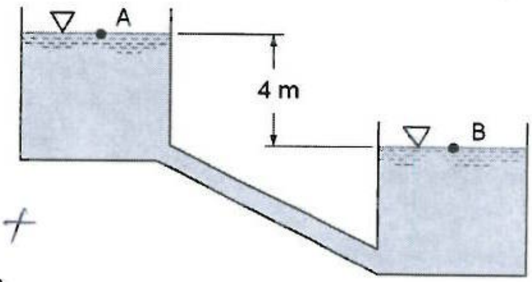
Quiz Feedback

MA3006 - Fluid Mechanics CA2 (28 March 2019) **Serial No :** ___________

Name : ______________________________ **Time : 45 minutes**

1 Oil flows from reservoir A to reservoir B through a pipe of length 50 m, diameter 0.1 m as shown. Determine the volume flow rate through the pipe. Is the flow laminar? The density of oil is 800 kg/m^3 and its dynamic viscosity is 0.1 Ns/m^2. To increase the volume flow rate, a pipe of diameter 0.2 m and length 50 m is used to replace the existing pipe. Determine the new volume flow rate. You may assume that the difference in elevation between the free surfaces of the 2 reservoirs remains constant throughout. For turbulent flow, you may assume that the friction factor is 0.02. All minor losses can be neglected.
(10 marks)



Apply energy equation A to B

$$H_{TA} = H_{TB} + H_{L\,A-B}$$

$$\frac{P_A}{\rho g} + \frac{V_A^2}{2g} + Z_A = \frac{P_B}{\rho g} + \frac{V_B^2}{2g} + Z_B + \frac{fL}{D}\frac{V^2}{2g}$$

$$\Rightarrow 4 = \frac{fL}{D}\frac{V^2}{2g} \quad — \quad (1)$$

a) 1st case, $D = 0.1$, can assume either $f = 64/Re$ or $f = 0.02$ and

then substitute into (1) to find V

Check find Reynolds number & see if assumption is correct

b) 2nd case, $D = 0.2$, same as (a) and repeat

2 A 1/10 scale model aircraft is tested in a pressurized wind tunnel. The prototype operates at 900 km/h where the ambient pressure is 100 kPa and temperature is 30^0C. Given that the temperature in the wind tunnel is 30^0C, what should be the pressure in the wind tunnel and the speed of the model for both Mach number and Reynolds number similarity to be observed? If the drag force on the model is 200 N, what is the drag force on the prototype? You may assume that the dynamic viscosity of the fluid is independent of pressure. The speed of sound is given by $c = \sqrt{\gamma RT}$ where γ =1.4, R = 287 J/(kg.K) and T is the absolute temperature. (10 marks)

$Mach)_{model} = Mach)_{prototype}$

a) $\dfrac{V_m}{C_m} = \dfrac{V_p}{C_p}$ solve to get V_m

b) $Re)_m = Re)_p$

$\left.\dfrac{\rho V L}{\mu}\right)_m = \left.\dfrac{\rho V L}{\mu}\right)_p$ $\mu_m = \mu_p$

solve to get ρ_m in terms of ρ_p

But $P = \rho R T$

solve to get P_m

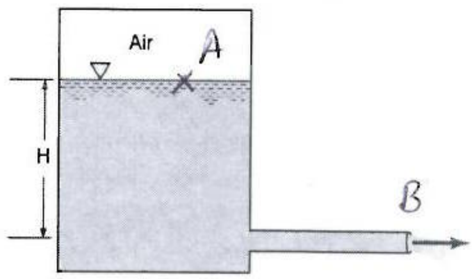
c) $\left.\dfrac{F_D}{\rho V^2 L^2}\right)_m = \left.\dfrac{F_D}{\rho V^2 L^2}\right)_p$

solve to get $F_D)_m$.

MA3006 - Fluid Mechanics CA2 (27 March 2019) **Serial No :** ____________

Name : ________________________________ **Time : 45 minutes**

1 A fluid flows from a closed tank and exits to the atmosphere through a horizontal pipe of diameter 0.1 m and length 20 m as shown. The density of the fluid is 800 kg/m^3 and its dynamic viscosity is 0.1 Ns/m^2. If the pressure of the air in the tank is 100 kPa (absolute) and the average velocity through the pipe is 2 m/s, determine the Reynolds number and the height H. Is the flow laminar? To increase the volume flow rate, the pressure of the air is increased to 300 kPa (absolute), determine the new volume flow rate through the pipe. You may assume that the height of the water in the tank remains constant throughout. The atmospheric pressure is 100 kPa. For turbulent flow, you may assume that the friction factor is 0.02. All minor losses can be neglected. (10 marks)



$$Re = \frac{\rho V D}{\mu} = \_\_\_\_\_\_$$

Apply energy equation A to B

$$H_{TA} = H_{TB} + H_{LA-B}$$

$$\frac{P_A}{\rho g} + \frac{V_A^2}{2g} + Z_A = \frac{P_B}{\rho g} + \frac{V_B^2}{2g} + Z_B + \frac{fL}{D}\frac{V^2}{2g} \quad \text{— (1)}$$

Part (1)

$P_A = 100$ kPa

$P_B = 100$ kPa

$f = 64/Re$

$$H = \frac{V_B^2}{2g} + \frac{fL}{D}\frac{V^2}{2g}$$

solve for H

Part (2) $P_A = 300$ kPa, $P_B = 100$ kPa

assume turbulent flow or laminar flow

substitute into equation (1) to solve for V

Checking :- compute Re to see if assumption is correct.

2 Experiments on the flow and pressure drop in a circular pipe are to be conducted on a planet A (model) where the gravitational force is 1/4 that on the surface of the earth (prototype). The same fluid is used in both experiments and the fluid properties can be assumed to be constant. Given that both Reynolds number and Froude number similarity are to be observed, determine the ratio of the flow velocities in the model to the prototype. What is the ratio of the pipe diameters of the model to the prototype? If the pressure drop measured on the model is 50 kPa, what is the pressure drop expected for the prototype?

(10 marks)

Given $g_m = \frac{1}{4} g_p$

Froude No :-

$$\frac{V_m}{\sqrt{g_m D_m}} = \frac{V_p}{\sqrt{g D_p}} \quad -①$$

Reynolds number

$$\left.\frac{\rho V D}{\mu}\right)_m = \left.\frac{\rho V D}{\mu}\right)_p \quad -②$$

solve for $\frac{D_m}{D_p}$ and $\frac{V_m}{V_p}$

Pressure coefficient:-

$$\left.\frac{\Delta p}{\rho V^2}\right)_m = \left.\frac{\Delta p}{\rho V^2}\right)_p$$

Given $\Delta p_m = 50\,kPa$, solve for

$\Delta p)_p$