



MACHAKOS UNIVERSITY

University Examinations for 2019/2020 Academic Year

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF MECHANICAL AND MANUFACTURING ENGINEERING

SECOND YEAR SPECIAL/SUPPLEMENTARY EXAMINATION FOR

DIPLOMA IN MECHANICAL ENGINEERING

MED – PR 208: FLUID MECHANICS II

DATE: 20/01/2021

TIME: 8.30-10.30 AM

INSTRUCTIONS

Answer Question One and Any Other Two Questions

QUESTION ONE

- a) The discharge, Q over a spill way is controlled by the velocity of flow, V the head causing flow, H the throat diameter, D and the gravitational acceleration, g . Show using Buckingham's pie-Theorem that the discharge is given by the expression;

$$Q = VD^2 \phi \left\{ \frac{V}{gD}, \frac{H}{D} \right\} \quad (10 \text{ marks})$$

- b) Show that the loss of head, H_L when a pipe undergoes a sudden increase in diameter is given by;

$$H_L = \frac{(v_1 - v_2)^2}{2g}$$

Where v_1 and v_2 are velocities at sections while g is the gravitational acceleration.

(10 marks)

- c) i Show from basic principles that for a steady fluid flow under laminar condition, The pressure gradient equals the shear gradient.

- ii Name three areas in engineering where lamina flow occurs (10 marks)
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SECTION B: (ATTEMPT ANY TWO QUESTIONS IN THIS SECTION)

QUESTION TWO

- a) i The variables controlling the discharge, Q , of a centrifugal pump depends on the Mass density (ρ), the speed of the pump (N), the diameter of the impeller (D), the Manometric head (H_m), the dynamic viscosity (μ) and the gravitational acceleration (g). Using Buckingham's pie- theorem, show that the discharge is given by;

$$Q = N D^3 \phi \left\{ \frac{g H_m}{N^2 D^2}, \frac{\mu}{\rho N D^2} \right\} \quad (15 \text{ marks})$$

- ii) A 1/6 model of the above phenomena is to be tested to study the performance of a new design of the pump. The pump is to run at 1500 rpm. If the model delivers a discharge of $3 \text{ m}^3/\text{s}$ of water under a total head of 2.5m when running at 1800 rpm. Determine for the prototype;
- The discharge
 - The head
 - The power
- (5 marks)

QUESTION THREE

- a) i Explain the **THREE** laws of similitude used in model testing.
- ii Show from first principles the requirement for complete dynamic similarity between two fluid motions when considering;
- viscous resistance
 - Wave resistance
- (14 marks)
- b) The thrust (P) on a sphere is expressed as;

$$P = \rho V^2 D^2 \phi \left\{ \frac{VD}{\nu} \right\}$$

Where ρ =density, V =velocity of flow, D =diameter of sphere and ν =kinematic viscosity.

A sphere of certain dimensions obeys the above phenomenon and when placed in water moving with a velocity of 1.5m/s experiences a drag of 4.5N. Another sphere of twice the diameter is placed in a wind tunnel. The kinematic viscosity of air is 13 times that of water and the density of air is 1.28 kg/m^3 . Determine the velocity of air for dynamical similarity and the drag at this velocity.

(6 marks)

QUESTION FOUR

- a) Stating the assumptions made, show from basic principles that Frictional head loss h_f of a fluid flowing at a mean velocity, $\bar{v}$, in a horizontal Pipe of length L and diameter D is given by;

$$h_f = 4f \frac{L \bar{v}^2}{D 2g}.$$

Where g is gravitational acceleration and f is the friction coefficient. (14 marks)

- b) Water of dynamic viscosity 0.00114Ns/m^2 is pumped at a rate of 4 litres per minute through a circular pipe of 40mm diameter and 750m long. Determine the pump power required. (6 marks)

QUESTION FIVE

- a) Show that the flow rate (Q), of a fluid of dynamic viscosity (μ), flowing under laminar conditions through a horizontal circular pipe of diameter (D), length (L), with mean velocity (v) and pressure difference between the ends (p) is given by;

$$Q = \frac{\pi p D^4}{128 \mu L}$$

Hence show that the pressure difference can be expressed as;

$$P = \frac{32 \mu L V}{D^2} \quad (12 \text{ marks})$$

- b) Oil is pumped a pipe 100 mm diameter and 10m long. The pressure difference between the ends is 14.715KN/m^2 , dynamic viscosity is 0.97Ns/m^2 and relative density is 0.90. Determine the;
- Shear stress at the pipe wall
 - Power required to maintain flow (8 marks)