PROGRAM	:	NATIONAL DIPLOMA EXTRACTION METALLURGY
SUBJECT	:	**PROCESS ENGINEERING 2**
CODE	:	**MPE 21- 1**
DATE	:	WINTER EXAMINATION 07 JUNE 2016
DURATION	:	(SESSION 2) 12:30
WEIGHT	:	40 : 60
TOTAL MARKS	:	95

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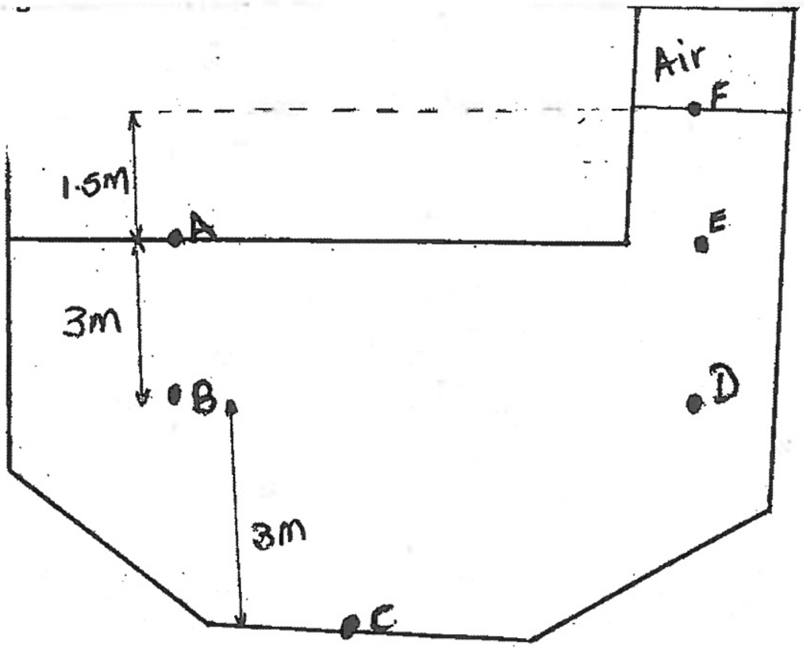
NUMBER OF PAGES	:	4 PAGES AND 2 ANNEXURES	

INSTRUCTIONS	:	ANSWER ALL QUESTIONS.
REQUIREMENTS	:	2 SHEETS OF GRAPH PAPER PER STUDENT

QUESTION 1

1.1 Figure shows a tank of oil with one side open to the atmosphere and other side sealed with air above oil. The oil has a specific gravity of 0.9. Calculate the gage pressures at A, B, C, D, E and air pressure at right hand side of the tank. (15)



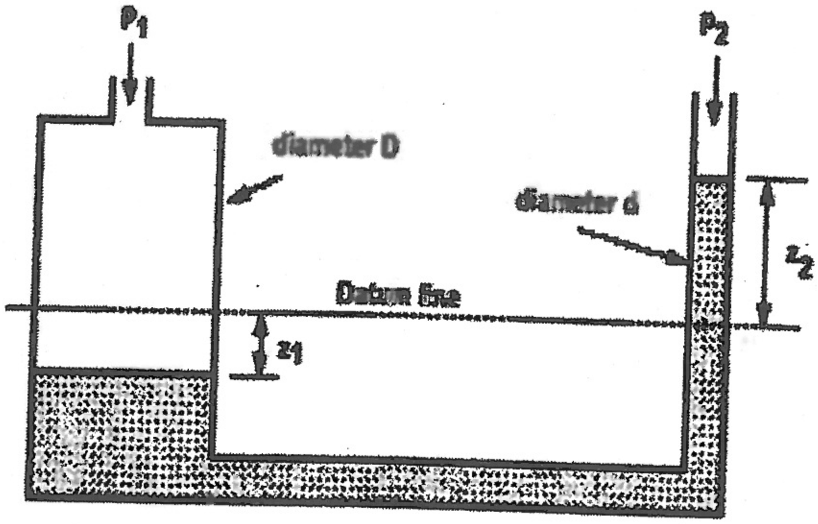
1.2 In a fluid the velocity measured at a distance of 75 mm from the boundary is 1.125m/s. The fluid has absolute viscosity 0.048 Pa.s and relative density of 0.193. What is the velocity gradient and shear stress at the boundary assuming a linear velocity distribution? Determine its kinematic viscosity. (15)

[30]

QUESTION 2

2.1 The U-Tube manometer shown below, proves that the difference in pressure is given by:

$$P_1 - P_2 = \rho \times g \times Z_2 [1 + (d/D)^2]$$



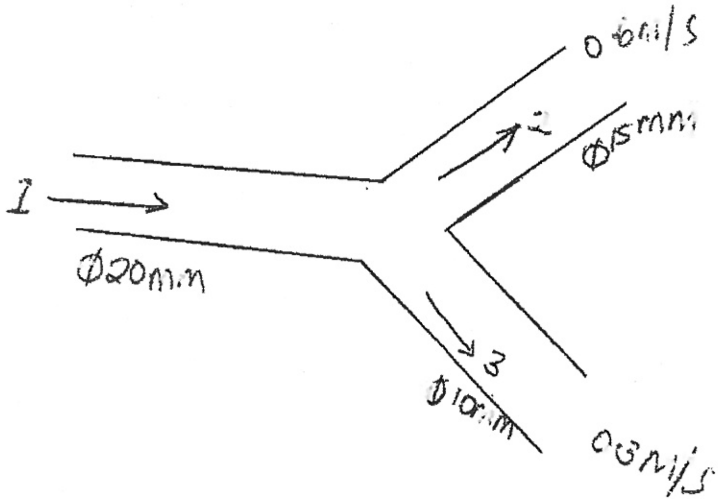
By calculations proof that:

$P_1 - P_2 = \rho \times g \times Z_2 [1 + (d/D)^2]$

(8)

2.2 A 20mm dam pipe fork, one branch being 10mm in diameter and the other 15mm in diameter. If the velocity in 10mm diameter pipe is 0.3m/s and that in 15mm is 0.6m/s, calculate the rate of flow cm³/s and velocity m/s in 20mm diameter pipe.

(10)



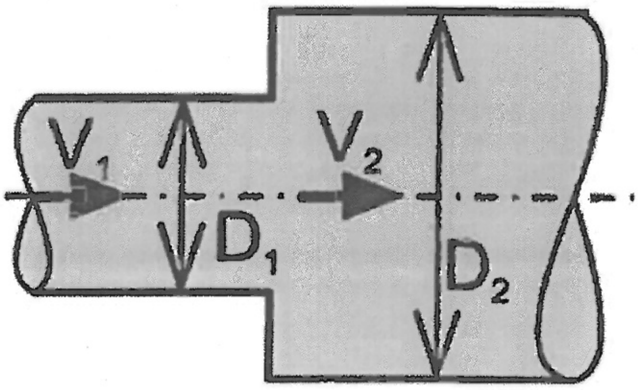
2.3 Water at 36m above sea level has a velocity of 18m/s and a pressure of 350 kN/m^2. Determine the potential, kinetic and pressure energy of the water in meters of head. Also determine the total head. (8)

[26]

QUESTION 3

3.1 Water (T= 20 °C) flows at a rate of 0.05 m^3/s in a 20 cm asphalted cast-iron pipe. What is the head loss (frictional losses) per kilometer of pipe? (Hint : use Moody chart) (12)

3.2 On a circular conduit there are different diameters: diameter $\mathbf{D_1 = 2\ m}$ changes into $\mathbf{D_2 = 3\ m}$. The velocity in the entrance profile was measured: $\mathbf{v_1 = 3\ ms^{-1}}$. Calculate the discharge and mean velocity at the outlet profile.
Determine also type of flow in both conduit profiles (whether the flow is laminar or turbulent). At the temperature of **T = 12° C**, kinematic viscosity of water = 1.24 x 10-6 m^2/s.

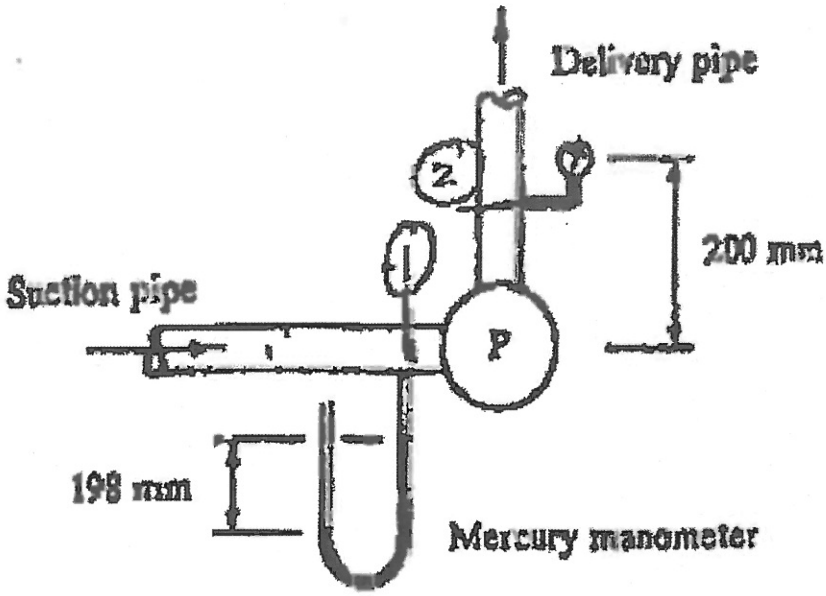


(12)

[24]

Question 4

4.1 A centrifugal pump has a 100 mm diameter suction pipe and a 75 mm diameter delivery pipe. When discharging 15 l/s of water, the inlet water mercury manometer with one limb exposed to the atmosphere recorded a vacuum deflection of 198 mm; the mercury level on the suction side was 100 mm below the pipe centerline. The delivery pressure gauge, 200 mm above the pump inlet, recorded a pressure of 0.95 bar. The measured in put power was 3.2 kW. Calculate the pump efficiency.


Delivery pipe
2
200 mm
1
Suction pipe
P
198 mm
Mercury manometer

[15]

TOTAL **[95]**

Pipe roughness

pipe material	pipe roughness ε (mm)
glass, drawn brass, copper	0.0015
commercial steel or wrought iron	0.045
asphalted cast iron	0.12
galvanized iron	0.15
cast iron	0.26
concrete	0.18-0.6
rivet steel	0.9-9.0
corrugated metal	45
PVC	0.12

$\frac{\varepsilon}{d}$ Must be dimensionless!

	Water		Air	
Temp. (°C)	Viscosity, μ (Pa s $\times 10^5$)	Kinematic viscosity, ν ($m^2/s \times 10^6$)	Viscosity, μ (Pa s $\times 10^5$)	Kinematic viscosity, ν ($m^2/s \times 10^6$)
0	179.2	1.792	1.724	13.33
10	130.7	1.307	1.773	14.21
20	100.2	1.004	1.822	15.12
30	79.7	0.801	1.869	16.04
40	65.3	0.658	1.915	16.98

FORMULA SHEET

$$\tau = \mu \frac{du}{dy}$$

$$\nu = \frac{\mu}{\rho}$$

$$p = \rho g h$$

$$R = \rho g \bar{z} A$$

R = pressure at centroid × area

$$S_c = \frac{I_{xx}}{A\bar{x}}$$

$$I_{xx} = I_{gg} + A\bar{x}^2$$

$$Q = Au = A_1 u_1 = A_2 u_2$$

$$\frac{p_1}{\rho g} + \frac{u_1^2}{2g} + z_1 = \frac{p_2}{\rho g} + \frac{u_2^2}{2g} + z_2 + h_f$$

$$u = \sqrt{2g(h_2 - h_1)}$$

$$u_1 = \sqrt{\frac{2gH(\rho_m - \rho)}{\rho}}$$

$$h_f = \frac{32\mu L u}{\rho g d^2}$$

$$Q_{actual} = C_d A_1 A_2 \sqrt{\frac{2gh\left(\frac{\rho_{man}}{\rho} - 1\right)}{A_1^2 - A_2^2}}$$

$$Q = C_d A_o \sqrt{2gh}$$

$$Q_{theoretical} = \sqrt{2g} \int_0^H b h^{1/2} \, dh$$

$$Q_{actual} = C_d A_1 A_2 \sqrt{\frac{2g\left[\frac{p_1 - p_2}{\rho g} + z_1 - z_2\right]}{A_1^2 - A_2^2}}$$

$$Q = C_d \frac{2}{3} B \sqrt{2g} H^{3/2}$$

$$Q = C_d \frac{8}{15} \sqrt{2g} \tan\left(\frac{\theta}{2}\right) H^{5/2}$$

$$F_T = F_R + F_B + F_P$$

$$Re = \frac{\rho u d}{\mu}$$

$$Q = \frac{\Delta p}{L} \frac{\pi d^4}{128\mu}$$

$$F = Q\rho(u_2 - u_1)$$

$$h_f = \frac{32\mu L d}{\rho g}$$

Pipe Flow

Darcy-Weisbach formula $h_f = \frac{4flv^3}{2gd} = \frac{flQ^2}{3d^5}$

Rough pipe formula $\frac{1}{\sqrt{f}} = 4.0\log_{10}\left(\frac{R}{k_s}\right) + 3.48$

Colebrooke-White formula $\frac{1}{\sqrt{f}} = -4.0\log_{10}\left(\frac{2.51}{2R_e\sqrt{f}} + \frac{k_s}{3.7d}\right)$

Pumps

Work done per unit weight of fluid $= \frac{1}{g}\left(V_{w2}u_2 - V_{w1}u_1\right)$

Hydraulic efficiency $\eta_h = \frac{gH}{V_{w2}\,u_2}$

Specific speed $N_s = \frac{N\sqrt{Q}}{H^{3/4}}$

Open channel hydraulics

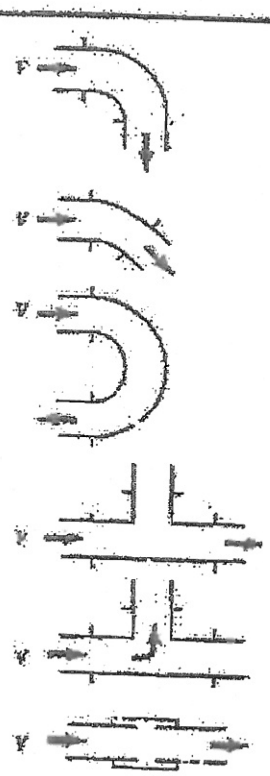
Chezy formula $Q = AC\sqrt{mi}$

Manning's formula $C = \frac{1}{n}m^{1/6}$

TABLE 8.2

Loss Coefficients for Pipe Components $\left(h_L = K_L \frac{V^2}{2g}\right)$ (Data from Refs. 5, 10, 27)

Component	K_L
a. Elbows	
Regular 90°, flanged	0.3
Regular 90°, threaded	1.5
Long radius 90°, flanged	0.2
Long radius 90°, threaded	0.7
Long radius 45°, flanged	0.2
Regular 45°, threaded	0.4
b. 180° return bends	
180° return bend, flanged	0.2
180° return bend, threaded	1.5
c. Tees	
Line flow, flanged	0.2
Line flow, threaded	0.9
Branch flow, flanged	1.0
Branch flow, threaded	2.0
d. Union, threaded	0.08
e. Valves[a]	
Globe, fully open	10
Angle, fully open	2
Gate, fully open	0.15
Gate, $\frac{1}{4}$ closed	0.26
Gate, $\frac{1}{2}$ closed	2.1
Gate, $\frac{3}{4}$ closed	17
Swing check, forward flow	2
Swing check, backward flow	∞
Ball valve, fully open	0.05
Ball valve, $\frac{1}{3}$ closed	5.5
Ball valve, $\frac{2}{3}$ closed	210



[a] See Fig. 8.34 for typical valve geometry

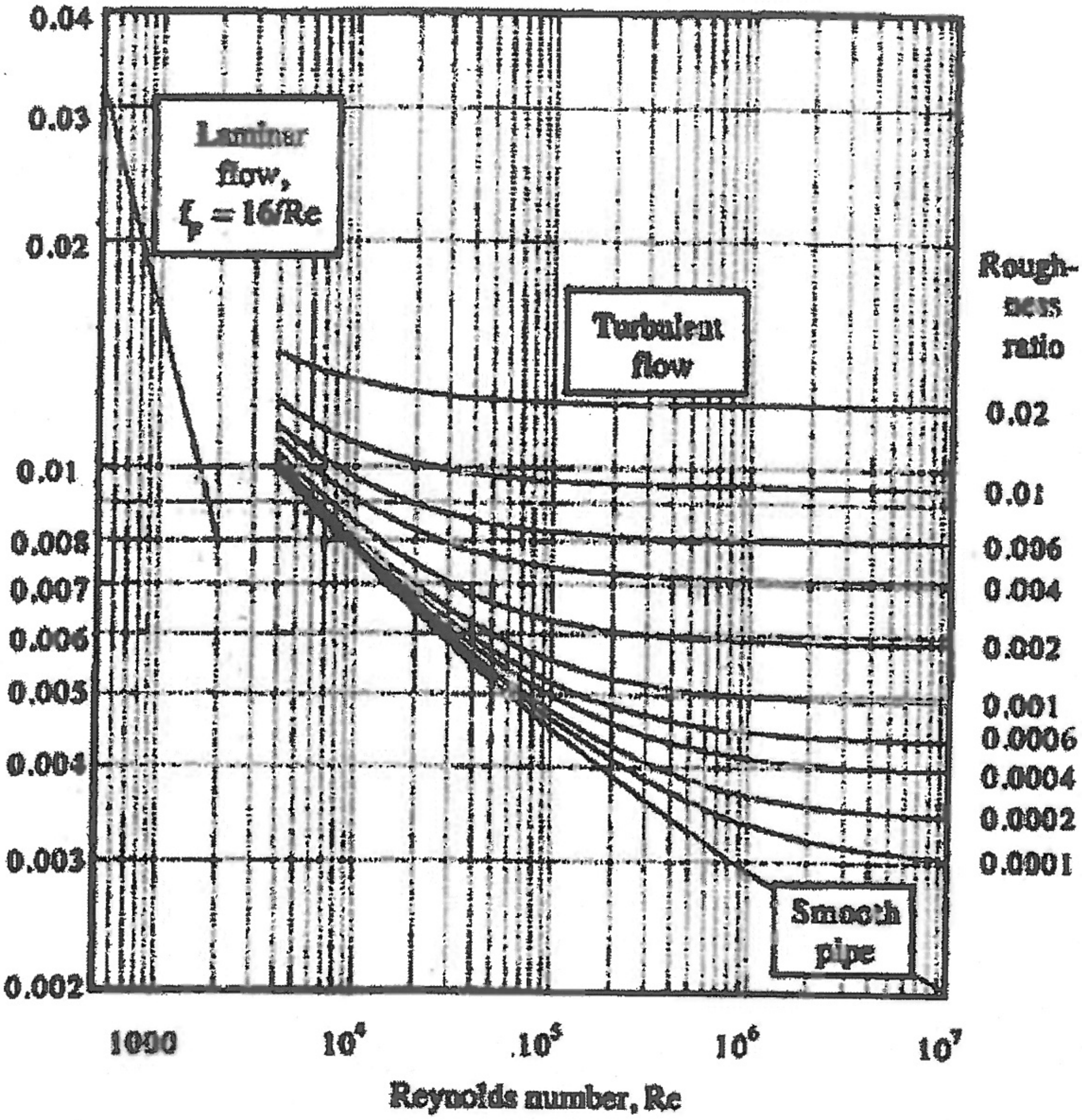


Fig. 3.10 Fanning friction factor for flow in pipes. The turbulent region is based on the Colebrook and White equation.