ENGR 292 Fluids and Thermodynamics

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ENGR 292

- **D2L (ready)**
  - Assignment 1 (ready)
  - Submission (ready); Grading (ready)
  - Notes (ready)

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Review of Last Class

- **Examples (9-12) with given conditions to obtain the Pressures**

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Review of Last Class

- **Absolute and Gage Pressure (a good question)**
  - When making calculations involving pressure in fluid, you must make the measurements relative to some reference pressure
  - Normally the reference pressure is that of the atmosphere, and the resulting measured pressure is called gage pressure.

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Review of Last Class

- **Absolute and Gage Pressure**
  - Pressure measured relative to a perfect vacuum is called absolute pressure.

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Review of Last Class

- **Absolute and Gage Pressure**

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

where
P_{abs} = Absolute pressure
P_{gage} = Gage pressure
P_{atm} = Atmospheric pressure

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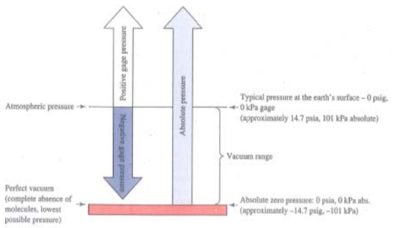
Review of Last Class

- **_Absolute and Gage Pressure_**



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Review of Last Class

- **_Absolute and Gage Pressure_**
  - **_A perfect vacuum is the lowest possible pressure. Therefore, an absolute pressure will always positive_**
  - **_A gage pressure above atmospheric pressure is positive_**
  - **_A gage pressure below atmospheric pressure is negative, sometimes called vacuum_**

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Review of Last Class

- **_Absolute and Gage Pressure_**
  - **_Gage pressure will be indicated in the units of Pa (gage) or psig._**
  - **_Absolute pressure will be indicated in the units of Pa (abs) or psia_**
  - **_The magnitude of the atmospheric pressure varies with location and with climatic conditions._**

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Review of Last Class

- **_Absolute and Gage Pressure_**
  - **_In the course, we will assume the atmospheric pressure to be 101 kpa (abs) or 14.7 psia._**

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Example 13

- **_Express a pressure of 155 kPa (gage) as an absolute pressure. The local atmospheric pressure is 98 kPa (abs)_**
- **_Solution:_**

$$P_{abs} = P_{gage} + P_{atm}$$
$$= 155kPa\ (gage) + 98\ kPa\ (abs) = 253\ kPa\ (abs)$$

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Example 14

- **_Express a pressure of 225 kPa (abs) as a gage pressure. The local atmospheric pressure is 101 kPa (abs)_**
- **_Solution:_**

$$P_{abs} = P_{gage} + P_{atm}$$
$$P_{gage} = P_{abs} - P_{atm}$$
$$= 225kPa\ (abs) - 101\ kPa\ (abs)$$
$$= 124kPa\ (gage)$$

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Example 15

- **_Express a pressure of 10.9 psia as a gage pressure. The local atmospheric pressure is 15 psia._**
- **_Solution:_**

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

$P_{gage} = P_{abs} - P_{atm} = 10.9\, psia - 15.0\, psia = -4.1\, psig$

Notice that the result is negative. This can be also be read "4.1 psi below atmospheric pressure" or "4.1 psi vacuum"

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Example 16

- **_Express a pressure -6.2 psig as an absolute pressure._**
- **_Solution:_**

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

Because no value was given for the atmospheric pressure, we will use $P_{atm} = 14.7 psia$

$P_{abs} = P_{gage} + P_{atm} = -6.2\, psig + 14.715.0\, psia = 8.5\, psia$

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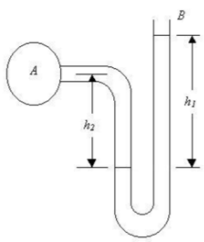
Review of Last Class

- **_Manometer – Pressure Measurement; As a default, we use gage pressure._**



$$p_A = p_B + \gamma_B h_1 - \gamma_A h_2$$

_If_ $P_B = P_{atm} = 0\ psig$

$P_A = gage\ pressure$

_If_ $P_B = P_{atm} = 14.7\ psia$

$P_A = Absolute\ pressure$

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Review of Last Class

- **_Forces due to statics Fluids_**
  - **_Vertical Rectangular Wall_**
    - **_Average Pressure (P_{avg})_**

$$P_{avg} = \gamma\left(\frac{h}{2}\right)$$

    - **_Magnitude of the Force_**

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

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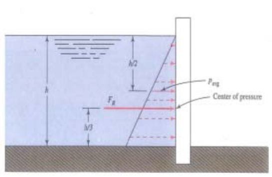
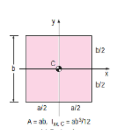
Review of Last Class

- **_Forces due to statics Fluids_**
  - **_Vertical Rectangular Wall_**
    - **_Center of Pressure_**

$$y_{cp} = \bar{y} + \left(\frac{I}{A\bar{y}}\right)$$





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Review of Last Class

- **_Buoyancy_**
  - **_The principles were discovered by the Greek_**
  - **_Definition: A body in a fluid, whether floating or submerged, is buoyed up by an upward force equal to the weight of the fluid displaced by the object_**

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Review of Last Class

- **Buoyant Force:**

$$F_b = \gamma_f V_d$$

where

F_b = Buoyant force

γ_f = Specific weight of the fluid

V_d = Displaced volume of the fluid

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Review of Last Class

- **Weight of the object:**

$$W = \gamma_o V_o$$

where

W = Weight of the object

γ_o = Specific weight of the object

V_o = The volume of the object

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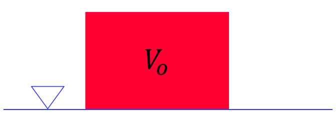
Review of Last Class

- **Object above the surface of the fluid:**



Fluid $V_d = 0$

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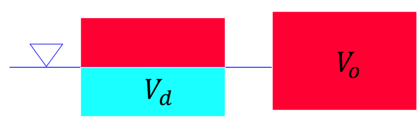
Review of Last Class

- **Object partially submerged into the fluid:**



Fluid $V_d < V_o$

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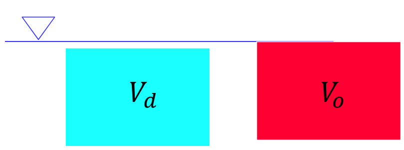
Review of Last Class

- **Object fully submerged into the fluid:**



Fluid $V_d = V_o$

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Review of Last Class

Float or Sink?

As we know: $0 \le V_d \le V_o$

Therefore:

Max Buoyancy: $F_{bmax} = \gamma_f V_o$

Min Buoyancy: $F_{bmin} = 0$

Forces	Specific Weight	Float or Sink
$F_{bmax} > W$	$\gamma_f > \gamma_d$	Float
$F_{bmax} = W$	$\gamma_f = \gamma_d$	Anywhere: Float or Sink
$F_{bmax} < W$	$\gamma_f < \gamma_d$	Sink

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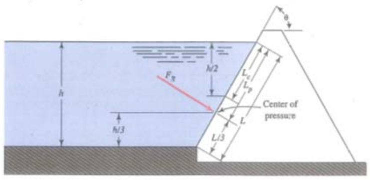
Forces due to static Fluids

- ***Inclined Rectangular Wall***
  - *Center of Pressure (example 4.5)*



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Forces due to static Fluids

- ***Inclined Rectangular Wall***
  - ***Average Pressure (P_{avg})***

$$P_{avg} = \gamma(\frac{h}{2})$$

  - ***Magnitude of the Force***

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

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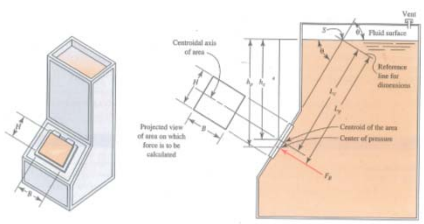
Submerged plane Areas - General

- ***Either Vertical or Inclined Rectangular Wall***



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Submerged plane Areas - General

- ***Details:***
  - ***F_R Resultant force on the area due to the fluid pressure.***
  - ***θ Angle of inclination of the area***
  - ***h_c Depth of fluid from the free surface to the centroid of the area***
  - ***L_c Distance from the level of the free surface of the fluid to the centroid of the area, measured along the angle of inclination of the area***

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Submerged plane Areas - General

- ***Details:***
  - ***L_p Distance from the level of the free surface of the fluid to the center of pressure of the area, measured along the angle of inclination of the area***
  - ***h_p Vertical distance from the free surface to the center of pressure of the area***
  - ***B, H Dimensions of the area***

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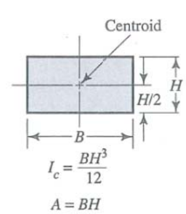
Submerged plane Areas - General

- ***Details:***
  - $F_R = \gamma h_c A$
  - $L_p = L_c + \frac{I_c}{L_c A}$
  - $h_P = L_p sin\theta$
  - $h_P = h_c + \frac{I_c \sin^2\theta}{h_c A}$



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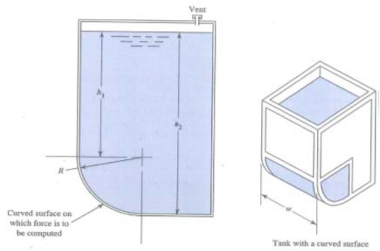
Submerged Curved Surface

- ***Tank with a curved surface containing a static fluid***



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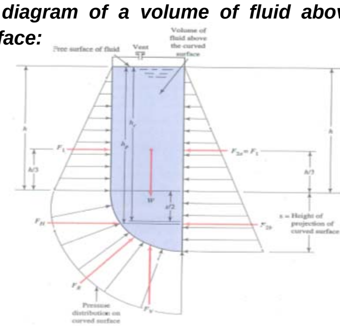
Submerged Curved Surface

- ***Free-body diagram of a volume of fluid above the curved surface:***



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Submerged Curved Surface

- ***Horizontal Component***

$F_H = F_{2b}$

$F_{2b} = \gamma h_c A = \gamma s w (h + \frac{s}{2})$

$h_p - h_c = I_c/(h_c A)$

$I_c = w s^3/12$

$A = sw$

$$h_p - h_c = I_c/(h_c A) = \frac{ws^3}{12(h_c)(sw)} = \frac{s^2}{12h_c}$$

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Submerged Curved Surface

- ***Vertical Component***

$$F_V = \gamma(volume) = \gamma A_v w$$

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Submerged Curved Surface

- ***Resultant Force***

$$F_R = \sqrt{F_H^2 + F_V^2}$$

The resultant force acts at angle ϕ relative to the horizontal found from:

$$\phi = \tan^{-1}(F_V/F_H)$$

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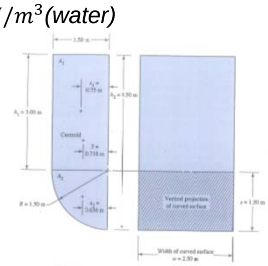
Example 17

- ***Given:*** $h_1 = 3.00\ m;\ h_2 = 4.50\ m;\ w = 2.50\ m;$ $\gamma = 9.81\ kN/m^3$*(water)*



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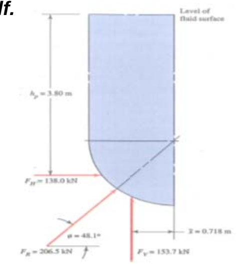
Example 17

- *Compute the horizontal and vertical components of the resultant force on the curved surface and the resultant force itself.*



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Assignment 1

- ***Due: Midnight Jan.31, 2017***
  - *D2L Dropbox*

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What is next?

- ***Any Questions?***
- ***Next class, we will wrap up the Fluid Statics***
  - *Buoyancy Stability and anything left*

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