CONFIDENTIAL

UNIVERSITY COLLEGE TATI

UNIVERSITY COLLEGE TATI (UC TATI)

FINAL EXAMINATION QUESTION BOOKLET	
COURSE CODE	: DTC 1053
COURSE	: FLUID MECHANICS
SEMESTER/SESSION	: 1 / 2024-25
DURATION	: 3 HOURS

Instructions:

1. This booklet contains 4 questions. Answer **ALL** questions.
2. All answers should be written in answer booklet.
3. Write legibly and draw sketches wherever required.
4. If in doubt, raise your hands and ask the invigilator.

DO NOT OPEN THIS BOOKLET UNTIL YOU ARE TOLD TO DO SO

THIS BOOKLET CONTAINS 8 PRINTED PAGES INCLUDING COVER PAGE

QUESTION 1

a) For fluid that occupies a volume of 24 L weighs 225 N at a location where the gravitational acceleration is 9.80 m/s^2. Identify the mass of this fluid and its density. (8 marks)

b) Figure 1 shows water in a 3 m high from the ground with 8 m diameter swimming pool is to be emptied by a 3 cm diameter, 25 m long pipe attached horizontally to the bottom of the pool. Compute the maximum discharge rate of water through the pipe. (10 marks)

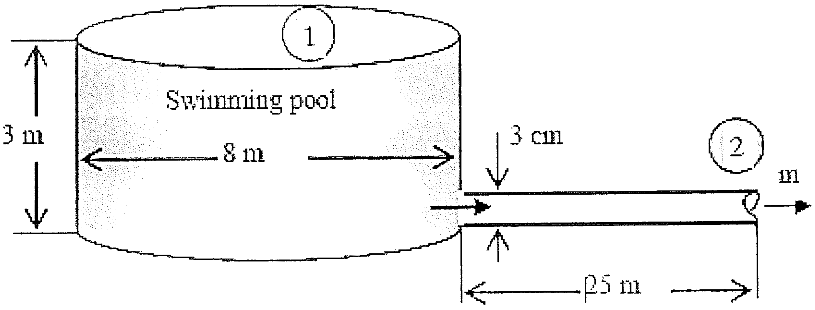


Figure 1

c) Low velocity water enters the turbine nozzles at 800 kPa absolute (Figure 2). Compute the maximum velocity to which water can be hastened by the nozzles before striking the turbine blades, if the outlet nozzle is exposed to atmospheric pressure of 100 kPa. (10 marks)

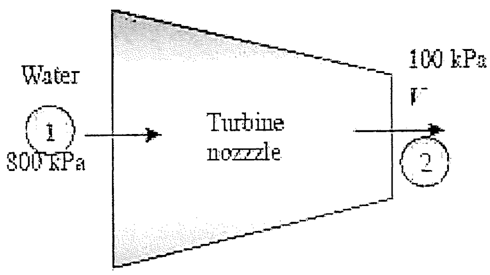


Figure 2

QUESTION 2

a) Consider a U-tube (Fig.3) whose arms are open to the atmosphere. Now water is poured into the U-tube from one arm, and light oil (ρ= 790 kg/m3) from the other. One arm contains 70-cm-high water, while the other arm contains both fluids with an oil-to-water height ratio of 6. Solve the height of each fluid in that arm. (10 marks)

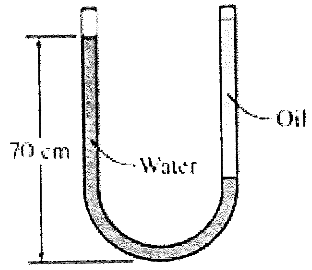


Figure 3

b) A 0.75m^3 rigid tank initially contains air whose density is 1.18 kg/m^3 as shown in Figure 4. The tank is connected to a high-pressure supply line through a valve. The valve is opened, and air is allowed to enter the tank until the density in the tank rises to 4.95 kg/m^3. Calculate the mass of air that has entered the tank. (10 marks)

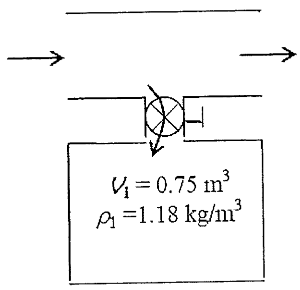


Figure 4

QUESTION 3

a) In a tank contains fluid 1 (ρ = 500 kg/m^3), fluid 2 (ρ =750 kg/m^3) and fluid 3 (ρ=1000 kg/m^3). Calculate the pressure at position 1 in Figure 5. Given P_{atm} =100 kPa. (8 marks)

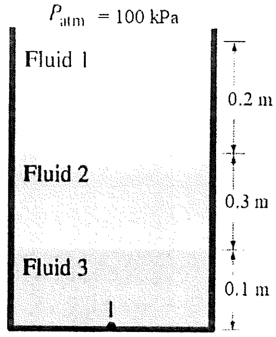


Figure 5

b) Referring to Fig.6, given velocity at A is 1.5 m/s, estimate the value of:

i) flow rate at point A (4 marks)

ii) velocity at point B (4 marks)

iii) flow rate at point B (2 marks)

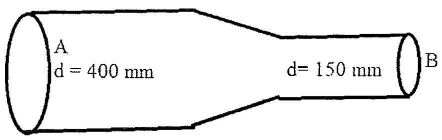


Figure 6

QUESTION 4

a) Water at 50°C (ρ = 992.1 kg/m^3 and μ = 0.653×10^{-3} kg/m.s) is flowing steadily in a 7 cm-diameter horizontal pipe made of stainless steel at a rate of 250 L/min over a 60 m-long section of pipe. Calculate:

i) The average velocity. (2 marks)

ii) The flow regime based from Re number, N_{Re}. (2 marks)

iii) The relative roughness of the pipe ($\frac{\varepsilon}{D}$). (2 marks)

iv) The friction factor (f). (3 marks)

v) The pressure drop (ΔP_L) (3 marks)

vi) The head loss (h_L). (3 marks)

vii) The requirement of pumping power to overcome this pressure drop($\dot{W}$). (4 marks)

b) The flow rate of methanol at 20°C (ρ= 788.4 kg/m^3 and μ= 5.857 x10^{-4} kg/m·s) through a 4 cm diameter pipe is to be measured with a 3 cm diameter orifice meter equipped with a mercury manometer across the orifice plate, as shown in Figure 8. If the differential height of the manometer is 11 cm, calculate the flow rate of methanol through the pipe.

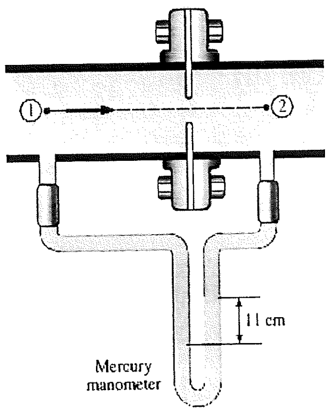


Figure 8

---End of question---

FORMULA

Specific weight = Weight/Volume $\qquad$ W = mg

$$\frac{P_1}{\rho g}+\frac{v_1^2}{2g}+z_1=\frac{P_2}{\rho g}+\frac{v_2^2}{2g}+z_2 \quad SG=\rho_{substance}/\rho_{water}$$

$$\dot{V}=A\vartheta A_a\vartheta_a=A_b\vartheta_b$$

$$\dot{m}_1=\dot{m}_2 \rightarrow \quad \rho_1\vartheta_1A_1=\rho_2\vartheta_2A_2$$

P=ρRT

$$Re=\frac{\rho VD}{\mu} \qquad Re=\frac{VD}{\upsilon}$$

$$\Delta P=\Delta P_L=f\frac{L}{D}\frac{\rho V^2}{2} \qquad H_L=f\frac{L}{D}\frac{V_{avg}^2}{2g}$$

$$\frac{1}{\sqrt{f}}=-1.8log\left[\frac{6.9}{Re}+\left(\frac{\varepsilon/D}{3.7}\right)\right]$$

C_d =Q/Q_{th}

$$\dot{V}=A_0C_d\sqrt{\frac{2(P_1-P_2)}{\rho(1-\beta^4)}}$$

$$\dot{W}=\dot{V}\Delta P_L$$

$D=4\frac{A}{p}$(A- cross-sectional area,$p$is its wetted perimeter)

$$A_0=A_2=\pi d^2/4$$

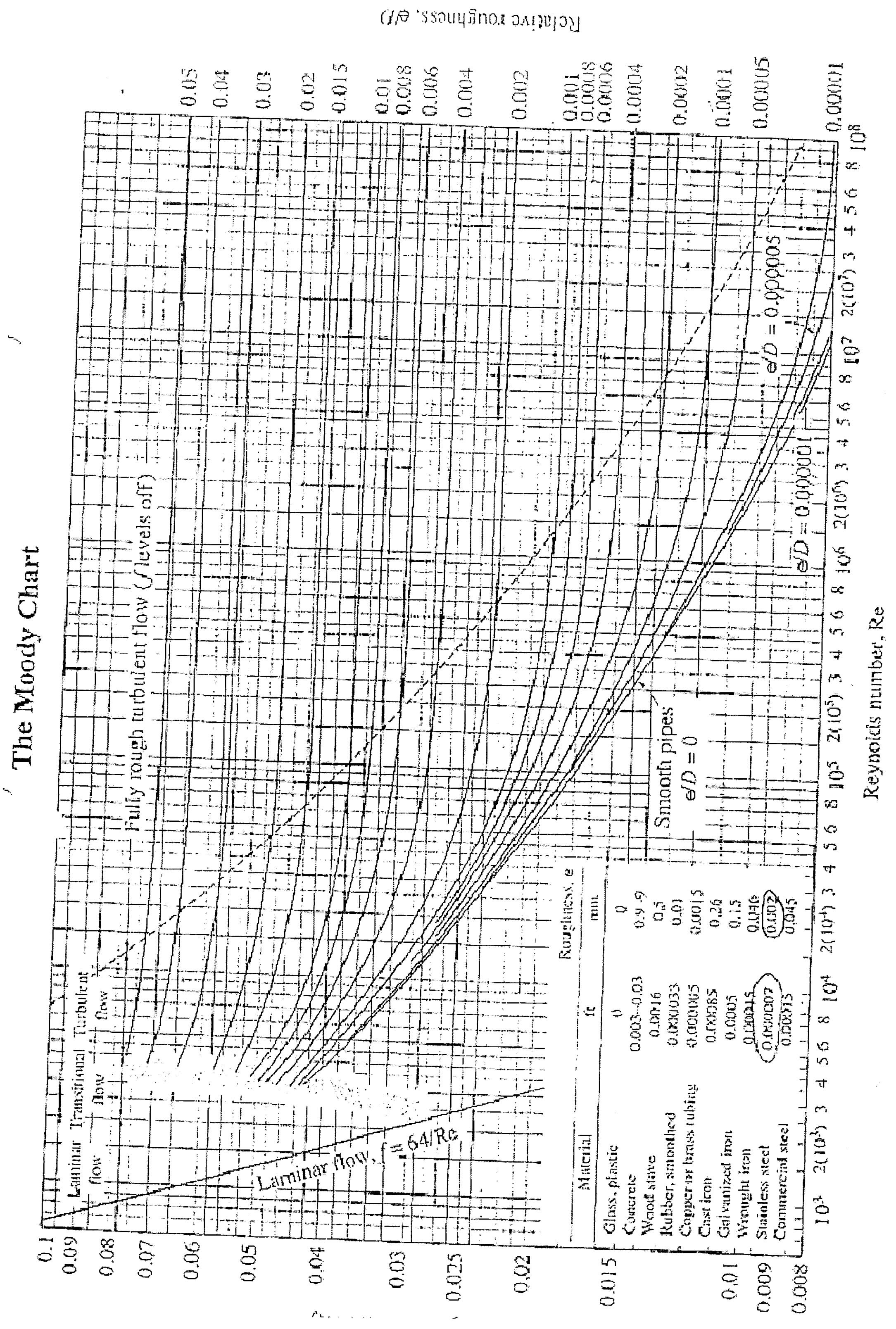
$$\beta=d/D$$

Density of water is $1000\frac{kg}{m^3}$, unless stated otherwise.

Useful conversion factor $\frac{1000kg.m/s^2}{1\,kPa.m^2}$, $\frac{1000N/m^2}{1\,kPa}$, $\frac{1\,kg.m/s^2}{1\,N}$

Unit Conversion Table

Name, Symbol, Dimensions			Conversion Formula
Length	L	L	1 m = 3.281 ft = 1.094 yd = 39.37 in = km/1000 = 10^6 μm 1 ft = 0.3048 m = 12 in = mile/5280 = km/3281 1 mm = m/1000 = in/25.4 = 39.37 mil = 1000 μm = 10^7 Å
Speed	V	L/T	1 m/s = 3.600 km/hr = 3.281 ft/s = 2.237 mph = 1.944 knots 1 ft/s = 0.3048 m/s = 0.6818 mph = 1.097 km/hr = 0.5925 knots
Mass	m	M	1 kg = 2.205 lbm = 1000 g = slug/14.59 = (metric ton or tonne or Mg)/1000 1 lbm = lbf·s^2/(32.17ft) = kg/2.205 = slug/32.17 = 453.6 g = 16 oz = 7000 grains = short ton/2000 = metric ton (tonne)/2205
Density	ρ	M/L^3	1000 kg/m^3 = 62.43 lbm/ft^3 = 1.940 slug/ft^3 = 8.345 lbm/gal (US)
Force	F	ML/T^2	1 lbf = 4.448 N = 32.17 lbm·ft/s^2 1 N = kg·m/s^2 = 0.2248 lbf = 10^5 dyne
Pressure	P	M/LT^2	1 Pa = N/m^2 = kg/m · s^2 = 10^{-5} bar = 1.450 × 10^{-4} lbf/in^2 = inch H_2O/249.1 = 0.007501 torr = 10.00 dyne/cm^2 1 atm = 101.3 kPa = 2116 psf = 1.013 bar = 14.70 lbf/in^2 = 33.90 ft of water = 29.92 in of mercury = 10.33 m of water = 760 mm of mercury = 760 torr 1 psi = atm/14.70 = 6.895 kPa = 27.68 in H_2O = 51.71 torr
Volume	V	L^3	1 m^3 = 35.31 ft^3 = 1000 L = 264.2 U.S. gal 1 ft^3 = 0.02832 m^3 = 28.32 L = 7.481 U.S. gal = acre-ft/43,560 1 U.S. gal = 231 in^3 = barrel (petroleum)/42 = 4 U.S. quarts = 8 U.S. pints = 3.785 L = 0.003785 m^3
Volume Flow Rate (Discharge)	Q	L^3/T	1 m^3/s = 35.31 ft^3/s = 2119 cfm = 264.2 gal (US)/s = 15850 gal (US)/m 1 cfs = 1 ft^3/s = 28.32 L/s = 7.481 gal (US)/s = 448.8 gal (US)/m
Mass Flow Rate	$\dot{m}$	M/T	1 kg/s = 2.205 lbm/s = 0.06852 slug/s
Energy and Work	E, W	ML^2/T^2	1 J = kg·m^2/s^2 = N·m = W·s = volt·coulomb = 0.7376 ft·lbf = 9.478 × 10^{-4} Btu = 0.2388 cal = 10^7 erg = kWh/3.600 × 10^6
Power	P, $\dot{E}$, $\dot{W}$	ML^2/T^3	1 W = J/s = N·m/s = kg·m^2/ s^3 = 1.341 × 10^{-3} hp = 0.7376 ft · lbf/s = 1.0 volt-ampere = 0.2388 cal/s = 9.478 × 10^{-4} Btu/s 1 hp = 0.7457 kW = 550 ft·lbf/s = 33,000 ft·lbf/min = 2544 Btu/h


The Moody Chart
Relative roughness, e/D
Laminar flow
Transitional flow
Turbulent flow
Fully rough turbulent flow (f levels off)
Laminar flow, f = 64/Re
Smooth pipes
e/D = 0
e/D = 0.000005
e/D = 0.000001
Reynolds number, Re
Material
Roughness, e
ft
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