UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 8 Examination in Engineering: November 2016

Module Number: ME8302 **Module Name: Industrial Fluid Dynamics**

[Three Hours]

[Answer all questions, each question carries twelve marks]

Q1 a) List out four applications of pipe flow systems in industry

[1 Mark]

b) Explain the terms 'major losses' and 'minor losses' in pipe systems?

[1 Mark]

c) What are the factors that cause minor losses in pipe systems?

[2 Marks]

d) Irrigation Department has planned to construct a dam across a river in order to supply water for a mini hydro power plant. Figure Q1 (d) shows details of proposed pipe system lay out in brief. The total length of 25 cm diameter Cast iron tube pipes ABCDEF are 30 m. All the valves fitted in the pipe system are in fully open position. Evaluate,

(i) The discharge through the pipe line.

(ii) The pressure at the point D of the pipe line, if ABCD pipe length is 15 m.

(iii) The Velocity of water jet, if end of the pipeline is fitted with a nozzle of diameter 5 cm.

You may take $\rho = 10^3$ kg/m^3 and $\mu = 0.89\times10^{-3}$ Ns/m^2 for water

[8 Marks]

Q2 a) What are the functions of Air Conditioning ducting systems in buildings?

[1 Mark]

b) "Cross sectional area of the HVAC duct system increases, the noise created by the duct system can be reduced". Explain advantages and disadvantages of the solution.

[2 Marks]

...Question Q2 is continued on page 2

Question Q2 is continued from page 1...

c) What are the most common configurations available for supply ducts? Explain with clear sketches.

[1 Mark]

d) Figure Q2 d(i) shows the schematic of a typical supply air duct lay out plan of a kitchen in a proposed hotel project. The air flow rate requirements for each space and the length of main and branches of the duct system are also shown in the figure. The duct material is galvanized steel and the cross section is in rectangular shape with aspect ratio 1.5:1. Use equal-friction method to design the duct system and determine,

(i) Total frictional losses in ducts.

(ii) Fan Total Pressure (FTP).

(iii) Power required to supply air.

(iv) Required sheet metal area for fabricating duct system using chart in Figure Q2 d(ii).

Note: Take the velocity of air in the main duct AB as 8 m/s, a dynamic loss coefficient of 0.3 for upstream to downstream and 0.7 for upstream to branches and for elbows. The dynamic loss coefficient for the outlet may be taken as 1.0.

Use the following equation to calculate frictional pressure gradient of the ducts

$$\frac{\Delta P_f}{L} = \frac{0.022243Q^{1.852}}{Deq^{4.973}}$$

Symbols of the equation shows usual notation.

[8 Marks]

Q3 a) Discuss the assumptions that should be made to analysis a complex pipe network.

[2 Marks]

b) If the head loss of a pipe is given as $H_L = K.Q^x$, derive a mathematical expression for correction of a flow (Δ) in terms of head loss and assumed flow rate.

[2 Marks]

...Question Q3 is continued on page 3

Question Q3 is continued from page 2...

c) The pipe network of two loops as shown in Figure Q3(c) has to be analyzed by the Hardy Cross method for pipe flows for given pipe lengths L and pipe diameters D. The nodal inflow at node A and nodal outflow at node C are shown in the Figure Q3 (c). Use Darcy-Weisbach method to calculate head loss and assume a constant Darcy-Weisbach friction factor as $f_{DW} = 0.02$.

Find the flow rates in all pipes by two iterations.

[Hint: Assume $Q_{AB} = 0.1\,m^3/s$, $Q_{AC} = 0.1\ m^3/s$, $g = 9.81\ m/s^2$ and $H_L = \frac{8Lf_{DW}}{\pi^2 gD^5}Q^2$.

[8 Marks]

Q4 a) What is meant by a Slip of a reciprocating pump and write a reason for it.

[2 Marks]

b) Briefly describe what is manometric (η_{man}) efficiency of a centrifugal pump and write a mathematical expression for it.

[2 Marks]

c) A centrifugal pump is running at 1,000 rpm. The outlet vane angle of the impeller is 45° and velocity of flow at outlet is 2.5 m/s. The discharge through the pump is 0.2 m^3/s when the pump is working against a total head of 20 m. If the manometric efficiency of the pump is 80%, determine:

(i) The outside diameter of the impeller

(ii) The width of the impeller at outlet.

[8 Marks]

Q5 a) "It is erroneous to use homogeneous flow model for predicting frictional pressure drop in two-phase annular flow" Explain the facts in the sentence.

[2 Marks]

b) Describe the homogeneous flow model used to estimate two-phase frictional pressure gradient in pipe flow.

[2 Marks]

...Question Q5 is continued on page 4

Question Q5 is continued from page 3...

c) In a fuel transportation pipeline, fuel flows as a mixture of liquid fuel and vapour at a high ambient temperature. The length and diameter of the pipeline are 15 km and 10 cm, respectively. At the temperature of 30 °C, mass flux of the two-phase mixture and mass quality are 460 kg/m^{2}s and 0.05, respectively. The physical properties of the liquid fuel and vapour at 30 °C are ρ_L=810 kg/m^3, ρ_G=1.2 kg/m^3, μ_L=1.41 × 10^{-3} Pa.s and μ_G=1.789 × 10^{-5} Pa.s. Evaluate;

(i) The single phase frictional pressure drop

(ii) The frictional pressure drop across the pipe line if the entire flow is liquid fuel

(iii) The two-phase frictional pressure drop across the pipeline using Homogeneous Flow Model.

[8 Marks]

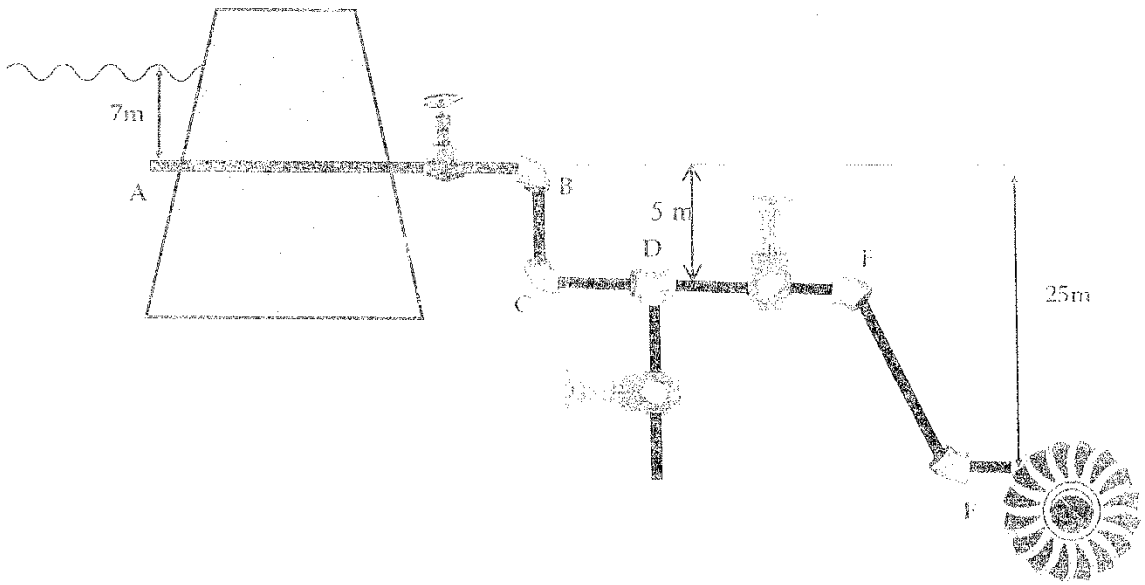


Figure Q1 (d)

Table Q1 (d) : Local resistance coefficients of valves and fittings

Valves / Fittings	Position	Local resistance coefficient
Gate valve	Fully open	0.17
	¾ open	0.9
	½ open	4.5
	¼ open	24.0
Globe valve	Fully open	9.00
	¾ open	13.0
	½ open	36.0
	¼ open	112.0
90^0 elbow regular	-	0.75
45^0 elbow regular	-	0.35
Tee with run flow	-	0.45

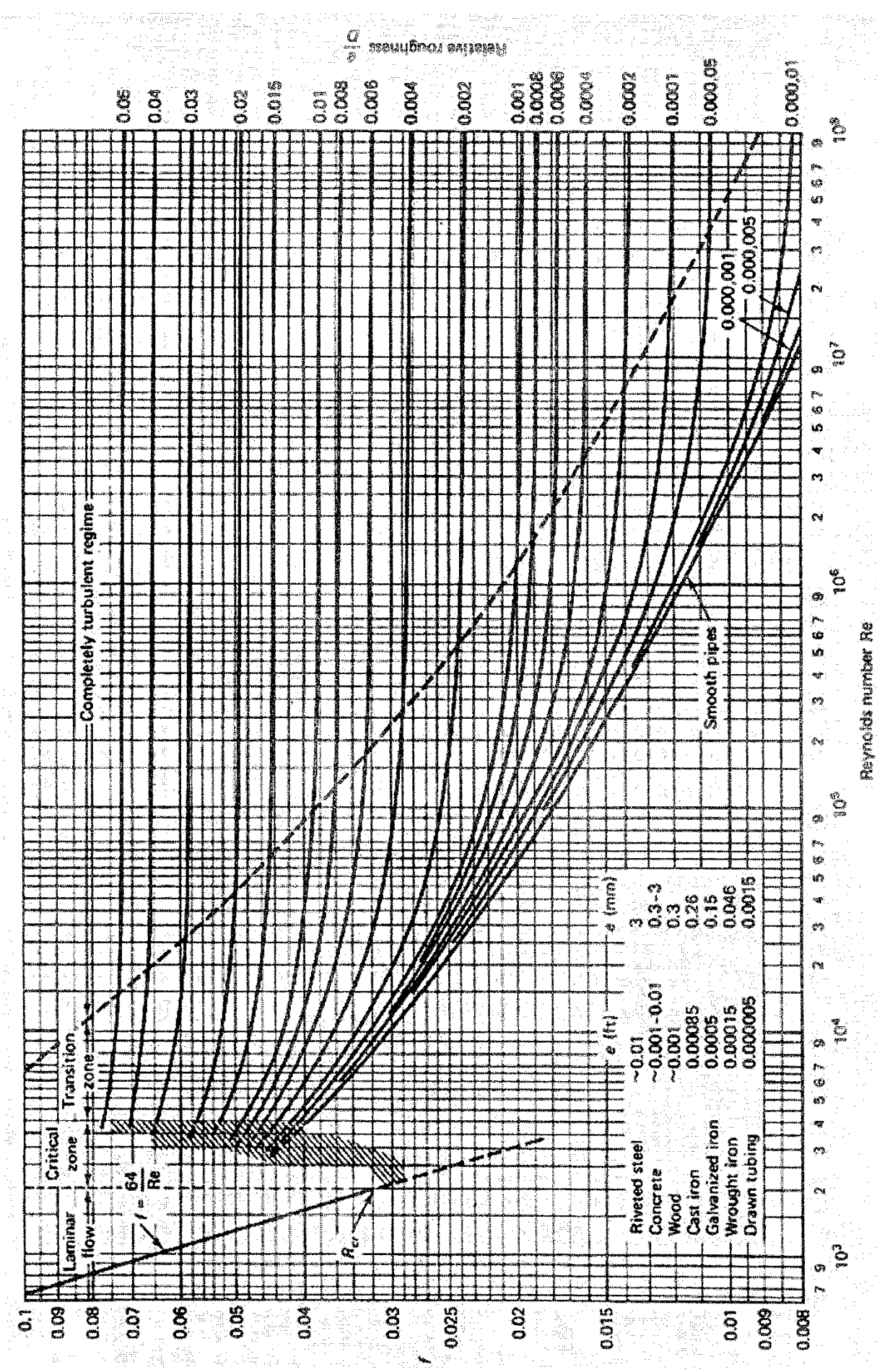
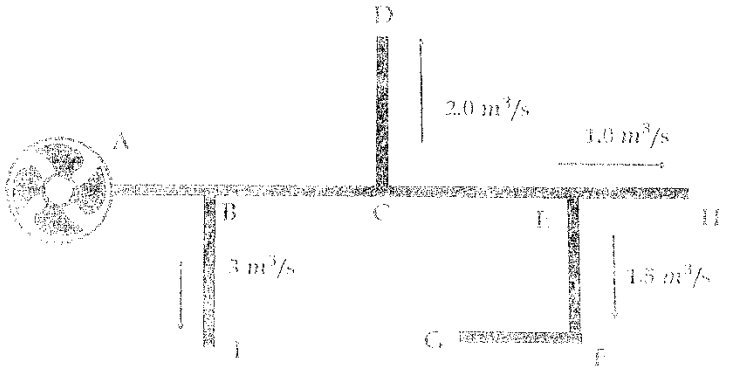

Laminar flow
Critical zone
Transition zone
Completely turbulent regime
$f = \frac{64}{Re}$
A_{cr}
Smooth pipes
0.000,001
0.000,005
Reynolds number Re
Relative roughness $\frac{e}{D}$
e (ft)
e (mm)
Riveted steel ~0.01 3
Concrete ~0.001-0.01 0.3-3
Wood ~0.001 0.3
Cast iron 0.00085 0.26
Galvanized iron 0.0005 0.15
Wrought iron 0.00015 0.046
Drawn tubing 0.000005 0.0015

Chart Q1 (d)



Duct	Length (m)
AB	5
BC	10
CD	5
CE	10
EH	5
EF	5
FG	2
BI	5

Figure Q2 d (i)

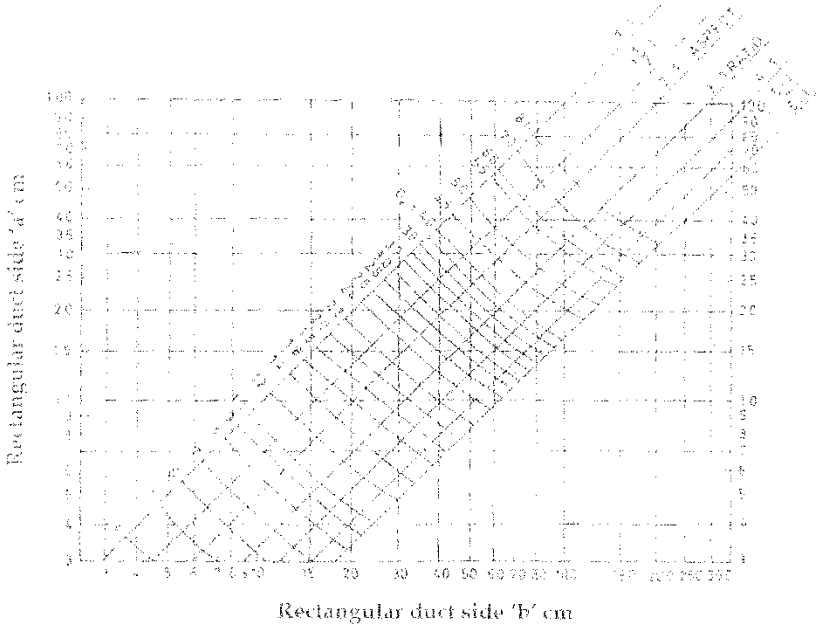


Figure Q2 d (ii)

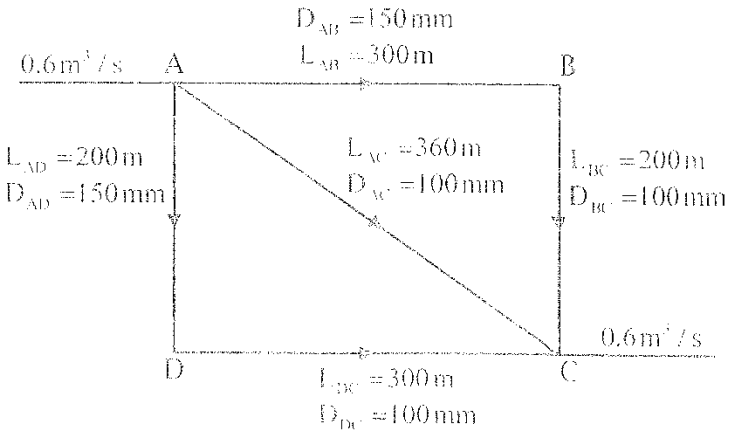


Figure Q3 (c)