MACHAKOS UNIVERSITY

University Examinations 2018/2019

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF MECHANICAL AND MANUFACTURING ENGINEERING

THIRD YEAR SPECIAL/SUPPLEMENTARY EXAMINATION FOR

BACHELOR OF SCIENCE IN MECHANICAL ENGINEERING

EMM 312 FLUID MECHANICS III

DATE: 23/7/2019 **TIME: 2.00-4.00 PM**

INSTRUCTIONS:

Answer Question One and Any Other Two Questions

QUESTION ONE (COMPULSORY QUESTION) [30 MARKS]

a) Define the term

i. Specific Energy (2 marks)

ii. Critical depth (2 marks)

b) i for an open rectangular channel of critical depth Dc, breadth B and critical velocity Vc, show that;

$$Dc = 2\left[\frac{Vc^2}{2g}\right]$$

Where; g = acceleration due to gravity (4 marks)

ii in a rectangular channel the specific energy of flow is 1.8m. calculate

- the critical depth (2 marks)
- discharge per unit width of this depth (2 marks)

c) i derive the Chezy formula for an open rectangular channel using usual notation and explaining the meaning of all the symbols (4 marks)

assume that the resistance to flow is proportional to the square of the velocity of flow.

ii an open channel is trapezoidal shaped in cross-section with a bottom width of 45m slopes of 1 vertical to $1^1/_2$ horizontal. The bed slope is 1 in 180 and the depth of water 1.15m calculate the volumetric flow rate if the Chezy constant c = 40 (6 marks)

d) i) Derive an expression for discharge over a flat-topped broad crested weir forming a spillway to a large reservoir. (3 marks)

ii) Show that the maximum discharge Q max is given by;

$$Q_{max} = Cd1.706LH^{\frac{2}{3}}$$

Where Cd=coefficient of discharge

L=breadth of the reservoir

H=height

G =9.81m/s^2 (2 marks)

iii) a flat topped broad crested weir is designed for a maximum discharge of 7.03m^3/sec. calculate the appropriate water level upstream of the weir if the width is 15m and the coefficient of discharge is 0.6 (3 marks)

QUESTION TWO (20 MARKS)

a) Describe the phenomenon of water hammer in a pipeline resulting from the complete and instantaneous closure of a valve; friction being neglected (3 marks)

b) Explain using suitable diagram the pressure variation with time at a point in the immediate neighborhood of the value and at a point half-way the length of the pipe (4 marks)

c) Show that the pressure rise at the value (P) is given by;

$$P = V\sqrt{\frac{e}{\frac{1}{K} + \frac{d}{4tE}(5 - v)}}$$

Where

V=velocity of flow before closure of the valve

d = diameter of the pipe

t = pipe thickness

E = Young Modulus of elasticity of the pipe

K= Bulk Modulus of water

v = poison's ratio

e = mass density of valve (10 marks)

d) Calculate the maximum permissible discharge in a 160mm dimeter pipe, if the pressure is not to exceed 1500kN/m^2, when the outlet is suddenly closed;

Assume: the pipe is rigis

For water K=2.07x10^9 N/m^2 and

density = 10^{3}kg/m^3. (3marks)

QUESTION THREE (20 MARKS)

a) Show that the compressible adiabatic mass flowrate ($\dot{M}$) through a horizontal venturimeter is given by;

$$\dot{M} = \frac{CdP_1A_1}{RT_1}\sqrt{\frac{2(\frac{\gamma}{\gamma-1})RT_1\left[1-\frac{\gamma-1}{\gamma}\right]}{\left[\frac{A_1}{A_2}\right]^2\left(\frac{1}{r_P}\right)^{\frac{2}{\gamma}}-1}}$$

Where;

Cd=coefficient of discharge

P_1= absolute pressure at inlet

A_1= x-sectional area of inlet pipe

$T_1 = absolute\ temperature\ at\ entry$

R = universal gas constant

$r_P = \frac{P_2}{P_1}$

$\gamma = adiabatic\ expansion)\ compression\ ratio$ (8 marks)

b) It is required to design a venturimeter so that when the flow rate is 1.6kg/sec, thw pressure ratio is 0.75, the other parameters being as follows; cd = 0.96, R = 0.287kJ/kgK, P_1 = 150kN/m^2 also the T_1=200C, d_1=0.25m and $\gamma = 1.4$

Calculate the throat diameter required.

Assume $\left(\frac{\gamma}{\gamma-1)}\right)\frac{P}{e} + \frac{v^2}{2} = constant$ (12 marks)

QUESTION FOUR (20 MARKS)

a) Prove that the maximum continuous discharge of air through a small orifice fitted in the side of a large vessel takes place when the pressure in the throat is 0.528 of the pressure inside the vessel.

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

b) Determine the mass flow rate through an orifice of 225mm diameter connected to a large tank if the air in the tank is at 140kN/m^2 absolute and the barometric pressure 100kN/m^2

Assume; air temperature is 20^0C

R = 0.287kJ/kgK

$\gamma = 1.4$ (10 marks)

QUESTION FIVE (20 MARKS)

a) What is a shockwave? (2 marks)

b) Distinguish between a normal and oblique shock wave (3 marks)

c) A normal shock wave moves through still air (101.0kN/m^2 pressure and 298^0C temperature) with a constant velocity of 1500m/se

Calculate;

i) Velocity of air below the wave (5 marks)

ii) Static pressure (5 marks)

iii) Temperature (5 marks)

Assume R = 292.7 kJ/kgK