UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
(ONLINE)
SEMESTER II
SESI 2020/2021

COURSE NAME	:	FLUID MECHANICS
COURSE CODE	:	BFC 10403
PROGRAMME CODE	:	BFF
EXAMINATION DATE	:	JULY 2021
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **FOUR (4)** QUESTIONS ONLY

THIS QUESTION PAPER CONSISTS OF **TEN (10)** PAGES

Q1 (a) Discuss the difference between *Newtonian fluid* and *non-Newtonian fluid.*
(5 marks)

(b) A vertical gate of height 5 m and width of 3 m opposes the water at one of its sides. The deep of the water in the reservoir is 20 m. Determine the pressure and the force acting at the centroid of the gate.
(8 marks)

(c) A 20×20 cm cubical block slides on an oil surface over the inclined plane at 20° horizontal. Steady state velocity is 0.4 m/s. The thickness of the oil film between the block and the surface is 0.4 mm, and the mass of the block is 6.52 kg.

(i) Illustrate the free body diagram for the above condition.
(2 marks)

(ii) Calculate the kinematic viscosity of the oil if the specific gravity of the oil that you choose must be in the range between 0.78 to 0.86.
(10 marks)

Q2 (a) Given a condition of a rectangular plate of 0.3 m $\times$ 0.5 m is immersed vertically in the water with its longer side is vertical, and the total hydrostatic force on one side of the plate is 17.6 kN. Comment if the plate is turned in a vertical plane about its center of gravity by 60° and all other parameters are the same, what would happen to the total hydrostatic force and the center of pressure of the plate.
(5 marks)

(b) Left-arm of the machine, as shown in **Figure Q2(b)**, is subjected to 100 kN load. The diameter of the left and right are 10 cm and 1 cm, respectively. Determine the force to be applied on the right arm to keep the fluid X at the same level.
(8 marks)

(c) **Figure Q2(c)** shows a homogenous 1.2 m wide and 3 m long rectangular gate is held in place by a horizontal flexible cable. Water acts against the gate, which is hinged at point A. Calculate the magnitude, F_R and location of the resultant force, y_R.
(12 marks)

Q3 (a) Describe **FIVE (5)** basic assumptions upon the application of the Bernoulli equation.

(5 marks)

(b) A pitot tube and a piezometric tube are installed in a horizontal pipe adjacent to each other, as shown in **Figure Q3(b)**. The fluid flows in the pipe with velocity, v. Derive the expression of the flow velocity in the pipe, v in terms of h_1 and h_2. Neglect the head losses.

(8 marks)

(c) A jet of water (at 10°C) of diameter 2.5 cm flows freely in the atmosphere in a horizontal plane with the initial velocity of 6.5 m/s is deflected by a curved vane 90°.

(i) Illustrate the force diagram.

(3 marks)

(ii) Calculate the forces exerted on the water by the vane in x- and y-direction.

(9 marks)

Q4 (a) Discuss briefly the minor losses in pipes and give **THREE (3)** contributors to the minor losses in pipes.

(5 marks)

(b) Water is flowing fully turbulent in a straight galvanized iron pipe with a cross-sectional area of 1.963×10^{-3} m^2.

(i) Determine the relative roughness of the pipe.

(2 marks)

(ii) Explain in detail the procedure to determine the friction factor.

(3 marks)

(iii) Determine the friction factor from **Figure Q4(b)**. *(Note: Please attach the Moody diagram that has been marked with your answer together with the answer script)*

(3 marks)

(c) A smooth pipe with a constant diameter of 0.20 m carries water at a temperature of 30°C (Refer **Table Q4(c)**). The pipe pressure at section 1 and section 2 is 50 kPa and 20 kPa, respectively. Section 1 is located 2 m lower than section 1. Determine the head loss in the pipe.

(12 marks)

Q5 (a) Differentiate between pipe connected in series and pipes connected in parallel by sketching them with respect to the continuity (flow rates) and the total head losses.

(5 marks)

(b) The discharge and velocity of flow over the model of a spillway are 4 m^3/s and 3.2 m/s, respectively. Determine the velocity and discharge over the prototype, which is 25 times the size of the model. Refer to **Table 5(b)**.

(8 marks)

(c) Using Rayleigh theorem, estimate an expression for the drag force on a smooth sphere of diameter, D moving with a uniform velocity, V in a fluid density, ρ and dynamic viscosity, μ. Refer to **Table 5(c)**.

(12 marks)

– END OF QUESTIONS –

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LIST OF FORMULA

$$y_R = \frac{I_{xc}}{y_c A} + y_c \qquad I_{xc} = \frac{bh^3}{12} \qquad h_L = E_1 - E_2$$

$$P = \rho g h \qquad F = \rho g h A \qquad F_R = \gamma h_c A$$

$$E = \frac{P}{\rho g} + \frac{V^2}{2g} + z \qquad Q = AV \qquad F = \rho Q(V_2 - V_1)$$

$$\tau = \frac{F}{A} \qquad \tau = \mu \frac{du}{dy} \qquad \upsilon = \frac{\mu}{\rho}$$

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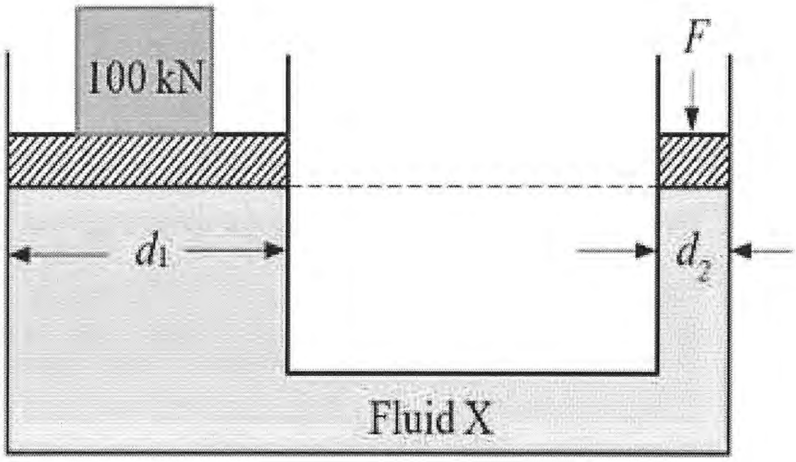

FIGURE Q2(b)

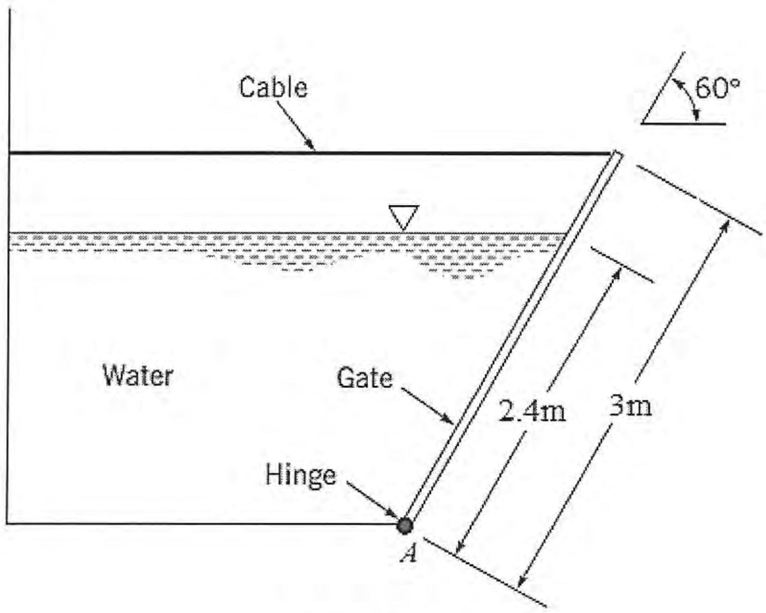

FIGURE Q2(c)

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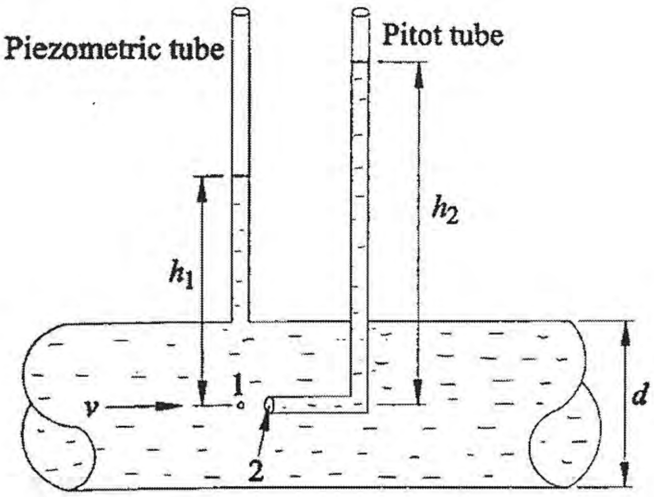

FIGURE Q3(b)

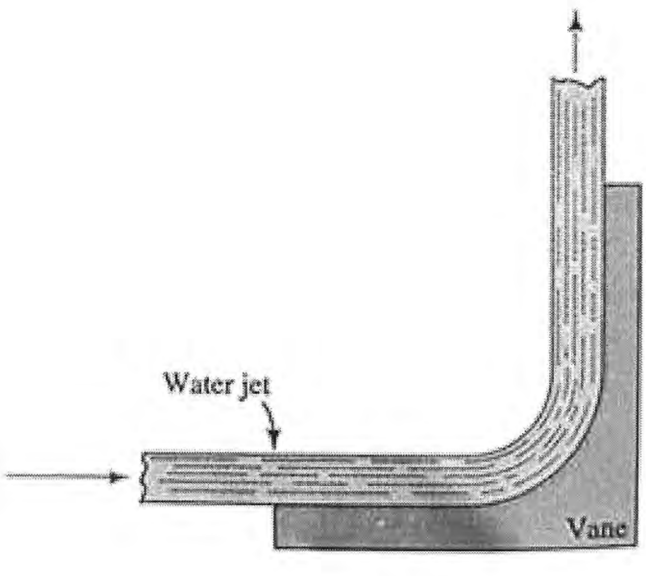

FIGURE Q3(c)

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The Moody Chart

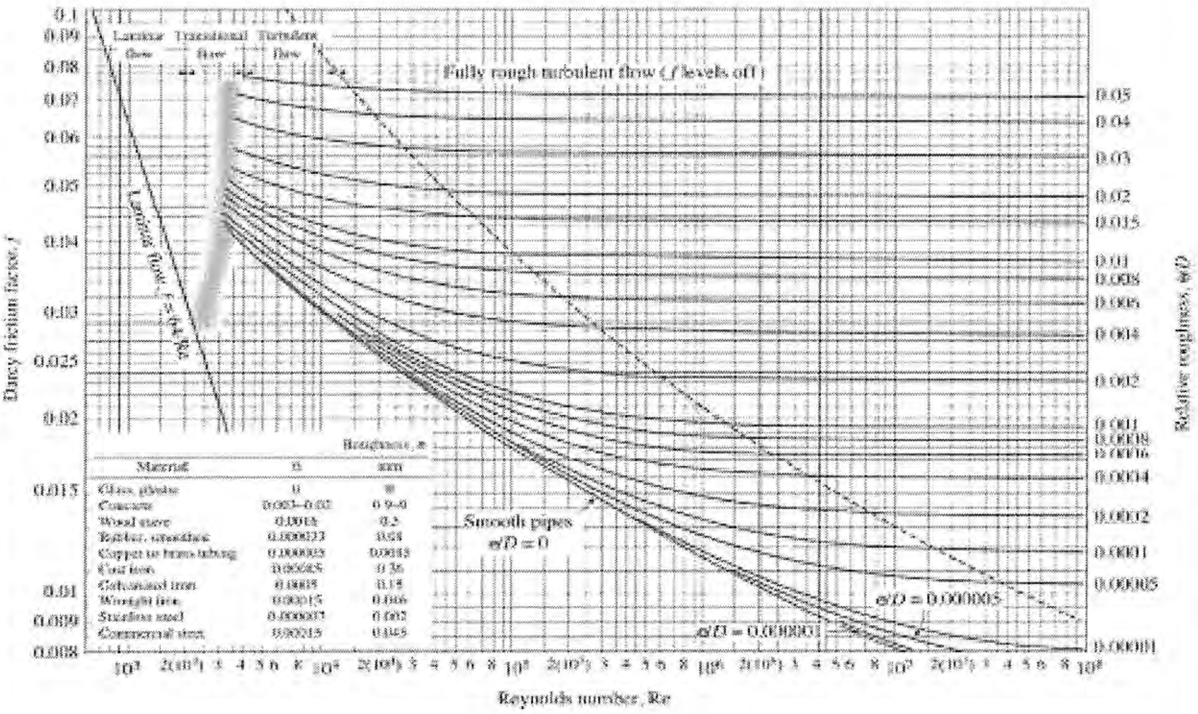

FIGURE Q4(b)

TABLE Q4(c)

Temperature °C	Density ρ kg/m³	Specific weight γ N/m³	Dynamic viscosity μ Ns/m²	Surface tension σ N/m	Saturation vapor pressure kN/m² abs
0	1000	9810	1.75×10^{-3}	0.0756	0.611
10	1000	9810	1.30×10^{-3}	0.0742	1.230
20	998	9790	1.02×10^{-3}	0.0728	2.34
30	996	9770	8.00×10^{-4}	0.0712	4.24
40	992	9730	6.51×10^{-4}	0.0696	7.38
50	988	9690	5.41×10^{-4}	0.0679	12.33
60	984	9650	4.60×10^{-4}	0.0662	19.92
70	978	9590	4.02×10^{-4}	0.0644	31.16
80	971	9530	3.50×10^{-4}	0.0626	47.34
90	965	9470	3.11×10^{-4}	0.0608	70.10
100	958	9400	2.82×10^{-4}	0.0589	101.33

*Interface with water

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TABLE Q5(b)

		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 Q5(c)

No.	Kuantiti	*Quantity*	Dimensi (*Dimension*)	
			Sistem M-L-T	Sistem F-L-T
A	***Kuantiti Asasi***	***Fundamental Quantities***		
1	Jisim m	*Mass m*	M	$FL^{-1}T^{2}$
2	Panjang L	*Length L*	L	L
3	Masa t	*Time t*	T	T
B	***Kuantiti Geometrik***	***Geometric Quantities***		
4	Luas A	*Area A*	L^{2}	L^{2}
5	Isipadu $\forall$	*Volume* $\forall$	L^{3}	L^{3}
6	Momen inersia	*Moment of inertia*	L^{4}	L^{4}
C	***Kuantiti Kinematik***	***Kinematic Quantities***		
7	Halaju linear U, V	*Linear velocity U, V*	LT^{-1}	LT^{-1}
8	Halaju sudut ω	*Angular velocity* ω	T^{-1}	T^{-1}
9	Halaju putaran N	*Rotational speed N*	T^{-1}	T^{-1}
10	Pecutan a	*Acceleration a*	LT^{-2}	LT^{-2}
11	Pecutan sudut α	*Angular acceleration* α	T^{-2}	T^{-2}
12	Kadar alir Q	*Flow rate Q*	$L^{3}T^{-1}$	$L^{3}T^{-1}$
13	Graviti g	*Gravity g*	LT^{-2}	LT^{-2}
14	Kelikatan kinematik ν	*Kinematic viscosity* ν	$L^{2}T^{-1}$	$L^{2}T^{-1}$
15	Fungsi arus ψ	*Stream function* ψ	$L^{2}T^{-1}$	$L^{2}T^{-1}$
16	Putaran Γ	*Circulation* Γ	$L^{2}T^{-1}$	$L^{2}T^{-1}$
17	Vortisiti Ω	*Vorticity* Ω	T^{-1}	T^{-1}
D	***Kuantiti Dinamik***	***Dynamic Quantities***		
18	Daya F	*Force F*	MLT^{-2}	F
19	Ketumpatan ρ	*Density* ρ	ML^{-3}	$FL^{-4}T^{2}$
20	Berat tentu γ	*Specific weight* γ	$ML^{-2}T^{-2}$	FL^{-3}
21	Kelikatan dinamik μ	*Dynamic viscosity* μ	$ML^{-1}T^{-1}$	$FL^{-2}T$
22	Tekanan p	*Pressure p*	$ML^{-1}T^{-2}$	FL^{-2}
23	Tegasan ricih τ	*Shear stress* τ	$ML^{-1}T^{-2}$	FL^{-2}
24	Modulus keanjalan E, K	*Modulus of elasticity E, K*	$ML^{-1}T^{-2}$	FT
25	Momentum	*Momentum*	MLT^{-1}	FLT
26	Momentum sudut	*Angular momentum*	$ML^{2}T^{-1}$	FLT
27	Momen momentum	*Moment of momentum*	$ML^{2}T^{-1}$	$FL^{-4}T^{2}$
28	Kerja W	*Work W*	$ML^{2}T^{-2}$	FL
29	Tenaga E	*Energy E*	$ML^{2}T^{-2}$	FL
30	Torque T	*Torque T*	$ML^{2}T^{-2}$	FL
31	Kuasa P	*Power P*	$ML^{2}T^{-3}$	FLT^{-1}