Fluid Mechanics- MSE 223

Final Exam- Apr, 15, 2017

Student Name: **Student Number:**

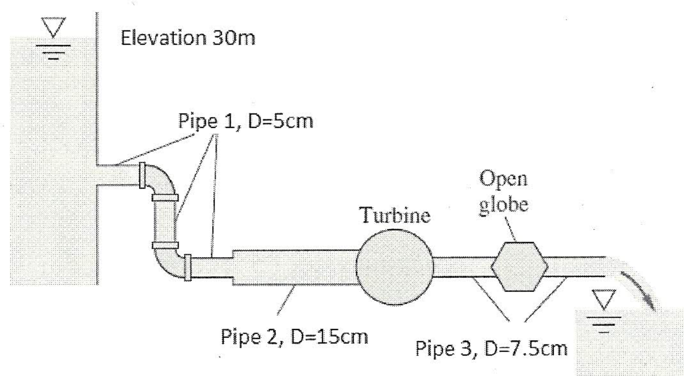
Q1- The size ***d(m)*** of droplets produced by a liquid spray nozzle is thought to depend upon the nozzle diameter ***D(m)***, jet velocity ***U(m/s)***, and the properties of the liquid; density ρ (kg/m^3), viscosity μ(kg/m.s) and surface tension **Y**(N/m). Find the dimensionless parameters by using PI theorem. Take ***D***, ρ, and ***U*** as repeating variables.

(Score: 15)

Q2- Find the total acceleration of a particle if the velocity vector field is given by: $\vec{V} = 5tx\vec{i} + 3txz\vec{j} + 2ty^2\vec{k}$ and compute the acceleration vector at the point (x,y,z)=(1,1,0).

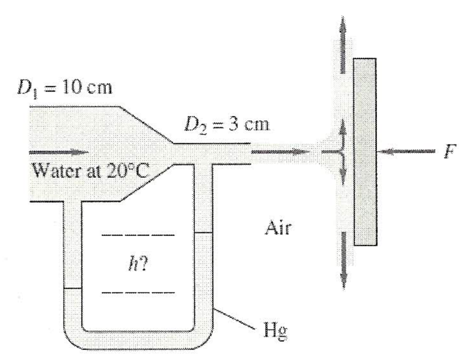
(Score: 30)

Q3- In figure below, pipe 1 is 37 m long with 5-cm diameter; pipe 2 is 23 m long with 15-cm diameter and pipe 3 is 45 m long with 7.5-cm diameter, all cast iron ($\epsilon = 0.26mm$). There are two 90° regular elbows (K=0.95), and an open globe valve (K=6.3), all screwed. If the exit elevation is zero, what horsepower is extracted by the turbine when the flow rate is 4530 cm^3/s of water at 20°C? Pipe 1 has a sharp entrance (K=0.5) and a sudden expansion K=0.79. Also exit loss of pipe 3 is K=1.0. Assume the friction factors for the pipes are: (f_1=0.0315, f_2=0.027 and f_3=0.029) ($\rho_{water} = 998\ {kg}/{m^3}$, $\mu_{water} = 1.003E-3\ kg/(m.s)$) **(Score: 30)**



Q4- Water flows through a circular nozzle, exits into the air as a jet, and strikes a plate, as shown in figure below. The force required to hold the plate steady is 70 N. Assuming frictionless one-dimensional flow, find:
(a) the velocities at sections (1) and (2); (b) the mercury manometer reading **h**.

($\rho_{water} = 998\ {kg}/{m^3}$ and $\rho_{mercury} = 13550\ {kg}/{m^3}$) **(Score: 25)**



Good Luck - Sam Behfarshad

Q1 - Final Exam, MSE 223 - SFU, Intro to Fluid Mech., Spring 2017

Given: Size of droplet = $d = f(D, U, \rho, \mu, Y)$, Repeating Var. = D, ρ, U

$Y \rightarrow$ surface tension (N/m) $\hookrightarrow \frac{kg\,m}{s^2} \cdot \frac{1}{m}$

Find: $(P_i)_s$

Six variables, $d, D, U, \rho, \mu, Y \Rightarrow n = 6$

$d \rightarrow L$, $D \rightarrow L$, $U \rightarrow LT^{-1}$, $\rho \rightarrow ML^{-3}$, $\mu \rightarrow ML^{-1}T^{-1}$, $Y \rightarrow MT^{-2}$

$j = 3$, $(L, M, T) \Rightarrow$

No of $\pi = n - j = 6 - 3 = 3$, π_1, π_2, π_3 , Repeating Var. = D, ρ, U

$$\pi_1 = D^a \rho^b U^c d = (L)^a (ML^{-3})^b (LT^{-1})^c (L) = L^0 M^0 T^0$$

For L $\Rightarrow$ $a - 3b + c + 1 = 0 \Rightarrow \boxed{a = -1}$

" M $\Rightarrow$ $b = 0 \Rightarrow \boxed{b = 0}$

" T $\Rightarrow$ $-c = 0 \Rightarrow \boxed{c = 0}$

$\Rightarrow \pi_1 = D^{-1} d \Rightarrow \boxed{\pi_1 = \frac{d}{D}}$

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$$\pi_2 = D^a \rho^b U^c \mu = (L)^a (ML^{-3})^b (LT^{-1})^c (ML^{-1}T^{-1}) = M^0 L^0 T^0$$

for L $\Rightarrow$ $a - 3b + c - 1 = 0 \Rightarrow a - 3(-1) + (-1) - 1 = 0 \Rightarrow \boxed{a = -1}$

" M $\Rightarrow$ $b + 1 = 0 \Rightarrow \boxed{b = -1}$

" T $\Rightarrow$ $-c - 1 = 0 \Rightarrow \boxed{c = -1}$

$\Rightarrow \pi_2 = D^{-1} \rho^{-1} U^{-1} \mu = \frac{\mu}{D \rho U} \Rightarrow \boxed{\pi_2 = \frac{D \rho U}{\mu}}$

Re. No.

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$$\pi_3 = D^a \rho^b U^c Y = (L)^a (ML^{-3})^b (LT^{-1})^c (MT^{-2}) = M^0 L^0 T^0$$

for L $\Rightarrow$ $a - 3b + c = 0 \Rightarrow a - 3(-1) + (-2) = 0 \Rightarrow \boxed{a = -1}$

" M $\Rightarrow$ $b + 1 = 0 \Rightarrow \boxed{b = -1}$

" T $\Rightarrow$ $-c - 2 = 0 \Rightarrow \boxed{c = -2}$

$\Rightarrow \pi_3 = D^{-1} \rho^{-1} U^{-2} Y \Rightarrow \boxed{\pi_3 = \frac{Y}{\rho D U^2}}$

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So $\frac{d}{D} = f\left(\frac{\rho D U}{\mu}, \frac{\rho U^2 D}{Y}\right)$ 3π

Ans.