UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 8 Examination in Engineering: February 2020

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

[Three Hours]

[Answer **all questions**; each question carries **twelve marks**; provide neat sketches where necessary; make reasonable assumptions and state them clearly]

Q1 a) List out, **four** valve types used in fluid systems.

[1.5 Marks]

b) Discuss **two** factors which create local losses in fluid systems.

[1.5 Marks]

c) Explain **four** methods available to determine local resistance coefficient in fluid systems.

[2.0 Marks]

d) Explain, how friction factor of a fluid system changes while it is operating at the designed flow rate.

[2.0 Marks]

e) Figure Q1(e) shows a pipe flow system which distribute water from a large open tank through a pipe of total length 250 m that contains a number of valves and fittings. The discharge of the pipe flow is at atmospheric pressure. Section ABCD and DCH are on the same horizontal plane. The pipe and all components are made out of galvanized iron having a common effective diameter of 6 cm. If the friction factor for the galvanized iron pipe is 0.026, calculate the following.

i) The maximum discharge of the system.

[2.0 Marks]

ii) Pressure at the point D of the pipe line, if ABD is 175 m long.

[2.0 Marks]

iii) Calculate the local resistance coefficient, if the end of the pipeline is fitted with a nozzle of diameter 5 cm, which makes a head loss of 3 m.

[1.0 Mark]

You may take density and dynamic viscosity of water as 1000 kg/m^3 and 0.89×10^3 Ns/m^2, respectively. Also, for galvanized iron tubes, the absolute roughness is 0.15 mm. Further, refer Table Q1(e) for local resistance coefficients of valves and bends.

Q2 a) Explain **two** advantages of round ducts over rectangular ducts.

[1.0 Mark]

b) List out **two** most common configurations for a supply duct.

[1.0 Mark]

c) Describe **four** general rules in duct designing.

[3.0 Marks]

d) List out **four** methods of duct sizing.

[2.0 Marks]

e) Figure Q2 (e) is a proposed layout plan of a supply air duct in a hotel. The air flow rate requirements for each space and the length of the main duct and its branches are also shown in the same figure. The duct material is galvanized steel and the cross section is a rectangular with an aspect ratio of 3:2. Determine the following by using the equal-friction method in duct designing.

i) The frictional pressure drop in the AB duct segment.

[1.0 Mark]

ii) Minimum power required to supply air to the duct system.

[3.0 Marks]

iii) Calculate the amount of damping required for all duct runs.

[1.0 Marks]

Note: The velocity of air in the main duct AB is 8 m/s. The dynamic loss coefficient for the upstream to downstream is 0.3, and it is 0.7 for upstream to branches, respectively. The dynamic loss coefficient for all the outlets is 0.5 and the density of the air is 1.2 kg/m^3. Use the following equation to calculate frictional pressure gradient of the ducts, where the symbols of the equation are having their usual meaning.

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

Q3 a) Derive an equation for Euler head of a centrifugal pump. Also, find an equation for the manometric efficiency of a centrifugal pump.

[3.0 Marks]

b) An impeller of a centrifugal pump has an outer diameter which is three times that of the inner diameter. The pump works at 1200 rpm and develops a net head of 46 m. The velocity of flow is 2.6 m/s and is constant across the impeller. The vanes are curved backwards with an exit angle of 36°. If the outer diameter of the impeller is 46 cm and the width at the pump outlet is 6 cm, calculate the following.

i) Vane angle at the inlet.

[3.0 Marks]

ii) Work done by the impeller on water per second.

[3.0 Marks]

iii) Manometric efficiency of the pump.

[3.0 Marks]

Q4 a) "Fabrication of an efficient duct systems is very important in HVAC applications in order to minimize the energy losses". Provide justification for this statement. You may use free hand sketching to justify the answer.

[3.0 Marks]

b) "The energy loss in a curved conduit is much larger than that of a straight conduit of the same length". Provide justification for this statement. You may use free hand sketching to justify the answer.

[2.0 Marks]

c) What are the functions of the following in the context of a centrifugal pump?

i) Suction pipe
ii) Delivery pipe
iii) Delivery valve
iv) Priming

[3.0 Marks]

d) Briefly describe the effect of cavitation for the performance of a centrifugal pump.

[2.0 Marks]

e) Briefly describe the main and operating characteristic curves of a centrifugal pump. Also, state how to determine the design discharge of a centrifugal pump.

[2.0 Marks]

Q5 a) Describe the selection of flow models to estimate the two-phase frictional pressure gradient based on the two-phase flow structure in horizontal and vertical tubes.

[2.0 Marks]

b) A mixture of vapour and liquid of a petroleum product is transported in a smooth horizontal tube of diameter 25 cm. The mass flux of the mixture is 850 kg/m^{2}s and the mass quality is 0.04. The physical properties of the individual phases are ρ_G=1.19 kg/m^3, ρ_L = 810 kg/m^3, μ_G=1.789x10^{-5}Pas and μ_L=1.41x10^{-3}Pas, respectively. Considering the separated flow model, determine the following.

i) The single-phase pressure gradients.

[3.0 Marks]

ii) The Lockhart and Martinelli parameter (X).

[2.0 Marks]

iii) The two-phase multipliers using the Chisholm C coefficient method.

[3.0 Marks]

iv) The two-phase pressure gradient.

[2.0 Marks]

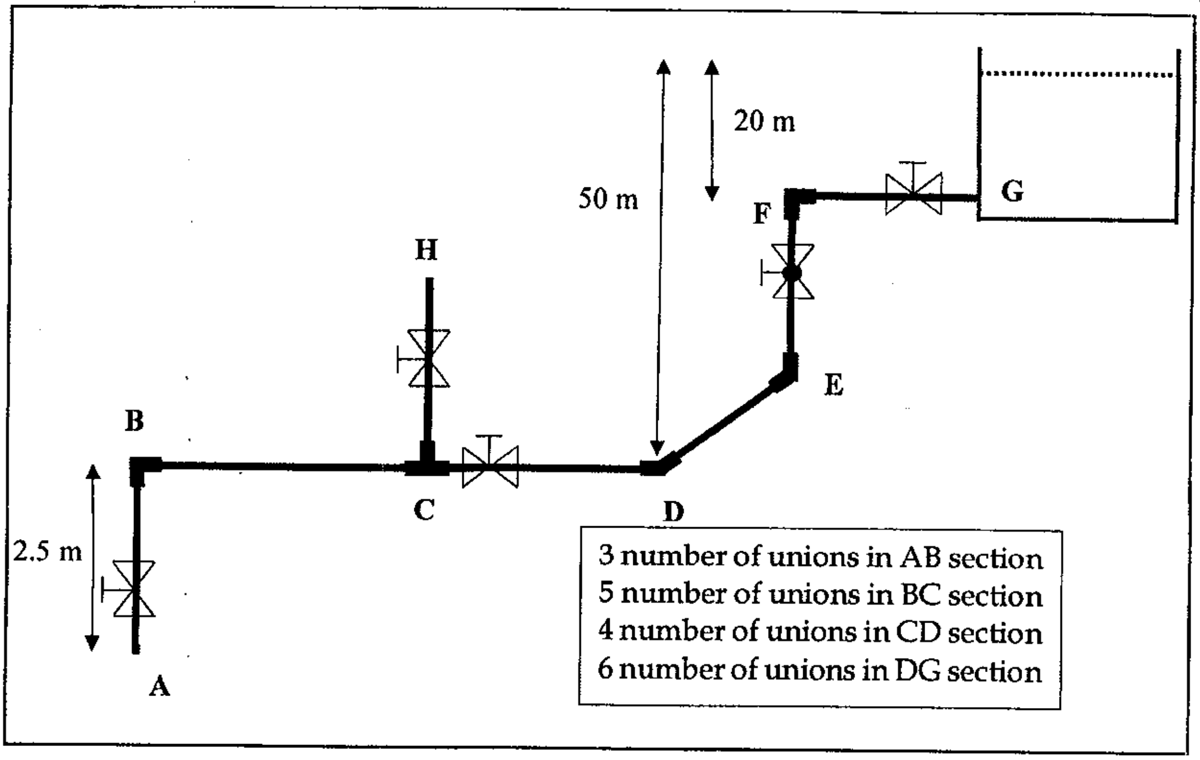

Figure Q1(e): Proposed pipe layout

Table Q1(e): Local resistance coefficients of valves and bends

Type of Valve / Bend	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° elbows regular	-	0.75
45° elbow regular	-	0.35
Tee with run flow	-	0.45
Union	-	0.25

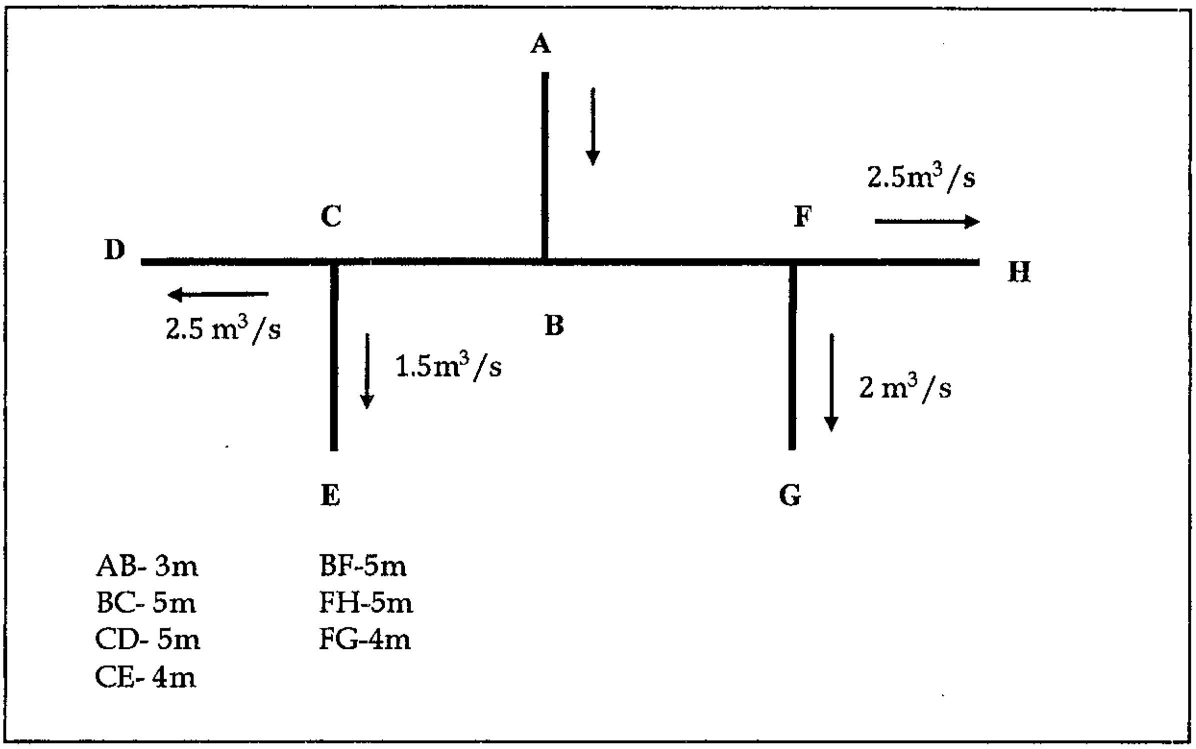

Figure Q2(e): Duct layout