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UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2019/2020

COURSE NAME	:	FLUID MECHANICS
COURSE CODE	:	DAK 12403
PROGRAMME CODE	:	DAK
EXAMINATION DATE	:	DECEMBER 2019 / JANUARY 2020
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **FIVE (5)** QUESTIONS ONLY

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

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Q1 (a) Define all the terms below.

(i) Fluid.

(ii) Mechanics.

(iii) Shear Stress.

(6 marks)

(b) Consider a fluid placed between two parallel plates.

(i) Sketch a diagram to show the location of no-slip condition when all fluid layer started to flow.

(ii) State the name of a fluid property derived from this theory.

(4 marks)

(c) Continuity equation can be derived from the conservation of mass theory.

(i) Write the continuity equation for an incompressible fluid.

(ii) Write the continuity equation for a compressible fluid.

(4 marks)

(d) A liquid coolant with specific gravity of 0.86 flows into a pump via a 2 cm × 3 cm square pipe with the velocity of 2.5 m/s. The coolant is discharged from the pump through a 1-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 relationship between:

(i) Vapor pressure and pump cavitation.

(ii) Mass of fluid flow and the heat flow, based on the equation $Q = mc\Delta T$.

(4 marks)

(b) Compare the speed of sound when air travels on the water and steel medium. Given that the bulk modulus, ß for water is 2.1×10^9 N and steel is 159×10^9 N. Steel density is 7900 kg.m^{-3}.

(4 marks)

(c) A force of 5.1×10^{-3} N is required to pull a 5 cm long wire placed on top of a thin film of fluid.

(i) Calculate the surface tension of 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 1.5-meter wide and 3-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)

Q3 (a) Pressure is defined as the normal force exerted by a fluid per unit area.

(i) Define gauge pressure and absolute pressure.

(ii) State **two (2)** common SI units for pressure.

(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) An even size of square cube with 90 cm of width is made of a rigid foam material and floats in glycerol with 70 cm of the cube height is under the surface. Given that glycerol specific gravity is 1.13.

(i) Calculate its buoyant force (N).

(ii) If the foam density is 450 $kg.m^{-3}$, 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) An open tank contains water with 1.3 meter deep. It is sitting on the elevator's floor. Calculate the gauge pressure at the bottom of the water tank when the elevator is accelerating upwards at the rate of 3 $m.s^{-2}$.

(3 marks)

Q4 (a) State **three (3)** major forms of energy involved in a fluid flow.

(3 marks)

(b) A water jet with 20 mm in diameter exits vertically upwards from a nozzle at a velocity of 10 m/s. Assuming the jet retains a circular cross-section, calculate the diameter (in meter) of the water jet at a point of 3 meter above the nozzle exit. Take density of water as 1000 kg/m .

(5 marks)

(c) Derive the volumetric flowrate equation, Q based on **Figure Q4 (c)** and the Bernoulli's equation.
[Hint: $z_1 = z_2,\ A_1v_1 = A_1v_1,\ Q = A \times v$]

(12 marks)

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

(i) Define the term control volume.

(ii) State **one (1)** example of fixed control volume and **one (1)** example of deforming control volume.

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

(6 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 21 m/s, determine the pumping capacity in m^3/s.

(4 marks)

(c) A police is using a fire hose to disperse a crowd. The fire hose delivers 0.01 m^3/s 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. Calculate the force that will make the flange tear apart when the water is pumped at 1 atm.

(5 marks)

Q6 (a) Explain the experiment carried out by Mr. Osborne Reynolds, including **three (3)** types of flows that he discovered.

(3 marks)

(b) Explain what is major loss and minor loss in pipe flow.

(5 marks)

(c) As a design engineer, you are given a budget of RM 550 to install sufficient 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.

(12 marks)

– END OF QUESTIONS –

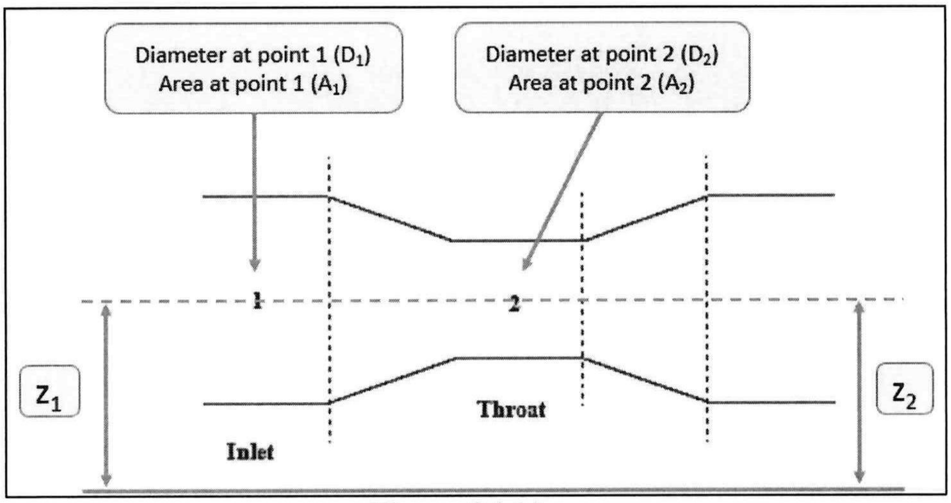


Figure Q4 (c)

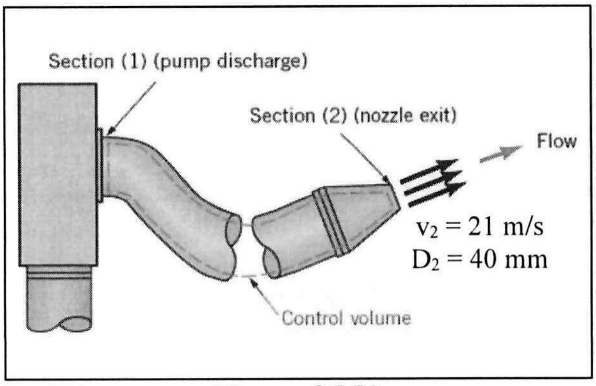
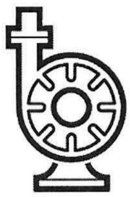
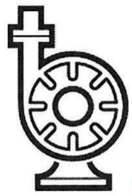


Figure Q5(b)

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

FINAL EXAMINATION

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List of formula

$A = \pi D^2/4$

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

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

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

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

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

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

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

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

$F_B = \rho_f g V$

$W = \rho_{obj} g V$

1 N/m = 1000 dyne/cm

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

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

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

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

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

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

1 m^3 = 1000 Liter

$Q = A \times v$

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

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

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

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

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