(6)

Fluid Mechanics Past Year Paper Solution April / May 2015

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1. a. $F = 10^6$ N

Cylinder ⌀ $d = 0.2$ m

$h_o = 300$ mm $K_o = 1500 \times 10^6$ Pa

$h_w = 600$ mm $K_w = 2150 \times 10^6$ Pa

$\Delta P = -K \, \Delta V / V$

$\Leftrightarrow \Delta P = -K_o \dfrac{\Delta V_o}{V_o} = -K_w \dfrac{\Delta V_w}{V_w}$

$\dfrac{10^6}{\frac{1}{4}\pi 0.2^2} = -1500 \cdot 10^6 \dfrac{\Delta h_o}{300} = -2150 \cdot 10^6 \dfrac{\Delta h_w}{600}$

$\Delta h_o = 6.37$ mm

$\Delta h_w = 8.88$ mm

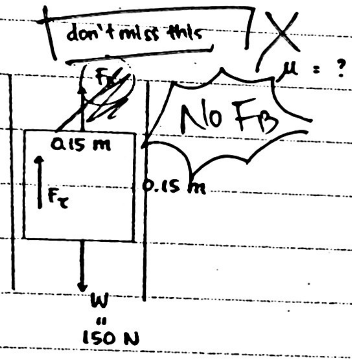
$\therefore \Delta h_{total} = 6.37 + 8.88 = 15.25$ mm

b. Cylinder.

$v = 1$ m/s

$a = 1$ m/s²

$S = 0.05$ mm



$\Sigma F = m \times a$

$W - \cancel{F_B} - F_\tau = m \times a$ friction FBD! selimut

$W - \cancel{\rho g V_i} - \mu \cdot \frac{V}{S} \times \pi d h = \frac{W}{g} \times a$

$150 - \cancel{860 \times 9.81 \times \frac{1}{4}\pi 0.15^2 \, 0.15} - \mu \frac{1}{5 \times 10^{-5}} \times \pi 0.15^2 = \frac{150}{9.81}$

$150 - \cancel{22.3631} - 1413.7167\,\mu = 15.2905$

$\therefore \mu = 0.0795$ Ns/m²

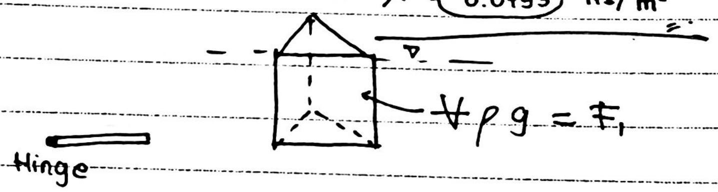
0.09529 Ns/m²

c. $P_{left} = P_{right}$

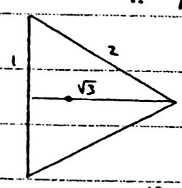
$\rho_w g h_w = \rho_w g h_w + \rho g h$

$1000 \times 0.2 = 1000 \times 0.05 + \rho \times 0.1$

$\therefore \rho = 1500$ kg/m³



d.



$F_h = \rho g A_\Delta h_c$

$F_h = 900 \times 9.81 \times \frac{1}{2} \times \cancel{1}\sqrt{3} \times 2$

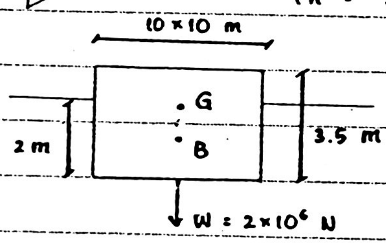
$F_h = 30585$ N

$\Sigma M = 0$ centroid of Δ

$30585 \times \frac{1}{3}\sqrt{3} = F\sqrt{3}$

$\therefore F = 10195$ N

e.



→ $G = 2$ m

→ $F_B = W$

$\rho g A h = 2 \times 10^6$

$h = \dfrac{2000\,000}{1025 \times g \times 100} = 1.989$ m

$\therefore B = \frac{1}{2} h = 0.9945$ m

↳ $BG = 1.0055$ m

$\frac{1}{12} bh^3$, h is the shorter one.

→ $BM = \dfrac{I_{yy}}{V_i} = \dfrac{\frac{1}{12}\, 10 \times 10^3}{100 \times 1.989} = 4.1897$ m

$\therefore$ Since $BG < BM \Rightarrow$ Stable!

If you wish to have my other solution for CV1012 PYPs

2. a. $\rho_m g h_m = P_1 + \rho_w g h_w$

$13600 \times 9.81 \times 0.05 = P_1 + 1000 \times 9.81 \times 0.1$

$\therefore P_1 = 5689.8 \text{ Pa}$

Continuity : $v_1 A_1 = v_2 A_2$

$v_1\, 100^2 = v_2\, 30^2$

$v_2 = \frac{100}{9} v_1$

Bernoulli : $\frac{5689.8}{\rho g} + \frac{v_1^2}{2g} + 0 = 0 + \frac{v_2^2}{2g} + 0.2$

$0.58 - 0.2 = \frac{\frac{10000}{81} - 1}{2g} v_1^2$

$0.38 = 6.2414\, v_1^2$

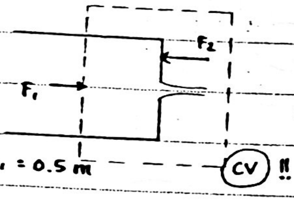
$\therefore v_1 = 0.2467 \text{ m/s}$

$Q_2 = Q_1 = A_1 v_1$

$Q_2 = \frac{1}{4}\pi\, 0.1^2 \times 0.2467$

$\therefore Q_2 = 1.9379 \times 10^{-3} \text{ m}^3/\text{s}$

b.



$d_1 = 0.5 \text{ m}$ CV !!

$\left.\begin{array}{l} d_2 = 0.05 \text{ m} \\ Q = 0.05 \text{ m}^3/\text{s} \end{array}\right\}$ $v_2 = \frac{0.05}{\frac{1}{4}\pi\, 0.05^2} = 25.46 \text{ m/s}$

$v_1 \times 0.5^2 = v_2 \times 0.05^2$

$v_1 = 0.2546 \text{ m/s}$

Bernoulli : $\frac{P_1}{\rho g} + \frac{0.2546^2}{2g} = \frac{25.46^2}{2g}$

$F_1 / A_1 = 324073$

$F_1 = 324073 \times \frac{1}{4}\pi\, 0.5^2$

$F_1 = 63632 \text{ N}$

Momentum Eqn : $F_1 - F_2 = \rho Q (v_2 - v_1)$ → there is F_1 cz It is a close conduit.

$63632 - F_2 = 1000 \times 0.05\, (25.46 - 0.2546)$

$\therefore F_2 = 62372 \text{ N}$

3. a. Flow governed by gravity → Froud num. similarity

$\frac{v_m}{\sqrt{g L_m}} = \frac{v_p}{\sqrt{g L_p}}$

$\frac{v_p}{v_m} = \sqrt{\frac{L_p}{L_m}}$

$\therefore V_r = L_r^{1/2}$

b. Laminar Flow : A flow with Re < 2100, and has only one component of velocity.

Turbulent Flow : A flow with Re > 4000, and has random velocity components in all directions.

Wholly Turbulent Flow : A turbulent flow with very large Re such that f is then dependent only on ε/D!

c. $l_m = 0.8$ m $Q_p = 67\ m^3/s$

$Q_m = 0.9\ m^3/s$

Viscosity & surface tension neglected → Froud num w/ $v_r = l_r^{1/2}$

$$\frac{Q_P}{Q_m} = \frac{l_p^2\, v_p}{l_m^2\, l_p} = \frac{l_p}{l_m^{5/2}}$$

$$l_p = 0.8\left(\frac{67}{0.9}\right)^{2/5}$$

$$\frac{67}{0.9} = \left(\frac{l_p}{0.8}\right)^{5/2}$$

$\therefore l_p = 4.49$ m

$F_m = 10$ N   → $\rho g A h_c = l^3$

$$\frac{F_p}{F_m} = \frac{l_p^3}{l_m^3}$$

$$F_p = \left(\frac{4.49}{0.8}\right)^3 \times 10$$

$\therefore F_p = 1762.78$ N

d. $\nu = 10^{-6}\ m^2/s$

$d = 0.1$ m

$e = 0.1$ mm } $e/d = 10^{-3}$

$L = 20$ m

$z_B - z_A = 7$ m

$P_A = 38 \times 10^4\ N/m^2$

$P_B = 27 \times 10^4\ N/m^2$

(i) Let's say the flow direction is A → B.

Check : $\frac{P_A}{\rho g} + z_A = \frac{P_B}{\rho g} + z_B + h_f$

$$\frac{38\times10^4}{\rho g} = \frac{27\times10^4}{\rho g} + 7 + h_f$$

$h_f = 4.21$ m   (positive)

$\therefore$ Thus, assumption is correct, Flow from A to B

(ii) $4.21 = f \cdot \frac{20}{0.1} \cdot \frac{v^2}{2g}$

$0.4133 = f v^2$ ⇒ Trial & Error

$Re = \frac{VD}{10^{-6}}$

$= V\,10^5$

#1. Since $\varepsilon/D = 0.001$, assume wholy turbulent, $f = 0.0195$

$0.4133 = 0.0195\, v^2$

$v = 4.6038$ m/s

↳ $Re = vD/\nu = 460379$

$f = 0.023$

$f = 0.021$

Check moody for $Re = 460379$ and $e/D = 0.001$, $f = 0.0205$ (too big)

#2. Take $f = 0.0205$

↳ $v = 4.4901$ m/s

↳ $Re = 449010$

Check moody, $f \approx 0.0205$, almost no change → ok!

$\therefore f = 0.0205$

$v = 4.49$ m/s

For Greater Minds

4 a. (i) For laminar flow in which $Re < 2100$, f depends on Re only, i.e. $f = \frac{64}{Re}$

(ii) For transitional range, $2100 < Re < 4000$, f is indetermineable

(iii) For wholy turbulent flow region, f is dependant on ε/D only

(iv) For turbulent flow, f depends on both Re and ε/D.

b. $\Delta z = 40$ m

$L = 500$ m

$D = 0.3$ m

$f = 0.025$

PPC → $H = 150 - 2Q^2$

SSC ?

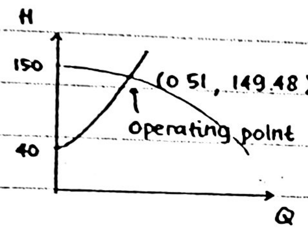
$$H + \cancel{\frac{P_1}{\rho g}} + \cancel{\frac{v_1^2}{2g}} + z_1 = \cancel{\frac{P_2}{\rho g}} + \cancel{\frac{v_2^2}{2g}} + z_2 + h_f$$

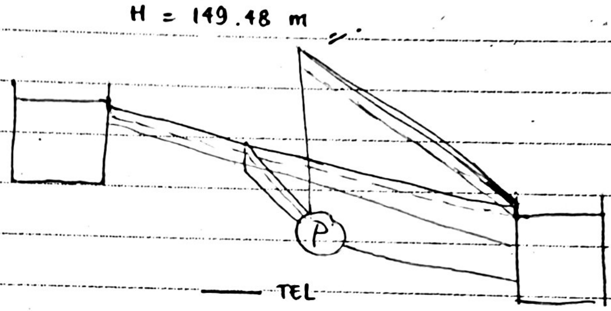
$$H = 40 + 0.025 \times \frac{500}{0.3} \times \frac{1}{2g} \times \frac{Q^2}{(\frac{1}{4}\pi 0.3^2)^2}$$

$$H = 40 + 425Q^2$$

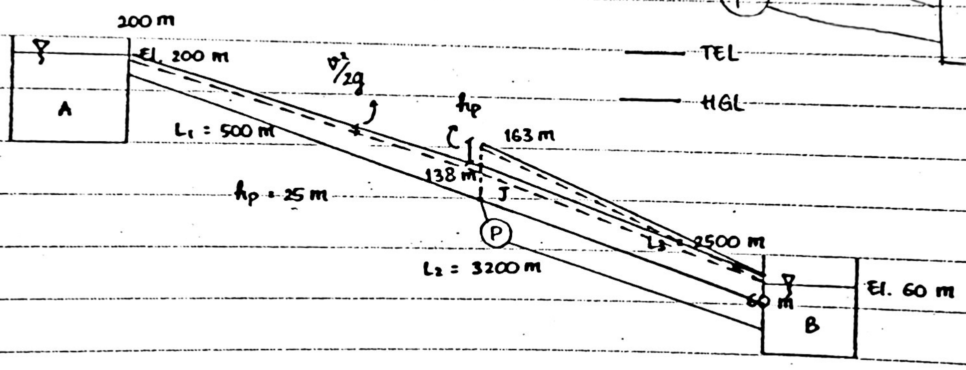
Solving PPC & SSC Eq$^{\underline{n}}$, we have $Q = 0.51$ m³/s

$H = 149.48$ m





c.



$D_{all} = 0.5$ m

$f_{all} = 0.02$

$$h_f = \underbrace{\frac{8fL}{g\pi^2 D^5}}_{\text{"K"}} Q^2$$

$K_1 = \frac{8 \times 0.02}{g\pi^2 0.5^5} \times 500 = 26.44$

$K_2 = \quad ... \quad \times 3200 = 169.22$

$K_3 = \quad ... \quad \times 2500 = 132.20$

Head Eq$^{\underline{n}}$ # from Bernoulli!

$h_A - h_J = h_{f1}$

$h_J - h_B = h_{f3}$

$h_J + h_p - h_B = h_{f2}$

#1. Trial 1 $\quad h_J = 100$ m

$200 - 100 = 26.44 Q_1^2 \rightarrow Q_1 = 1.94$

$100 - 60 = 132.2 Q_3^2 \rightarrow Q_3 = 0.55$

$100 + 25 - 60 = 169.22 Q_2^2 \rightarrow Q_2 = 0.62$

$Q_1 > Q_2 + Q_3 \Rightarrow \Uparrow h_J$

$\Delta Q = 0.77$

#2. Trial 2 $\quad h_J = 120$ m

$200 - 120 = 26.44 Q_1^2 \rightarrow Q_1 = 1.74$

$120 - 60 = 132.2 Q_3^2 \rightarrow Q_3 = 0.67$

$120 + 25 - 60 = 169.22 Q_2^2 \rightarrow Q_2 = 0.71$

$Q_1 > Q_2 + Q_3 \Rightarrow \hat{\Uparrow} h_J$

$\Delta Q = 0.365$

Wait! Trial again ??? No, ∵ there are 2 data use LOG