MACHAKOS UNIVERSITY

University Regular Examinations 2022/2023

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF MECHANICAL AND MANUFACTURING ENGINEERING

SECOND YEAR SECOND SEMESTER EXAMINATIONS FOR

BACHELOR OF SCIENCE (MECHANICAL ENGINEERING)

EMM 205: FLUID MECHANICS II

DATE: 13/4/2023 TIME: 11:00 – 1:00 PM

INSTRUCTIONS

This paper contains FIVE questions
Question ONE is **compulsory** and carries 30 Marks.
Questions TWO – FIVE carries 20 Marks each.
Answer question **ONE** and any other **TWO** questions**.**

QUESTION ONE (COMPULSORY) (30 MARKS)

a) A horizontal jet of cross-sectional area, a m^2, mass density ρ kg/m^3moving at a speed v m/s from the nozzle strikes an inclined plane at an angle of θ degrees to the normal to plate. Derive an expression for the force exerted by the jet normal to the plate in terms of a**,** ρ, v and θ. **(2 Marks)**

b) If the plate is now moving at u m/s (where v > u) in the direction of the jet, derive an expression for the;

i) Normal force exerted on the plate by the jet in Newtons **(3 Marks)**

ii) Work done per second in Watts **(3 Marks)**

iii) Efficiency of the arrangement **(4 Marks)**

Note: Derive these expressions in terms of a**,** ρ, v, u and θ

c) A horizontal jet of water 50 mm in diameter moving at a velocity of 18 m/s strikes an inclined flat plate at 65^0 to the normal to the plate. Determine

i) Norma; force exerted on the plate if the plate is stationary. **(3 Marks)**

ii) Normal force exerted on the plate if the plate is moving at 5 m/s in the direction of the jet **(5 Marks)**

iii) Work done per second **(4 Marks)**

iv) Efficiency of the operation **(6 Marks)**

QUESTION TWO (20 MARKS)

a) Derive an expression for the loss of head due to friction in a pipeline in terms of the velocity head, assuming that the frictional resistance per unit area of the pipewall is proportional to the square of mean velocity of flow (The Darcy/Weisbach Formula). **(10 Marks)**

b) Water flows through a 150 mm diameter pipe which is 360 m long at the rate of 0.042 m^3/s. Calculate the head loss due to friction. Assume f = 0.005. **(5 Marks)**

c) Determine the power loss due to firction. **(5 Marks)**

QUESTION THREE (20 MARKS)

Water flows from a tank at the rate of 0.0303 m^3/s into a horizontal pipeline 150 mm in diameter. The pipe suddenly changes to 200 mm in diameter. The 200 mm diameter part after a length of 20 m suddenly reduces to 120 mm diameter. Determine the head loss;

i) at entry into the pipe **(5 Marks)**

ii) due to sudden enlargement **(5 Marks)**

iii) due to sudden contraction **(5 Marks)**

iv) due to friction on the 20 m portion **(5 Marks)**
Assume f = 0.007.

QUESTION FOUR (20 MARKS)

a) What do you understand by the term dynamic similarity? **(2 Marks)**

b) A resistance F is acting on a ball dm in diameter, moving at v m/s, through a fluid of mass density ρ kg/m^3 and a coefficient of dynamic viscosity η kg/ms. By means of dimensional analysis, show that; **(8 Marks)**

$$F = \rho v^2 d^2 \, f\left(\frac{\eta}{\rho v d}\right)$$

c) A 150 mm diameter sphere is a model of 400 mm diameter sphere prototype. It is tested in a wind tunnel. The prototype travels at 96 km/h in standard air. Compressibility effects are to be neglected;
Calculate;

i) Speed of the model in the wind tunnel under dynamically similar flow patterns. **(5 marks)**

ii) Force on the prototype if the force on the model was measured as 15 N. **(5 Marks)**

QUESTION FIVE (20 MARKS)

a) Working from first principles, stating the assumptions made and explaining the meaning of symbols used, show that the loss of pressure (p) due to laminar flow in a horizontal circular pipe is given by:

$p = \frac{32\eta vL}{d^2}$

Where: η – coefficient of dynamic viscosity

v – mean velocity of the liquid

L – length of the pipe

d – diameter of the pipe **(10 Marks)**

b) The discharge of oil of specific gravity 0.9 through a pipeline 6 m long of a 25 mm diamweter is 1.473 litres per second. The coefficient of dynamic viscosity of the oil is 1.3 kg/(m-sec). Calculate;

i) Velocity of oil at a distance of 3 mm from the pipe wall **(5 Marks)**

ii) Pressure drop over the 6 metres length **(5 Marks)**