



UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 3 Examination in Engineering: August 2015

Module Number: ME3301

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} m²/s and density = 1.248 kg/m³ 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]

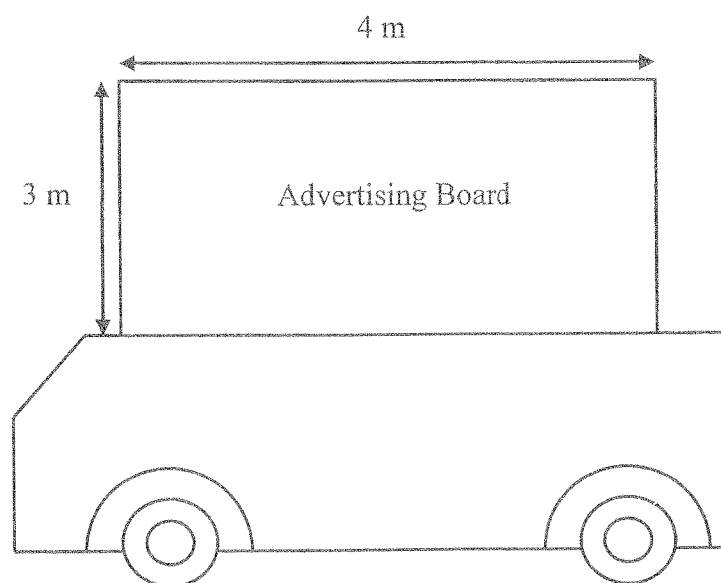
iii) The discharge,

[3 Marks]

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

[3 Marks]

Figure Q1



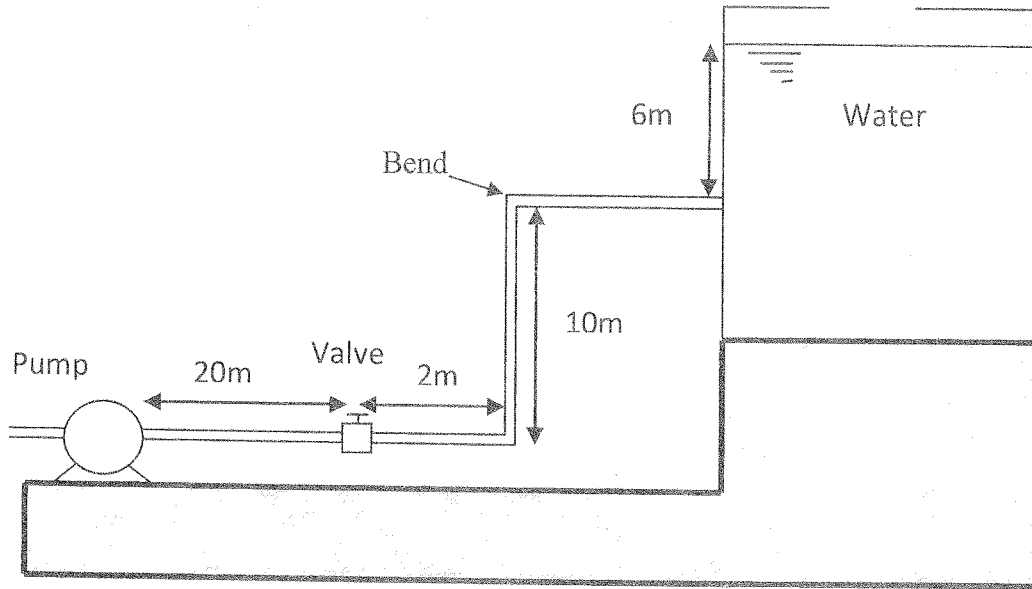


Figure Q2