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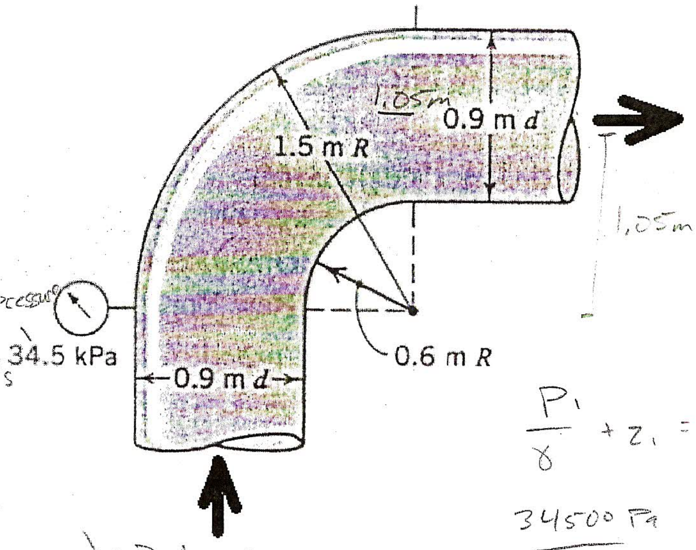
ENCE 3318
Fluid Mechanics for Civil Engineering

TEST 3

(20) 1. The axes of the pipes below are in a vertical plane. The flow-rate is 2.83 m^3/s of water (upward). Calculate the magnitude, direction, and location of the resultant force on the water in the pipe bend.

$\gamma = 9870 N/m^3$



Area $= \left(\frac{\pi}{4}\right)(.9)^2$

A = .6359

Q = 2.83 m^3/s

Q = vA

$v = \frac{Q}{A} = \frac{2.83}{.6359} = 4.45\ m/s$

(S) Arc length = $r\theta$

$S = \left(\frac{\pi}{2}\right)(1.05) = 1.65m$

Volume = Area × Arc length

$(.6359\ m^2)(1.65m)$

V = 1.05 m^3

$V_1 = V_2$

$\frac{P_1}{\gamma} + z_1 = \frac{P_2}{\gamma} + z_2$

$\frac{34500\ Pa}{9870\ N/m^3} + 0 = \frac{P_2}{9870\ N/m^3} + 1.05m$

$P_2 = 24136.5\ Pa$ or $24.1365\ kPa$

$F_{mx} = \left(\frac{\gamma}{g}\right) Q (V_{2x} - V_{1x}) = P_1A_1 + P_2A_2 - F_x$

$\left(\frac{9870}{9.81}\right)(2.83\ m^3/s)(4.45 - 0) = (24137)(.6359) - F_x$

$F_x = 2678.7$ ✗ 28,022N

−5

$F_{my} = \frac{\gamma}{g} Q(V_{2x} - V_{1x}) = P_1A_1 + P_2A_2 - \text{Volume}\ \gamma - F_y$

$34500(.6359) + 0 - (1.049)(9870) - F_y = \frac{9870}{9.81}(2.83\ m^3/s)(0 - 4.45\ m/s)$

$F_y = 24255.4$ ✓

$\tan\theta = \frac{y}{x}$

$F_r = \sqrt{F_x^2 + F_y^2}$

$\tan^{-1}\frac{y}{x} = \theta$

$F_r = \sqrt{2678.7^2 + 24255.4^2}$

$\theta = \tan^{-1}\frac{24255.4}{2678.7}$

$F_r = 24403\ N$ ✗

$\theta = 83.69°$ ✗

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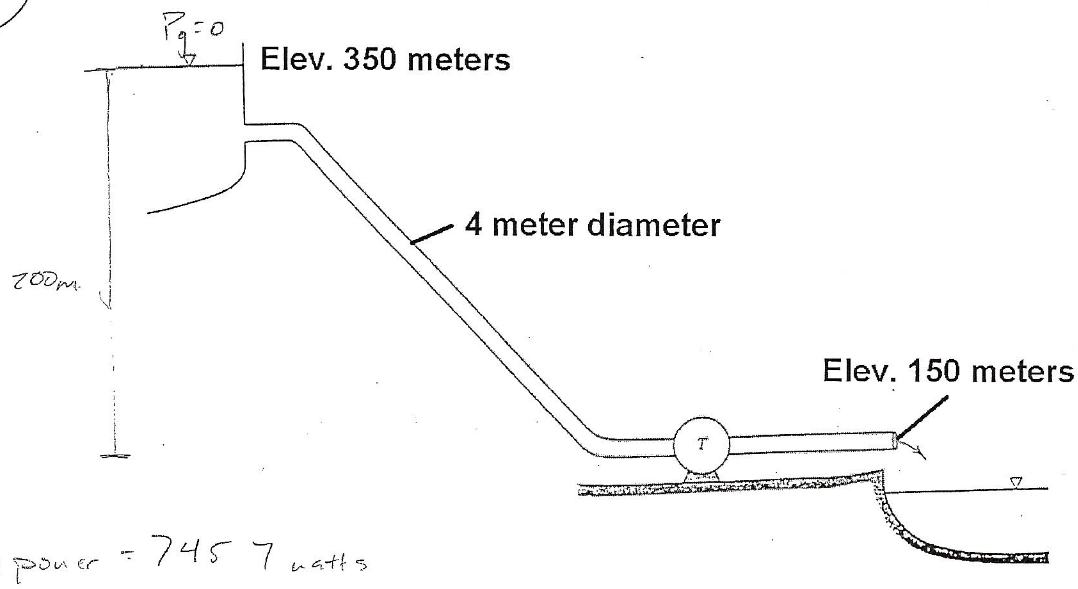
2. The turbine extracts power from the water flowing from the reservoir. Find the **horsepower** extracted if the flow through the system is 400 m^3/s. Assume there is no loss of energy through the system.



1 horse power = 745.7 watts

$A = \frac{\pi}{4}(4)^2 = 12.566\ m^2$

$Q = VA \Rightarrow V = \frac{Q}{A} = \frac{400\ m^3/s}{12.56}$

$V = 31.83\ m/s$

$\frac{P_1}{\gamma} + z_1 + \frac{V_1^2}{2g} = \frac{P_2}{\gamma} + z_2 + \frac{V_2^2}{2g}\ h_L$

$200\ m - \frac{(31.83\ m/s)^2}{2(9.81\ m/s^2)} = h_L$

$h_L = 148.4$

Power equation

$hp = \frac{\gamma Q h_L}{745.7} = \frac{(9810\ N/m^3)(400\ m^3/s)(148.4\ m)}{745.7} = 780905.9944\ hP$

3. Water at 30°C is discharging from a pipe with a diameter of 8 mm. What is the Reynolds number for this flow if it fills a 10 liter bottle in:

a) 30 seconds

b) 5.0 minutes.

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$R_n = \frac{Vd}{\nu}$ $Q = \frac{V}{t}$ $V = \frac{Q}{A}$

$d = .008 m$

ν @ 30° = $.800 \times 10^{-6} m^2/s$

$V = 10 L$ or $10 L \cdot \frac{.001 m^3}{1 L} = .01 m^3$

$A = \frac{\pi}{4}(.008)^2 = 5.027 \times 10^{-5} m^2$

a) $Q = \frac{V}{t} = \frac{.01 m^3}{30 s} = 3.33 \times 10^{-4} m^3/s$

$R_n = \frac{Vd}{\nu} = \frac{\frac{Q}{A} d}{\nu} = \frac{\left(\frac{3.33 \times 10^{-4} m^3/s}{5.027 \times 10^{-5} m^2}\right)(.008 m)}{.800 \times 10^{-6} m^2/s} = 66308.6$ ✓

b) $Q = \frac{V}{t} = \frac{.01}{300 s} = 3.33 \times 10^{-5}$

$R_n = \frac{Vd}{\nu} = \frac{\frac{Q}{A} d}{\nu} = \frac{\left(\frac{3.33 \times 10^{-5} m^3/s}{5.027 \times 10^{-5} m^2}\right)(.008 m)}{.800 \times 10^{-6} m^2/s}$

$R_n = 6630.8$ ✓

4. A pressure drop of 120 N/m^2 is available to carry water at 30°C across a 7.5 m long horizontal wrought iron pipe with a diameter of 0.20 m and a Darcy friction coefficient f of 0.002.

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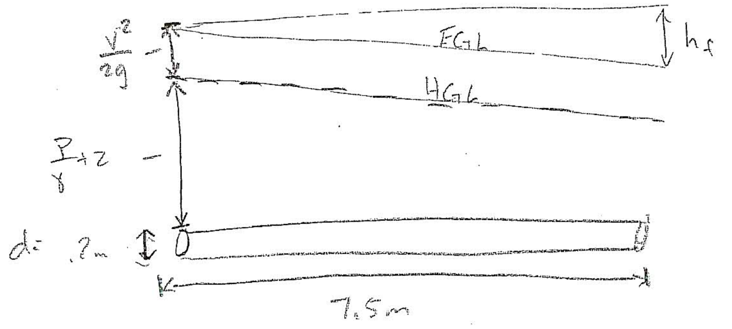
a) What is the discharge in the pipe under these conditions?

b) What shear stress will be applied to the pipe boundary by this flow?



$L = 7.5m$

$d = .2$

$A = \frac{\pi}{4}(d)^2 = .0314\ m^2$

$f = .002$

$\gamma = 9764\ N/m^3$

a) $h_f = \frac{\Delta p}{\gamma} = \frac{120 N/m^2}{9764 N/m^3} = .0123m$

$h_f = f\frac{L}{d}\frac{v^2}{2g} = (.002)\left(\frac{7.5m}{.2m}\right)\frac{v^2}{2(9.81)} = .0123m$

$\sqrt{v^2} = \sqrt{3.218}$

$v = 1.794$

$Q = VA = (1.794\ m/s)(.0314\ m^2)$

$Q = .0563\ m^3/s$ ✓

b) $\tau_0 = \gamma R S_f$ $R = d/4$ $S_f = \frac{h_f}{L}$

$\tau_0 = 9764\frac{N}{m^3}\left(\frac{.2m}{4}\right)\left(\frac{.0123m}{7.5m}\right) = .801\ N/m^2 = \tau$ ✓