



MACHAKOS UNIVERSITY

University Examinations for 2024/2025 Academic Year

SCHOOL OF ENGINEERING AND TECHNOLOGY
DEPARTMENT OF BUILDING AND CIVIL ENGINEERING

THIRD YEAR FIRST SEMESTER EXAMINATION FOR DEGREE IN
BACHELOR OF SCIENCE IN CIVIL ENGINEERING

ECV 302: HYDRAULICS I

DATE: 20TH JANUARY, 2025

TIME: 11.00 AM – 1.00 AM

INSTRUCTIONS:

Answer question ONE (Compulsory) and any other TWO questions

QUESTION ONE (COMPULSORY) (30 MARKS)

- a) Define the term open channel flow. (2 marks)
- b) Discuss four applications of hydraulic jumps in open channel flow. (4 marks)
- c) Explain the main differences between pipe flow and open channel flow. (4 marks)
- d) Derive the Chezy's formula for determination of discharge through an open channel. (5 marks)
- e) Show that for the most economical or efficient rectangular channel, either the depth of flow is half the width of the channel or hydraulic radius is half the depth of flow. (4 marks)
- f) A rectangular channel with a width of 4.5m and water depth of 1.2m is laid on a slope of 0.0009 and is laid with rubber masonry having a Manning's roughness coefficient of $n=0.017$, what saving in excavation and lining in terms of area can be done by using the best hydraulic dimensions, but at the same time keeping the same shape, discharge, and slope. (6 marks)
- g) A rectangular channel with a width of 5.5m and water depth of 1.25m has a channel bed slope of 1 in 900. Determine the discharge when Manning's roughness coefficient $n=0.015$. By changing the size of the channel but keeping the same quantity of lining, determine the new dimensions (water depth and width) if it is desired to increase the discharge to a maximum and also calculate percentage increase in discharge. (5 marks)

QUESTION TWO (20 MARKS)

- a) Find the bed slope of trapezoidal channel of bed width 6 m, depth of water 3 m and side slope of 3 horizontal to 4 vertical, when the discharge through the channel is $30 \text{ m}^3/\text{s}$.
Take Chezy's constant, $C = 70$. (3 marks)
- b) A rectangular channel with a semicircular bottom of 2m diameter is used to discharge effluent. Calculate the discharge through the channel when the depth of flow is 2m. Take Chezy's constant $C = 70$ and the bed slope is 1 in 1000. (5 marks)
- c) Prove with illustrations that for a most economical section of a trapezoidal channel, either
- One of the sloping sides is equal half of the top width. (3 marks)
 - The hydraulic radius is half the depth of flow. (3 marks)
- d) A trapezoidal channel has side slopes of 1 horizontal to 2 vertical and the slope of the bed is 1 in 1500, the cross sectional area of flow is 40 m^2 . Find the dimensions of the section if it is most economical. Determine the discharge of the most economical section if $C=50$. (6 marks)

QUESTION THREE (20 MARKS)

- a) Define the term hydraulic jump. (2 marks)
- b) State the conditions necessary for the formation of a hydraulic jump. (4 marks)
- c) Discuss five classification of hydraulic jumps in terms of their Froude numbers and energy dissipation. (5 marks)
- d) The depth and velocity of a stream of water are 0.9m and 6m/s respectively. Determine if the hydraulic jump will occur. If so, determine the values of its depth, velocity and loss of specific energy after the jump. (4 marks)
- e) A sluice spans the entry of a 3.5m wide rectangular channel and admits $5.5 \text{ m}^3/\text{s}$ of water with a uniform velocity of 4.2m/s. Assuming that conditions for a hydraulic jump exist, determine the following
- Depth of flow. (1 mark)
 - Height of the jump. (1 mark)
 - Head loss in the jump. (1 mark)
 - Rate of dissipation of energy. (2 marks)

QUESTION FOUR (20 MARKS)

- a) Define the term specific energy. (2 marks)
 - b) Differentiate the term alternate depth and critical depth. (2 marks)
 - c) With an aid of a well labeled diagram, draw a specific energy diagram. (5 marks)
 - d) A channel of 6m wide is discharging $20\text{m}^3/\text{s}$ of water. If the specific energy of flowing water is at minimum, determine its depth and critical velocity of the flowing water. (3 marks)
 - e) A channel of rectangular section is 7.5m wide is discharging water at a rate of $12\text{m}^3/\text{s}$ with an average velocity of 1.5m/s, calculate the following,
 - i. Specific energy head of the flowing water. (1 mark)
 - ii. Depth of water when the specific energy is minimum. (1 mark)
 - iii. Velocity of water when the specific energy is minimum. (1 mark)
 - iv. Minimum specific energy head of the flowing water. (1 mark)
 - v. Type of flow. (1 mark)
- a) A rectangular channel 2.50 m wide has a specific energy of 1.50 m when carrying a discharge of $6.48\text{ m}^3/\text{sec}$. Calculate the following
- i. Alternate depths and corresponding Froude numbers. (2 marks)
 - ii. Determine the type of flows. (1 marks)

QUESTION FIVE (20 MARKS)

- a) Discuss the factors that affects velocity distribution of an open channel. (4 marks)
- b) A rectangular channel with a bottom width of 4.0 m and a bottom slope of 0.0008 has a discharge of $1.50\text{ m}^3/\text{sec}$. In a gradually varied flow in this channel, the depth at a certain location is found to be 0.30 m. assuming $n = 0.016$, determine the type of GVF profile. (4 marks)
- c) A broad crested weir of height 0.6m in a channel 1.5m wide has a flow over it of $0.27\text{m}^3/\text{sec}$. what is water depth just upstream of the weir.? Take C_d as 0.62. (4 marks)

- d) The discharge of water through a rectangular channel of width 8m, is $15 \text{ m}^3/\text{s}$ when depth of flow of water is 1.2 m. Calculate:
- i. Specific energy of the flowing water (1 mark)
 - ii. Critical depth and critical velocity (1 mark)
 - iii. Value of minimum specific energy (1 mark)
- e) A Rectangular Channel 4 m wide has depth of water 1.5 m. The slope of the bed of the channel is 1 in 1000 and value of Chezy's constant $C = 55$. It is desired to increase the discharge to a maximum by changing the dimensions of the section for constant area of cross section, slope of the bed and roughness of the channel. Find the new dimensions of the channel and increase in discharge. (5 marks)