UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 3 (Repeat) Examination in Engineering: August 2015

Module Number: ME3307 **Module Name: Fluid Mechanics**

[Three Hours]

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

Q1 a) Compare the growth of laminar and turbulent boundary layer thickness in a two dimensional flow along a flat plate.

[3 Marks]

b) An advertising board with dimension 4 m x 3 m is mounted on the top of a truck as shown in **Figure Q1**. The thickness of the board is negligible and its 3 m edge is faced in the direction of motion of the truck. If the truck moves in a straight road with a speed of 80 km/hr, determine the following,

i) The drag force on the board due to boundary layer development,

ii) The additional power needed for the truck due to the drag on the board,

iii) If the board length increases one meter more, what percentage of power is needed to be increased?

[9 Marks]

Note : Assume that kinematic viscosity = 1.53×10^{-5} m^2/s and density = 1.248 kg/m^3 for air.

Q2 Water is pumped from the sump side to an overhead storage tank, which is vented to atmosphere, by means of a pump discharging through a pipeline 50 m long and 0.1 m in diameter. The static pressure at the pump outlet into the pipeline is 2.8 bar (gauge pressure). There is a flow control valve at a distance of 20 m from the pump outlet. The flow control valve is fully open and has a negligible head loss at that condition. The head loss through the 90° bends can be estimated by the equation $1.3V^2/2g$. The pipe line enters the overhead tank 10 m above the level of the pump outlet and 6 m below surface of the water in the tank

as shown in the **Figure Q2**. If the friction factor f for the pipe is 0.007 calculate the following, assuming that the velocity head at the pump outlet is negligible,

i) The volume rate of flow in the pipeline

[4 Marks]

ii) The gauge pressure of the ~~oil~~ water at the entry to the control valve,

[4 Marks]

iii) Sketch the hydraulic gradient line putting in the most important values. [4 Marks]

Q3 a) Explain the important benefits which designers and engineers in the field of fluid mechanics expect by conducting hydraulic model studies.

[2 Marks]

b) The rate of flow Q of a fluid of density ρ and viscosity μ is to be measured by means of an orifice meter of diameter d installed in the pipeline of diameter D. The pressure loss over the orifice plate is Δp. Show by using the method of dimensional analysis that

$$Q = Cd^2\sqrt{\frac{\Delta p}{\rho}}$$

in which C is a discharge coefficient dependent upon the parameter $\frac{\rho Q}{\mu d}$ and d/D.

[5 Marks]

c) A model of a fishing boat 70 cm long is tested in a towing tank at a speed of 40 cm per second. If the real boat is 15 m long, determine the following,

i) The corresponding speed of the real boat,

ii) The propulsive force required for the real boat when the model requires a force of 2.5 N in the towing tank.

[5 Marks]

Q4 a) For what purposes are pumps used in engineering applications? Explain three different types of pumps by paying attention to their application.

[3 Marks]

b) Draw a neat sketch of a screw pump and explain how it accomplishes pumping of a liquid.

[3 Marks]

c) Explain a type of centrifugal pump that can be used to lift the water with solid particles.

[3 Marks]

d) Why should the centrifugal pump manufacturers provide performance characteristic curves of the pump to users?

[3 Marks]

Q5 a) Define and explain the following efficiencies of a centrifugal pump,

i) The manometric efficiency

ii) The mechanical efficiency

iii) The overall efficiency.

[2 Marks]

b) A centrifugal pump delivers water against a net head of 15.5 m with a designed speed of 1500 rpm. The vanes are curved back at an angle 30° with the periphery. The impeller diameter at outlet is 30 cm and outlet width 5 cm. The manometric efficiency of the pump is estimated as 95%. Determine the following of the pump,

i) The theoretical head, [2 Marks]

ii) The velocity of the flow through the impeller, [2 Marks]

iii) The discharge, [3 Marks]

iv) The power required, if the pump's overall efficiency is 80%. [3 Marks]

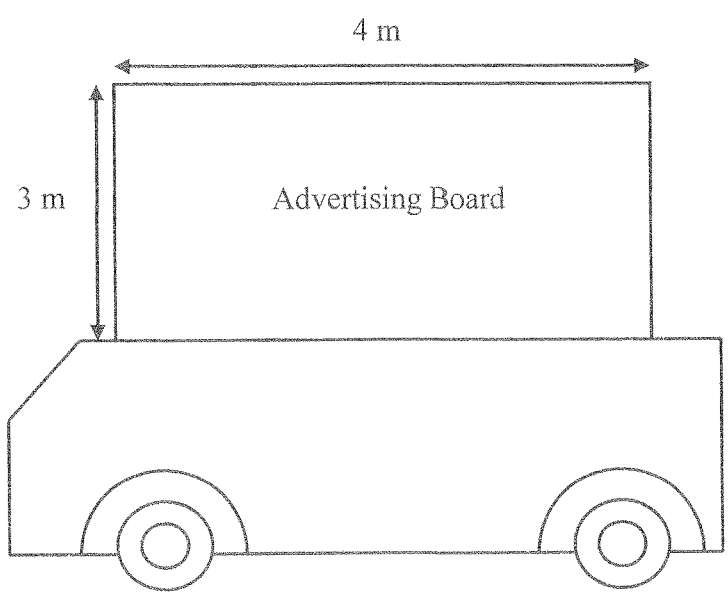

Figure Q1

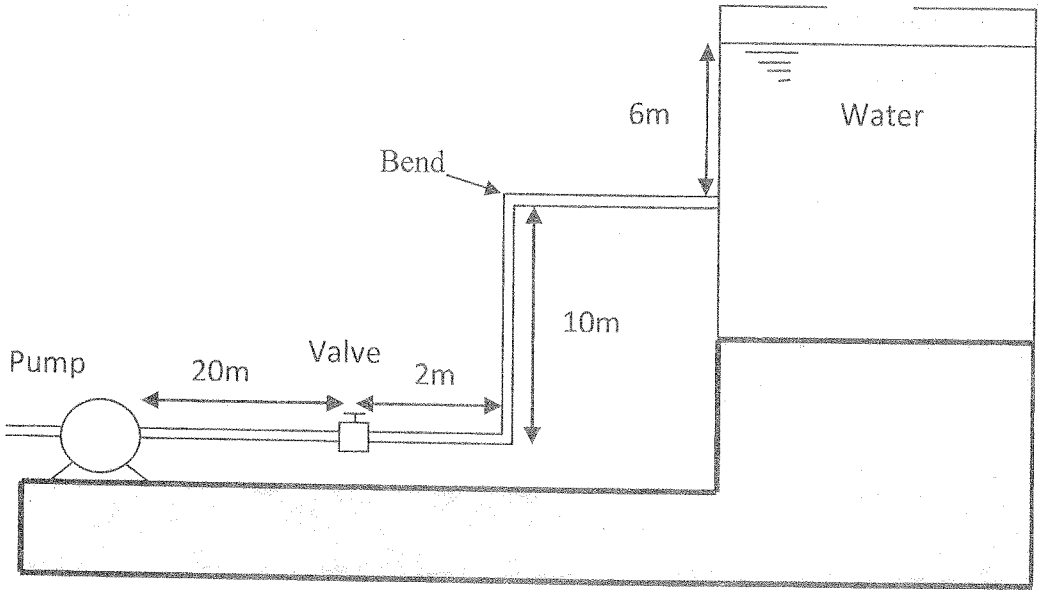

Figure Q2