UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 3 Examination in Engineering: July 2022

Module Number: ME3302 **Module Name: Fluid Mechanics**

[Three Hours]

[Answer **all questions**, each question carries **12** marks]

Q1 a) "The local losses are also referred to as minor losses in some literature, but these losses may not be so minor in some situations". Provide reasons to validate the statement.

[2 Marks]

b) A horizontal pipe of diameter 500 mm is suddenly contracted to a diameter of 250 mm and carries water. 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.

[4 Marks]

c) Eq Q1 (c.1) and Q1 (c.2) represent characteristics of the pump installed in the pipeline shown in Figure Q1(c). Determine the flow rate and efficiency at the operation point by considering the co-efficient of friction and diameter of pipeline as 0.00375 and 15cm respectively. Take dynamic viscosity of water as 0.001 kg/ms. Neglect the local losses.

$H_P=70-500\,Q^2$ ⟶ Equation Q1(c.1)

$\eta=-1500\,Q^2+700\,Q$ ⟶ Equation Q1(c.2)

H_P, η, and Q are pressure head, pump efficiency, and flow rate, respectively.

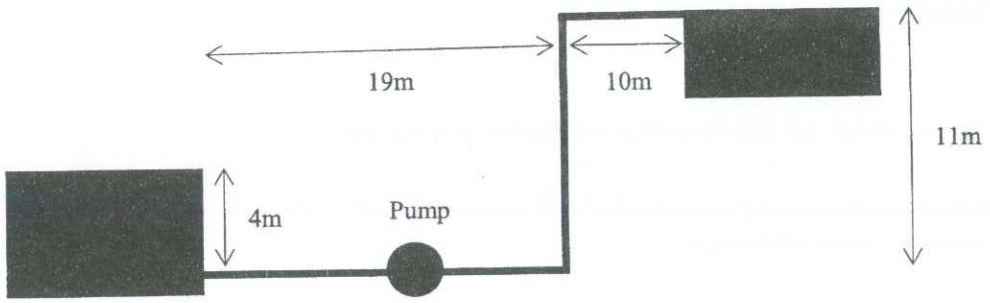

Figure Q1(c)

[6 Marks]

Q2 a) Explain the characteristics of Doublet which is a potential and an ideal super imposed flow pattern.

[2 Marks]

b) Derive expressions to represent the stream and potential functions of the Doublet and draw two separate sketches to illustrate the stream and potential lines. Clearly mention the notations used to represent the parameters of the equations.

[6 Marks]

c) A point P (0.5, 1) is situated in the flow field of a doublet of strength 5 m^2/s. Calculate the velocity at this point.

[4 Marks]

Q3 a) Briefly describe 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 centrifugal pumps and their applications based on the type of liquid to be handled.

[3.0 Marks]

c) The impeller of a centrifugal pump having external and internal diameters 500 mm and 250 mm respectively, width at outlet 50 mm and running at 1200 rpm. works against a head of 48 m. The velocity of flow through the impeller is constant and equal to 3.0 m/s. The vanes are set back at an angle of 40° at outlet. Determine:

i) Inlet vane angle.

[2.0 Marks]

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

[3.0 Marks]

iii) Manometric efficiency.

[2.0 Marks]

Q4 a) List out four main differences between impulse and reaction turbines.

[2.0 Marks]

b) Write brief descriptions of the following in the context of a Pelton turbine.

i) Penstock.

[1.0 Mark]

ii) Spear and nozzle.

[1.0 Mark]

iii) Runner with buckets.

[1.0 Mark]

c) A Pelton wheel operates under an available head of 550 m and develops 5 MW at a rotational speed of 450 rpm. Two equal water jets strike on the buckets of the turbine and deflection angle of buckets is 165°. The overall efficiency of the turbine is 88%. The coefficient of the velocity of the nozzle is 0.98 and the 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) Cross-sectional area of each jet.

[3.0 Marks]

ii) Bucket pitch circle diameter.

[2.0 Marks]

iii) Hydraulic efficiency of the turbine.

[2.0 Marks]

Q5 a) State four applications of dimensional and model analysis in solving engineering problems.

[2.0 Marks]

b) In order to predict the performance of a large centrifugal pump, a scale model of one-sixth size was made with the following specifications: Power P = 25 kW; Head H_{mano}= 7 m; Speed N = 1000 rpm. If the prototype pump has to work against a head of 22m, calculate the followings.

i) Working speed.

[2.0 Marks]

ii) The power required to drive the prototype pump.

[2.0 Marks]

c) The resistance R experienced by a partially submerged body depends upon the velocity V, length of the body l, viscosity of the fluid μ, density of the fluid ρ and gravitational acceleration g. Show that the R is given by,

$$R=l^2V^2\rho\,\varphi\left(\frac{\rho Vl}{\mu},\frac{V}{\sqrt{lg}}\right)$$

[6.0 Marks]