MACHAKOS UNIVERSITY

University Examinations for 2020/2021 Academic Year

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF MECHANICAL AND MANUFACTURING ENGINEERING

THIRD YEAR FIRST SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE (MECHANICAL ENGINEERING)

EMM 312: FLUID MECHANICS III

DATE: 16/8/2021 **TIME: 8.30-10.30 AM**

INSTRUCTIONS

Answer question ONE and any other two questions.

QUESTIONS ONE (COMPULSORY) (30 MARKS)

a) i Define the following terms with respect to open channel flow;

Specific energy (2 marks)

Critical depth (2 marks)

ii Working from first principles, stating the assumptions made and explaining the meaning of all the symbols used, derive the Chezy formula for a uniform flow in a rectangular open channel (7 marks)

iii. An open channel 0.9 m wide has vertical sides and it's bottom is V-shaped the angle of V is $2\theta^0$. The depth of water flowing along the channel measured from the bottom of the V is 0.6 m and the flow rate is 0.323 m/s when the bed has a slope of 1 in 1200. Calculate the angle 2θ in degrees. Assume C = 55. (9 marks)

b) Show that for isothermal flow through a pipe, ignoring change in kinetic energy due to change in direction is given; (10 marks)

$$P_2 = P_1\sqrt{\left(1 - \frac{4fLV_1^{\,2}}{RT}\right)}$$

Where;

P_2 = pressure gain at exit

P_1 = pressure gain at entrance

f = coefficient of friction

L = length of the pipe

V_1 = velocity of air at the entrance

T = temperature gain

QUESTIONS TWO (20 MARKS)

a) Explain the meaning of the following terms with regard to open channel flow;

i. Shooting flow (1 mark)

ii. Tranquil flow (1 mark)

b) What is a hydraulic jump? (3 marks)

c) Working from first principles, explaining the meaning of all symbols used and stating the assumptions made, derive the formula for height of a hydraulic jump. (6 marks)

d) A jump occurs in a channel of rectangular section open channel 6 m wide through which the discharge is 22.6 m^3/s. The depth of water before the jump occurs is 0.45 m. Determine;

i. Depth after the jump as taken place (5 marks)

ii. Loss in specific energy due to the jump (2 marks)

iii. Loss of power due to the jump (2 marks)

QUESTIONS THREE (20 MARKS)

a) A liquid of mass density ρ kg/m^3 and bulk modulus K N/m^2 flows at a uniform velocity of u m/s through a long thin-walled pipe of internal diameter d m and wall thickness t. The Young's Modulus of Elasticity is E N/m^2 and Poisson's ratio is ν for the pipe material. Derive an expression in terms of these symbols for the rise in pressure due to a sudden closing of the valve when the pipe is assumed to be

i. Rigid (6 marks)

ii. Elastic (8 marks)

b) A cast iron pipe 150 mm in internal diameter and 15 mm thick is conveying water when the outlet is suddenly closed. Calculate the maximum permissible discharge if the pressure rise is not to exceed 1700 kN/m^2. (6 marks)

Assume: K for water = 2.14×10^9 N/m^2

E for cast iron = 117×10^9 N/m^2

Ignore lateral strain effects

QUESTION FOUR (20 MARKS)

a) Derive the Bernoulli's Equation for a compressible flow over adiabatic condition. (10 marks)

b) Flow of air through a pipe is measured by a venturi meter with an inlet diameter of 75 mm and a throat diameter of 50 mm. The temperature at entry to the meter is 15^0C and the absolute pressure is 155 kN/m^2 while the absolute pressure at the throat is 112 kN/m^2. Determine the gas flow rate through the meter in m^3/s (Assume adiabatic flow).

$\gamma = 1.4$ and R = 287 J/kg K. (10 marks)

QUESTION FIVE (20 MARKS)

a) Show that when a compressible gas adiabatically flows from a container over constant pressure, under conditions such that maximum flow is realised, the velocity v of the gas through the orifice is given by;

$$v = \sqrt{\frac{P}{\gamma\rho}}$$ (8 marks)

Where;

P = pressure of the air immediately in front of the orifice (N/m^2)

ρ = mass density of the air immediately in front of the orifice (kg/m^3)

b) Air from a large reservoir discharge into atmosphere through a small orifice on its side. The pressure of the gas in the reservoir is 207 kN/m^2 absolute. The diameter of the orifice is 25 mm. The mass flow rate of air into the atmosphere is 0.154 kg/s. Calculate the temperature of the air in ^0C. (12 marks)

Assume: $\gamma = 1.4$ and

R = 287 J/kg^0K.

Atmospheric pressure = 103.5 kN/m^2