UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 8 Examination in Engineering: August 2022

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) Briefly describe the reasons for cavitation occurring in a centrifugal pump and state some of the common precautions which can be taken to minimize it.

[2.0 Marks]

b) List out **three** types of impellers used in a centrifugal pump and their applications based on the type of liquid to be handled.

[2.0 Marks]

c) A centrifugal pump runs at 900 r.p.m. having external and internal diameters 480 mm and 240 mm, respectively. The rate of flow through the pump is 0.065 m^3/s and the velocity of flow is constant and equal to 2.5 m/s. The diameters of the suction and delivery pipes are 170 mm and 130 mm respectively. Further, the suction and delivery heads are 7.5 m (abs.) and 35 m of water respectively. The power required to drive the pump is 25kW and the outlet vane angle is 45°. If the height of the inlet and outlet of the pump from the datum line is equal, determine the following.

i) Vane angle at the inlet.

[2.0 Marks]

ii) The overall efficiency of the pump.

[3.0 Marks]

iii) The manometric efficiency of the pump.

[3.0 Marks]

Q2 a) List out four main differences between impulse and reaction turbines.

[2.0 Marks]

b) Briefly describe the selection of a suitable turbine for a varying load application using the operating characteristic curve of hydraulic turbines.

[2.0 Marks]

Q2 continues to page 2

c) A Pelton wheel operates under an available head of 550 m and develops 5 MW at a rotational speed of 450 r.p.m. Two equal water jets strike on the buckets of the turbine and deflection angle of the bucket is 165°. The overall efficiency of the turbine is 88%. The coefficient of the velocity of the nozzle is 0.98 and blade speed ratio is 0.46. The relative velocity of water at the exit from a given bucket is 0.85 times the relative velocity at the inlet. Determine the following.

i) The cross-sectional area of a water jet.

[2.0 Marks]

ii) Pitch circle diameter of the buckets.

[2.0 Marks]

iii) Hydraulic efficiency of the turbine.

[2.0 Marks]

iv) For a performance evaluation of this turbine, a geometrically similar 1:8 model which runs at the same efficiency and speed is planned to be used in a laboratory experiment. Calculate the expected power generated by the turbine.

[2.0 Marks]

Q3 a) Mention **two** advantages and **two** disadvantages of using gate valves in pipe systems.

[1.0 Mark]

b) "The local losses are also referred to as minor losses in some literature, but these losses may not be so minor in some cases". Provide reasons to justify the statement.

[1.5 Marks]

c) Make a suggestion to decrease the pressure drop across a strainer fitted to a pipe system that carries water.

[1.5 Marks]

d) A horizontal pipe of diameter 500 mm carries water and is suddenly contracted to a diameter of 250 mm. The pressure intensities in the large and smaller pipe are given as 13.734 N/cm^2 and 11.772 N/cm^2, respectively. Find the loss of head due to contraction if the contraction loss coefficient is 0.62.

[3.0 Marks]

Q3 continues to page 3

e) Eq Q3.e.1 and Q3.e.2 represent characteristics of the pump installed in the pipeline shown in Figure Q3(e). Neglecting any losses, determine the flow rate and efficiency at the operating point by considering the co-efficient of friction and diameter of pipeline as 0.00375 and 15cm respectively. Take the dynamic viscosity of water as 0.001kg/ms. Water is pumped from tank A to tank B.

$$H_P = 70 - 500\,Q^2 \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (Q3e.1)$$

$$\eta = -1500\,Q^2 + 700\,Q \quad \ldots\ldots\ldots\ldots\ldots \quad (Q3(e.2)$$

Here, H_P, η, and Q represent the pressure head, efficiency, and flow rate of the pump, respectively.

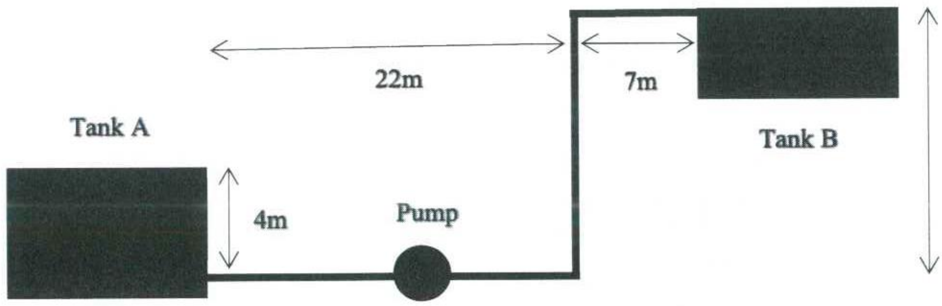


Figure Q3(e)

[5.0 Marks]

Q4 a) Briefly explain **two** methods of reducing noise in HVAC systems.

[2.0 Marks]

b) Discuss **two** disadvantages of flexible ducting compared to nonflexible ducting.

[2.0 Marks]

c) Briefly describe two advantages of using fibreglass over galvanized steel for manufacturing ducts.

[2.0 Marks]

d) Figure Q4 (d) represents a poorly designed ducting layout proposed to be installed in a building HVAC system. Give a better ducting layout assuming the input and output duct sizes and locations remain the same.

Q4 continues to page 4

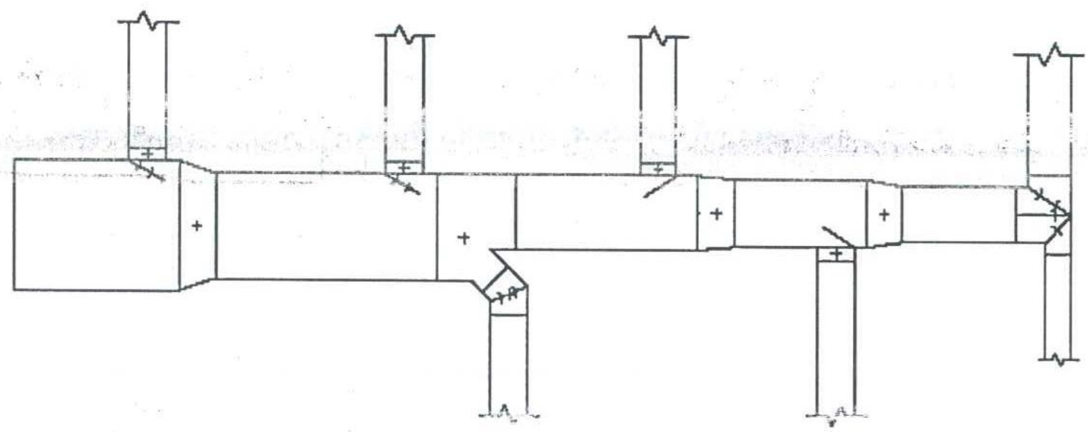


Figure Q4 (d)

[1.0 Mark]

e) Figure Q4 (e) illustrates a ducting layout proposed for a restaurant area of a five-star hotel. Corresponding airflow rates required at each key point and lengths of respective ducts are also given there. The duct material is to be galvanized steel and the cross-section of each duct is rectangular with an aspect ratio of 3:2.

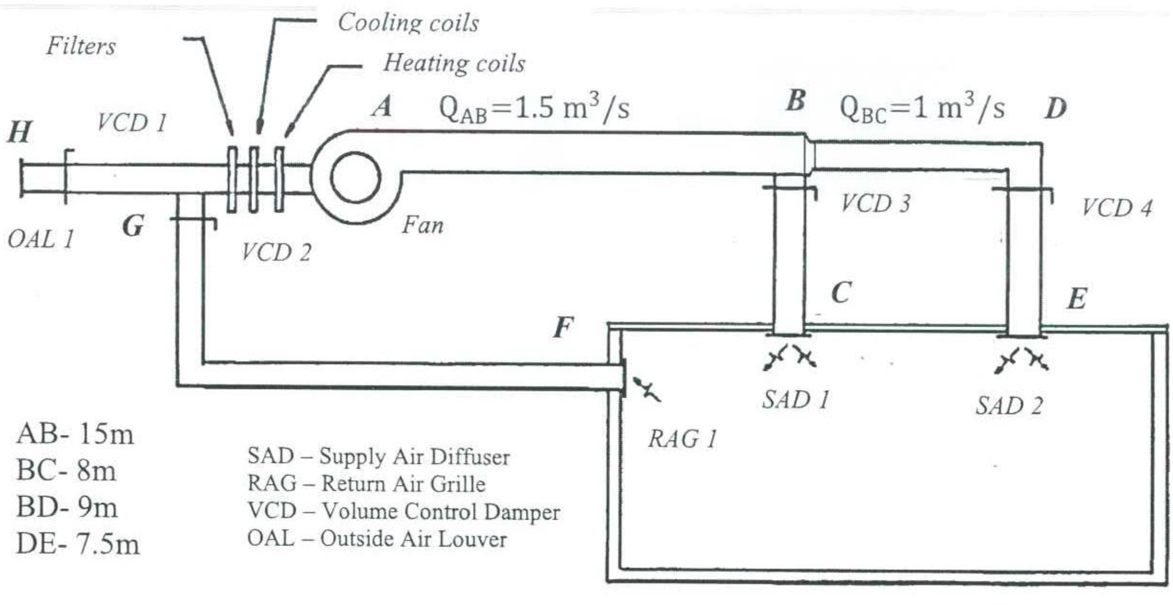


Figure Q4 (e)

Note: The velocity of air in the main duct AB is 6m/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/m³. Use the following equation to calculate the frictional pressure gradient of the ducts, where the symbols of the equation are having their usual meaning.

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

Q4 continues to page 5

Determine the following by using the equal-friction method in duct designing. Neglect HA and FG ducting from the calculation.

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

[1.0 Mark]

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

[3.0 Marks]

iii) Calculate the amount of damping required from VCD 3.

[1.0 Mark]

Q5 a) Mention **two** industrial applications of two-phase flows.

[2.0 Marks]

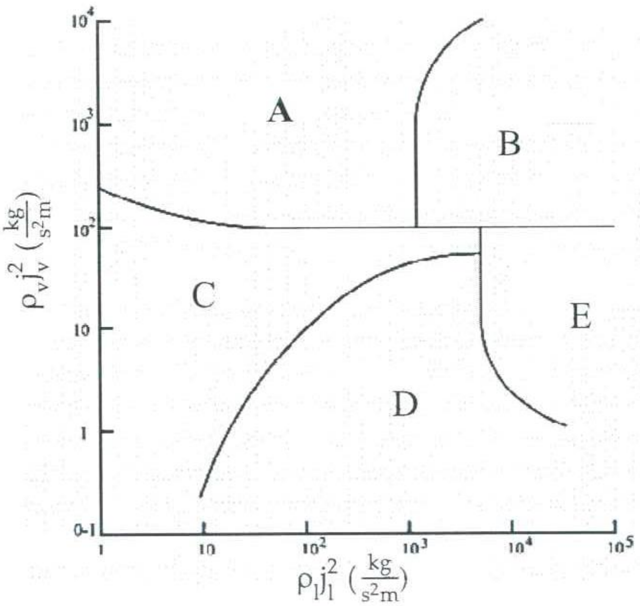
b) What are the reasons for calculations complexities associated with a two-phase flow compared to a single-phase flow?

[2.0 Marks]

c) State **two** assumptions that are used to simplify the pressure drop of a two-phase flow.

[2.0 Marks]

d) Figure Q5 (d) represents the flow-pattern map of a vertical upward gas-liquid co-current flow. Identify the A to E regions of the Figure.



Note: j_v and j_l are the superficial velocities of vapour and liquid r

Figure Q5 (d)

[2.0 Marks]

Q5 continues to page 6

e) Refrigerant R134a flows through a vertical 10 mm diameter tube and it has a vertical upward flow of 0.08 kg/s. The refrigerant is at -20 °C and mass quality is 25%. Liquid and vapour densities of the R134a at -20 °C are 1358 kg/m^3 and 6.785 kg/m^3 respectively. Determine the following.

i) Mass flux of the refrigerant through the tube.

[1.0 Mark]

ii) Superficial velocities of liquid and vapor phases of the refrigerant.

[2.0 Marks]

iii) Identify the flow regime of the refrigerant by considering Figure Q5 (d).

[1.0 Mark]