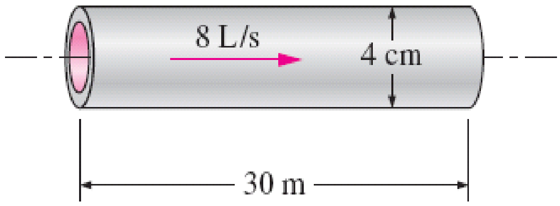
PROGRAM	:	BACHELOR OF ENGINEERING TECHNOLOGY
		CHEMICAL ENGINEERING
SUBJECT	:	**PROCESS FLUID FLOW 2A**
CODE	:	**PFFCHA2**
DATE	:	WINTER EXAMINATION
		08 JUNE 2019
DURATION	:	3 HOURS
WEIGHT	:	40 : 60
TOTAL MARKS	:	123
FULL MARKS	:	120
EXAMINER(S)	:	MS THANDIWE SITHOLE
MODERATOR	:	PROF M BELAID
NUMBER OF PAGES	:	08 PAGES
REQUIREMENTS	:	Use of scientific (non-programmable) calculator is permitted (only one per candidate); graph paper

HINTS AND INSTRUCTIONS TO CANDIDATE(S):

- Purpose of assessment is to determine not only if you can write down an answer, but also to assess whether you understand the concepts, principles, expressions involved. The assessment builds towards the development of Graduate Attributes (Gas) 1 and 2. Set out solutions in a logical and concise manner with justification for the steps followed.
- **ATTEMPT ALL QUESTIONS**. Please answer each question to the best of your ability.
- Write your details (module name and code, ID number, student number etc.) on script(s).
- Number each question clearly; questions may be answered in any order.
- Make sure that you read each question carefully before attempting to answer the question.
- Show all steps (and units) in calculations; this is a 'closed book' test.
- Ensure your responses are legible, clear and include relevant units (where appropriate).

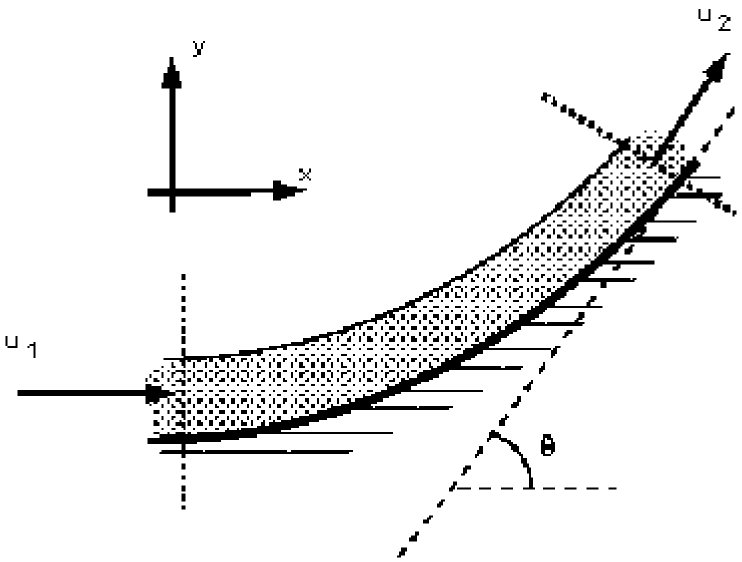
Question 1 (17 Marks)

Water at 15 °C (ρ=1000 kg/m3, μ=1.3×10^{-3} kg/m*s) is flowing steadily in a 30-m long, 4-cm-diameter horizontal pipe. The pipe is made of stainless steel with a roughness e = 2 µm. The flow rate is 8 L/s. Determine the pressure drop.



Question 2 (18 Marks)

A curved plate deflects a 75mm diameter jet through an angle of 45. For a velocity in the jet of 40m/s to the right, compute the components of the force developed against the curved plate. (Assume no friction).



Question 3 (30 Marks)

Air is flowing through a smooth pipe 100mm in diameter and 30m long. The upstream pressure is 300kPa, and the downstream pressure is 267kPa, and the flow is isothermal at 273K. The viscosity of air is 0.000015Pas. R=8.314Pam3mol-1K-1. MWair = 29gmol-1.

$$\left(\frac{G}{A}\right)^2 \ln\frac{v_2}{v_1} + \frac{P_2^2 - P_1^2}{2P_1 v_1} + 2f\frac{L}{d}\left(\frac{G}{A}\right)^2 = 0$$

3.1. What is the % pressure drop over the pipe? (4)

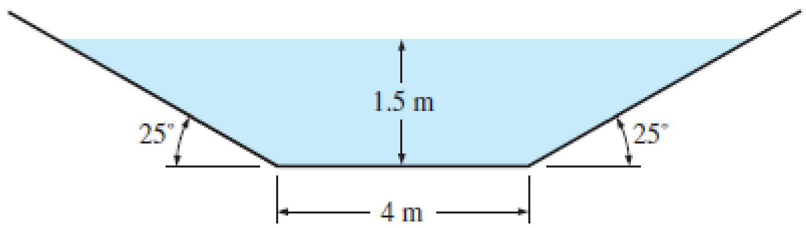
3.2. Is the flow compressible? (2)

3.3. What is the mass flux in kgm-^{2}s^{-1}? (NB: Make all the necessary assumptions)

(24)

Question 4 (16 Marks)

A trapezoidal channel with brick lining has a bottom slope of 0.001 and a base width of 4 m, and the side surfaces are angled 25℃ from the horizontal, as shown in Figure 1. If the normal depth is measured to be 1.5 m, estimate the flowrate of water through the channel.



Question 5 (25 Marks)

As a Process Engineer, you are requested to scale up the laboratory-size or pilot-size agitation system to a full-scale the agitation system where equal rate of mass transfer is desired. The agitation system has to be fitted with six flat disk blade turbine agitator. The given conditions and sizes of the agitation system is as follows:

D_{T1} = 1.83 m, Da_1 = 0.61 m

W_1 = 0.122 m, J_1 = 0.15 m,

N_1 = 90/60 = 1.50 rev/s, ρ = 929 kg/m^3 and μ = 0.01 Pa.s.

It is desired to scale up these results for a vessel whose volume is 3.0 times as large.

Question 6 (17 Marks)

The head-discharge curve for a centrifugal pump is given by $H = 44.5 - 0.4\times10^{-6}Q^2$ where $Q = 60000Q'$, Q is in L/min. The system curve is given by $H_{sys} = 20 + 0.6\times10^{-6}Q^2$. Determine the operating point and the power required.

Total Marks **[123]**

Useful Formulae

$$N_2 = N_1\left(\frac{1}{R}\right)^n = N_1\left(\frac{D_{T1}}{D_{T2}}\right)^n \qquad N_2 = N_1\left(\frac{1}{R}\right)^n = N_1\left(\frac{D_{T1}}{D_{T2}}\right)^n \qquad \tau = \mu\frac{dV}{dy}$$

$$\text{NPSH} = \frac{p_s}{\gamma} + \frac{V_s^2}{2g} - \frac{p_v}{\gamma} \qquad C = \frac{1}{n}R_h^{\ 1/6} \qquad \text{Re} = \frac{\rho V R_h}{\mu}$$

$$V = C\sqrt{R_h S_0} \qquad V = \frac{1}{n}R_h^{\ 2/3}S_0^{\ 1/2} \qquad p = b + \frac{2y}{\sin\theta}$$

$$\Delta P = \Delta P_L = f\frac{L}{D}\frac{\rho V^2}{2} \qquad A_c = y\left(b + \frac{y}{\tan\theta}\right)$$

$$R_h = \frac{A_c}{p}$$

$$H_{\text{required}} = h_{\text{pump, }u} = \frac{P_2 - P_1}{\rho g} + \frac{\alpha_2 V_2^2 - \alpha_1 V_1^2}{2g} + (z_2 - z_1) + h_{L,\text{ total}}$$

$$\left(\frac{G}{A}\right)^2 \ln\frac{v_2}{v_1} + \frac{P_2^2 - P_1^2}{2P_1 v_1} + 2f\frac{L}{d}\left(\frac{G}{A}\right)^2 = 0$$

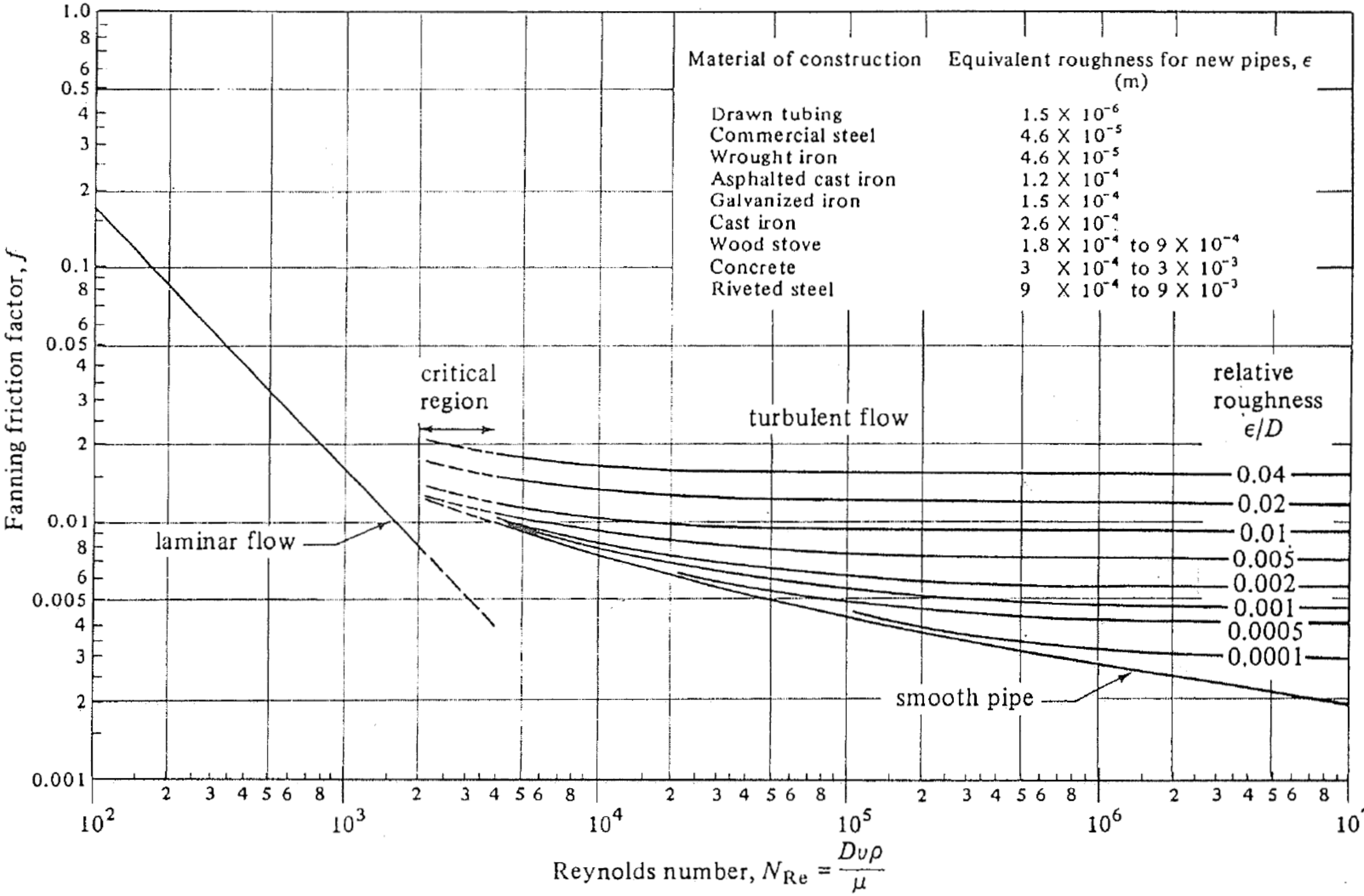


FIGURE 2.10-3. *Friction factors for fluids inside pipes.* [*Based on L. F. Moody, Trans. A.S.M.E.,* **66**, *671, (1944); Mech. Eng.* **69**, *1005 (1947). With permission.*]

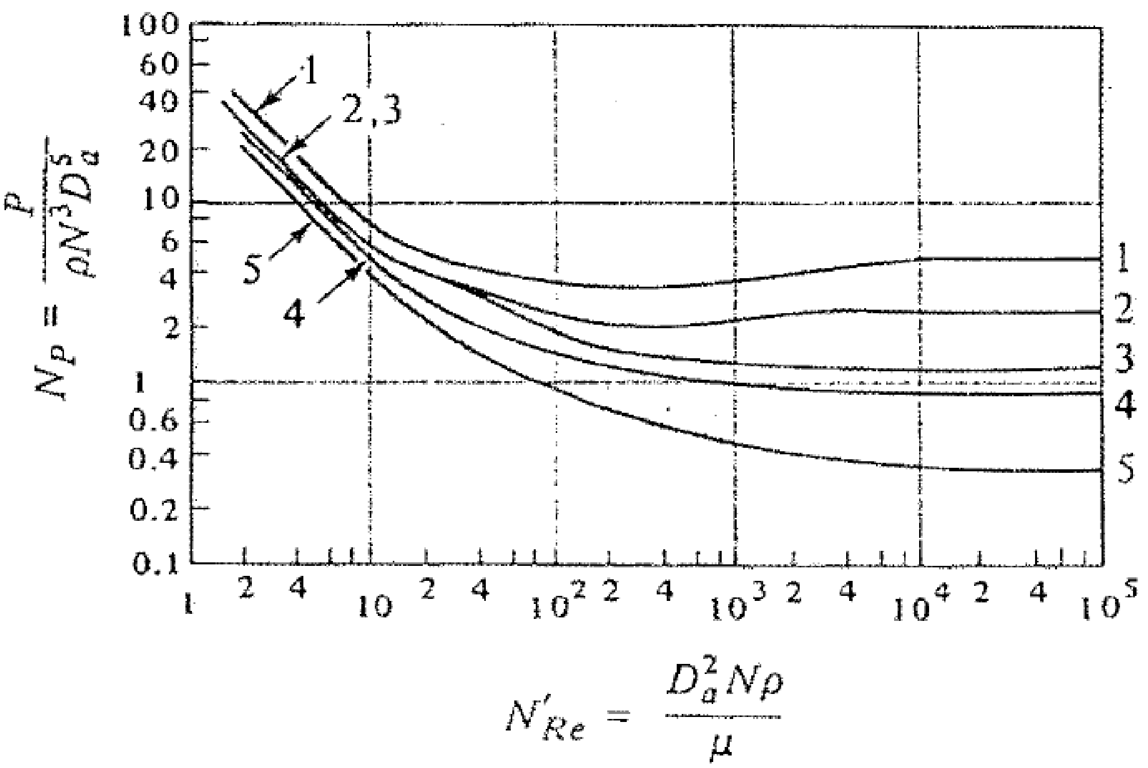
Material	*Absolute roughness* *e (in m)*
Drawn tubing	0.0000015
Commercial steel and wrought iron	0.000045
Asphalted cast iron	0.00012
Galvanized iron	0.00015
Cast iron	0.00026
Wood stave	0.00018–0.0009
Concrete	0.00030–0.0030
Riveted steel	0.0009–0.009

TABLE 5.1

Loss coefficients for standard threaded pipe fittings[9b]

Fitting	K_f
Elbow, standard	
45°	0.35
90°	0.75
Tee	
Straight through	0.4
Used as elbow	1.0
Return bend, 180°	1.5
Gate valve	
Half open	4.5
Wide open	0.17
Angle valve, wide open	2.0
Globe valve, wide open	6.0

Fitting	L_e/d
Elbow, 90° standard	35
Tee, flow straight through	20
Tee, flow through bend	60
Globe valve, fully open	340
Gate Valve, fully open	25



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.*

where $n = 1$ for equal liquid motion, $n = \frac{3}{4}$ for equal suspension of solids, and $n = \frac{2}{3}$ for equal rates of mass transfer (which is equivalent to equal power per unit volume). This value of n is based on empirical and theoretical considerations.