Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2023/2024

COURSE NAME	:	FLUID MECHANICS
COURSE CODE	:	BFC10403
PROGRAMME CODE	:	BFF
EXAMINATION DATE	:	JANUARY / FEBRUARY 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) Viscosity is a measure of the resistance of fluid against shear stress or tensile stress. State the effect of temperature on viscosity.

(3 marks)

(b) With the aid of sketches, explain the acting force on fluid if the surface tension occurs.

(4 marks)

(c) Nutrients dissolved in water are carried to upper parts of plants by tiny tubes partly because of the capillary effect. Determine 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 water temperature is 20°C with a contact angle of 15°.

(5 marks)

(d) The velocity distribution for a flow over a plate is given as $u = 5y - 4y^{1/2}$, where u is the velocity (m/s) at a distance y measured above the plate. If the dynamic viscosity is 0.85 Ns/m^2, calculate the velocity and shear stress on the boundary and at 0.25 m from the boundary.

(8 marks)

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

(a) Calculate the tension in the cable if the 258 N block shown in **Figure Q2.1** is completely submerged in seawater having a specific weight of 10.05 kN/m^3.

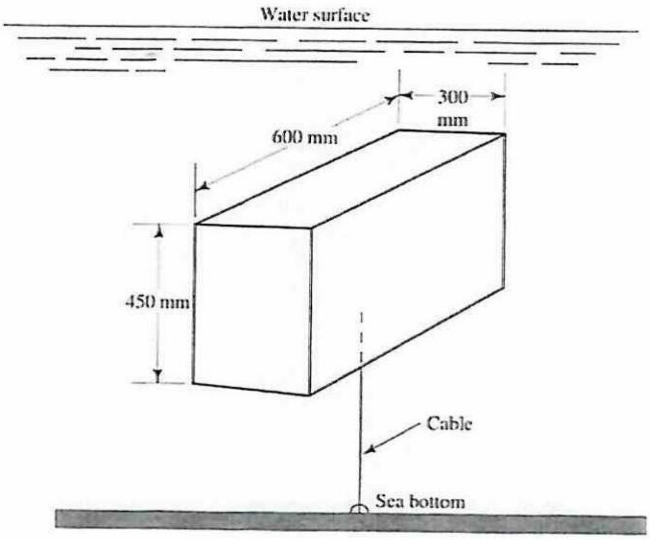


Figure Q2.1

(4 marks)

(b) An open tank contains water 1.40 m deep covered by a 2 m thick layer of oil with specific gravity of 0.855. Estimate the pressure head at the bottom of the tank, in terms of a water column.

(6 marks)

(c) A sector gate, as shown in **Figure Q2.2** is under the equilibrium conditions, with radius of 4 m and length 5 m. It controls the flow of water in a horizontal channel. Determine the total force on the gate.

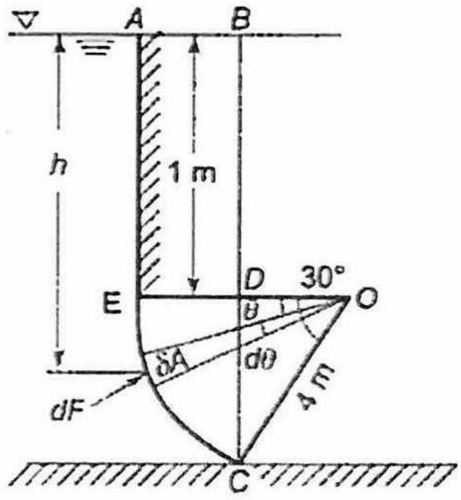


Figure Q2.2

(10 marks)

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

(a) Water at 10°C flows from section 1 to section 2. At section 1, which is 25 mm in diameter, the gage pressure is 345 kPa and the velocity of flow is 3.0 m/s. Section 2, which is 50 mm diameter is 2.0 m above section 1. Assuming there are no energy losses in the system, calculate the pressure at section 2.

(4 marks)

(b) Oil with specific gravity of 0.90 is flowing downward through the venturi meter shown in **Figure Q3.1**. If the manometer deflection h is 700 mm, determine the volume flow rate of oil.

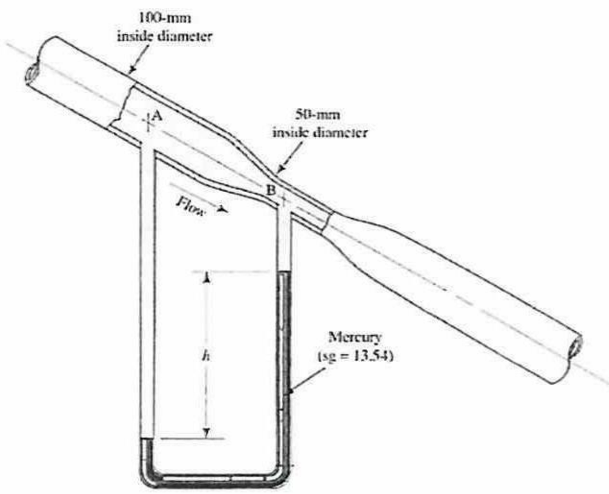


Figure Q3.1

(8 marks)

(c) In a fountain, 0.05 m^3/s of water having a velocity of 8 m/s is being deflected by the angled chute shown in **Figure Q3.2**. Determine the reactions on the chute in the x and y directions shown. Also, calculate the total resultant force and the direction in which it acts. Neglect elevation changes.

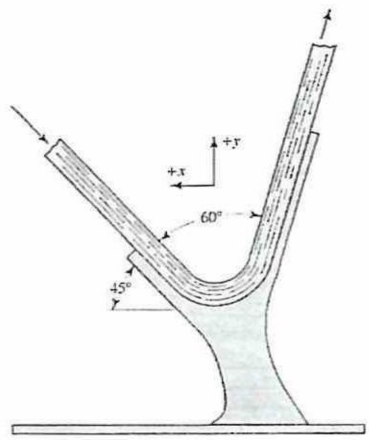


Figure Q3.2

(8 marks)

Q4 Analysis of flow in pipes is a crucial aspect of fluid mechanics and is essential for understanding various fluid transport systems. The analysis involves examining the behaviour of fluids as they move through pipes of different shapes and sizes. The following questions will list several key parameters and equations to describe and understand the flow in pipes.

(a) Describe **THREE (3)** different types of flow according to Reynold number values

(6 marks)

(b) Determine the pressure after an abrupt expansion in a horizontal water pipe, where the water velocity and pressure in the smaller diameter pipe are given in **Figure Q4.1**. Assume the friction head losses is 3.5 m.

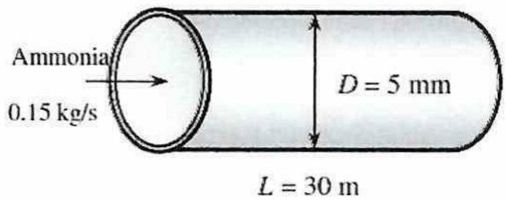


Figure Q4.1

(6 marks)

(c) Liquid ammonia is flowing through a copper tube at a specified mass flow rate as shown in **Figure Q4.2**. Determine the pressure drop and the head loss required to overcome the frictional losses in the tube. 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.

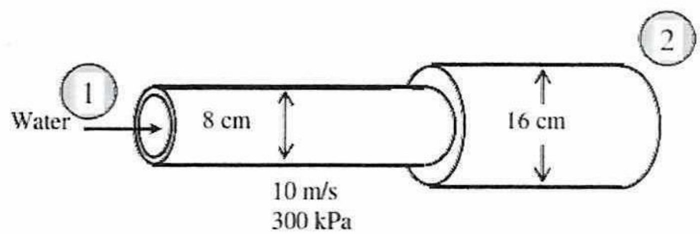


Figure Q4.2

(8 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) Explain the key distinctions between a model and a prototype, particularly in the context of product development.

(4 marks)

(b) Using Buckingham Theorem, derived an equation of non-dimension group to describe the resistance force *(F)*. The resistance force *(F)* for a ship influenced by the function length, *L*, velocity *V*, acceleration gravity *g*, density flow ρ and dynamic viscosity μ. Please use length, velocity and density of the flow as the repeating variables.

(10 marks)

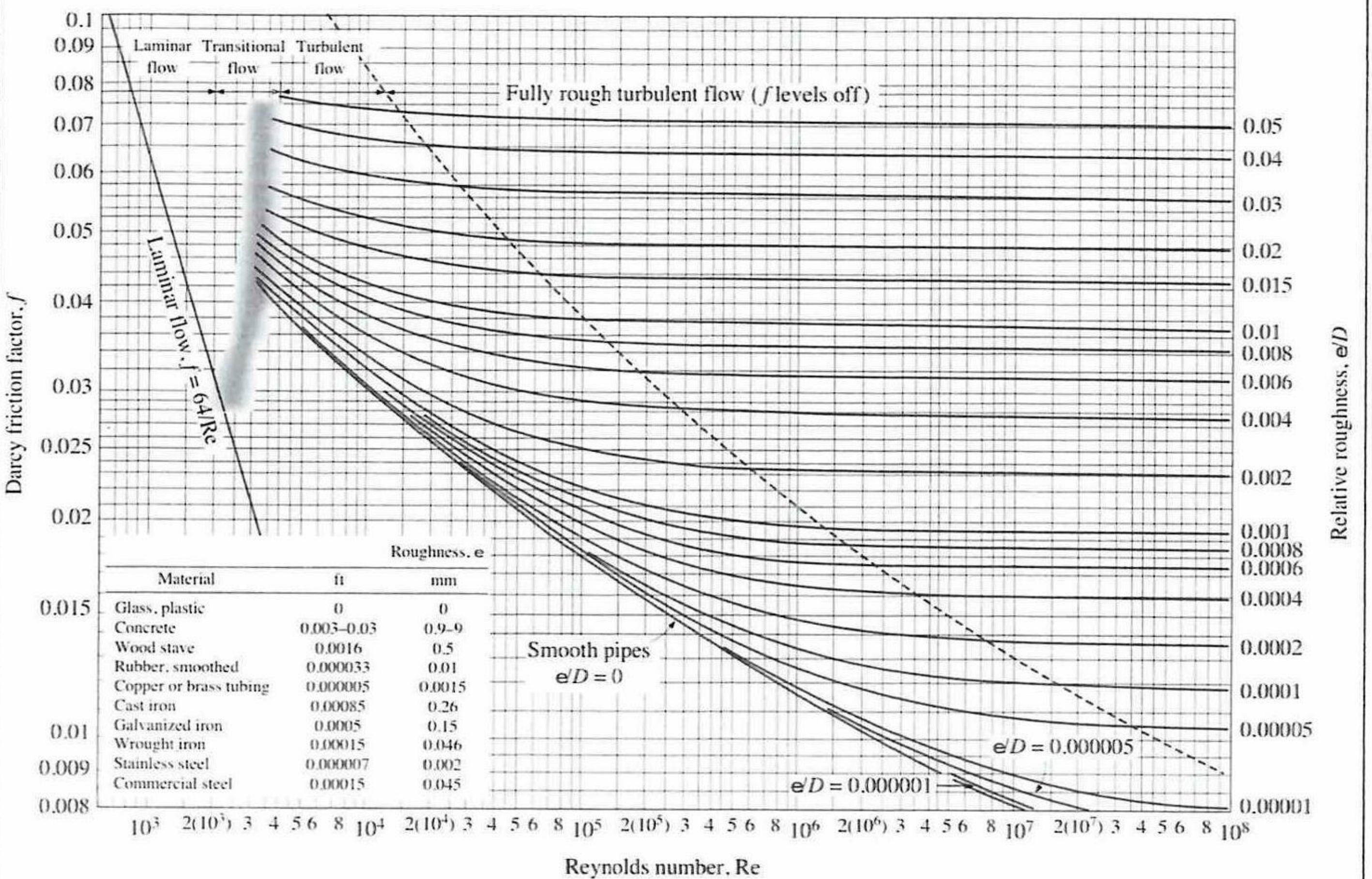
(c) Explain the concept of similitude and how dimensional analysis is applied to ensure model accuracy in civil engineering experiments. Provide a detailed example of using dimensional analysis to study the behaviour of a prototype piping system with different flow conditions.

(6 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	$L_r^{1/2}g\text{-}^{1/2}$
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}	

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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	$h_m = k \frac{v^2}{2g}$