Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2022/2023

COURSE NAME	:	FLUID MECHANICS
COURSE CODE	:	DAK12403
PROGRAMME CODE	:	DAK
EXAMINATION DATE	:	FEBRUARY 2023
DURATION	:	3 HOURS
INSTRUCTION	:	1. ANSWER ALL QUESTIONS
		2.THIS FINAL EXAMINATION IS CONDUCTED VIA **CLOSED BOOK**.
		3. STUDENTS ARE **PROHIBITED** TO CONSULT THEIR OWN MATERIAL OR ANY EXTERNAL RESOURCES DURING THE EXAMINATION CONDUCTED VIA CLOSED BOOK

THIS QUESTION PAPER CONSISTS OF **EIGHT (8)** PAGES

Q1 (a) Fluid is a substance that deforms continuously under applied shear stress. Define shear stress and state the symbol used to represent shear stress.

(2 marks)

(b) Pressure is an important parameter in fluid mechanics. Discuss the relation between Pressure (P), Force (F), Area (A), with the unit Pascal (Pa), and Newton (N).

(4 marks)

(c) A 15.0 L of an incompressible liquid exerts a force of 25 N at the earth's surface. Calculate the force exerted by 2.3 L liquid on the surface of the moon. Given the gravitational acceleration of the surface of the moon is 1.67 m/s^2.

(7 marks)

(d) A river has a continuous water flow (Q) of 10 m^3/s between two bridges that are 1000 m apart. At bridge A, upstream, the river has a cross-sectional area of 150 m^2, while at bridge B, downstream, the river has a cross-sectional area of 100 m^2. Estimate the increase in water velocity (ΔV), between the two bridges.

(3 marks)

(e) A plate 0.05 mm distant from a fixed plate moves at 1.2 m/s and requires a shear stress of 2.2 N/m^2 to maintain this velocity. Calculate the viscosity of the fluid between the plates.

(4 marks)

Q2 (a) Define gauge pressure, absolute pressure, and atmospheric pressure.
(3 marks)

(b) A pressure tube is used to measure the pressure of oil (the oil density is 640 kg/m) in a pipeline. If the oil rises to a height of 1.2 m above the center of the pipe. Calculate the gauge pressure at that point.
(2 marks)

(c) Estimate the absolute pressure on the bottom of the sea at the depth of 250 m. Given the density of seawater, ρ_{sw}, is 1,030 kg/m^3, and the atmospheric pressure, p_0, is 1013.3 Pa.
(4 marks)

(d) Mercury is used as the working fluid for measuring the pressure of water of a U-shaped manometer. The water pressure at one entrance of the manometer is 300 kPa, and the pressure at the other entrance is 230 kPa. The densities of the mercury and water are 13,600 kg/m^3 and 1,000 kg/m^3, respectively. Calculate the height of the mercury in the column. Given, h is equal to $(p_1-p_2)/[(\rho_{hg}-\rho_w)/g]$
(3 marks)

(e) A 5 kg sphere is hanging from a scale while being totally submerged in a lake full of water. If the reading on the scale is 39.05 N, determine the radius of the sphere in cm.
(8 marks)

Q3 (a) The amount of mass flowing through a control surface per unit of time is called the mass flow rate. Show the relationship between mass flow rate and volume flow rate.

(1 mark)

(b) The Bernoulli equation is involved with the conservation of kinetic, potential, and flow energies of a fluid stream and their conversion to each other. From your understanding of the equation, define the concept of the conservation of energy.

(2 marks)

(c) List **three (3)** causes of energy loss in pipe flow

(3 marks)

(d) Air enters a compressor with a density of 1.2 kg/m^3 at a mean velocity of 4 m/s in a 6 cm × 6 cm square inlet duct. Air is discharged from the compressor with a mean velocity of 3 m/s in a 5 cm diameter circular pipe. Assuming the fluid is compressible, determine:

(i) The mass flow rate

(6 marks)

(ii) The air density at the outlet pipe.

(3 marks)

(e) Ethanol is flowing in a pipe at a velocity of 1 m/s and a pressure of 101.3 kPa (P1) in a chemical refinery plant. Subsequently, the refinery process needs the ethanol to be at a pressure of 202.6 kPa (P2) on a lower level. The process flow rate is static (no change in fluid velocity) and the density of ethanol is 789 kg/m^3. By applying the Bernoulli equation, determine the pipe level difference (Δh) of the ethanol piping line to achieve the required pressure (P2).

(5 marks)

Q4 (a) A control volume is an arbitrary region in space through which fluid flows. State **three (3)** types of control volume.

(3 marks)

(b) Newton's laws are the relations between the motions of bodies and the forces acting on them. Based on your understanding, define

(i) Newton's first law

(ii) Newton's second law

(2 marks)

(c) A security officer is using water from a high-pressure pipe to scatter an illegal gathering. The pipe release about 0.02 cubic meter per second of water at a velocity of 25 meters per second. One man from the crowd picked up a dustbin cover and use it as a defense to repel the water. If the man is holding the dustbin cover vertically, determine the force (F) needed by the man from the crowd to withstand the force from the water spray.

(5 marks)

(d) A nozzle has an inlet with a radius of 4 cm, and it discharges water into the atmosphere. The inlet gauge pressure is 3 bar. Calculate the resultant force on the nozzle in Pa. Given 1 bar is equal to 1×10^5 Pa.

(4 marks)

(e) Based on **Figure Q4 (e),** determine the force at X direction (F_x) on the vane of a windmill if a water jet with 0.05 m in diameter and 18 m/s velocity strikes the vane tangentially and deflects without friction.

(6 marks)

Q5 (a) Describe **two (2)** characteristics of turbulent flow.

(2 marks)

(b) Estimate the mean velocity of water flow in a pipe. The Reynolds number is 3,000, the pipe diameter is 10 mm, and the kinematic viscosity of water is 1.01 x 10-6 m^2 /s.

(3 marks)

(c) Calculate the volumetric flow rate of oil flowing in a circular pipe of 50 mm diameter. Given the Reynolds number is 2320, the density of oil is 920 kg/m^3, and the dynamic viscosity of the oil is 50 mPa s.

(5 marks)

(d) Water is flowing with a volumetric flow rate (Q) of 1.00 x 10^{-3} m^3/s in a tubular pipe with a diameter of 50 mm, and a length of 20 m. Given the density of water is 997 kg/m^3, and the kinematic viscosity is 1.00 x 10^{-6} m^2 /s. Calculate:

(i) The cross-sectional mean velocity of water flow in a pipe.

(3 marks)

(ii) The Reynolds number.

(2 marks)

(iii) The friction factors.

(2 marks)

(iv) The pressure drops.

(3 marks)

-END OF QUESTIONS-

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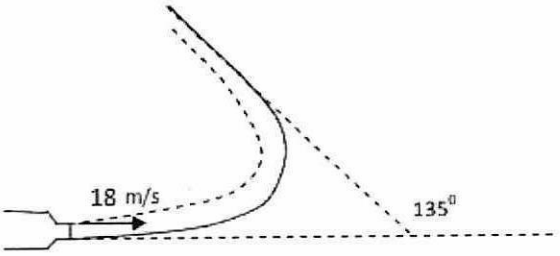

Figure Q4 (e)

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List of Formula

$A = \pi D^2/4$

$v = \sqrt{\frac{\beta}{\rho}}$

$\dot{m} = Q \times \rho$

$\sigma = \frac{F}{2L} = N/m$

$SG = \rho_{fluid}/\rho_{water}$

$F_R = \frac{1}{2}\rho g d \times Bd$

$Y_R = 0.5d + \frac{Bd^3}{12 \times 0.5d \times (Bd)}$

$F_R = \left(\rho g s + \frac{1}{2}\rho g d\right) \times Bd$

$F_R = P_C A$

$Y_R = (s + 0.5d) + \frac{Bd^3}{12 \times (s + 0.5d) \times (Bd)}$

$F_B = \rho_f g V$

$W = \rho_{obj} g V$

$P_C = P_{atm} + \rho g h_C$

$P_C = P_{atm} + \rho g h_C \sin\theta A$

$Re_D = \frac{\rho V D}{\mu} = \frac{VD}{\nu}$

$\Delta p = f_D \frac{L}{D} \frac{\rho V^2}{2}$

Δp – pressure loss in N/m^2

$\dot{m} = \rho \times A \times v$

$\rho_1 \times A_1 \times v_1 = \rho_2 \times A_2 \times v_2$

$\frac{P_1}{\rho g} + \frac{v_1^2}{2g} + z_1 = \frac{P_2}{\rho g} + \frac{v_2^2}{2g} + z_2$

$\frac{dM}{dt} = \frac{\partial}{\partial t}\int_{CV} \rho . dV + \int_{CS} \rho \vec{v} . \vec{n} . dA$

$F_X = \rho Q\left(v_{x.in} - v_{x.out}\right)$

$F_X = PA_{in} - PA_{out}$

1 m^3 = 1000 Liter

$Q = A \times v$

$Q = ms\Delta T$

$Re = \frac{\rho D v}{\mu}$

$f = \frac{64}{Re}(laminar)$

$f = \frac{0.316}{Re^{(0.25)}}(turbulent)$

$h_L = f \times \frac{L}{D} \times \frac{v^2}{2g}$

$P_0 = \rho g h_L \times Q$ = Watt

$\nu = \mu / \rho$

$V = \frac{4}{3}\pi r^3$