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UNIVERSITY COLLEGE TATI

UNIVERSITY COLLEGE TATI (UC TATI)

FINAL EXAMINATION QUESTION BOOKLET	
COURSE CODE	: BCE 2134
COURSE	: FLUID MECHANICS
SEMESTER/SESSION	: 2 / 2023-24
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. (5 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. Calculate the maximum discharge rate of water through the pipe. (10marks)

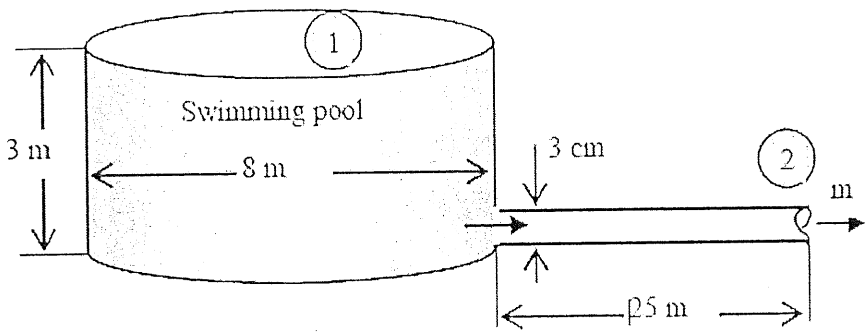


Figure 1

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 are exposed to atmospheric pressure of 100 kPa. (10 marks)

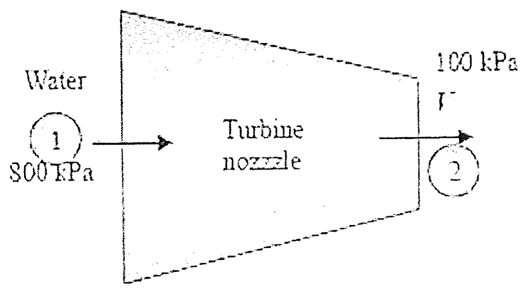


Figure 2

QUESTION 2

a) The basic barometer can be used to measure the height of a building (Figure 3). If the barometric readings at the top and at the bottom of a building are 730 and 755 mmHg, respectively, predict the height of the building. Assume an average air density of 1.18 kg/m^3.(ρ_{Hg}=13,600 kg/m^3) (10 marks)

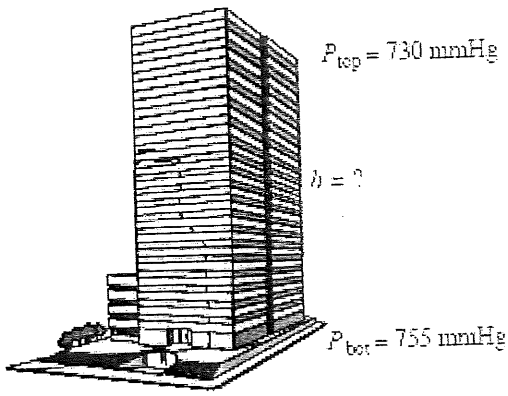


Figure 3

b) A 0.75 m^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)

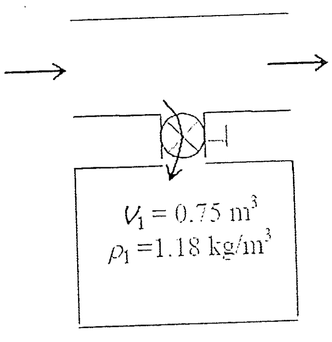


Figure 4

c) Calculate the Reynolds number for water flowing through an open channel 2 m wide when the flow is 1 m deep? The flow rate is 800 L/s. The kinematic viscosity(υ) is 1.23 × 10^{-6} m^2/s. Use $D = 4\frac{A}{p}$, where A is the cross-sectional area of the pipe and p is its wetted perimeter (8 marks)

QUESTION 3

a) While traveling on a dirt road, the bottom of a car hits a sharp rock and a small hole develops at the bottom of its gas tank (Figure 5). If the height of the gasoline in the tank is 30 cm, determine the initial velocity of the gasoline at the hole. Discuss how the velocity will change with time. (7 marks)

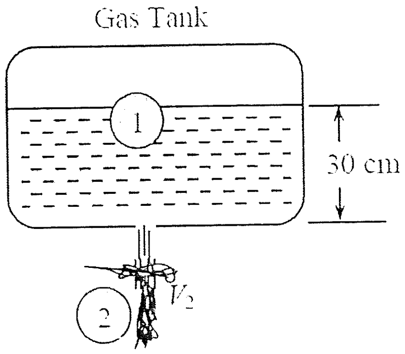


Figure 5

b) A very large tank contains air at 102 kPa at a location where the atmospheric air is at 100 kPa and 20°C (Figure 6). Now a 2 cm diameter tap is opened. Determine the maximum flow rate of air through the hole. (10 marks)

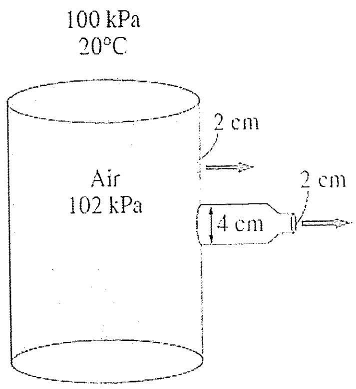


Figure 6

QUESTION 4

a) Water at 108 °C (ρ = 999.7 kg/m³ and μ =1.307x 10⁻³ kg/m·s) is flowing steadily in a 0.12 cm diameter, 15 m long pipe at an average velocity of 0.9 m/s. Calculate:

(i) the pressure drop, (3 marks)

(ii) the head loss and (3 marks)

(iii) the pumping power requirement to overcome this pressure drop (4 marks)

b) Referring to Fig.7, given velocity at A is 1.5 m/s, solve 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)

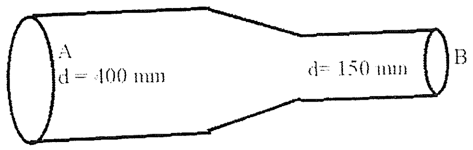


Figure 7

c) The flow rate of methanol at 20°C (ρ= 788.4 kg/m³ 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. (10 marks)

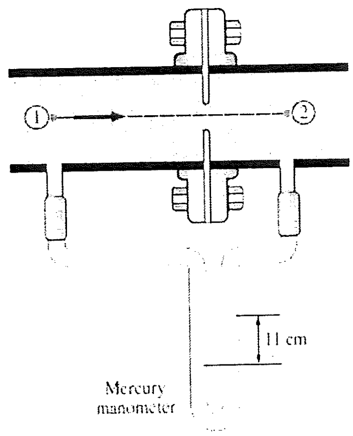


Figure 8

---End of question---

FORMULA

Specific weight = Weight/Volume

W = mg

$$\frac{P_1}{\rho g} + \frac{v_1^2}{2g} + z_1 = \frac{P_2}{\rho g} + \frac{v_2^2}{2g} + z_2$$

$$SG = \rho_{substance}/\rho_{water}$$

$$\dot{V} = A\vartheta$$

$$A_a\vartheta_a = A_b\vartheta_b$$

$$\dot{m}_1 = \dot{m}_2 \rightarrow \quad \rho_1\vartheta_1 A_1 = \rho_2\vartheta_2 A_2$$

P=ρRT

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

$$Re = \frac{VD}{\upsilon}$$

$$\Delta P = \Delta P_L = f\frac{L}{D}\frac{\rho V^2}{2}$$

$$H_L = f\frac{L}{D}\frac{V_{avg}^2}{2g}$$

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

$C_d = Q/Q_{th}$

$$\dot{V} = A_0 C_d\sqrt{\frac{2(P_1 - P_2)}{\rho(1 - \beta^4)}}$$

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

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

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

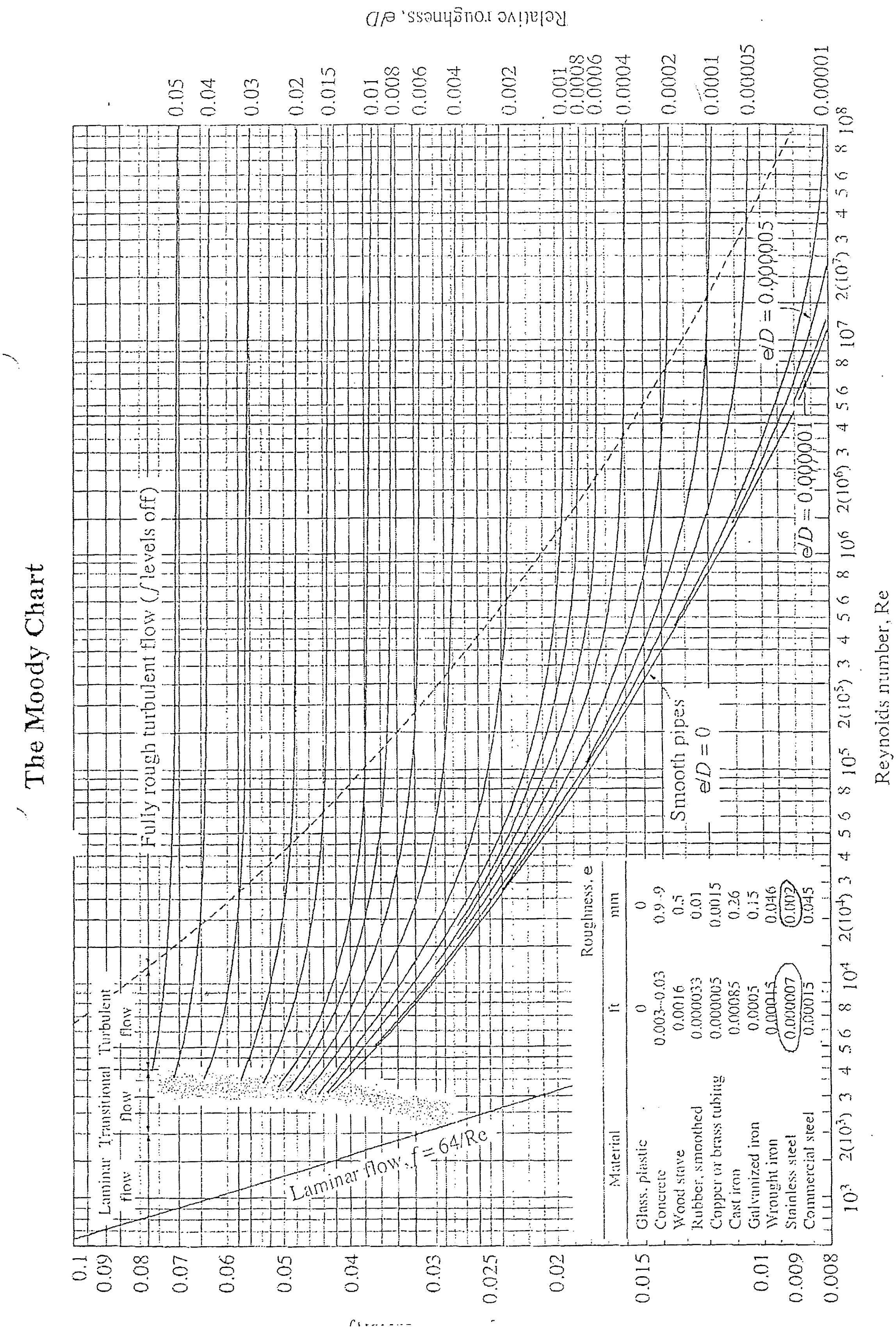
$$\beta = d/D$$

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	$\forall$	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



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