



UNIVERSITI KUALA LUMPUR
MALAYSIAN INSTITUTE OF CHEMICAL AND BIO-ENGINEERING TECHNOLOGY

FINAL EXAMINATION
OCTOBER 2025 SEMESTER

COURSE CODE : CPB12303
COURSE TITLE : FLUID MECHANICS
PROGRAMME NAME : BACHELOR OF CHEMICAL ENGINEERING TECHNOLOGY
WITH HONOURS
DATE : 25 JANUARY 2026
TIME : 9:00AM - 12:00PM
DURATION : 3 HOURS

INSTRUCTIONS TO CANDIDATES

1. Please read the instructions given in the question paper CAREFULLY.
2. This question paper is printed on both sides of the paper.
3. This question paper consist of TWO sections.
4. Answer ALL questions for Section A.
5. Section B consist of four questions. Answer THREE (3) questions only.
6. Please write your answer on the answer booklet provided.
7. Please answer all questions in English only.
8. Please answer MCQ/EMQ questions using OMR sheet. ☐ *Tick if applicable*
9. Refer to the attached Formula/ Appendies. ☐ *Tick if applicable*

THERE ARE 7 PAGES OF QUESTIONS INCLUDING THIS PAGE

SECTION A (Total: 40 marks)

Answer ALL questions.

Please use the answer booklet provided.

Question 1

Answer all questions

- (a) State the Pascal's law of pressure at a point in a fluid. (2 marks)
- (b) Differentiate between laminar flow and turbulent flow. (4 marks)
- (c) Determine the type of flow for water flowing at 2 m/s in a 50 mm pipe with the kinematic viscosity, $(\nu) = 1 \times 10^{-6} \text{ m}^2/\text{s}$. (4 marks)
- (d) The ventilating fan of a building has a volume flow rate of 30 L/s and runs continuously. If the density of air inside is 1.20 kg/m^3 , determine the mass of air vented out in one day. (5 marks)
- (e) A U-tube manometer is used to measure the pressure of water in a pipe. The right limb of the manometer is open to the atmosphere. The mercury level in the right limb is 15 cm higher than in the left limb, and the water-mercury interface in the left limb is 10 cm below the pipe center. Calculate the gauge pressure in the pipe. (5 marks)

Question 2

Answer all questions

- (a) Oil flows through a pipe that tapers from a diameter of 450 mm at Point A to 300 mm at Point B. If the velocity at Point A is 2.5 m/s, calculate the volumetric flow rate (Q).
(3 marks)
- (b) Mercury flows in a glass tube of diameter 1.2 mm. The contact angle between mercury and glass is 140° and the surface tension of mercury is 0.485 N/m. Determine the capillary rise or depression of mercury in the tube.
(5 marks)
- (c) A plastic tank with volume 0.2 m^3 and 3 kg of mass is filled with water. Determine the weight of the combined system. $\rho_{\text{water}} = 1000 \text{ kg/m}^3$.
(6 marks)
- (d) Water is pumped through a 100 m long horizontal plastic pipe with an internal diameter of 0.05 m at a velocity of 3 m/s. If the friction factor (f) is 0.02, calculate the head loss due to friction and the pressure drop.
(6 marks)

SECTION B (Total: 60 marks)

Answer THREE (3) questions only.

Please use the answer booklet provided.

Question 1

Answer all questions

- (a) The information on a can of pop indicates that it contains 355 mL. The mass of a full can is 0.369 kg, while the weight of the empty can is 0.153 N. Calculate:
- i. Specific weight of the pop. (6 marks)
 - ii. Density of the pop. (2 marks)
 - iii. Specific gravity of the pop. (2 marks)
- (b) A 20 m³ of tank contains nitrogen at 27 C and 700 kPa. Some nitrogen is allowed to escape until the pressure in the tank drops to 550 kPa. If the temperature at this point is 20 C, determine the amount of nitrogen that has escape. ($R = 0.2968 \text{ kPa}\cdot\text{m}^3/\text{kg}\cdot\text{K}$). (10 marks)

Question 2

Answer all questions

- (a) The gauge pressure of air in the tank shown in figure below is measured to be 65 kPa. Determine the differential height, h of the mercury column.

Refer Below - Figure1 : U tube manometer .

(8 marks)

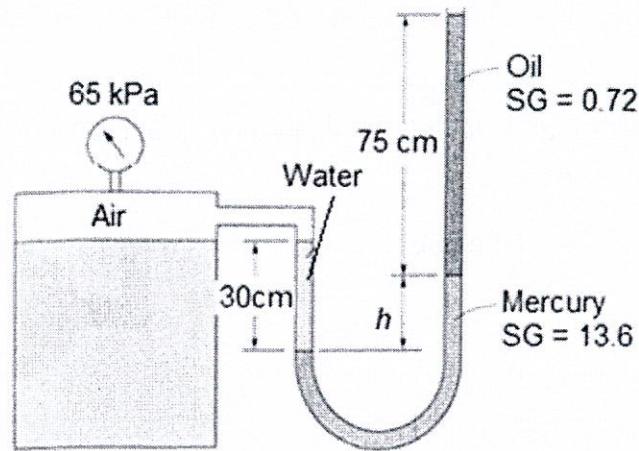


Figure 1: U tube manometer

- (b) A chemical engineering team is installing a submerged reactor ballast system for an offshore wastewater treatment unit. During installation, a crane is used to lower a solid spherical steel ballast block into a freshwater lake that simulates offshore conditions during testing. The ballast block has a diameter of 3 ft and is attached to the crane using a steel cable. The density of steel is 494 lbm/ft^3 , while the density of freshwater is 62.4 lbm/ft^3 . For safe crane operation and load monitoring, determine the tension in the lifting cable:

- i. When the steel ballast is suspended in air during initial lifting.

(6 marks)

- ii. When the ballast is fully submerged in water before being positioned at the reactor base.

(6 marks)

Question 3

Answer all questions

- (a) Water at 15 °C ($\rho = 999.1 \text{ kg/m}^3$ and $\mu = 1.138 \times 10^{-3} \text{ kg/m.s}$) flows steadily in a 30 m long and 2.5 cm radius horizontal pipe made of stainless steel ($\epsilon = 2 \times 10^{-6} \text{ m}$) at a rate of 9 L/s. Determine:

i. The head loss.

(17 marks)

ii. The pressure drop.

(3 marks)

Question 4

Answer all questions

- (a) In a chemical processing facility, a thin flat metal plate is installed inside a forced-air duct used to remove excess heat from process equipment. The plate is positioned parallel to the direction of airflow so that flow separation is avoided and only skin-friction drag is produced. The plate has a length of 1.2 m measured in the direction of flow and a width of 0.6 m. Air flows steadily over the surface of the plate at a uniform velocity of 10 m/s. The plate surface is smooth, and the effects of plate edges are neglected. At the operating conditions, the properties of air are $\rho = 1.18 \text{ kg/m}^3$, $\mu = 1.85 \times 10^{-5} \text{ Pa}\cdot\text{s}$. Determine the total drag force acting on one side of the plate due to viscous effects.

(10 marks)

- (b) In a gas–solid separation unit (vertical riser of a fluidized catalytic cracking system), catalyst particles are transported upward by an air stream. For stable operation, it is critical that the gas velocity remains below the terminal velocity of the particles to prevent excessive entrainment. A spherical catalyst particle of diameter 180 μm and density 2600 kg/m^3 is released from rest in a large vertical column filled with quiescent air at 1 atm and 25°C. Air properties: $\rho_f = 1.18 \text{ kg/m}^3$, $\mu = 1.85 \times 10^{-5} \text{ Pa}\cdot\text{s}$. Determine the minimum upward gas velocity required to just suspend the particle.

(10 marks)

END OF EXAMINATION PAPER

APPENDIX 1

$$\rho_{\text{mercury}} = 13600 \frac{\text{kg}}{\text{m}^3}$$

$$\rho_{\text{water}} = 1000 \frac{\text{kg}}{\text{m}^3}$$

$$\rho_{\text{glycerin}} = 1260 \frac{\text{kg}}{\text{m}^3}$$

$$\rho = \frac{m}{v}$$

$$v = \frac{\mu}{\rho}$$

$$w = mg$$

$$P = \rho gh$$

$$SG = \frac{\rho_{\text{liquid}}}{\rho_{\text{water}}}$$

$$\gamma = \rho g$$

$$\rho = \frac{P}{RT}$$

$$\tau = \mu \left(\frac{u}{y} \right)$$

$$P = \rho gh$$

$$h = \frac{2\sigma \cos \theta}{\rho g r}$$

$$\gamma = \frac{w}{V}$$

$$P = \frac{F}{A}$$

$$\text{Re} = \frac{\rho u d}{\mu}$$

$$Q = AU$$

$$Q = A_1 u_1 = A_2 u_2$$

$$Q = \frac{\dot{m}}{\rho}$$

$$U^2 = \frac{2\Delta P}{\rho} \text{ where } \Delta P = h(\rho_{\text{man}} - \rho)g$$

$$U^2 = \frac{2h(\rho_{\text{man}} - \rho)g}{\rho}$$

$$F_D = 3\pi\mu_f u d \text{ (Stoke's law)}$$

$$Q_{\text{Hagen-Poiseuille}} = \frac{\pi\Delta P D^4}{128\mu L}$$

$$Q_{\text{actual}} = C_d A_1 A_2 \sqrt{\frac{2g \left[\frac{P_1 - P_2}{\rho g} \right] + Z_1 - Z_2}{A_1^2 - A_2^2}}$$

$$Q_{\text{actual}} = C_d A_1 A_2 \sqrt{\frac{2gh \left[\frac{\rho_{\text{man}}}{\rho} - 1 \right]}{A_1^2 - A_2^2}}$$

$$U_{\text{theoretical}} = \sqrt{2gh}$$

$$F_D = C_f A \frac{\rho u^2}{2}$$

$$Q_{\text{actual}} = A_{\text{actual}} U_{\text{actual}}$$

$$U_{\text{actual}} = C_v U_{\text{theoretical}}$$

$$Q_{\text{actual}} = C_d A_{\text{orifice}} U_{\text{theoretical}}$$

$$A_{\text{actual}} = C_c A_{\text{orifice}}$$

$$Q_{\text{actual}} = C_c C_v A_{\text{orifice}} \sqrt{2gh}$$

$$f = \frac{64}{\text{Re}}$$

$$f = \frac{0.3164}{\text{Re}^{0.25}}$$

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

$$h_L = f \frac{L}{D} \frac{V^2}{2g}$$

$$U = \frac{\rho g h_f D^2}{32\mu L}$$

$$v_T = \frac{d^2 g (\rho_s - \rho_f)}{18\mu_f}$$

$$C_f = \frac{1.33}{\text{Re}_L^{1/2}}; \text{Re}_L < 5 \times 10^5 \text{ (Laminar flow)}$$

$$C_f = \frac{0.074}{\text{Re}_L^{1/5}}; 5 \times 10^5 \ll \text{Re}_L \ll 10^7 \text{ (Turbulent flow)}$$

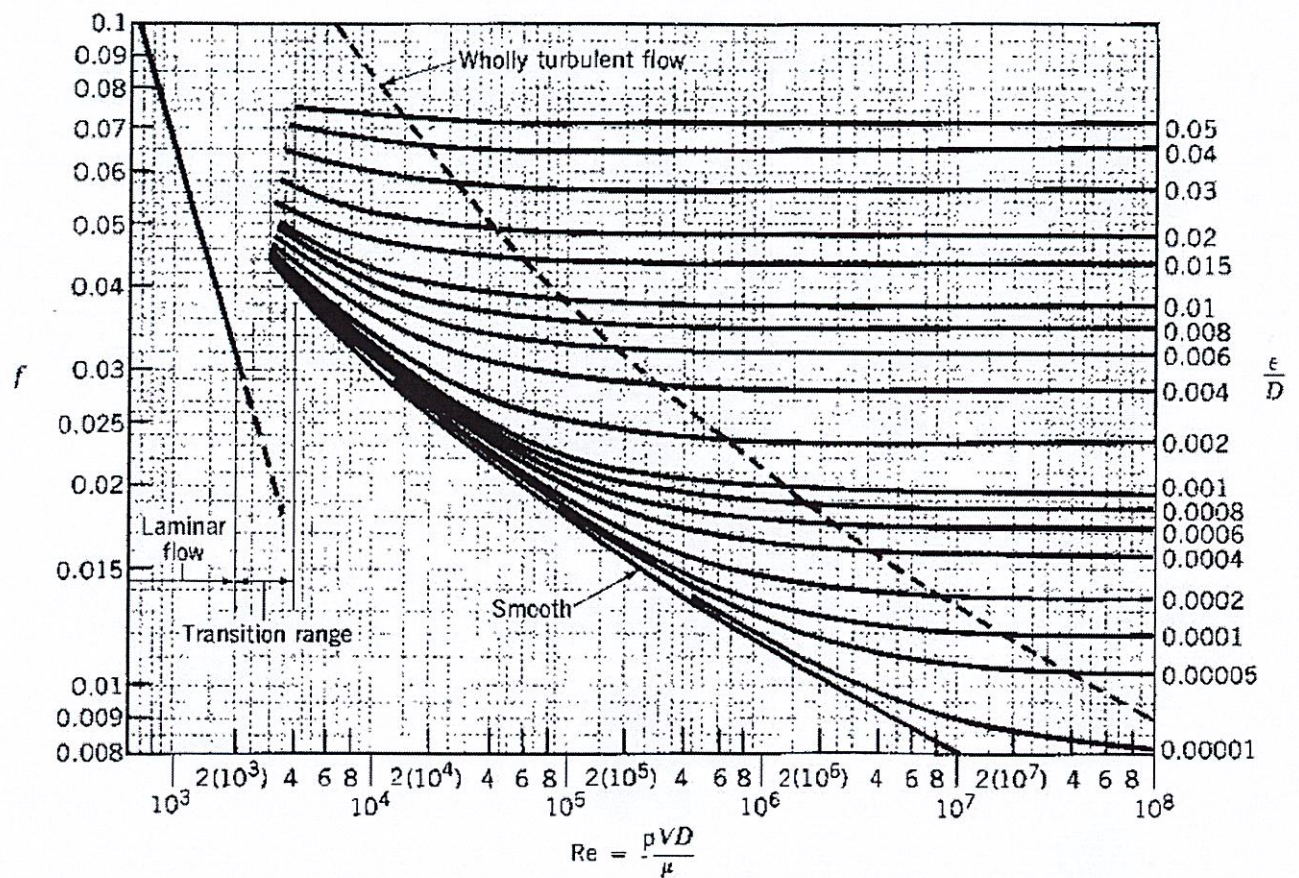
$$\text{Bernoulli's equation: } \frac{P_1}{\rho g} + Z_1 + \frac{u_1^2}{2g} = \frac{P_2}{\rho g} + Z_2 + \frac{u_2^2}{2g} + h_L$$

APPENDIX 2

FACTORS FOR UNIT CONVERSIONS

Quantity	Equivalent Values
Mass	$1 \text{ kg} = 1000 \text{ g} = 0.001 \text{ metric ton} = 2.20462 \text{ lb}_m = 35.27392 \text{ oz}$ $1 \text{ lb}_m = 16 \text{ oz} = 5 \times 10^{-4} \text{ ton} = 453.593 \text{ g} = 0.453593 \text{ kg}$
Length	$1 \text{ m} = 100 \text{ cm} = 1000 \text{ mm} = 10^6 \text{ microns } (\mu\text{m}) = 10^{10} \text{ angstroms } (\text{\AA})$ $= 39.37 \text{ in} = 3.2808 \text{ ft} = 1.0936 \text{ yd} = 0.0006214 \text{ mile}$ $1 \text{ ft} = 12 \text{ in} = 1/3 \text{ yd} = 0.3048 \text{ m} = 30.48 \text{ cm}$
Volume	$1 \text{ m}^3 = 1000 \text{ liters} = 10^6 \text{ cm}^3 = 10^6 \text{ ml}$ $= 35.3145 \text{ ft}^3 = 220.83 \text{ imperial gallons} = 264.17 \text{ gal}$ $= 1056.68 \text{ qt}$ $1 \text{ ft}^3 = 1728 \text{ in}^3 = 7.4805 \text{ gal} = 0.028317 \text{ m}^3 = 28.317 \text{ liters}$ $= 28 \text{ 317 cm}^3$
Force	$1 \text{ N} = 1 \text{ kg}\cdot\text{m}/\text{s}^2 = 10^5 \text{ dynes} = 10^5 \text{ g}\cdot\text{cm}/\text{s}^2 = 0.22481 \text{ lb}_f$ $1 \text{ lb}_f = 32.174 \text{ lb}_m\cdot\text{ft}/\text{s}^2 = 4.4482 \text{ N} = 4.4482 \times 10^5 \text{ dynes}$
Pressure	$1 \text{ atm} = 1.01325 \times 10^5 \text{ N}/\text{m}^2 (\text{Pa}) = 101.325 \text{ kPa} = 1.01325 \text{ bars}$ $= 1.01325 \times 10^6 \text{ dynes}/\text{cm}^2$ $= 760 \text{ mm Hg at } 0^\circ\text{C (torr)} = 10.333 \text{ m H}_2\text{O at } 4^\circ\text{C}$ $= 14.696 \text{ lb}_f/\text{in}^2 (\text{psi}) = 33.9 \text{ ft H}_2\text{O at } 4^\circ\text{C}$ $= 29.921 \text{ in Hg at } 0^\circ\text{C}$
Energy	$1 \text{ J} = 1 \text{ N}\cdot\text{m} = 10^7 \text{ ergs} = 10^7 \text{ dyne}\cdot\text{cm}$ $= 2.778 \times 10^{-7} \text{ kW}\cdot\text{h} = 0.23901 \text{ cal}$
Power	$= 0.7376 \text{ ft}\cdot\text{lb}_f = 9.486 \times 10^{-4} \text{ Btu}$ $1 \text{ W} = 1 \text{ J}/\text{s} = 0.23901 \text{ cal}/\text{s} = 0.7376 \text{ ft}\cdot\text{lb}_f/\text{s} = 9.486 \times 10^{-4} \text{ Btu}/\text{s}$ $= 1.341 \times 10^{-3} \text{ hp}$

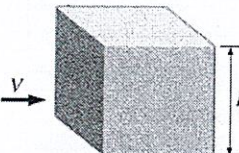
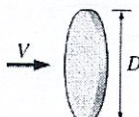
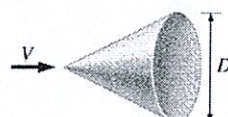
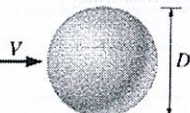
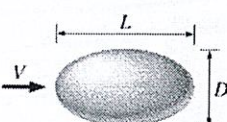
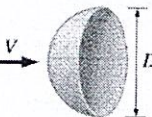
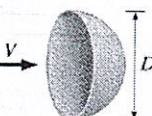
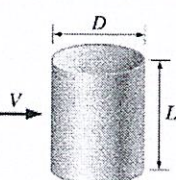
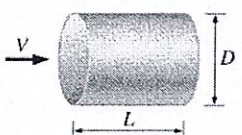
APPENDIX 3: Moody Diagram



APPENDIX 4

TABLE 11-2

Representative drag coefficients C_D for various three-dimensional bodies for $Re > 10^4$ based on the frontal area (for use in the drag force relation $F_D = C_D A \rho V^2 / 2$ where V is the upstream velocity)

Cube, $A = D^2$  $C_D = 1.05$	Thin circular disk, $A = \pi D^2/4$  $C_D = 1.1$	Cone (for $\theta = 30^\circ$), $A = \pi D^2/4$  $C_D = 0.5$																										
Sphere, $A = \pi D^2/4$  Laminar: $C_D = 0.5$ Turbulent: $C_D = 0.2$	Ellipsoid, $A = \pi D^2/4$  <table border="1"> <thead> <tr> <th rowspan="2">L/D</th> <th colspan="2">C_D</th> </tr> <tr> <th>Laminar</th> <th>Turbulent</th> </tr> </thead> <tbody> <tr> <td>0.75</td> <td>0.5</td> <td>0.2</td> </tr> <tr> <td>1</td> <td>0.5</td> <td>0.2</td> </tr> <tr> <td>2</td> <td>0.3</td> <td>0.1</td> </tr> <tr> <td>4</td> <td>0.3</td> <td>0.1</td> </tr> <tr> <td>8</td> <td>0.2</td> <td>0.1</td> </tr> </tbody> </table>		L/D	C_D		Laminar	Turbulent	0.75	0.5	0.2	1	0.5	0.2	2	0.3	0.1	4	0.3	0.1	8	0.2	0.1						
L/D	C_D																											
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Hemisphere, $A = \pi D^2/4$  $C_D = 0.4$  $C_D = 1.2$	Short cylinder, vertical, $A = LD$  <table border="1"> <thead> <tr> <th>L/D</th> <th>C_D</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>0.6</td> </tr> <tr> <td>2</td> <td>0.7</td> </tr> <tr> <td>5</td> <td>0.8</td> </tr> <tr> <td>10</td> <td>0.9</td> </tr> <tr> <td>40</td> <td>1.0</td> </tr> <tr> <td>∞</td> <td>1.2</td> </tr> </tbody> </table> Values are for laminar flow	L/D	C_D	1	0.6	2	0.7	5	0.8	10	0.9	40	1.0	∞	1.2	Short cylinder, horizontal, $A = \pi D^2/4$  <table border="1"> <thead> <tr> <th>L/D</th> <th>C_D</th> </tr> </thead> <tbody> <tr> <td>0.5</td> <td>1.1</td> </tr> <tr> <td>1</td> <td>0.9</td> </tr> <tr> <td>2</td> <td>0.9</td> </tr> <tr> <td>4</td> <td>0.9</td> </tr> <tr> <td>8</td> <td>1.0</td> </tr> </tbody> </table>	L/D	C_D	0.5	1.1	1	0.9	2	0.9	4	0.9	8	1.0
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