KENYATTA UNIVERSITY

UNIVERSITY EXAMINATIONS 2011/2012

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

EMM 205: FLUID MECHANICS II

DATE: WEDNESDAY, 11TH APRIL 2012 **TIME: 11.00 A.M. – 1.00 P.M.**

INSTRUCTIONS

Answer any 3 of the 5 questions.

All questions carry 20 equal marks each.

Use clear and neat diagrams.

Q1 (a) Differentiate between laminar and turbulent flows of fluid. (2 marks)

(b) Derive the Bernoulli's equation as applied to flow of fluids using the principle of momentum. (6 marks)

(c) Water flows at the rate of 0.5m^{3}/s around a 50^{0} contracting pipe bend which lies in a horizontal plane. The diameter at the bend entrance is 700mm and at the exit is 500mm as shown in figure Q1 (c). If the pressure at the entrance to the bend is 200KN/m^{2}, determine the magnitude and direction of the force exerted by the fluid on the bend. Comment on the reason why friction losses may be neglected in this analysis. (12 marks)

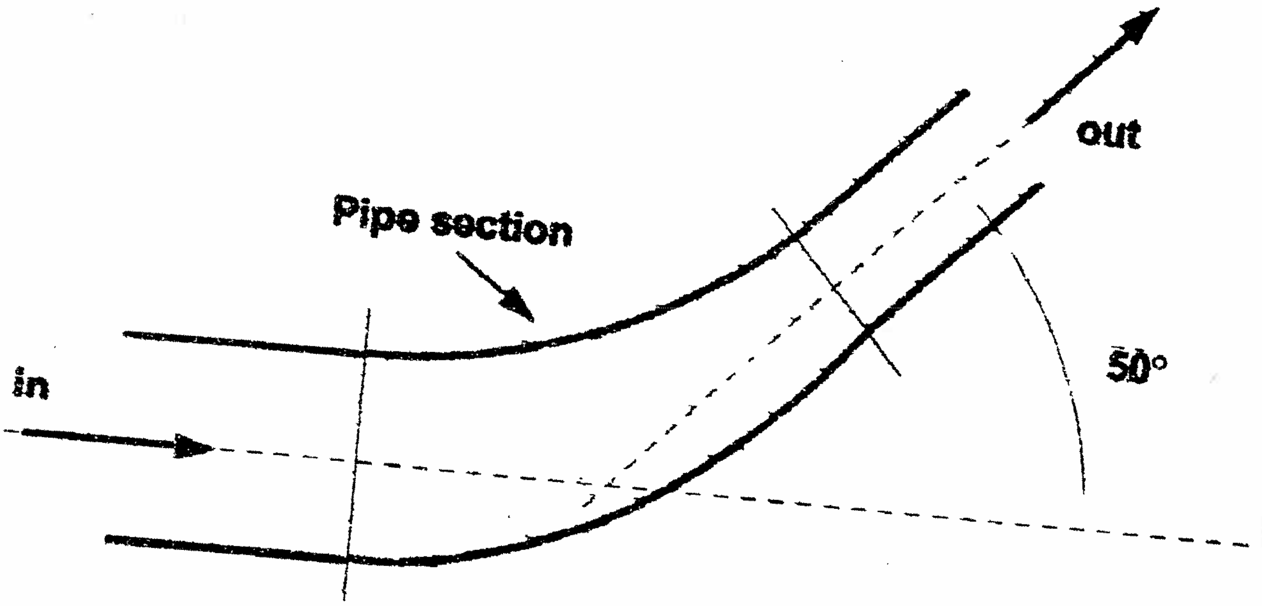

Figure Q 1 (c)

Q2 (a) (i) State the meaning of the terms critical velocity and critical Reynolds's number.

(ii) With the aid of clear diagrams, briefly describe Reynolds's experiment and discuss the results using graphs. (5 marks)

(b) (i) A liquid whose coefficient of viscosity is μ flows in a circular pipe of diameter d and with mean velocity u. Show that the pressure loss in a length of pipe is $32\ \mu\ u/d^2$

(ii) Oil of viscosity 0.05kg/ms flows through a pipe of diameter. 0.1m with a velocity of 0.6m/s.

Calculate the loss of pressure in a length of 120m. (6 marks)

(c) A plunger of 0.08m diameter and length 0.13m has four small holes of diameter 5/1600 metres drilled through in the direction of its length. The plunger is close fit inside a cylinder, containing oil, such that no oil is assumed to pass between the plunger and the cylinder. If the plunger is subjected to a vertical downward force of 45N (including its own weight) and it is assumed that the upward flow through the four small holes is laminar, determine the speed of fall of the plunger. The coefficient of viscosity of the oil is 0.2kg/ms. (9 marks)

Q3 (a) Explain how loss of energy can be accounted for in all pipeline problems where the total energy is known between two points, naming the different losses. (6 marks)

(b) (i) A pipeline of a given length and diameter has a difference of head H between the input and output ends. Show by means of sketch diagrams how the head lost in friction h_f the power head hp, the power P and the efficiency of power transmission η vary with the discharge Q.

(ii) Determine the condition for maximum transmission of power through a pipe assuming loss of head due to friction only. (6 marks)

(c) Two reservoirs which have a constant difference of levels of 100m, are connected by a pipe 4km long, 200mm diameter and with a frictional coefficient f = 0.008. at a point B, halfway along the pipe, water is drawn off at a rate of $1.5m/^3min$. Calculate:-

(i) The rate of flow into the lower reservoir in m^3/min;

(ii) The pressure head in the pipe just after B if it is 30m above the level of the water surface in the lower reservoir, measured vertically.

(8 marks)

Q4. (a) What is: (i) Dimensional Analysis?

(ii) Dimensional homogeneity?

(iii) Corresponding speed? (6marks)

(b) (i) When a fluid flows at a steady rate through a long horizontal pipe the force exerted on the water in order to maintain the flow must be resisted by a tangential force exerted at the pipe wall. If this force is thought of as a tangential stress τ exerted by the pipe wall show that:-

$$\tau = \Delta p \frac{d}{4L}$$

Where Δp is the pressure drop in a length L of pipe diameter d?

(3 marks)

(ii) The rational expression used for pipe loss is

$$h_f = \frac{4fL}{d}\frac{c^2}{2g}$$

Use this and the expression for τ in (b) (i) to show that

$$f = \frac{2\tau}{pc^2}$$

(3 marks)

(c) Using the method of dimensions show that for the pipe in Q4 (b) (i)

$$\tau = pc^2\varphi \frac{\rho cd}{\mu}, \frac{L}{d}, \frac{\varepsilon}{d}$$ and hence that

$$f = \phi\left(\text{Re}, \frac{1}{d}. \frac{\varepsilon}{d}\right)$$

Where ρ and μ are the density and viscosity of the fluid, C is the mean velocity of flow and ε is the surface roughness.

(8 marks)

Q5. (a) What is meant by:

(i) Geometrical similarity

(ii) Kinematic similarity

(iii) Dynamical similarity (3 marks)

(b) What are the requirements for dynamical similarity between two fluids motions when considering:-

(i) Viscous resistance

(ii) Wave resistance

(iii) Compressibility resistance

(iv) Surface tension resistance (8 marks)

(c) The flow of a gas in a uniform duct is to be simulated by means of water flow in a ¼ scale transparent model. The full-scale gas velocity is expected to be 24m/s.

Find

(i) The corresponding water velocity in the model.

(ii) The pressure drop to be expected per unit length of the full scale duct if the pressure drop per unit length of the model is $13.8 kN/m^2$

Take: 1kg of gas under conditions in the full-scale duct occupies $0.686 m^3$

μ for water is 62 times μ for gas.

By dimensional analysis $F = \rho c^2 \phi\left(\frac{\rho c d}{\mu}\right)$

Where F = frictional force per unit area,

ρ= mass density, c = velocity

d=diameter of the pipe and

μ=coefficient of dynamic viscosity (9 marks)

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