KARATINA UNIVERSITY

UNIVERSITY EXAMINATIONS

2023/2024 ACADEMIC YEAR

THIRD YEAR SPECIAL/ SUPPLIMENTARY EXAMINATION

FOR THE DEGREE OF

BACHELOR OF SCIENCE WITH EDUCATION, BACHELOR OF EDUCATION SCIENCE AND BACHELOR OF SCIENCE

COURSE CODE: MAT 325

COURSE TITLE: FLUID MECHANICS I

DATE: 16th JULY 2024 TIME: 12.00noon-2.00pm

INSTRUCTION TO CANDIDATES

SEE INSIDE

ANSWER **QUESTION ONE (COMPULSORY)** AND ANY OTHER **TWO QUESTIONS**

SECTION A

QUESTION ONE (30 marks)

a) Outline four characteristics of streamlines. (4marks)

b) Calculate the pressure due to a column of 0.35 m of

i. petroleum diesel of mass density 0.85 kg/l (3marks)

ii. ethanol of relative density 0.78 (3marks)

Take density of water as 1000kg/m^3 .

c) Highlight three different ways in which density of a fluid can be expressed. (3marks)

d) The velocity distribution for water (20°C) near a wall is given by $u = (ay/b)^{1/6}$, where a = 10 m/s, b = 2 mm, and y is the distance from the wall in mm. Determine the shear stress in the water at y = 1 mm. (3marks)

e) A 10cm diameter pipe contains sea water that flows with a mean velocity of 5 m/s. Find the volume flow rate (discharge) and the mass flow rate. Take sea water density as 1026kg/m^3 . (2marks)

f) Determine the gas constant and density of a gas that weighs 16N/m^3 at 25^0c and at an absolute pressure of 0.25N/mm^2. (4marks)

g) Show that Newton's law of viscosity is given by $\tau = \mu \frac{du}{dy}$ where τ is the shear stress, μ dynamic viscosity u is fluid velocity. (7marks)

QUESTION TWO (20 marks)

a) A horizontal pipe carrying water suddenly increases its diameter from 10 cm to 20cm. Find out the loss of head due to sudden increase in diameter if the discharge through the pipe is 150 litres/s. (6marks)

b) The velocity components of a flow field are given by

$$u = \frac{y}{(x^2 + y^2)^{3/2}} \quad v = \frac{-x}{(x^2 + y^2)^{3/2}}$$

Determine whether continuity principle is satisfied (7marks)

c) Two horizontal plates are placed 1.25cm apart, the space between them being filled with oil of viscosity 14 poises. Calculate the shear stress in oil if upper plate is moved with a velocity of 2.5 m/s (7marks)

QUESTION THREE (20 marks)

a) A body weighs 1960 N when exposed to a standard earth gravity $g = 9.81 m/s^2$. Determine.

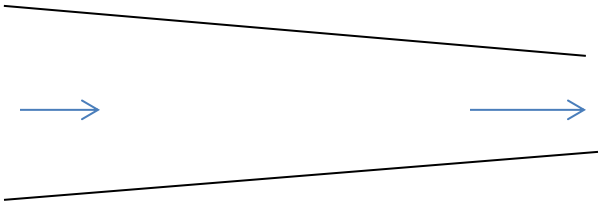
i. Its Mass. (2marks)

ii. Its weight if it is exposed to Mars' average gravitational acceleration g=3.72076 ms^{-2}. (2marks)

iii. How fast it will accelerate if a net force of 250 kg is applied to it on the Earth. (2marks)

b) The bulk modulus of elasticity of ethyl alcohol is $1.06 \times 10^9 Pa$. For water, it is $2.15 \times 10^9 Pa$. Explain which of these liquids is easier to compress. (3marks)

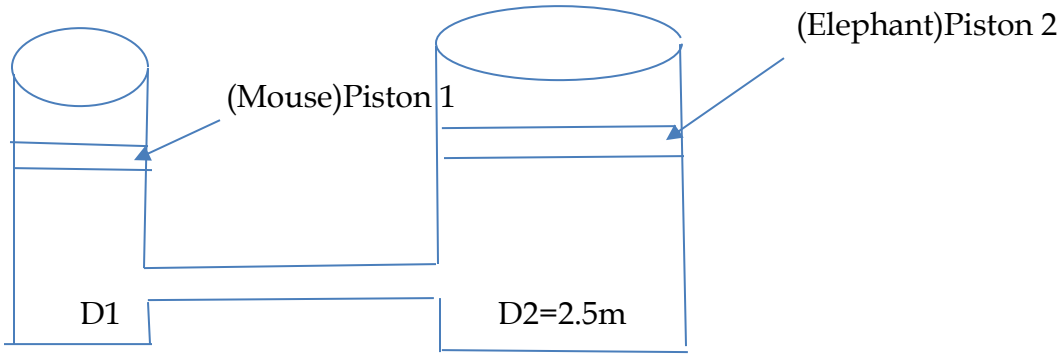
c) Consider the tube below



Section 1 section 2

A fluid, density $\rho = 1345 kgm^{-3}$ is flowing steadily through the tube above. The section diameters are $d_1 = 105mm$ and $d_2 = 76mm$, the gauge pressure and velocity at 1 are $p_1 = 175kN/m^2$ and $u_1 = 12m/s$ respectively. Given that the tube is horizontal, determine the gauge pressure at section 2. (6marks)

d) A mouse can have a mass of 25g and an elephant a mass of 7500kg. Determine a value of D1 so that the mouse can support the elephant. Diameter of piston 2 is D2. (5marks)



QUESTION FOUR (**20 marks**)

a) Water is flowing through a pipe having diameter 300mm and 200mm at the bottom and upper end respectively. The intensity of pressure at the bottom end is 24.525N/cm^2 and the pressure at the upper end is 9.81N/cm^2. Determine the difference in datum head if the rate of flow through the pipe is 40lit/s. (8marks)

b) Consider a cylindrical element of fluid cross sectional area=A, mass density= ρ,

i. Show that for a vertical element the hydrostatic pressure change is given by $p_1 - p_2 = -\rho g(z_2 - z_1)$ (7marks)

ii. If the element in (i) is tilted at an angle $\propto$ along its axis write the general equation for pressure change in differential form and hence use this equation to explain the case where the cylinder is tilted to a horizontal position. (3marks)

iii. Determine pressure change for a fluid element of relative density 0.7 tilted at an angle of 76^0c . (2marks)

QUESTION FIVE (**20 marks**)

a) A tank has a square base of 9m square and a height of 2.4 m. It contains water in the lower 1.3 m depth. The upper remaining portion is filled with oil of relative density 0.9. Calculate

i. pressure at the oil -water interface (3marks)

ii. force exerted at the bottom of the tank by the liquid (4marks)

b) A plate 0.025mm distance from a fixed plate, moves at 60cm/s and requires a force of 2 N per unit area to maintain this speed. Determine the fluid viscosity between the plates. (6marks)

c) Two pipelines, one carrying oil of relative density 0.9 and other carrying water are connected to a manometer as shown in figure below. Find the amount by which pressure in water pipeline should be increased so that mercury levels in both the limbs of the manometer becomes equal. (7marks)