UNIVERSITY OF JOHANNESBURG

PROGRAM	:	BACHELOR OF TECHNOLOGY *CHEMICAL ENGINEERING*
SUBJECT	:	**CHEMICAL ENGINEERING TECHNOLOGY 4A - FLUID FLOW**
CODE	:	**WARA432**
DATE	:	SSA EXAMINATION 26 July 2016
DURATION	:	(SESSION 2) 11:30 - 14:30
WEIGHT	:	40: 60
TOTAL MARKS	:	115

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

A cylindrical tank, 5 m in diameter, discharges through a mild steel (ε = 0.2 mm) pipe 90 m long and 200 mm diameter connected to the base of the tank. It is desired to drain the tank from a height of 3 m to 1 m above the bottom.

1.1 Derive an expression for the time required to drain the tank as a function of h (15)

1.2 Calculate the time required to drain the tank. (5)

Density of water = 998.21 kg.m^{-3}, viscosity = 1.00×10^{-3} kg m^{-1} s^{-1}, $g = 9.81$ m s^{-2}

[20]

QUESTION 2

A pump is used to convey water from a sump to a storage tank. The water level in the tank is 80 m above that in the sump. The delivery pipe connecting the pump and the tank is 575 m in length and 0.15 m in diameter, and has a Moody friction factor $f = 0.08$. The pump characteristics at speed 2800 rpm are as follows:

Pump characteristics at 2800 rpm:

Discharge (L s^{-1}):	0	10	20	30	40	50
Head (m):	110	124.3	127.1	118.6	98.6	67.1
Efficiency (%):	—	47	68	75	70	45

2.1 Determine the rate of flow and the power supplied to the pump. (15)

2.2 A second identical pump is connected in series with the original pump. Find the total discharge and power consumption if the pumps are connected in series. (15)

Density of water = 1000 kg.m^{-3}, viscosity = 1.109 × 10^{-3} kg m^{-1} s^{-1}, g = 9.81 m s^{-2}

[30]

QUESTION 3

A 45° reducing pipe-bend (in a horizontal plane) tapers from 600 mm diameter at inlet to 300 mm diameter at outlet (see Fig. 1). The gauge pressure at inlet is 140 kPa and the rate of flow of water through the bend is 0.425 m^3·s^{-1}. Neglecting friction, calculate the net resultant horizontal force exerted by the water on the bend. (20)
Density of water = 1000 kg.m^{-3}.

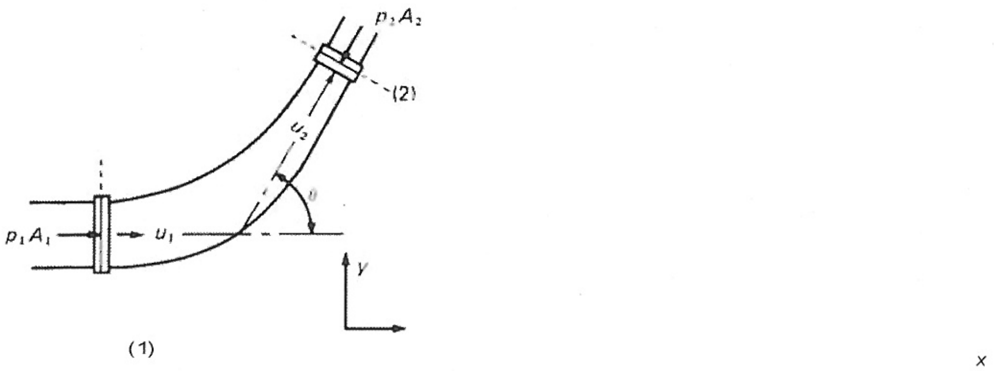
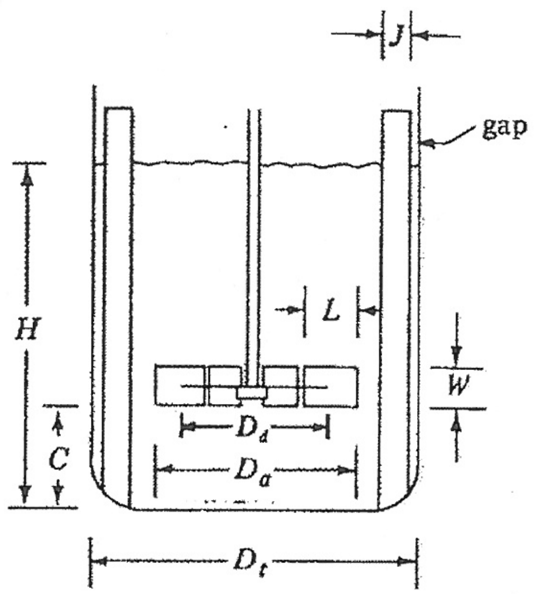


Fig. 1

[20]

QUESTION 4

4.1 An agitation system is to be designed for a fluid having a density of 950 kg/m^3 and viscosity of 0.005 Pa·s. The vessel volume is 1.50 m^3 and a standard six-blade open turbine with blades at 45° is to be used with $D_a/D_t = 0.35$. For the preliminary design a power of 0.5 kW/m^3 volume is to be used. Calculate the dimensions of the agitation system, rpm, and kW power. (15)



4.2 A channel of symmetrical trapezoidal section, 900 mm deep and with top and bottom widths 1.8 m and 600 mm respectively, carries water at a depth of 600 mm. If the channel slopes uniformly at horiz:vert = 1: 2600 and Chézy's coefficient is 60 $m^{1/2} \cdot s^{-1}$, calculate the steady rate of flow in the channel. (10)

[25]

QUESTION 5

A disc of diameter D immersed in a fluid of density ρ and viscosity μ has a constant rotational speed ω. The power required to drive the disc is P. Show that

$P = \rho\omega^3 D^5 \phi\left(\frac{\rho\omega D^2}{\mu}\right)$. (14)

A disc 225 mm diameter rotating at 144.5 rad·s^{-1} (23 rev/s) in water requires a driving torque of 1.1 N·m. Calculate the corresponding speed and the torque required to drive a similar disc 675 mm diameter rotating in air. (Dynamic viscosities: air 1.86×10^{-5} Pa · s; water 1.01×10^{-3} Pa · s. Densities: air 1.20 kg ·m^{-3}; water 1000 kg ·m^{-3}.) (6)
Power = torque×speed

[20]

TOTAL MARKS [115]

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ANNEXURE

Formulas

$$-\frac{dp}{ds} - \gamma\, Sin\theta = \rho\, a_s$$

$$-\frac{dp}{dn} - \gamma\, Cos\theta = \rho\, a_n$$

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

$$B = mB$$

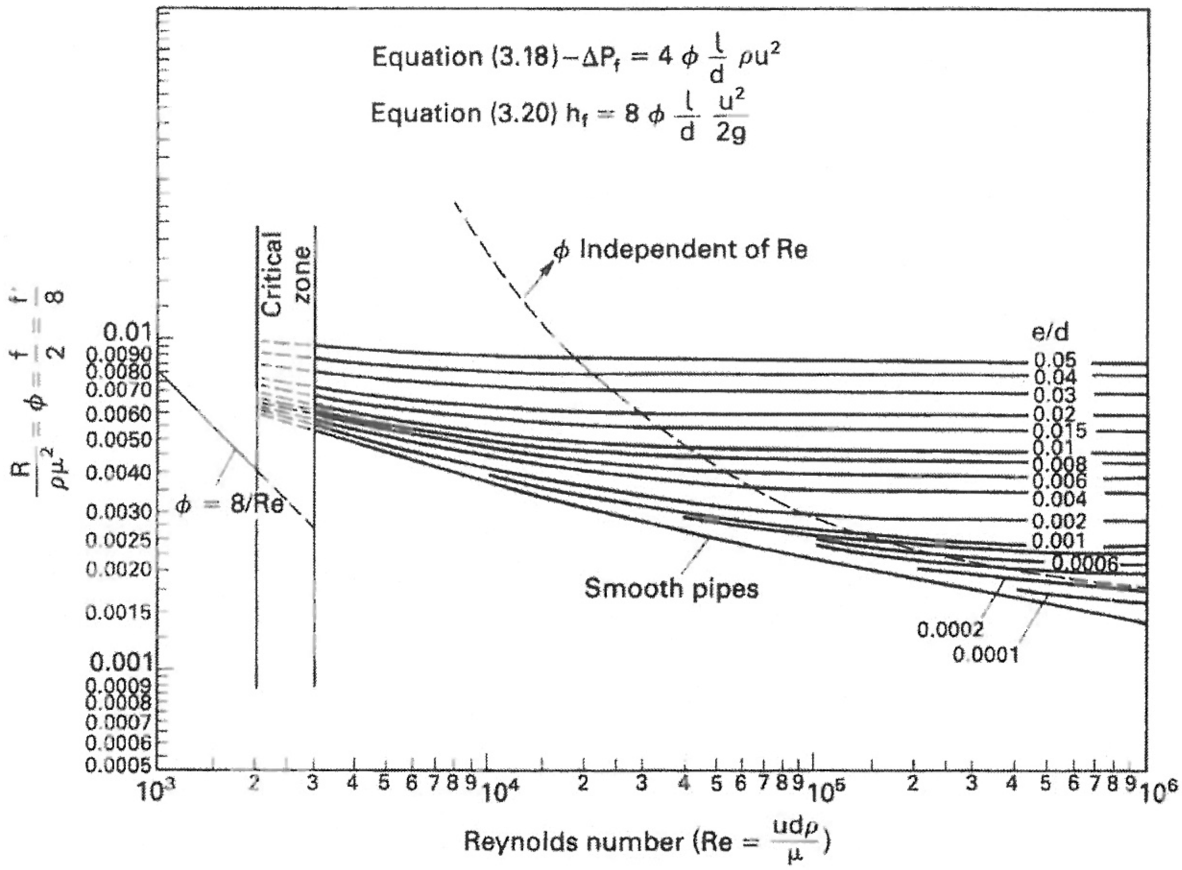
$$C = \frac{1}{n} R_h^{1/6}$$

$$\mathrm{Fr} = V/(g\,l)^{1/2}$$

$$\gamma = K' 8^{n'-1}$$

$$(\mu_a)_p = K_p' \left(\frac{8}{d_i}\right)^{n'-1}$$

Friction factor chart



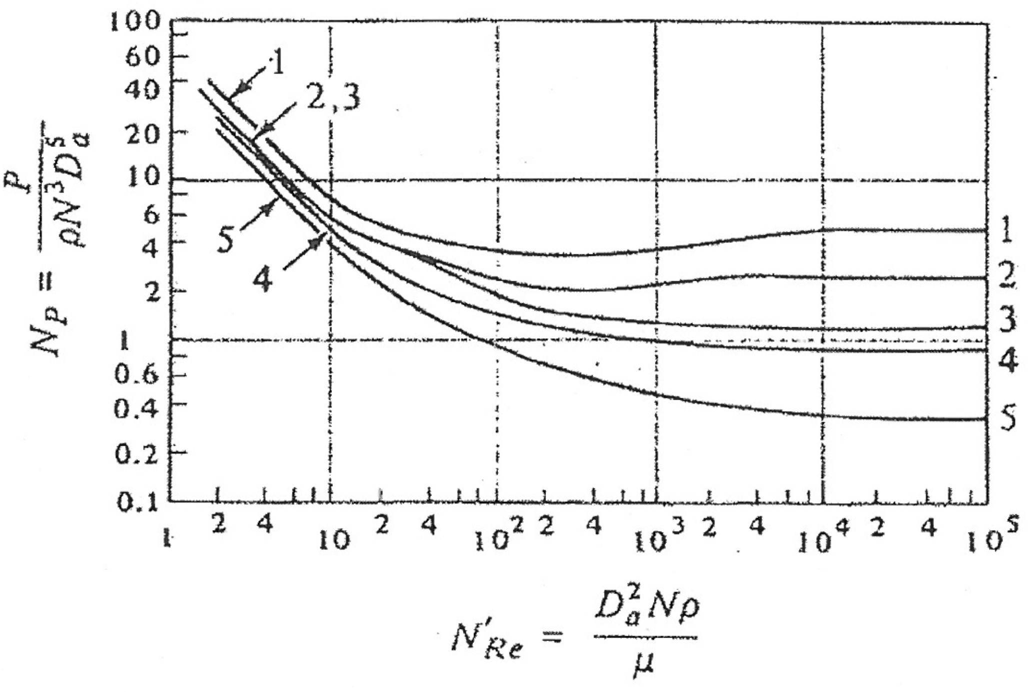
Note:

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.*