UNIVERSITY OF JOHANNESBURG

PROGRAM	:	BACHELOR OF TECHNOLOGY *CHEMICAL ENGINEERING*
SUBJECT	:	**CHEMICAL ENGINEERING TECHNOLOGY 4A - FLUID FLOW**
CODE	:	**WARA432**
DATE	:	WINTER EXAMINATION 7 June 2016
DURATION	:	(SESSION 2) 12:30 – 15:30
WEIGHT	:	40: 60
TOTAL MARKS	:	133

EXAMINER	:	PROF F. NTULI
MODERATOR	:	PROF M. ONYANGO
NUMBER OF PAGES	:	5 PAGES AND 4 ANNEXURES

REQUIREMENTS	:	GRAPH PAPER (ONE PER STUDENT)

INSTRUCTIONS TO CANDIDATES:

1. NUMBER ALL QUESTIONS CORRECTLY.
2. ANSWER ALL THE FIVE QUESTIONS.
3. THE MARKS ALLOCATED TO EACH QUESTION ARE INDICATED AFTER THE QUESTION AND THE TOTAL MARKS AT THE END.

QUESTION 1

Kerosene of relative density 0.82 and kinematic viscosity 2.3 $mm^2 \cdot s^{-1}$ is to be pumped through 185 m of galvanized iron pipe (ε = 0.15 mm) at 40 $L \cdot s^{-1}$ into a storage tank. The pressure at the inlet end of the pipe (i.e. pump outlet) is 370 kPa (abs) and the liquid level in the storage tank is 20 m above that of the pump. Neglecting losses other than those due to pipe friction and kinetic energy changes determine the size of pipe necessary.

Density of water = 1000 $kg \cdot m^{-3}$, g = 9.81 m s^{-2}, Atmospheric pressure = 100 kPa,

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QUESTION 2

A pump draws water from a large open sump through a short length of suction pipe as shown in Figure 1. The water is delivered through a 21.1 m length of 9 cm diameter pipe and via a submerged exit into an open tank. A control valve ($K_L = 0.05$) is installed in the delivery pipe, for which Fanning factor f = 0.0085. Dissipation other than friction and the loss at the valve may be ignored. The bottom of the tank is 10 m above the free surface of the water in the sump.

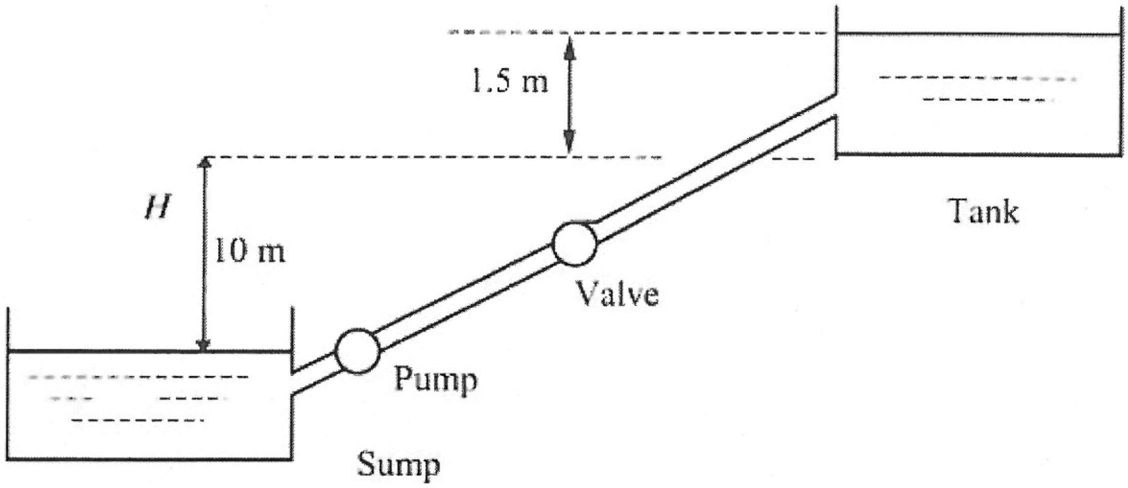

Figure 1

The pump characteristics at the operational speed are given below.

Q ($m^3 \cdot s^{-1}$)	0	0.006	0.012	0.018	0.024	0.030	0.036	0.042	0.052
H (m)	15	16	16.5	16.5	15.5	13.5	10.5	7	0
η (%)	0	30	55	70	76	70	57	38	0

2.1 Find the system characteristic (head as a function of discharge), giving numerical values and the units that you have chosen to use for head and discharge. (10)

2.2 Find the discharge and power consumption at the duty point (16)

2.3 If the $NPSH_R$ for the pumps is 7 m, determine the maximum height above the water level in the sump, that the pump must be located in order to avoid cavitation. Assume the pump is operating at the duty point determined in (2.2) and the vapour pressure of water in the sump is 2.30 kPa (10)

Density of water = 1000 kg.m^{-3}, g = 9.81 m s^{-2}, atmospheric pressure = 100 kPa

[36]

QUESTION 4

Steam and water flows through a pipe of internal diameter d_i = 0.08 m at a flow rates of 0.05 and 1.75 kg/s respectively. The pipe roughness ε = 0.00050 m. The viscosities of the steam and water at the flow conditions are $\mu_G = 0.0113 \times 10^{-3}$ N s/m^2 and $\mu_L = 0.52 \times 10^{-3}$ N s/m^2 respectively. The densities of the steam and water are $\rho_G = 0.788$ kg/m^3 and $\rho_L = 998$ kg/m^3 respectively. The weight fraction of gas is 0.160. Calculate the pressure drop per unit length of pipe assuming adiabatic conditions.

[20]

QUESTION 5

5.1 An open channel of trapezoidal section, 2.5 m wide at the base and having sides inclined at 60° to the horizontal, has a bed slope of 1 in 500. It is found that when the rate of flow is 1.24 m^3·s^{-1} the depth of water in the channel is 350 mm. Assuming the validity of Manning's formula, calculate the rate of flow when the depth is 500 mm.

(12)

5.2 An agitator is used to mix a liquid having a viscosity of 0.10 Pa·s and a density of 950 kg/m^3 in a tank having a diameter of 1.80 m conforming to the standard tank configuration as shown in Figure 2. The agitator to be used is a 6-blade open turbine with blades at 45° with an impeller diameter of 0.60 m operating at 1.50 rev/s.

5.2.1 Calculate the power required in kW/m^3. (8)

5.2.2 Scale up this system to a vessel having a volume 100 times the original for the case of equal suspension of solids i.e. $n = \frac{3}{4}$. Only give the new dimensions and values for D_t, D_a,, N, P, J and W. (12)

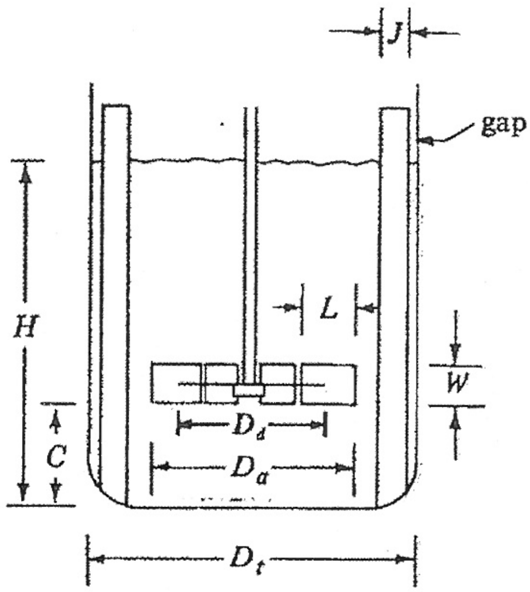

Figure 2

(20)

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TOTAL MARKS [133]

Formulas

$$\frac{d}{dt}B_{sys} = \frac{d}{dt}\int_{cv} b\rho d\forall + \sum_{cs} b\rho\vec{V}.\vec{A}$$

$$B = mB$$

$$h_f = 4f.\frac{L}{D}.\frac{V^2}{2g}$$

$$h_L = K_L.\frac{V^2}{2g}$$

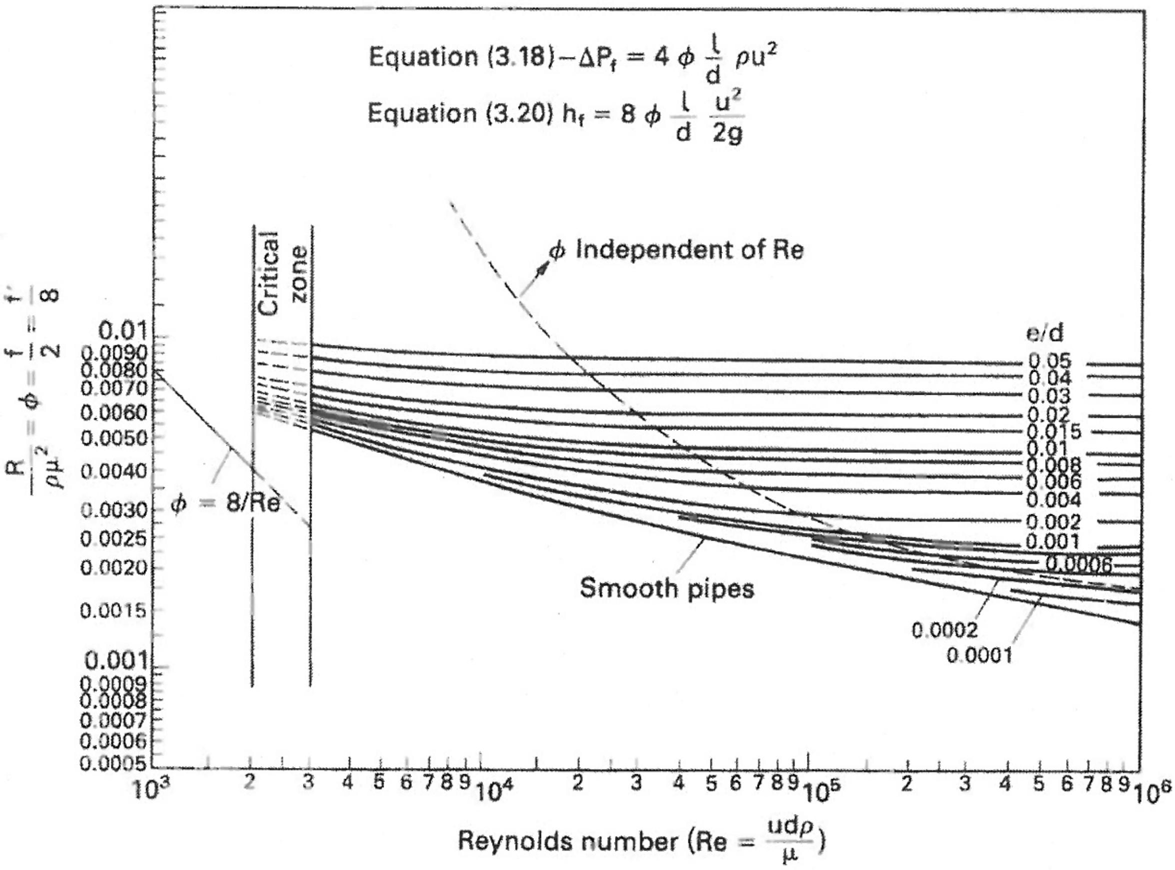
$$\tau = \mu\frac{dV}{dy}$$

$$C = \frac{1}{n}R_h^{1/6}$$

$$N_2 = N_1\left(\frac{1}{R}\right)^n$$

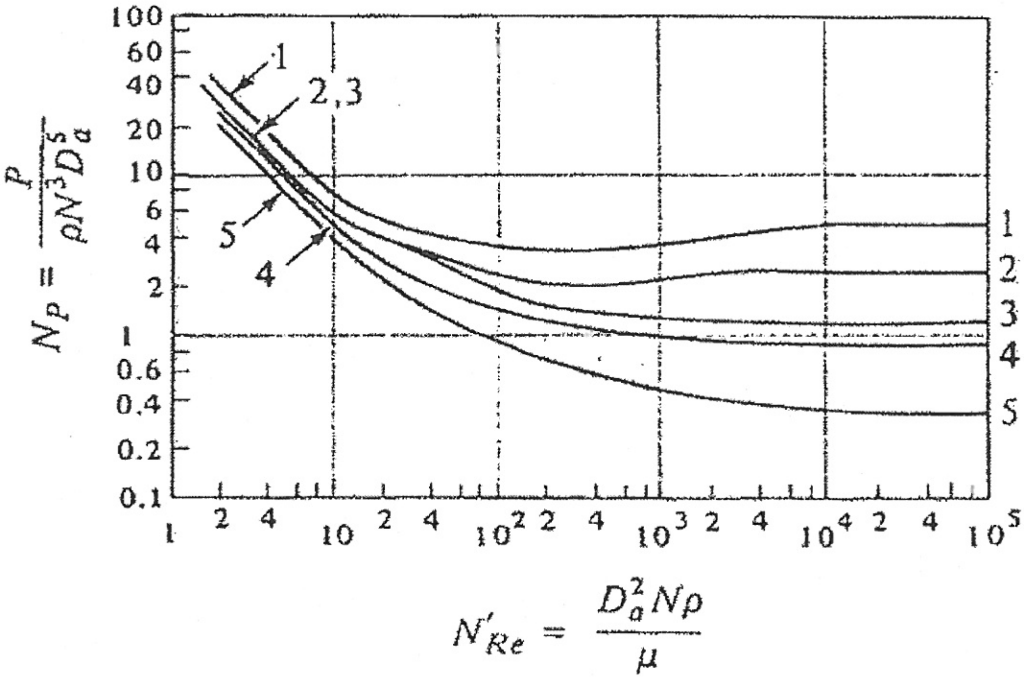
$$X_{tt} = \left[\frac{(1-w_G)}{w_G}\right]^{0.9}\left(\frac{\rho_G}{\rho_L}\right)^{0.5}\left(\frac{\mu_L}{\mu_G}\right)^{0.1}$$

Friction factor chart



Note:
f – Fanning factor
f' – Moody factor
ϕ - basic friction factor same as j_f

X_{tt}	ϕ^2
0,01	128
0,02	68,4
0,04	38,5
0,07	24,4
0,1	18,5
0,2	11,2
0,4	7,05
0,7	5,04
1	4,2
2	3,1
4	2,38
7	1,96
10	1,75
20	1,48
40	1,29
70	1,17
100	1,11



Curve 1. *Flat six-blade turbine with disk (like Fig. 3.4-3 but six blades); $D_a/W = 5$; four baffles each $D_t/J = 12$.*

Curve 2. *Flat six-blade open turbine (like Fig. 3.4-2c); $D_a/W = 8$; four baffles each $D_t/J = 12$.*

Curve 3. *Six-blade open turbine but blades at 45° (like Fig. 3.4-2d); $D_a/W = 8$; four baffles each $D_t/J = 12$.*

Curve 4. *Propeller (like Fig. 3.4-1); pitch = $2D_a$; four baffles each $D_t/J = 10$; also holds for same propeller in angular off-center position with no baffles.*

Curve 5. *Propeller; pitch = D_a; four baffles each $D_t/J = 10$; also holds for same propeller in angular off-center position with no baffles.*