KENYATTA UNIVERSITY

UNIVERSITY EXAMINATIONS 2011/2012

SECOND SEMESTER EXAMINATION FOR THE DEGREE OF BACHELOR OF SCIENCE (MECHANICAL ENGINEERING)

EMM 312: FLUID MECHANIC III

DATE: Friday 20th April 2012 **TIME:** 2.00p.m – 4.00p.m

INSTRUCTIONS

This paper contains 5 questions

All questions carry 20 marks each

Answer any three questions

Question 1

a) i) Show that Bernoulli's Equation for a compressible fluid flowing under steady adiabatic conditions is given by

$$\frac{1}{2}v^2 + \left(\frac{\gamma}{\gamma - 1}\right)\frac{P}{\rho} = \text{constant}$$

Where v = velocity of the fluid (m/s)

γ = adiabatic index of expansion /compression

P = pressure of the fluid in (N/m^2)

ρ = dimity of the fluid (Kg/m^3) [8marks]

ii) Using usual notation and explaining the meaning of all symbols used, derive an expression for mass flow rate of air through a horizontal venturimeter under adiabatic conditions. [6marks]

b) A venturimeter 300mm diameter at the inlet is used for measuring the flow rate of air. The pressure and temperature at the inlet were 140KN/m^2 absolute and 17°C, while pressure at the throat was 112KN/m^2 absolute.

If the mass flow rate is 2.061 Kg/sec determine the suitable diameter of the throat.

Assume: $\gamma = 1.4$

For air R = 0.287kJ/Kg° K

Cd for the meter = 0.96

[6marks]

[Total 20 marks]

Question 2

a) i) Making appropriate assumptions, derive the Chezy formula

$V = C\sqrt{m\ i}$ for a rectangular channel

$\frac{m}{s}$

m = the hydraulic mean depth (m)

i = bed slope of the channel

and C = Chezy constant

[7marks]

i) Determine the dimensional proportions of a rectangular channel of depth D and width B which will make the discharge a maximum for a given cross-sectional area A. Assume steady flow and that the constant C with Chezy formula is constant. [7marks]

b) A channel of rectangular cross-section conveys water at the rate of 9.12m^3/S; with a velocity of 1.5m/s.

Calculate the gradient required for uniform steady flow, if the dimensional proportions are those for maximum discharge.

Assume C = 50.

[6marks]

[Total 20 marks]

Question 3

a) Derive an expression for the rise in pressure in a thin walled pipeline due to the sudden closing of a valve when water is flowing through the pipe, allowing both for compressibility of water and expansion of the pipe. [10marks]

b) Describe the sequences of events which take place within the supply pipe due to sudden closure of valve at the end of a hydraulic pipeline. [4marks]

c) A steel pipe is 70mm in diameter and 5.5 mm thick. Calculate the highest velocity of water which can be suddenly stopped, without stressing the pipe to more than $6.5MN/m^2$. [6marks]

[Total 20 marks]

Assume:

Poisson's Ratio $\nu = 0.25$

For Steel $E = 200 \times 10^9 N/m^2$

Bulk modulus of water $K = 200 \times 10^7 N/m^3$

Density of water $\rho = 10^3 Kg//m^3$

Question 4

a) Define the term "Specific Energy" with respect to open channel flow. [2marks]

b) Working from first principles, explaining the meaning of all symbols and stating all the assumptions made, show that for a uniform flow along an open triangular channel,

$$Dc = \frac{4H}{5}$$ [6marks]

Where Dc = the critical depth of water flowing

H = Specific Energy Head of the flowing water.

c) i) Explaining the meaning of all symbols used derive an expression for maximum discharge over a broad crested weir ignoring the velocity of approach. [6marks]

ii) Calculate the maximum discharge over a broad-crested weir of length 4 m having no end contractions. The head above the sill of the weir is 0.5 and $C_d = 0.97$. [6marks]

[Total 20 marks]

Question 5

a) Distinguish between a normal and an oblique shock wave. [2marks]

b) Show that for a normal shock wave operating under adiabatic conditions.

$$\frac{1 + \gamma M_{a_1}^2}{M_{a_1}\left\{1 + \frac{1}{2}(\gamma - 1)M_{a_1}^2\right\}^{\frac{1}{2}}} = \frac{1 + \gamma M_{a_2}^2}{M_{a_2}\left\{1 + \frac{1}{2}(\gamma - 1)M_{a_2}^2\right\}^{\frac{1}{2}}}$$

Where γ = adiabatic index of compression/expansion

M_{a_1} = Mach No. upstream the shock wave

M_{a_1} = Mach No. dimension the shock wave [12marks]

c) A pitot-static tube is inserted into an air stream of velocity 50m/s and pressure 1 bar. It is connected differentially to a U-tube manometer. If the difference in mercury levels is 11.06mm. Calculate the temperature of the air stream. [6marks]

[Total 20 marks]