V}{V}}$$

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Review of Fluid Statics

- **Key Equations:**
  - Density:

$$\rho = \frac{m}{V}$$

  - Specific Weight:

$$\gamma = \frac{W}{V}$$

  - Specific Gravity

$$sg = \frac{\gamma_s}{\gamma_w @ 4°\text{C}} = \frac{\rho_s}{\rho_w @ 4°\text{C}}$$

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Review of Fluid Statics

- **Key Equations:**
  - $\gamma - \rho$ relation:

$$\gamma = \rho g$$

  - Dynamic Viscosity:

$$\eta = \frac{\tau}{\frac{\Delta v}{\Delta y}} = \tau\left(\frac{\Delta y}{\Delta v}\right)$$

  - Kinematic Viscosity:

$$v = \frac{\eta}{\rho}$$

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Review of Fluid Statics

- **Key Equations:**
  - Absolute and Gage Pressure

$$P_{abs} = P_{gage} + P_{atm}$$

  - Pressure-Elevation Relationship

$$\Delta p = \gamma h$$

  - Resultant force on a rectangular wall

$$F_R = \gamma\left(\frac{h}{2}\right)A$$

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Review of Fluid Statics

- **Key Equations:**
  - Location of Center of Pressure

$$L_p = L_c + \frac{I_c}{L_c A}$$

  - Buoyant force

$$F_b = \gamma_f V_d$$

  - Piezometric Head

$$h_a = p_a/\gamma$$

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Assignment 1

- **Due: Midnight tonight!**
  - D2L Dropbox
  - Format: PDF?

ENGR 292

- **Fluid Dynamics**
  - Start with an Example (a project)
  - Talk about the concepts, principles and equations during the problem-solving
  - You need to read books or other references of fluid dynamics to brush up on your memory to fully understand all the relevant stuffs, such as:
    - Control volume analysis
    - Bernoulli's Equation
    - Navier-Stokes Equation (NS Equation)
    - …

Fluid Dynamics

- Fluid statics dealt mostly with fluids at rest.
- Fluid dynamics deals with moving fluids, and primary emphasis is placed on the flow of fluids through pipes or tubes.

Fluid Dynamics

- You will learn several fundamental principles.
- Your ultimate goal is to build your knowledge and skills that are needed to design and analyze the performance of pumped piping systems.

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Fluid Dynamics

- **Fluid flow rate:**
  - Volume flow rate $Q = Av$
  - Weight flow rate $W = \gamma Q = \gamma A v$
  - Mass flow rate $M = \rho Q = \rho A v$

Fluid Dynamics

- ***Principle of continuity***
  - ***The method of calculating the velocity of flow of a fluid in a closed pipe system depends on the principle of continuity***
  - ***Continuity Equation for Any Fluid:***

$$\rho_1 A_1 v_1 = \rho_2 A_2 v_2$$

  - ***Continuity Equation for Liquids***

$$A_1 v_1 = A_2 v_2$$

Or

$$Q_1 = Q_2$$

Fluid Dynamics

- ***Three kinds of energy in fluid***
  - ***Kinetic energy***
  - ***Potential energy***
  - ***Flow energy***

Fluid Dynamics

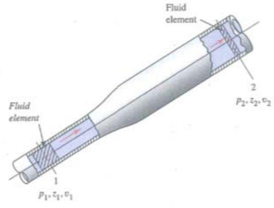
- ***Bernoulli's equation***
  - ***Based on the principle of conservation of energy***
  - ***As we know:***
    - ***Energy can be neither created or destroyed***
    - ***But it can be transformed from one form into another***
  - ***Restrictions on its use.***

Fluid Dynamics

- ***Restrictions on Bernoulli's Equation***
  - ***It is valid only for incompressible fluids***
  - ***There can be no mechanical devices between two sections of interest***
  - ***There can be no heat transferred into or out of the fluid***
  - ***There can be no energy lost due to friction***

Fluid Dynamics

- ***Fluid elements used in Bernoulli's equation:***



Fluid Dynamics

- ***Bernoulli's Equation:***

$$\frac{p_1}{\gamma} + z_1 + \frac{v_1^2}{2g} = \frac{p_2}{\gamma} + z_2 + \frac{v_2^2}{2g}$$

Fluid Dynamics

- ***In reality no system satisfies all these restriction.***
- ***However, there are many systems for which only a negligible error will result when Bernoulli's equation is used.***

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Fluid Dynamics

- ***Applications of Bernoulli's Equation***

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Fluid Dynamics

- ***Commercially available pipe and tubing***
- ***Specifying piping and tubing for a particular application is the responsibility of the designer (engineer, technologist, etc.) and it has significant impact on***
  - ***Cost***
  - ***Life,***
  - ***Safety***
  - ***Performance of the system***

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Fluid Dynamics

- ***For many applications, codes and standards, and specifications must be followed.***
  - ***Industry***
    - ***Oil and Gas: High pressure, High Temperature***
    - ***Mining:***
  - ***Residency: Plumbing***

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Fluid Dynamics

- ***Steel Pipes, NPS (Nominal Pipe Size)***
- ***Hydraulic Hoses***

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Fluid Dynamics

- ***Nomenclature of Energy Losses and Addition***
  - h_A***: Energy added to the fluid with a mechanical device such as a pump; this is often referred to as the total head on the pump***
  - h_R ***: Energy removed from the fluid by a mechanical device such as fluid motor***
  - h_L ***: Energy losses from the system due to friction in pipes or minor losses due to valves and fittings.***

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Fluid Dynamics

- ***General Energy Equation***

$$\frac{p_1}{\gamma} + z_1 + \frac{v_1^2}{2g} + h_A - h_R - h_L = \frac{p_2}{\gamma} + z_2 + \frac{v_2^2}{2g}$$

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What is next?

- ***Any Questions?***
- ***Next class, we will continue on Fluid Dynamics***

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