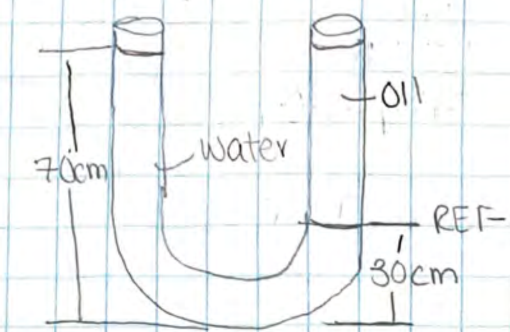
Amber Samm
MET 330
Test 1

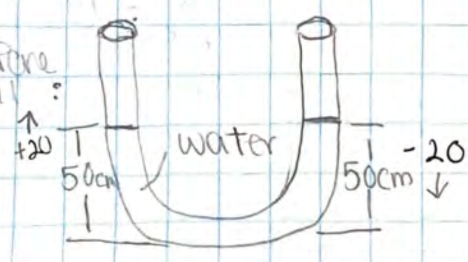
#1

Purpose: Determine the height of each fluid in the right arm of U-tube.

Drawing:



Before oil:



Sources:

MOTT, ROBERT L; UNTENER, JOSEPH A., APPLIED FLUID MECHANICS, 7th, 2015: SECTIONS 3.4, 3.6, APPENDIX A: Properties of Water

Data

$\rho_{oil} = 790 kg/m^3$ $\quad h_{w_{left}} = 0.7m$

$\rho_{water} = 1000 kg/m^3$

Design Considerations/Assumptions:

1. The densities of the fluid are different
2. The fluids do not mix
3. The diameter of the U-tube is uniform
4. The water in right arm moves down = distance that water in left arm moves up

Procedure:

- Choose reference
- Determine Equations

$P_L = P_R \qquad P = \rho g h$

Calculations:

$\rho_L \cdot \cancel{g} \cdot h_L = \rho_R \cdot \cancel{g} \cdot h_R$

$1000 kg/m^3 \cdot (.70m - .30m) = 790 kg/m^3 \cdot h_{oil}$

$400 kg/m^4 = 790 kg/m^3 \cdot h_{oil}$

$\boxed{0.506m = h_{oil}}$

h_{water_L} $50 + x = 70$, $x = 20cm$

h_{water_R} $50 - 20 = 30cm = 0.3m$

Materials: water, oil

Summary:

The height of the water in the right arm of the tube is 0.3m and the height of the oil is 0.506m.

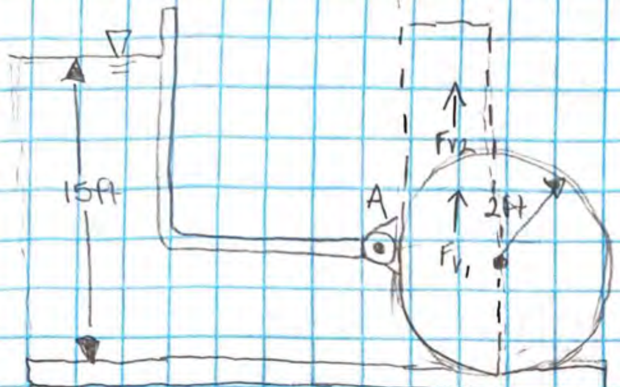
Analysis:

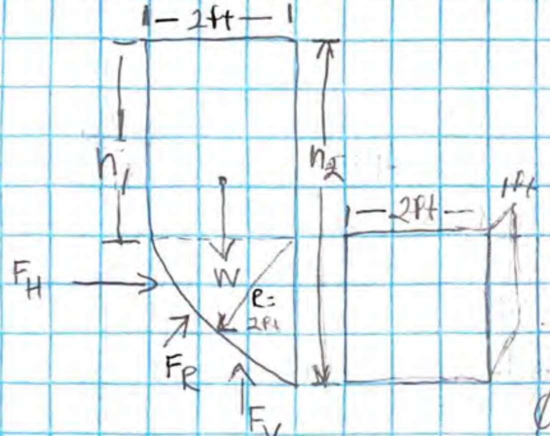
The water and oil are in equilibrium so we know that $P_L = P_R$; because both ends are open to atmosphere the atmospheric pressure cancels out. If one end were closed atmospheric pressure and gravity would not cancel and we would have to account for the pressure in the closed end.

#2 Purpose:

(a) determine the hydrostatic force acting on cylinder + line of action as gate opens
(b) weight of cylinder per ft length of cylinder

Drawing:





Sources:

MOTT, Robert L.; UNTENER, Joseph A., Applied Fluid Mechanics, 7th, -, 2015.
Section: 4.8, 4.10, 4.11

Materials: water

Data

$r = 2ft$

$\rho_{water} = 62.4 lb/ft^3$

$centroid = \frac{4r}{3\pi} = \frac{4(2)}{(3\pi)} = 0.849 ft$

Design considerations:

① curved surfaces must be broken into horizontal and vertical components.
② Incompressible Fluid

$\phi = \tan^{-1}\left(\frac{F_V}{F_H}\right) = \tan^{-1}\left(\frac{1818.4 lb}{1747.2 lb}\right) = \boxed{46.14°}$

$F_R = \sqrt{F_H^2 + F_V^2} = \sqrt{1747.2 lb^2 + 1818.4 lb^2} =$

$\boxed{= 2521.76 lb}$

$\Sigma M_A = 0 = -F_V(r) + W(r)$

$F_V \cancel{(r)} = W \cancel{(r)}$

$\boxed{1818.4 lb = W}$

Procedure:

Determine equations: $\Sigma M = 0$

$F_H = \rho g A h'$ (hydrostatic force)

$F_V = \gamma A w$ $\quad F_R = \sqrt{F_H^2 + F_V^2}$

$\phi = \tan^{-1}(F_V / F_H)$ $\quad h_p - h_c = \frac{ws^3}{12(h_c)(sw)}$

Calculations:

$F_H = \rho g A h' = 62.4 lb/ft^3 \times (2 \times 1) \times 14 ft$
$= 1747.2 lb$

$h_p = \frac{(1)(2)^3}{12(2)(14)} + 14 = 14.0238 ft$

$F_{V_1} = 62.4 lb/ft^3 \left(\frac{\pi (2ft)^2}{4}\right) = 196.04 lb$

$F_{V_2} = 62.4 lb/ft^3 (2 \times 13 \times 1) = 1622.4 lb$

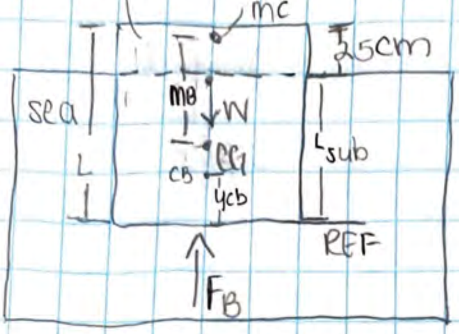
$F_{V net} = 1818.44 lb$

Summary: (a) The hydrostatic force is 2521.76 lb and line of action is 46.14°. (b) the W of cylinder is 1818.4 lb per foot length.

Analysis: The surface is curved so therefor we break the forces into horizontal and vertical components to solve. If the depth increased the pressure at point A would increase as well. If we used a less dense liquid, the depth would have to increase to move cylin

#3 Purpose: Determine whether the cubic ice block is stable.

Drawing:



$W_{ice} = F_B$

Sources:
MOTT, ROBERT L.; UNTENER, Joseph A., APPLIED FLUID MECHANICS, 7th, , 2015
Section 5.5

Data
$h_{above} = 25cm = 0.25m$
$h_{below} = L - 25cm$
$sg_{ice} = 0.89$
$sg_{water} = 1.035$

Procedure: choose reference point
Determine appropriate equations:
$MB = I / V_d$ $\quad y_{cg} = \frac{L}{2}$
$y_{mc} = y_{cb} + MB$ $\quad \rho V g = \rho V g$

Design considerations:
① specific gravity is proportional to density
② upward buoyant force = weight for floating bodies

Materials: seawater, ice

Calculation:
$sg_{ice} \cdot L^3 = sg_{water} \cdot L^2 \cdot L_{sub}$
$sg_{ice} \cdot L = sg_{water} \cdot (L - 25)$
$0.89L = 1.035(L - 25)$
$0.89L = 1.035L - 25.875$
$25.857 = 0.145L \quad L = 178.45cm$
$L_{sub} = 178.45cm - 25cm = 153.45cm$

$y_{cg} = \frac{178.45}{2} = 89.22cm = 0.892m$
$y_{cb} = \frac{153.45}{2} = 70.725cm = 0.767m$
$MB = I / V_d$
$= \frac{0.836m^4}{4.84m^3}$
$= 0.1728m$

$V_d = L^2 \cdot L_{sub} = (1.78m)^2 \cdot (153m)$
$= 4.84m^3$
$I = \frac{L \cdot L^3}{12} = \frac{(1.78m)^4}{12} = 0.836m^4$

$y_{mc} = y_{cb} + MB = 0.767m + 0.1728m =$
$y_{mc} = 0.940m$

$y_{mc} > y_{cg}$ ✓ YES - Body is stable.

Analysis:

The iceblock is stable because its metacenter is located above its center of gravity. If the shape were a rectangle and not a cube moment of inertia would decrease potentially causing instability, due to a lower metacenter.

Summary;
Since y_{mc} is greater than y_{cg}, the body is stable.