MACHAKOS UNIVERSITY

University Examinations 2016/2017

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF BUILDING AND CIVIL ENGINEERING

SECOND YEAR SECOND SEMESTER EXAMINATION FOR DEGREE IN

BACHELOR OF SCIENCE IN CIVIL ENGINEERING

ECV 207 FLUID MECHANICS II

DATE: 14/6/2017 **TIME: 8:30 – 10:30 AM**

INSTRUCTIONS

- **i) Answer Question One and Any Other Two Questions**
- **ii) Necessary charts and tables are attached**
- **iii) Assume water temperature, where required is 15^0C (Kinematic viscosity = 1.3 x 10-6 m2/s).**

QUESTION ONE (COMPULSORY) (30 MARKS)

a) A piston of 46 mm diameter slides concentrically in a fixed cylinder of 50 mm diameter. The cylinder is filled with water and when the piston moves into the cylinder the water flows through the annular gap surrounding the piston. If the velocity of the piston is 75 mm/s relative to the cylinder, what is the velocity of flow through the gap? (4 marks)

b) Show by the method of dimensions, that a rational formula for the flow over a vee-notch is given by:

$$Q = g^{1/2}h^{5/2}\phi\left(\frac{g^{1/2}h^{3/2}}{\nu}, \frac{gh^2\rho}{\tau}, \theta\right)$$

Where, Q is the flow, h is the head above the vertex, ρ is the density, υ is the kinematic viscosity and τ is the surface tension of the fluid, θ is the angle of the notch, and g is the acceleration due to gravity (4 marks)

c) Explain the difference between the following pairs of types of flows

i. Turbulent flow and laminar flow

ii. Steady flow and unsteady flow

iii. Uniform flow and non-uniform flow

iv. Rotational and irrotational flow (4 marks)

d) Derive the Bernoulli's energy equation for flow in pipes without energy losses, stating the assumptions made. (6 marks)

e) A venturi-metre measures the flow of water in a 75 mm diameter pipe. The difference of head between the throat and the entrance of the metre is measures by a U-tube containing mercury, which is in contact with the water. Determine the diameter of the throat of the metre in order that the difference in level of mercury be 250 mm when the quantity of water flowing in the pipe is 620 dm^3/min. Assume a coefficient of discharge of 0.97 (5 marks)

f) Water issues out of a conical tank whose radius of cross-section varies linearly with the height from 10 cm at the bottom of the tank. The slope of the tank wall with the vertical is 30o. A short pipe of 2 cm diameter is fitted at the bottom for discharging the water. Calculate the time taken for the tank to be emptied from an initial water level of 70 cm. Assume that the pipe entry loss coefficient is 0.5, and is constant at all-time (7 marks)

QUESTION TWO (20 MARKS)

a) Two reservoirs are connected by a pipe whose total length is 360 m. from the upper reservoirs the pipe is 300 mm diameter for a length of 150 m and the remaining 210 m is 450 mm diameter. The velocity of water in the smaller pipe is 1.2 m/s. Calculate: -

i. The loss of head at the entrance, at the junction and at the exit to the lower reservoir

ii. The difference in levels of the water in the two reservoirs, considering the losses

iii. Sketch the hydraulic gradient for the system

Take the coefficient of friction for the smaller and larger pipe as 0.006 and 0.005, respectively (8 marks)

b) Reservoir A delivers to reservoir B through two uniform pipelines AJ : JB of diameter 300 mm and 200 respectively. Just upstream of the change in section, which is assumed gradual, a controlled discharge of 30 l/s is taken off. Length AJ is 3000 m; length JB is 4000 m; effective roughness size of both pipes is 0.015 mm; gross head is 25 m.

i. Determine the discharge to reservoir B, neglecting the loss at J

ii. Sketch the system, showing the hydraulic and energy gradelines (12 marks)

QUESTION THREE (20 MARKS)

a) A fire engine pump develops a head of 50 m; i.e. it increases the energy per unit weight of the water passing through it by 50 Nm/N. The pump draws water from a sump, 2m below, through a 150 mm diameter pipe in which there is a loss of energy per unit weight due to friction, $h_s = 5v_s^2/2g$, varying with the mean velocity v_s in the suction pipe and discharges it through a 75 mm nozzle, 30 m above the pump, at the end of a 100 mm diameter delivery pipe in which there is a loss of energy per unit weight $h_d = 12v_d^2/2g$, varying with the velocity v_d in the delivery pipe. Calculate:-

i. The velocity of the jet issuing from the nozzle

ii. The pressure in the suction pipe at the inlet to the pump

iii. Draw a hydraulic and energy gradelines for the system. (14 marks)

b) If in (a) above, the fire hydrant nozzle is held at a height of 3m from the ground at an angle of 45^o with the horizontal; and the jet strikes the ground at a horizontal distance of 12 m from the nozzle, find:

i. The maximum height the jet can reach

ii. The horizontal distance from the nozzle at which the maximum height occurs

(6 marks)

QUESTION FOUR (20 MARKS)

a) A steel pipeline 2000 m long, 300 mm diameter, discharges water from a reservoir at atmosphere through a valve,at the downstream end, the discharge coefficient of which is 0.6. The valve is closed so that its area decreases linearly from 0.065 m^2 to zero in 21 seconds. The initial head at the valve is 3.0 m and the wave speed is 1333.3 m/s.

i. Calculate and plot a graph of variation of pressure head at the valve during its closure.

ii. Determine the maximum pressure rise at the valve.

Neglect friction losses in the pipe. (15 marks)

b) A surge chamber 10 m in diameter is situated at the downstream end of a low pressure tunnel 10 km long and 3 m in diameter. At a steady discharge of 36 m3/s the flow to the turbines is suddenly closed by the turbine inlet valves. Determine the maximum rise in level in the surge chamber and its time of occurrence (5 marks)

QUESTION FIVE (20 MARKS)

a) A horizontal bend in a pipeline conveying 1 m^3/s of water gradually reduces from 600 mm to 300 mm in diameter and deflects the flow through an angle of 60°. At the larger end the pressure is 170 kN/m^2. Determine the magnitude and direction of the force exerted on the bend(10 Marks)

b) Show that a correction factor to allow for velocity of approach to a rectangular notch can be expressed in the form:

$$\left[\left(1+\frac{\alpha h'}{H}\right)^{3/2}-\left(\frac{\alpha h'}{H}\right)^{3/2}\right]$$

Where H is the measured head, $h' = v^2/2g$, v is the velocity of approach and α is a factor to allow for the velocity not being uniform over the section of the channel (4 marks)

c) A rectangular channel 1.2 m wide has at the end a rectangular sharp-edged notch 0.9 m wide, with the sill 0.2 m from the bottom. Assuming α = 1.1, calculate the flow when the head is 250 mm, using the Francis formula (6 marks)