Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
(ONLINE)
SEMESTER I
SESSION 2020/2021

COURSE NAME	:	FLUID MECHANICS
COURSE CODE	:	DAK 12403
PROGRAMME CODE	:	DAK
EXAMINATION DATE	:	JANUARY / FEBRUARY 2021
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **FIVE (5)** QUESTIONS ONLY. **OPEN BOOK EXAMINATION**

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

Q1 (a) Fluid is a state of matter which exists in either liquid or gas.

(i) Explain the differences in molecules arrangement for liquid and solid.

(ii) Explain how fluid deform compares to solid.

(6 marks)

(b) Given a situation where **THREE (3)** layers of fluid placed between two parallel plates.

(i) Sketch a full diagram for the situation in **Q1 (b)** when both plates are static.

(ii) Sketch a full diagram for the situation in **Q1 (b)** when the top plate is moving to the right with the velocity *Ux*.

(4 marks)

(c) Control volume is an imaginary region in which fluid flows in and out of it.

(i) Write an equation to relate volume and mass of fluid.

(ii) Sketch **THREE (3)** diagrams to show a mass of fluid flows into and out of a control volume.

(4 marks)

(d) A liquid coolant with specific gravity of 0.80 flows into a pump via a 2 cm × 3 cm square pipe with the velocity of 3 m/s. The coolant is discharged from the pump through a 2-inch diameter circular pipe. Assume that the fluid is incompressible.

(i) Calculate mass flow rate of the coolant in kg/s.

(ii) Calculate velocity of coolant at the outlet pipe.

(6 marks)

Q2 (a) Explain the terms below:

(i) Vapor pressure.

(ii) Pump cavitation.

(4 marks)

(b) A 0.5-meter radius aluminium ball falls into the bottom of the sea where the pressure is 300 atm. The ball bulk modulus, β is 70×10^9 Nm^{-2}. 1 atm is equal to 101325 Pa. Calculate the new volume of the ball.

(4 marks)

(c) A force of 0.0207 N is required to pull a 15 cm long wire placed on top of a thin film of fluid. Given that 1 dyne/cm = 0.001 N/m.

(i) Calculate the surface tension of the fluid, in dyne/cm.

(ii) If the fluid is replaced with water, calculate the minimum force required to pull the wire out from the water. Water surface tension is 72 dyne/cm.

(5 marks)

(d) A rectangular mirror with the size of 1-meter wide and 3.5-meter high is placed vertically inside a water tank. The supplier indicates that the mirror can only withstand a maximum force of 30,000 N.

(i) Calculate the maximum mirror height that can be submerged in the water.

(ii) Calculate the centre of pressure for your answer in **Q2 (d)(ii)**.

(7 marks)

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Q3 (a) Pressure in the fluid is the same in all directions.

(i) Sketch a diagram for statement in **Q3 (a)**.

(ii) Explain how pressure values are used in orifice and venturi meters.

(4 marks)

(b) Orifice meter and venturi meter are two common flow rate measurement equipment for liquid. Compare the size and cost between orifice and venturi meter.

(4 marks)

(c) A 10 cm radius of foam ball floats in glycerol where 70% of its volume is under the glycerol surface. Given that glycerol specific gravity is 1.13.

(i) Calculate its buoyant force (N).

(ii) If the foam density is 550 kg.m^{-3}, calculate its weight (N).

(iii) Calculate the magnitude and direction of the net force experienced by the foam when it completely submerged in glycerol.

(9 marks)

(d) A small water tank sits on an elevator's floor. The water inside the tank is 900 cm deep and the elevator is accelerating upwards at the rate of 2 m.s^{-2}. Calculate the gauge pressure at the bottom of the water tank.

(3 marks)

Q4 (a) Explain briefly what are the symbol of *P*, *v* and *z* in the Bernoulli's equation.
(3 marks)

(b) A 20 mm-diameter water jet sends a stream of water vertically to the height of 3 meter. The water velocity at the height of 3 meter is measured at 3 m.s^{-2}.Take density of water as 1000 kg/m. Calculate the water jet velocity at the tip of water jet.
(5 marks)

(c) Derive the volumetric flowrate equation, Q based on **Figure Q4 (c)** and the Bernoulli's equation. Ignore the coefficient of discharge, *Cd* in the final equation.
[Hint: $z_1 = z_2$, $A_1 v_1 = A_1 v_1$, $Q = A \times v$]
(12 marks)

Q5 (a) Based on control volume and momentum balance theory:

(i) State **THREE (3)** types of control volume.
(3 marks)

(iii) Simplify the integral equation for conservation of mass, for a steady flow.
(3 marks)

(b) Seawater is pump in a steady condition through a conical-shaped nozzle installed at the end of a fire hose, as in **Figure Q5 (b)**. If the nozzle exit velocity is 15 m/s, determine the pumping capacity in m^3/s.
(4 marks)

(c) Police is using a fire hose to disperse a crowd. The fire hose delivers 60 Liter/min of water at a velocity of 15 m/s. One man from the crowd picked up a garbage lid and use it as a shield to deflect the water. If he is holding the lid vertically, calculate the amount of force required by him to withstand the water spray.
(5 marks)

(d) A nozzle is attached to a fire hose using a flange. The valve is closed and the bolts holding the flange are loose. The nozzle diameter is 2 inches. Calculate the force that will make the flange tear apart when the water is pumped at 1 atm (101325 Pa).
(5 marks)

Q6 (a) Explain briefly how pressure drop occur in pipe flow.

(2 marks)

(b) As a design engineer, you are given a budget of RM 550 to purchase and install pumps and pipe length to supply treated water (at 20°C, viscosity is 0.001 Pa.s) from a dam located 30 meter away to a research office at the rate of 0.001 m^3/s. The objective is to pump water with the lowest head loss and sufficient pump power, within the given budget. You are left with two decisions of A and B as shown in the **Table Q6 (b)** Select a suitable design and justify your decision.

(18 marks)

END OF QUESTIONS

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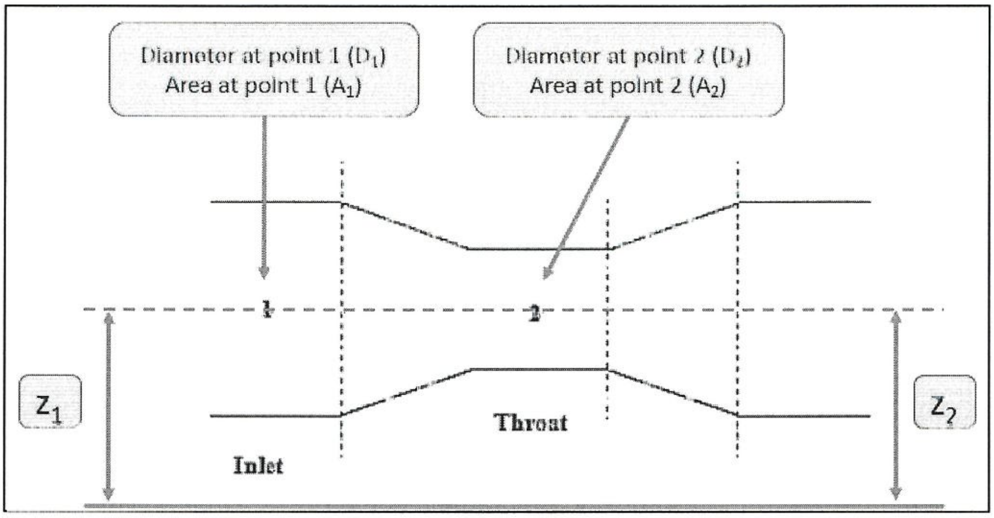


Figure Q4 (c)

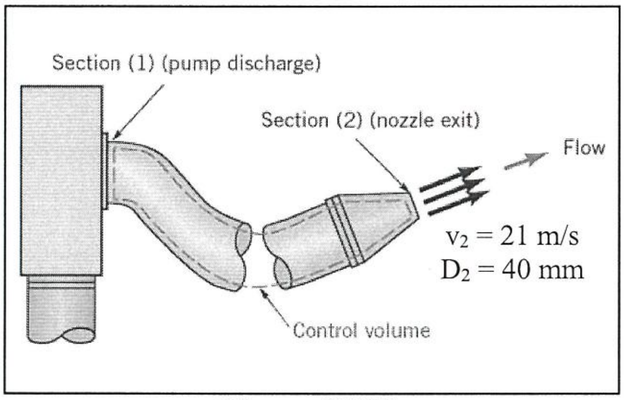
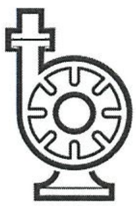
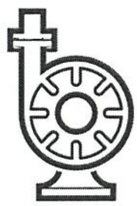


Figure Q5(b)

Table Q6 (b)

Design A	Design B
Pipe A diameter = 2.54 cm Pipe A price = RM 8/meter	Pipe B diameter = 3.81 cm Pipe B price = RM 9.50/meter
Pump A power = 17 Watt  Pump A price = RM 100/unit	Pump B power = 2 Watt  Pump B price = RM 85/unit
No fittings required	No fittings required

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List of formula

$A = \pi D^2/4$

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

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

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

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

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

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

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

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

$F_B = \rho_f g V$

$W = \rho_{obj} g V$

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

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

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

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

$F_X = \rho Q(v_{x,in} - v_{x,out})$

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

1 m^3 = 1000 Liter

$Q = A \times v$

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

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

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

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

$P_0 = \rho g h_L \times Q = \text{Watt}$

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