UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 8 Examination in Engineering: November 2017

Module Number: ME 8302 **Module Name: Industrial Fluid Dynamics**

[Three Hours]

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

You may use clearly labeled sketches to support your answers and make additional assumptions where necessary, but clearly state them in your answers.

Q1 a) "The energy loss in curved conduits is much larger than that of straight conduit of the same length", provide your view on above claim.

[4.0 Marks]

b) A horizontal 1.25 m diameter, galvanized-iron pipeline with five pumping stations is used to distribute SAE 30 oil between two locations. The oil flow is 300 million liters per day, at a density of 910 kg/m^3 and viscosity of 0.01 kg/m·s. Each pumping station, along the line raises the oil pressure to 8 MPa, which then drops, due to head loss, to 400 kPa at the entrance to the next pumping station. Estimate;

i) The distance between two pumping stations

[2.0 Marks]

ii) If the pumps are 88% efficient, calculate the total power requirement for this distribution network.

[3.0 Marks]

iii) To overcome the frequent failures of the pumps, maintenance engineer has proposed one strainer for each suction pipe. After the strainer installation, it has been observed 0.5 % oil flow rate reduction, calculate the resisstence coefficient of the strainer.

[3.0 Marks]

Q2 a) What is meant by the "slip of a pump" and state the reasons for that?

[1.0 Mark]

b) Write three different shapes of impeller blades, which are widely associated in centrifugal pumps?

[2.0 Marks]

Q2 is continued to page 2

c) With the aid of manometric efficiency (η_{man}) of a centrifugal pump, derive a mathematical expression for the "minimum speed" for starting a centrifugal pump?

Note: Manometric efficiency of a centrifugal pump is $\eta_{man} = \frac{gH_m}{V_{w2} \times u_2}$. Where, H_m, V_{w2}, u_2 are usual notations for Manometric head, Velocity of whirl at outlet and Tangential velocity of impeller at outlet respectively.

[4.0 Marks]

d) A centrifugal pump with 1.2 m diameter runs at 200 r.p.m. and pumps 1880 litres/s, the average lift being 6 m. The angle which the vanes make at exit with the tangent to the impeller is 26^0 and the radial velocity of flow is 2.5 m/s. Determine;

i) the manometric efficiency and

[2.0 Marks]

ii) the least speed to start pumping against a head of 6 m

The inner diameter of the impeller is 0.6 m.

[3.0 Marks]

Q3 a) What are the two distinct types of energy losses associated with an Industrial pipe line?

[2.0 Marks]

b) What are the two conditions that must be satisfied when analysis a complex pipe network?

[2.0 Marks]

c) According to the pipe network analysis method suggested by Hardy and Cross, flow through the pipe is firstly assumed and, a correction to these assumed flows is then computed successively for each pipe loop in the network, until the correction is reduced to an acceptable magnitude. If the frictional head loss through the pipe is given as $H_L = K.Q^x$, derive an expression for the error (Δ) by taking assumed flow rate as Q_a and actual flow is Q through the pipe.

[3.0 Marks]

Q3 is continued to page 3

d) Figure Q3 represents a piping network of an Irrigation system which consists of five pipes. Calculate the flow rate in each pipe of the network for two iterations. For each pipe, head loss h_f is given by KQ^2. The values of K for various pipes and also the inflow or outflows at nodes are also given in the Figure Q3. For the first trial, the assumed discharges (liters/minutes) are also indicated in the diagram.

[5.0 Marks]

Q4 a) What is meant by Gross head of a turbine?

[1.0 Mark]

b) Briefly describe the Hydraulic Efficiency of a turbine and the reason for that?

[1.0 Mark]

c) How to distinguish the difference between Impulse and Reaction turbines in terms of energy available at the inlet of the turbine?

[2.0 Marks]

d) A Pelton wheel is working under a gross head of 400 m. The water (ρ= 1000 kg/m^3) is supplied through a penstock of diameter 1 m and the distance between reservoir to the Pelton wheel is 4 km. The co-efficient of friction for the penstock is given as 0.008. Water jet of diameter 150 mm, strikes the buckets of the wheel and gets deflected through an angle of 165°. The relative velocity of water at outlet is reduced by 15% due to the friction between inside surface of the bucket and water. If the velocity of the bucket is 0.45 times of the jet velocity at the inlet and mechanical efficiency is 85%, determine;

i) Power given to the runner

[3.0 Marks]

ii) Shaft power

[3.0 Marks]

iii) Hydraulic efficiency and overall efficiency

[2.0 Marks]

Q5 a) Explain the terms " Homogeneous flow " and " Separated flow "

[2.0 Marks]

b) Provide three practical applications, where two phase flow calculations can be used.

[1.0 Mark]

Q5 is continued to page 4

c) Sketch the liquid gas phase variation with the increment of gas velocity in a two phase flow for a vertical tube.

[3.0 Marks]

d) In an air conditioning plant, cooling process is completed by using a refrigerant R-22 flowing through tube of internal diameter 15 mm and 5m length. The adiabatic flow is expected in the tubes and its mass flux and the vapour quality are 85 kg/m^2s and 0.06, respectively. The fluid R-22 is at a saturation temperature of 4 °C and saturation pressure of 5.6 bar and whose physical properties are ρ_L=1268.1 kg/m^3 , ρ_G=24 kg/m^3, μ_L=0.000201 Pas and μ_G=0.0000119 Pa.s. Evaluate ;

i) The single phase frictional pressure drop

[1.0 Mark]

ii) The frictional pressure drop across the pipe line, if the entire flow is liquid R-22

[1.0 Mark]

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

[2.0 Marks]

iv) The percentage of pressure drop increment due to two-phase mixture flow

[2.0 Marks]

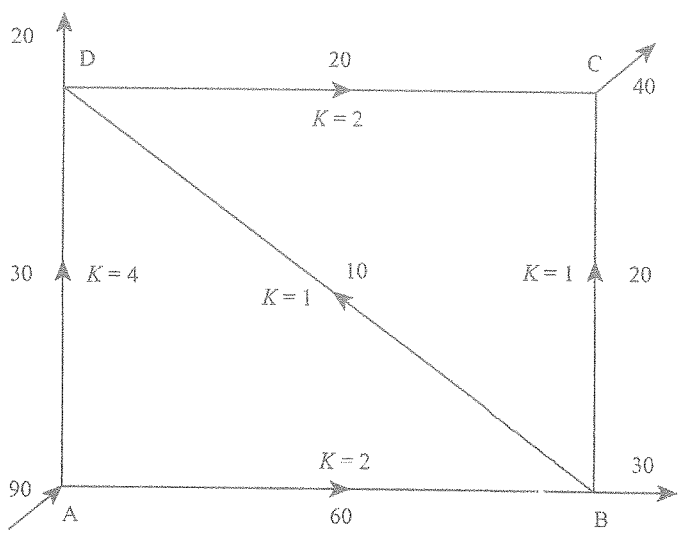
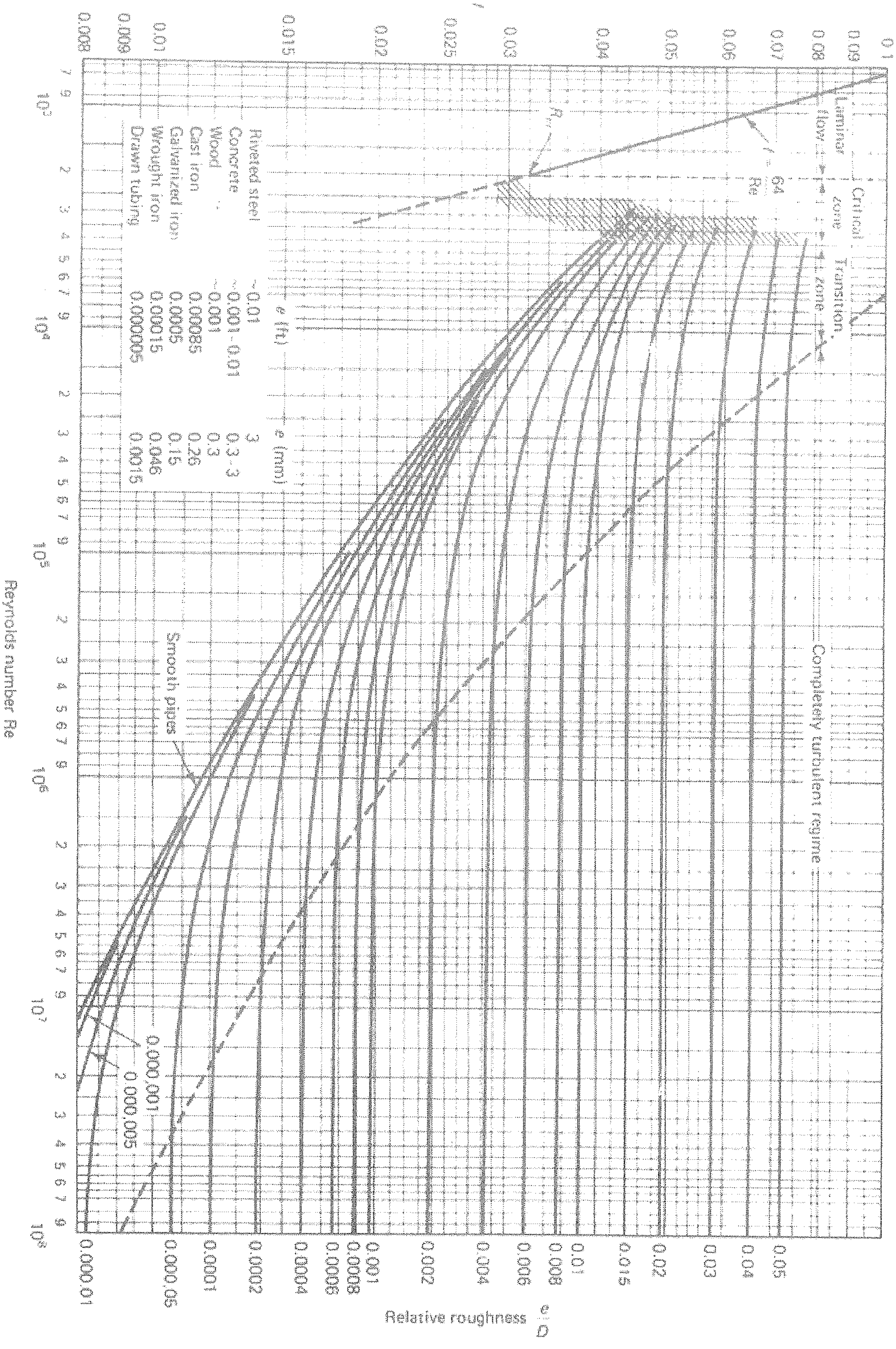


Figure Q3


Laminar flow
Critical zone
Transition zone
Completely turbulent regime
$f = \frac{64}{Re}$
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
0.000,001
0.000,005
Reynolds number Re
Relative roughness $\frac{e}{D}$