UNIVERSITY OF JOHANNESBURG

PROGRAMME	:	BACHELOR OF ENGINEERING TECHNOLOGY *CHEMICAL ENGINEERING*
SUBJECT	:	**PROCESS FLUID FLOW 2A**
CODE	:	**PFFCHA2**
DATE	:	SUPLEMENTARY EXAMINATION JULY 2019
DURATION	:	3 HOURS
WEIGHT	:	40 : 60
TOTAL MARKS	:	100
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).

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 and 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 (10 Marks)

Freshwater and seawater flowing in parallel horizontal pipelines are connected to each other by a double U-tube manometer, as shown in Figure 1. Determine the pressure difference between the two pipelines. Take the density of seawater at that location to be $\rho = 1035\ kg/m^3$. Can the air column be ignored in the analysis?

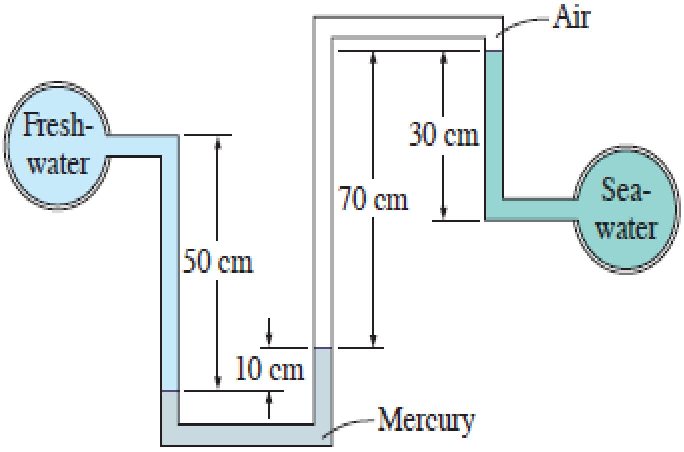


Figure 1. Manometer

Question 2: (25 marks)

Shell-and-tube heat exchangers with hundreds of tubes housed in a shell are commonly used to transfer energy between two fluids. Such a heat exchanger used in an active solar hot-water system transfers heat from a water-antifreeze solution flowing through the shell to fresh water flowing through the tubes at an average temperature of 60 degrees C and at a rate of 15 L/s. The heat exchanger contains 80 brass tubes 1 cm in diameter and 1.5 m in length. Disregarding inlet, exit, and header losses. After operating for a long time, a 1-mm thick scale with a roughness e of 0.4 mm builds up on the inner surfaces.

2.1. Determine the pressure drop across a single tube? (20)

2.2. Determine the pumping power required by the tube side of the heat exchanger? (5)

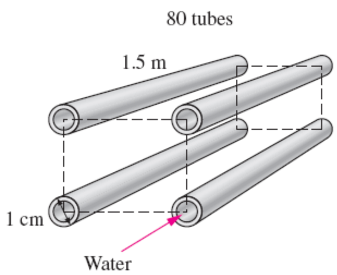


Figure 2. Heat Exchange containing 80 brass tubes

Question 3 (25 Marks)

Suppose you are looking into purchasing a water pump with the performance data shown in the below table. Your supervisor asks you to determine the operating point of the pump .The given conditions of the pumping system is that the pump discharges water to a tank 25 m vertically above it through a 130 mm diameter pipe which is 65 m long. If the Fanning coefficient of friction is 0.009:

Q' l/min	H (m)
0	50
1000	49
2000	48
3000	45
4000	41
5000	34
6000	28

Question 4 (30 marks)

$$\left(\frac{G}{A}\right)^2 \ln\left(\frac{v_2}{v_1}\right) + \frac{P_2^2 - P_1^2}{2P_1v_1} + 2f\frac{L}{d}\left(\frac{G}{A}\right)^2 = 0$$

Methane is generated in a fermenter for a mass flux of 19.25kgs^{-1}m^{-2} in a 0.4m diameter smooth pipeline, length of the pipe is 20000m length. The pressure in the fermenter is 250000Pa. The temperature of the methane remains close to 300K as it travels down the pipeline to the plant. Methane: μ=0.011×10^{-3}Pa.s; MW=16.042gmol^{-1}; R=8.314Pa.m^{3}mol^{-1}K^{-1}.

4.1. What is the pressure of the methane by the time it reaches the plant? (25)

4.2. Can the flow be classified as compressible or incompressible? (3)

4.3. Name two other type of compressible flow in the evaluation of $\int_{P_1}^{P_2} \frac{1}{v} dP$. (2)

Question 5 (10 marks)

5.1. Define what is meant by mixing and agitation? (4)

5.2. What are the purposes of agitation? (6)

Useful Formulae

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

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

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

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

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

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

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

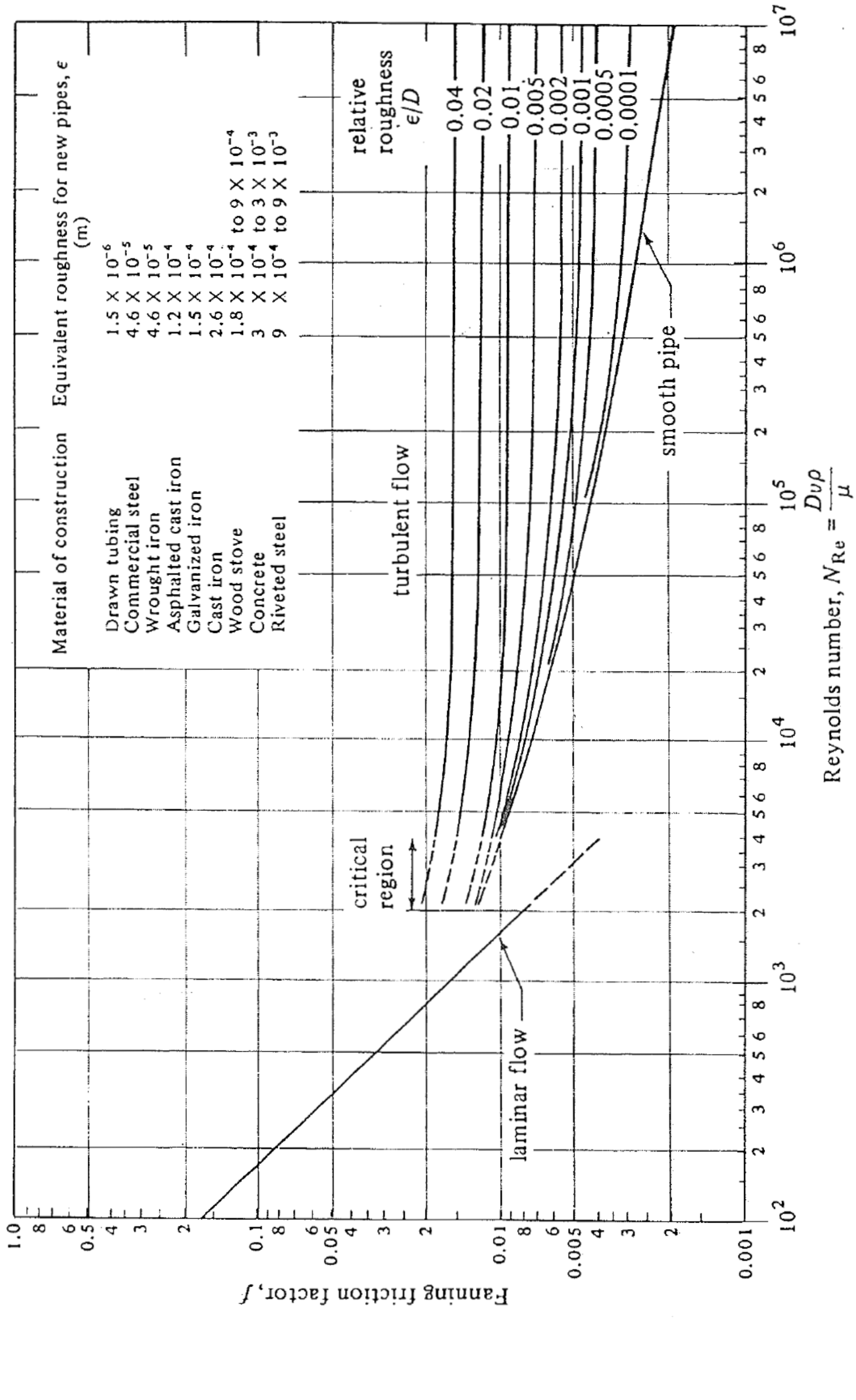


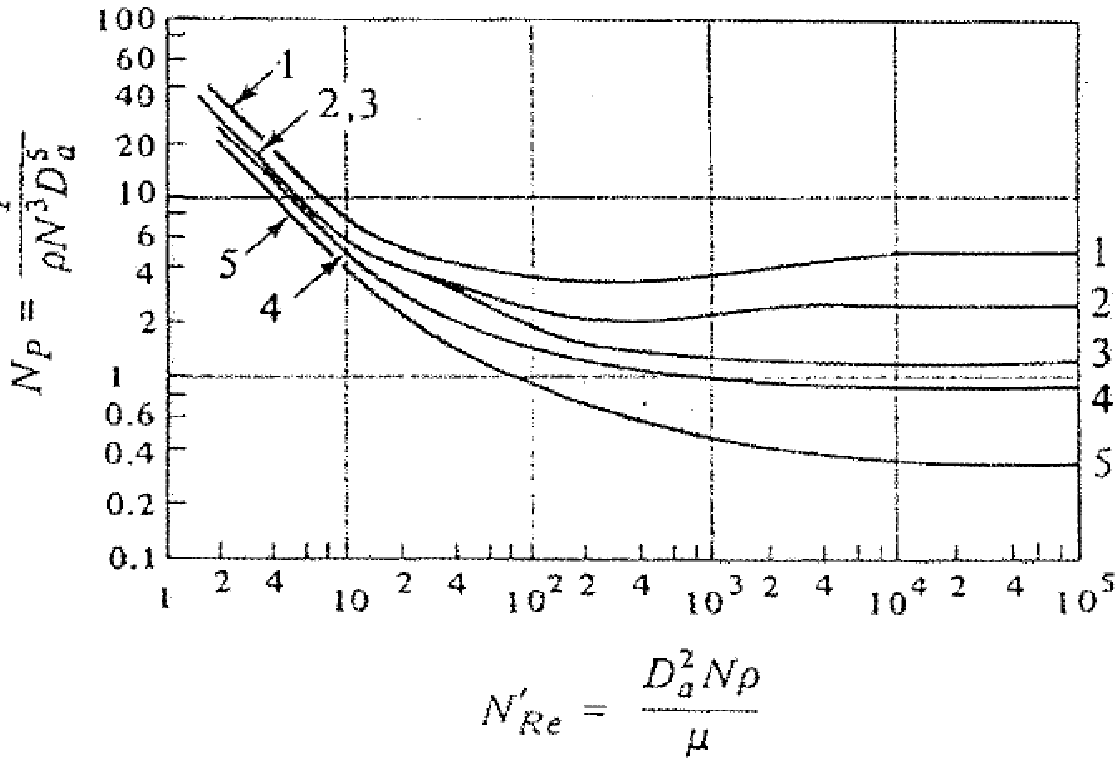
FIGURE 2.10-3. *Friction factors for fluids inside pipes. [Based on L. F. Moody, Trans. A.S.M.E.,* **66**, *671, (1944); Mech. Eng.* **69**, *1005 (1947). With permission.]*

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.