MACHAKOS UNIVERSITY

University Examinations for 2022/2023

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF MECHANICAL AND MANUFACTURING ENGINEERING

THIRD YEAR FIRST SEMESTER EXAMINATIONS FOR

BACHELOR OF SCIENCE (ELECTRICAL AND ELECTRONICS ENGINEERING)

EMM 312: FLUID MECHANICS III

DATE: **TIME:**

INSTRUCTIONS

This paper contains FIVE questions
Question ONE is **compulsory** and carries 30 Marks.
Questions TWO – FIVE carries 20 Marks each.
Answer question **ONE** and any other **TWO** questions**.**

QUESTION ONE (COMPULSORY) (30 MARKS)

a) Define the following terms with specific reference to open channels.

i) Specific energy **(1 mark)**

ii) Critical depth **(1 mark)**

iii) Shooting flow **(1 mark)**

iv) Tranquil flow **(1 mark)**

b) i) Show that the critical depth (D_c) in an open rectangular channel is given by;

$$\mathbf{D_c = \frac{2}{3}H}$$ **(6 marks)**

Where H is the specific Energy

ii) Show that in a rectangular open channel critical velocity is realised when the Froude's Number is equal to one. (3 marks)

iii) Water flows through a rectangular open channel of breadth 2 m at a velocity of 1.65 m/sec and the specific energy 1.4 m, Calculate the discharge under these conditions. (3 marks)

c) i) Show that the discharge through Q over a flat-topped broad crssted weir forming a spillway to a large reservoir is given by;

$$Q = C_d L\sqrt{2g}\,[Hh^2 - h^3]$$

Where: C_d – coefficient of discharge

g – acceleration due to gravity

H – head upstream of the weir

h – depth of water over the weir (4 marks)

ii) Show that for maximum discharge Q_{max} is given by:

$$Q_{max} = 1.706 C_d L H^{3/2}$$ (4 marks)

iii) The maximum discarge over a broad crested weir 30 m long with rounded enytrance is 18.5 m^3/sec. Calculatr the upstream head in metres if the coefficient of discarge C_d = 0.66, g = 9.81 m/s^2. (4 marks)

d) Distinguish between the terms Normal Shock wave and Oblique Shock wave. (3 Marks)

QUESTION TWO (20 MARKS)

a) Derive the Chezy formula for a rectanguar open channel with a gentle gradient. Work from first principles and explain the meaning of all symbols used. (8 marks)

b)

i) A water channel is V-shaped with each side making an angle of 45^0 to the vertical. The depth of water being conveyed is 0.25 m and the slope of the channel is 1 in 500. Calculate the discharge in m^3/sec. (6 marks)

ii) Assuming that the slope and Chezy constant remain the same and the discharge is doubled, determine the depth of water being conveyed. . (6 marks)
Assume the Chezy constant C = 56.

QUESTION THREE (20 MARKS)

a) Show that when a compressible gas adiabatically flows from a large vessel which is at constant pressure through an orifice at its side such that maximum flow is realised;

$$V = \sqrt{\frac{\gamma P}{\rho}}$$ (12 marks)

Where; V – velocity of the gas immediately in front of the orifice

γ - Adiabatic expansion constant

P – pressure immediately in front of the orifice

ρ – mass density

b) Air from a large reservoir discharges into the atmosphere through a small orifice at its side. The pressure and the temperature of the air are 210 kN/m^2 absolute and 15^{0}C respectively. The diameter of the orifice is 27.5 mm. Calculate the mass of air discharged into the atmosphere in kg/sec.

Assume: R = 287 J/KgK

γ = 1.4

Atmospheric pressure = 103.5 kN/m^2

Cd of the orifice = 0.64 (8 marks)

QUESTION FOUR (20 MARKS)

a) Show that for in a frictionless adiabatic flow of a compressible fluid through a horizontal pipe, Bernoulli's equation is given by:

$$\left(\frac{\gamma}{\gamma-1}\right)\frac{P}{\rho}+\frac{V^2}{2}=constant$$ (10 marks)

Where; v – velocity of the gas immediately in front of the orifice

γ - Adiabatic index of compression/expansion

P – pressure

ρ – mass density

b) Calculate the mass flowrate of air through a horizontal venturi meter with an inlet diameter 120 mm and a thick diameter of 60 mm. The absolute pressure at inlet and throat are 420 kN/m^2 and 350 kN/m^2 respectively. The temperature at inlet is 20^{0}C.

Assume: R = 287 J/KgK

γ = 1.4 (10 marks)

QUESTION FIVE (20 MARKS)

a) What is a hydraulic jump? (2 marks)

b) Concisely describe how hydraulic jump occurs in an open channel. (3 marks)

c) Derive a formula for the height of a hydraulic jump. Work from first principles and explain the meaning of all the symbols used. (8 marks)

d) A jump occurs in a channel of rectangular cross-section 5.5 m wide through which the discharge is 22.4 m^3/sec. The depth of water before the jump is 0.43 m.

Determine the;

i) Depth after the jump has taken place (1 mark)

ii) Specific energy of water after the jump (3 marks)

iii) Loss of pressure due to the jump (3 marks)