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Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2022/2023

COURSE NAME	:	FLUID MECHANICS
COURSE CODE	:	BFC 10403
PROGRAMME CODE	:	BFF
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 **NINE (9)** PAGES

Q1 (a) (i) State the importance of fluid mechanics to water resources

(1 mark)

(ii) List **THREE (3)** points to distinguish between liquids and gases.

(3 marks)

(b) Explain briefly with an aid of a sketch, the resultant hydrostatic force that acts on a submerged surface and the pressure center.

(5 marks)

(c) Referring to **FIGURE Q1 (c)**, calculate the pressure, P_A if the specific gravity of oil is 0.82.

(7 marks)

(d) A spring scale is used to determine the volume and average density of an irregularly shaped body. The body weight is 7200 N in air and 4790 N in water. Determine the volume and density of the body and indicate your assumptions.

(9 marks)

Q2 (a) List **FOUR (4)** basic assumptions in the application of the Bernoulli equation.

(4 marks)

(b) A pitot and a piezometric tube are installed in a horizontal pipe that is carrying a fluid at a certain velocity, v, as shown in **FIGURE Q2 (b)**. Derive the expression of the flow velocity in the pipe, v in terms of h_1 and h_2. Neglect the head losses.

(5 marks)

(c) Calculate the velocity at inlet and flow rate per meter width when water flows through a sluice gate as shown in **FIGURE Q2 (c)**. Given that y_1 and y_2 are 500 cm and 50 cm, respectively.

(7 marks)

(d) A water jet of diameter 2.5 cm flows freely into the atmosphere in a horizontal plane with an initial velocity of 6.5 m/s and is deflected by a curved vane of 90° as shown in **FIGURE Q2 (d)**. Analyze and locate the resulted forces exerted on the water by the vane in the x and y directions. Given the density of water is 1000 kg/m^3.

(9 marks)

Q3 (a) List **FIVE (5)** differences between turbulent and laminar flow.

(4 marks)

(b) Differentiate pipes connected in series and pipes connected in parallel by illustrating their continuity (flow rates) and total head losses.

(5 marks)

(c) Water is discharged from the tank to the atmosphere through a horizontal pipeline that is connected in series. Pipes A and B have a 10 cm diameter with a 25 m length, and a 12 cm diameter with a 35 m length, respectively. The water level in the tank is 10 m above the centerline of the pipe at the entrance. Considering all the head losses, calculate the discharge when pipe A is connected to the tank. Assume that the friction factor of pipes is 0.002 and the coefficient of entrance is 0.5.

(7 marks)

(d) Water is to be syphoned through a tube of 1 m long and 2 mm in diameter, as in **Figure Q3 (d)**. Given that density, $\rho = 998$ kg/m^3 and dynamic viscosity, $\mu = 0.001$ kg/ms.

(i) Determine the flow rate Q in m^3/h, if H is 50 cm. Assume laminar flow and neglect minor losses including the tube curvature.

(5 marks)

(ii) Estimate the H for which the flow begins to not be laminar, i.e., Re equal to 2000

(4 marks)

Q4 (a) Describe **TWO (2)** similarities between a model and its prototype.

(4 marks)

(b) Explain the Raleigh method for reducing the number of parameters during the design process.

(5 marks)

(c) The weir model was constructed with size ratio of 1:15 and has a flow rate of 1.15 m^3/s. If flood phenomena takes 10 hours using weir prototype to solve, how long should it take for a weir model using Froude number. Refer **TABLE Q4 (c)** for Froude number formula.

(6 marks)

(d) Express dimensionless equation for pressure drop (Δp) by a pump of a given geometry is known to depend upon the impeller diameter (D), rotational speed (N), flow rate (Q), density (ρ) and dynamic viscosity (μ). Repeating variables are density ρ, impeller diameter, D and rotational speed, N. Refer **TABLE Q4 (d)** for dimensionless parameter.

(10 marks)

– END OF QUESTIONS –

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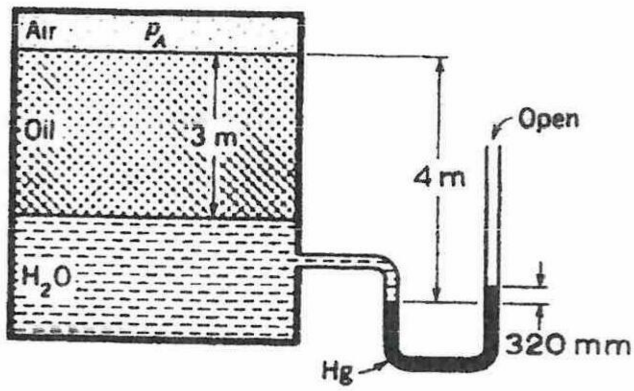

FIGURE Q1 (c)

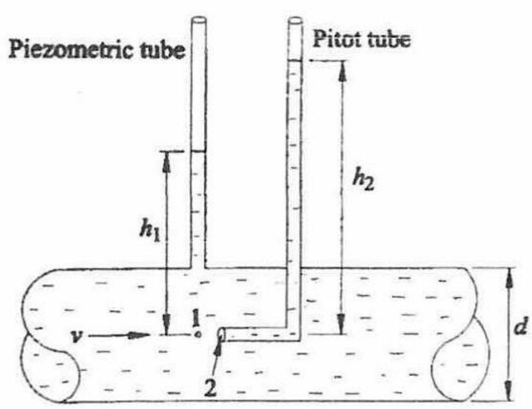

FIGURE Q2 (b)

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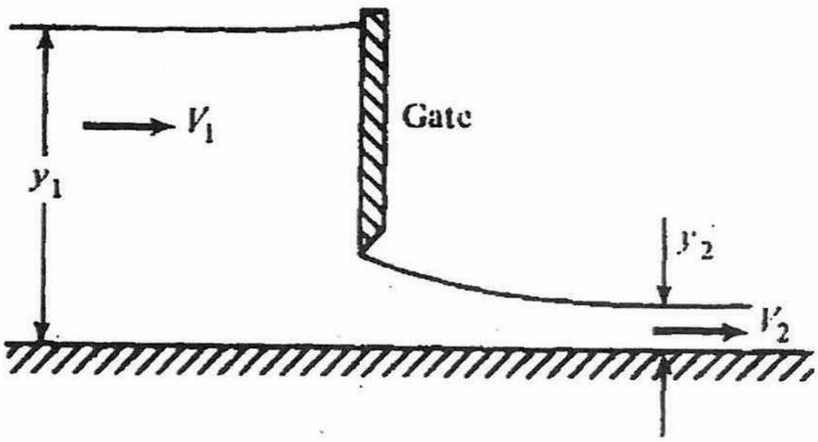

FIQURE Q2 (c)

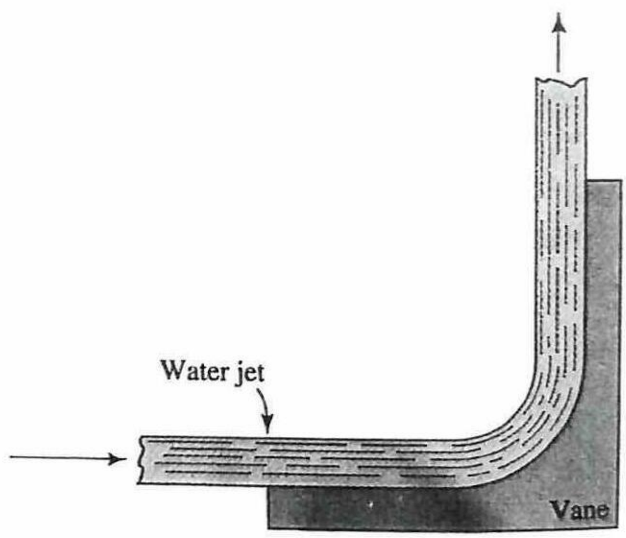

FIGURE Q2 (d)

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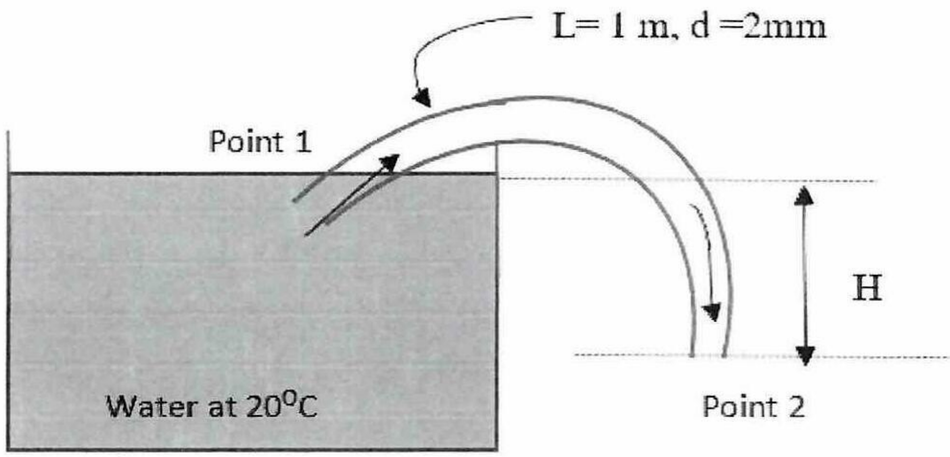

FIGURE Q3(d)

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TABLE Q4 (c) : scale ratios of fluid characteristics based on Reynolds, Froude and Mach number.

		Scale ratios for laws of		
Characteristic	**Dimension**	**Reynolds**	**Froude**	**Mach**
Geometric				
Length	L	L_r	L_r	L_r
Area	L^2	L_r^2	L_r^2	L_r^2
Volume	L^3	L_r^3	L_r^3	L_r^3
Kinematic				
Time	T	$\left(\frac{L^2\rho}{\mu}\right)_r$	$(L^{1/2}g^{-1/2})_r$	$\left(\frac{L\rho^{1/2}}{E_v^{1/2}}\right)_r$
Velocity	LT^{-1}	$\left(\frac{\mu}{L\rho}\right)_r$	$(L^{1/2}g^{1/2})_r$	$\left(\frac{E_v^{1/2}}{\rho^{1/2}}\right)_r$
Acceleration	LT^{-2}	$\left(\frac{\mu^2}{\rho^2L^3}\right)_r$	g_r	$\left(\frac{E_v}{L\rho}\right)_r$
Discharge	L^3T^{-1}	$\left(\frac{L\mu}{\rho}\right)_r$	$(L^{5/2}g^{1/2})_r$	$\left(\frac{L^2E_v^{1/2}}{\rho^{1/2}}\right)_r$
Dynamic				
Mass	M	$(L^3\rho)_r$	$(L^3\rho)_r$	$(L^3\rho)_r$
Force	MLT^{-2}	$\left(\frac{\mu^2}{\rho}\right)_r$	$(L^3\rho g)_r$	$(L^2E_v)_r$
Pressure	$ML^{-1}T^{-2}$	$\left(\frac{\mu^2}{L^2\rho}\right)_r$	$(L\rho g)_r$	$(E_v)_r$
Impulse and momentum	MLT^{-1}	$(L^2\mu)_r$	$(L^{7/2}\rho g^{1/2})_r$	$(L^3\rho^{1/2}E_v^{1/2})_r$
Energy and work	ML^2T^{-2}	$\left(\frac{L\mu^2}{\rho}\right)_r$	$(L^4\rho g)_r$	$(L^3E_v)_r$
Power	ML^2T^{-3}	$\left(\frac{\mu^3}{L\rho^2}\right)_r$	$(L^{7/2}\rho g^{3/2})_r$	$\left(\frac{L^2E_v^{3/2}}{\rho^{1/2}}\right)_r$

Note: Usually g is the same in model and prototype.

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TABLE Q4 (d) : Symbols and dimensions fluid mechanics quantities.

Quantity	**Symbol**	**Dimension**
FUNDAMENTAL		
Mass	m	M
Length	L	L
Time	t	T
GEOMETRIC		
Area	A	L^2
Volume	V	L^3
Angle	θ	$M^0L^0T^0$
First area moment	Ax	L^3
Second area moment	Ax^2	L^4
Strain	e	L^0
DINAMIC		
Force	F	MLT^{-2}
Weight	W	MLT^{-2}
Specific weight	γ	$ML^{-2}T^{-2}$
Density	ρ	ML^{-3}
Pressure	P	$ML^{-1}T^{-2}$
Shear stress	τ	$ML^{-1}T^{-2}$
Modulus of elasticity	E, K	$ML^{-1}T^{-2}$
Momentum	M	MLT^{-1}
Angular momentum		ML^2T^{-1}
Moment of momentum		ML^2T^{-1}
Force moment	T	ML^2T^{-2}
Torque	T	ML^2T^{-2}
Energy	E	L
Work	W	ML^2T^{-2}
Power	P	ML^2T^{-3}
Dynamic viscocity	μ	$ML^{-1}T^{-1}$
Surface tension	σ	MT^{-2}
KINEMATIC		
Linear velocity	U,v,u	LT^{-1}
Angular velocity	ω	T^{-1}
Rotational speed	N	T^{-1}
Acceleration	a	LT^{-2}
Angular acceleration	α	T^{-2}
Gravity	g	LT^{-2}
Discharge	Q	L^3T^{-1}
Kinematic viscosity	υ	L^2T^{-1}
Stream function	ψ	L^2T^{-1}
Circulation	Γ	L^2T^{-1}

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LIST OF FORMULAE:

$$P = \rho g h \qquad \boldsymbol{H = \frac{P}{\gamma} + z + \frac{V^2}{2g}} \qquad F = \boldsymbol{\rho Q}(V_2 - V_1) \qquad h_f = \frac{32\mu LV}{\rho g D^2}$$

$$h_f = \frac{fLV^2}{2gD} \qquad Q = VA$$