UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 3 Examination in Engineering: July 2016

Module Number: ME3301 **Module Name: Fluid Mechanics**

[Three Hours]

[Answer **all questions**, each question carries **twelve** marks]

Q1 a) Define the following terms and give two practical examples for each.

(i) Laminar flow

(ii) Turbulent flow

(iii) Steady flow

(iv) Uniform flow

[2 Marks]

b) Define the two-dimensional stream function and the velocity potential.

[2 Marks]

c) Show that the following stream function represents an irrotational flow:

$$\Psi = 6x - 4y + 7xy + 9$$

[4 Marks]

d) Find the velocity potential of the flow represented by the stream function given in above Q1 (c).

[4 Marks]

Q2 a) Explain the boundary layer development when a fluid flows over a thin flat plate.

[2 Marks]

b) Define boundary layer thickness and derive an expression for the displacement thickness.

[4 Marks]

c) Estimate the power required to overcome the drag force due to the skin friction of a large rocket having a diameter of 3.8 m and a height of 63 m. Its launching speed is found to be 9 km/s. Assume $\nu = 1.53 \times 10^{-5}$ m^2/s and $\rho = 1.248$ kg/m^3 for air.
Note: Neglect the drag forces due to the front nose of the rocket.

[6 Marks]

Q3 a) The energy losses in a fluid flowing pipe is classified as **major energy loss** and **minor energy losses**. Explain the above statement by giving examples.

[2 Marks]

b) Define and explain the following terms.

(i) Hydraulic Gradient Line

(ii) Total Energy Line

[2 Marks]

c) Water is pumped between two large reservoirs at a rate of 0.05 m^3/s through a 120 m long cast iron pipe of 10 cm diameter as shown in Figure Q3. The water levels of the reservoirs are measured from the datum which passes through the center of the pump and are found to be Z_1=6 m and Z_2=36 m. Loss coefficients (K) for values and fittings are given in the Table Q3. Taking density (ρ) = 1000 kg/m^3 and dynamic viscosity (μ) = 1.02×10^{-3} Ns/m^2 for water, determine the following.

(i) Whether the water flow through the pipe is either laminar or turbulent.

(ii) The head increased across the pump

(iii) Power required to run the pump, if its efficiency is 80%.

(iv) Hydraulic gradient line for the flow in the pipe.

[8 Marks]

Q4 a) What are the fundamental dimensions of the following variables?

(i) Absolute Roughness (k)

(ii) Kinematic viscosity (υ)

(iii) Force (F)

(iv) Energy (E)

[2 Marks]

b) The pressure difference Δp in a pipe of diameter D and length l due to turbulent flow depends on the velocity (V), viscosity (η) , density (ρ), and roughness (k). Using Buckingham's π –theorem, obtain the following expression for the Δp.

$$\Delta p = \rho V^2 \phi \left[\frac{l}{D}, \frac{\rho V D}{\mu}, \frac{k}{D}\right]$$

[6 Marks]

c) Water flows through a 80 cm diameter valve at a rate of 80 m^3/s. It is to be tested in a geometrically similar model of 10 cm diameter with water as the working fluid. Determine the required flow rate to be used in the model test in order to achieve dynamic similarity.

[4 Marks]

Q5 a) What are the applications of Positive Displacement Pumps (PDPs)? Explain one of PDPs by drawing a neat sketch of it.

[3 Marks]

b) What are the types of centrifugal pumps used in industrial applications? Explain them briefly.

[2 Marks]

c) A centrifugal pump is driven at 1000 rpm by a constant speed electric motor. The outlet vane angle of the pump impeller is 45° and the radial flow velocity at the pump outlet is 2.6 m/s. The discharge through the pump is 226 l/s when the pump is working against a total head of 18 m. If the manometric efficiency of the pump is 80%, determine:

i) The diameter of the impeller, and

ii) The width of the impeller at outlet.

[7 Marks]

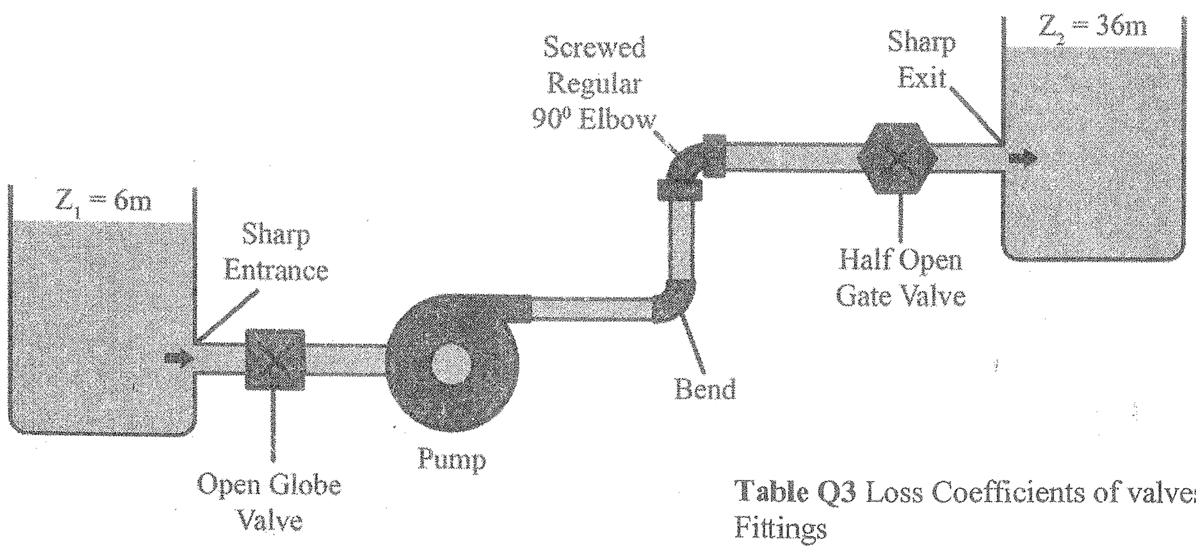
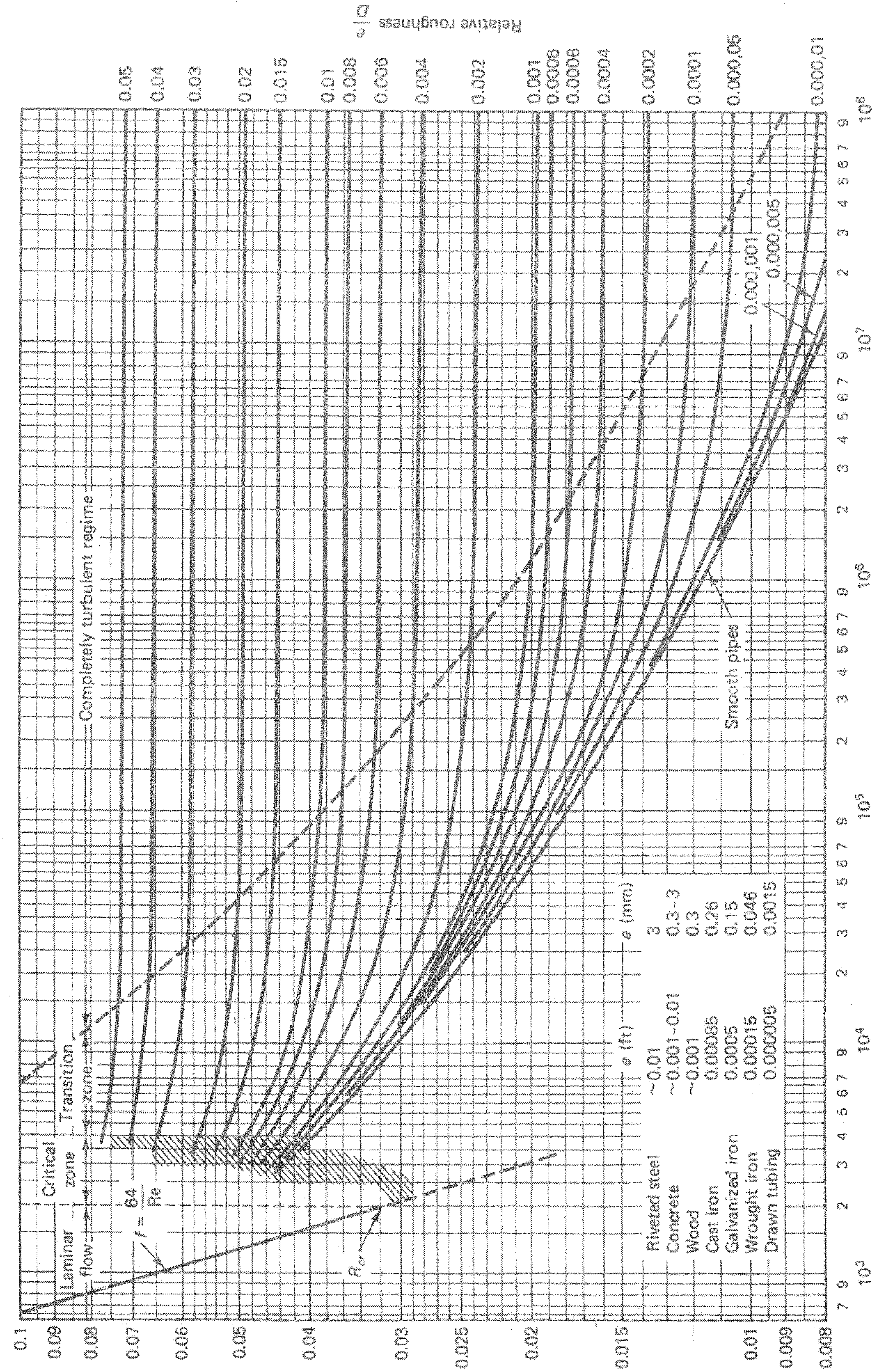


Figure Q3

Table Q3 Loss Coefficients of valves and Fittings

Loss element	*K*
Globe valve (open)	6.9
Bend (R/D = 2)	0.15
Elbow (threaded, 90^0, regular)	0.95
Gate valve (1/2 closed)	2.7



Laminar flow
Critical zone
Transition zone
Completely turbulent regime
f = 64/Re
R_cr
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
e (ft)
e (mm)
Smooth pipes
Reynolds number Re
f
Relative roughness e/D
0.05
0.04
0.03
0.02
0.015
0.01
0.008
0.006
0.004
0.002
0.001
0.0008
0.0006
0.0004
0.0002
0.0001
0.000,05
0.000,01
0.000,005
0.000,001