UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2023/2024

COURSE NAME	:	FLUID MECHANICS
COURSE CODE	:	BFC10403
PROGRAMME CODE	:	BFF
EXAMINATION DATE	:	JULY 2024
DURATION	:	3 HOURS
INSTRUCTIONS	:	1. ANSWER ALL QUESTIONS 2. THIS FINAL EXAMINATION IS CONDUCTED VIA ☐ Open book ☒ 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 All fluids, whether liquid or gas, have the same properties. Answer the following question based on your knowledge on fluid properties.

(a) Identify **FOUR (4)** examples of fluid mechanics application on human activities.

(4 marks)

(b) A tennis ball has fallen into the drain and its floats on the water surface. Explain with the aid of diagram, the surface tension involved in this phenomenon.

(6 marks)

(c) A reservoir had filled with 650 kg or 0.415 m^3 carbon tetrachloride (CCl_4). Calculate its density, specific volume and specific gravity. Assume ρ_{water} =1000 kg/m^3.

(6 marks)

(d) Nutrients dissolved in water are carried to upper parts of plants by tiny tubes partly because of the capillary effect. Analyse the height of water that will rise in a tree in a 0.005 mm diameter tube due to the capillary effect. Given that the surface tension is 0.0728N/m with a contact angle of 15°.

(4 marks)

Q2 Fluids at rest or in relative equilibrium are governed by principles of hydrostatic pressure and buoyancy.

(a) Compute the magnitude of the resultant force on the indicated area in **Figure Q2.1**.

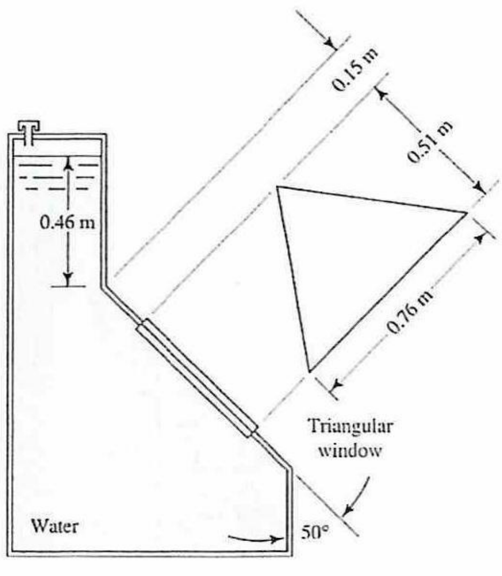


Figure Q2.1

(8 marks)

(b) The **Figure Q2.2** shows a metal part (object 2) hanging by a thin cord from a floating wood object (object 1). The wood block has a specific gravity SG_1 = 0.3 and dimensions of 50 mm x 50 mm x 10 mm. The metal part has a volume of 6600mm^3. Determine the weight, W of the metal part and the tension T in the cord.

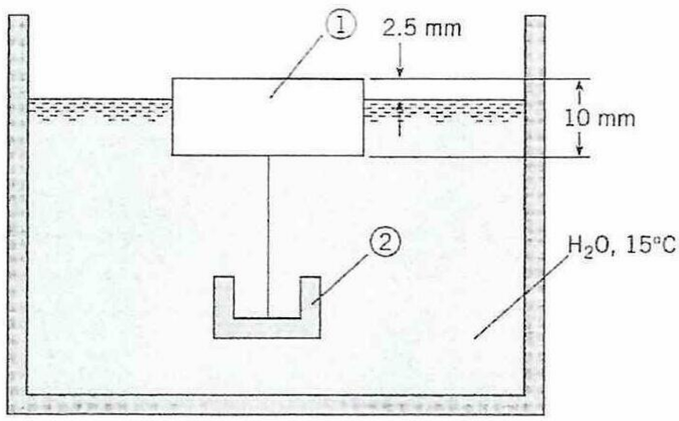


Figure Q2.2

(7 marks)

(c) By referring to **Figure Q2.3** calculate the pressure at point B, C and D in kPa. Given that specific weight of air, γ_{air} = 11.8 N/m^2, density of water = 1000 kg/m^3 and pressure of A is 36 kPa.

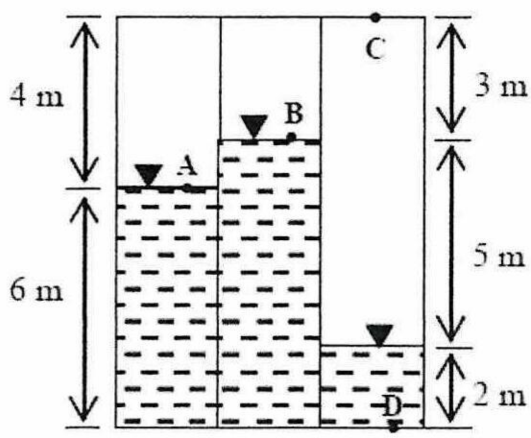


Figure Q2.3

(5 marks)

Q3 Fluid movement is explained by key equations in fluid mechanics. These questions explore these fundamental equations.

(a) Explain **THREE (3)** fundamental methods used in fluid mechanics for measuring flow rates.

(3 marks)

(b) A necked-down section in a pipe flow, called a venturi, develops a low throat pressure which can aspirate fluid upward from a reservoir, as shown in **Figure Q3.1**. Using Bernoulli's equation with no losses, derive an expression for the velocity V1 (in terms of h, D1, D2, and g) which is just sufficient to bring reservoir fluid into the throat.

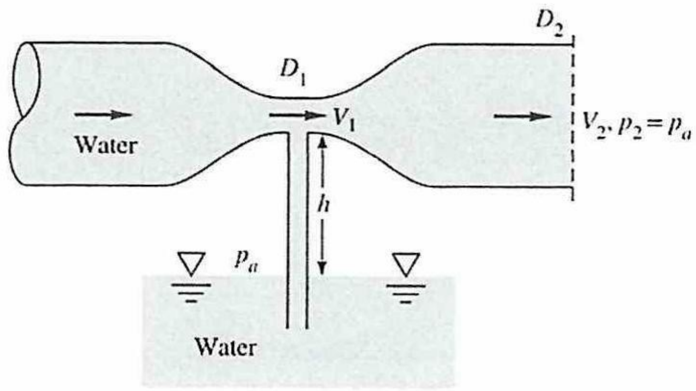


Figure Q3.1

(8 marks)

(c) A water jet strikes on a vane at 150^0 as shown in **Figure Q3.2**. If water flows and velocity are 0.68 kg/s and 24 m/s respectively. Determine the resultant force at vane if the vane moving at velocity 8 m/s in jet direction.

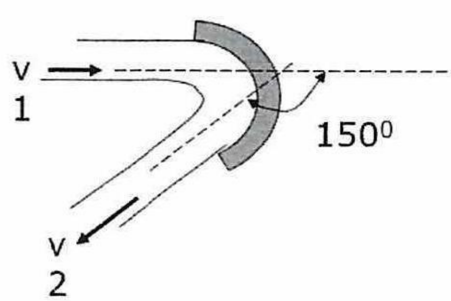


Figure Q3.2

(9 marks)

Q4 Analysis of flow in pipes is a crucial aspect of fluid mechanics and is essential for understanding various fluid transport systems. The following questions will describe and understand the flow in pipes.

(a) Ammonia liquid is flowing through a copper tube at a specified mass flow rate as shown in **Figure Q4.1**. Determine the pressure drop and the head loss required to overcome the frictional losses in the tube. Given the density and dynamic viscosity of NH_3 is 665.1 kg/m^3 and 9.8x10^{-6} Pa/s respectively. Refer **APPENDIX A** and attach together with answer scheme. (Assume that the flow is steady and incompressible, the entrance effects are negligible, and the pipe involves no components such as bends, valves, and connectors).

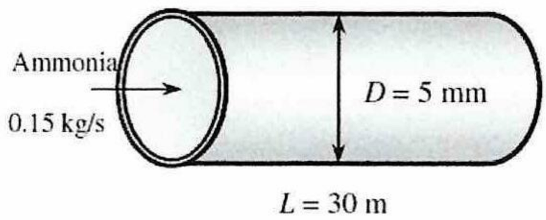


Figure Q4.1

(10 marks)

(b) A flow of water has been discharge through a horizontal pipeline to the atmosphere. The pipeline is connected in series and consisted of two pipes which are 10 cm diameter and 25 m long and 12 cm diameter and 35 m long. The friction factor is 0.002 for both pipes. The water level in the tank is 10 m above the centre-line of the pipe at the entrance (entrance factor = 0.5). Considering all the head losses, calculate the discharge when the 10 cm diameter pipe is connected to the tank.

(10 marks)

Q5 In civil engineering, dimensional analysis and similitude are vital for studying structures through scaled models. Engineers rely on these concepts for reliable predictions and informed decisions in design and analysis.

(a) Identify **THREE (3)** non-dimensional parameters in the context of fluid mechanics, explain their significance and application in analyzing flow behaviour.

(6 marks)

(b) Determine the discharge for spillway prototype if model with size ratio of 1:10 has a discharge of 1.05 m^3/s. If a flood phenomena takes 8 hours to occur using spillway prototype.

(3 marks)

(i) Estimate the flood occurrence for a model based on Froude number. Refer APPENDIX B for Froude number formula.

(3 marks)

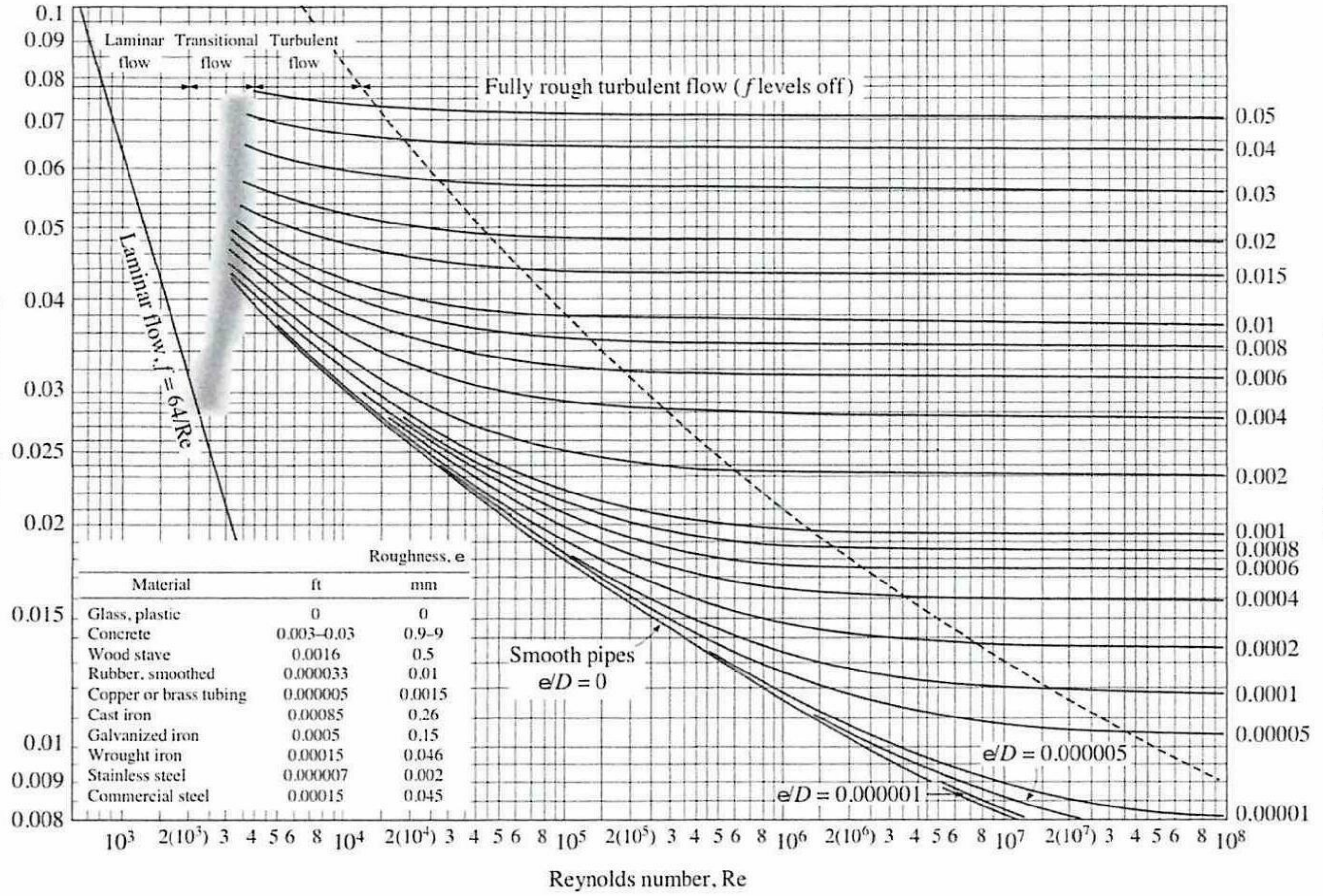
(c) Analyse shear stress, τ_o on the walls of triangular channel which depends on the vertex angle, θ, depth of flow, y, density, ρ and gravity, g. Obtain an expression in dimensionless equation using Buckingham Theorem if repeating variables are density, gravity and depth of flow.

(8 marks)

- END OF QUESTIONS -

APPENDIX A

The Moody Chart



Material	Roughness, e ft	Roughness, e mm
Glass, plastic	0	0
Concrete	0.003–0.03	0.9–9
Wood stave	0.0016	0.5
Rubber, smoothed	0.000033	0.01
Copper or brass tubing	0.000005	0.0015
Cast iron	0.00085	0.26
Galvanized iron	0.0005	0.15
Wrought iron	0.00015	0.046
Stainless steel	0.000007	0.002
Commercial steel	0.00015	0.045

APPENDIX B

Quantity	Symbol	Dimension	Froude
FUNDAMENTAL			
Mass	m	M	
Length	L	L	L_r
Time	t	T	$L_r^{1/2}g^{-1/2}$
GEOMETRIC			
Area	A	L^2	
Volume	V	L^3	L_r^2
Angle	θ	$M^0L^0T^0$	L_r^3
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}	$L_r^{1/2}g^{1/2}$
Angular velocity	ω	T^{-1}	
Rotational speed	N	T^{-1}	
Acceleration	a	LT^{-2}	g_r
Angular acceleration	α	T^{-2}	
Gravity	g	LT^{-2}	
Discharge	Q	L^3T^{-1}	$L_r^{5/2}g^{1/2}$
Kinematic viscosity	υ	L^2T^{-1}	
Stream function	ψ	L^2T^{-1}	
Circulation	Γ	L^2T^{-1}	

APPENDIX C

Equation	Formula
Shear stress	$\tau = \mu \frac{du}{dy}$
Capillary action	$h = \frac{4\delta \cos\theta}{\rho g d}$
Pressure with elevation	$P = \rho g h$
Horizontal resultant forces	$F_{RH} = \rho g h_c A$
Vertical resultant forces	$F_{RV} = \rho g V$
Centre of pressure	$Y_{RH} = \frac{I_{xc}}{y_c A} + y_c$
Second moment of area	$I_{xc} = \frac{bh^3}{12}$
Bernoulli theorem	$H = \frac{P}{\rho g} + z + \frac{v^2}{2g} + h_L$
Fluid in motion forces	$F = \rho Q \Delta V$
Reynold number	$R_e = \frac{\rho V D}{\mu} = \frac{DV}{\nu}$
Friction head losses	$h_f = \frac{32\mu L V}{\rho g D^2}$
Minor head losses	$h_m = k\frac{v^2}{2g}$