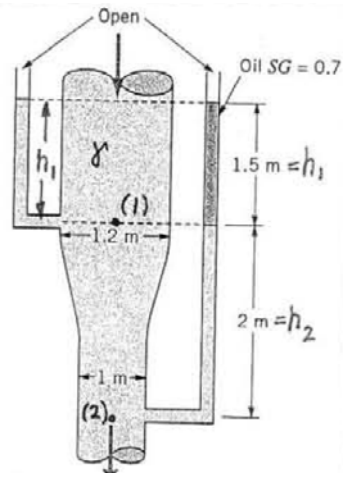
ID:---------- Midterm 1 Time: 50 minutes

Name: ---------- Course: 58:160, Fall 2009

Solutions:

1) Total=10 points



(3) $\frac{p_1}{\gamma}+\frac{V_1^2}{2g}+z_1=\frac{p_2}{\gamma}+\frac{V_2^2}{2g}+z_2$ (1)

(1) $z_1-z_2=2m$ (2)

(2) $A_2V_2=A_1V_1 \Rightarrow D_2^2V_2=D_1^2V_1$ (3)

(0.5) $\Rightarrow V_1=0.694V_2$

$p_1=\gamma h_1;\ p_2=\gamma h_2+\gamma_{oil}h_1 \Rightarrow$

(2) $\frac{p_2-p_1}{\gamma}=(h_2-h_1)+\frac{\gamma_{oil}}{\gamma}h_1$ (4)

(0.5) $=2-1.5+0.7\times1.5=1.55m$

(1), (2), (3), and (4)>>>>>>>>>>>>

(0.5) $V_2=4.13\ \ m/s$

(0.5) $\Rightarrow Q=\frac{\pi D_2^2}{4}V_2=3.24\ m^3/s$

2) Total=10 points

(1) $\sum F_x=\sum \dot{m}_{out}^i V_{out_x}^i-\sum \dot{m}_{in}^i V_{in_x}^i$ (1)

(1) $\sum F_z=\sum \dot{m}_{out}^i V_{out_z}^i-\sum \dot{m}_{in}^i V_{in_z}^i$ (2)

(1.5) $\dot{m}_{out}=\dot{m}_{in}=\rho Q=1000\times0.001=1\ kg/s$ (3)

(0.5) $V_{out}=V_{in}=Q/A=\frac{0.001}{\pi 0.02^2/4}=3.183\ m/s$ (4)

(0.5) $V_{out_x}=V_{in_z}=0$ (5)

(2.0) $\sum F_x = R_x + p_{gage}A = R_x + 30000 \times \pi 0.02^2 / 4$

(0.5) $= R_x + 9.42$ (6)

(2) $\sum F_z = R_z - W_{water+faucet} = R_z - 6$ (7)

(1),(3),(4),(5),(6)>>>>>>>>>>>>>>>>>>>>>>

(0.5) $\sum F_x = R_x + 9.42 = 1 \times (0 - 3.183) \Rightarrow R_x = -12.61 \ N$

(2),(3),(4),(5),(7)>>>>>>>>>>>>>>>>>>>>>>

(0.5) $\sum F_z = R_z - 6 = 1 \times (-3.183 - 0) \Rightarrow R_z = 2.817 \ N$

3) Total=10 points

(2) $\sum M = \sum_{out} \dot{m} r V - \sum_{in} \dot{m} r V$ (1)

(1.5) $\dot{m}_{nozzle} = \dot{m}_{total/4} = \rho Q = 1000 \times 0.02 / 4 = 5 \ kg/s$ (2)

(1) $V_{nozzle} = \dot{m}_{nozzle} / \rho A = 5 / (1000 \times \pi 0.01^2 / 4) = 63.66 \ m/s$ (3)

(1) $V_{sprinkler} = r\omega = 0.6 \times 2\pi / 60 \times 300 = 18.85 \ m/s$ (4)

(1.5) $V_{relative} = V_{nozzle} - V_{sprinkler} = 44.81 \ m/s$ (5)

(1),(2),(3),(4),(5)>>>>>>>>>>>>>>>>>>>>>>

(1.5) $\sum M = T = 4\dot{m}_{nozzle} r V_{relative} = 537.72 \ N.m$

(1.5) $P = T\omega = 537.72 \times (300 \times 2\pi / 60) = 16.9 \ KW$