Second Semester Examination

2021/2022 Academic Session

July/August 2022

EMH102 – Fluids Mechanic

Duration: 2 hours

Please check that this examination paper consists of **SEVEN (7)** pages including appendixes before you begin the examination.

INSTRUCTIONS:

Answer ALL **FOUR (4)** questions.

Answer to each question must begin from a new page.

1. (a) A gas vessel 1.5m x 1.5m x 2m containing Carbon Dioxide (CO_2) with a temperature of -3°C. The right vessel wall is fixed to the wall, as shown in Figure Q1 (a). A minimum force of 10kN is required to split/open the gas vessel. Calculate:

   i. Vacuum pressure of CO_2.
   ii. Mass of the CO_2.

   Take molecular weight for Oxygen= 16, Carbon = 12, atmospheric pressure 100kPa, and universal gas constant = 8314 $J \cdot kmol^{-1} \cdot K^{-1}$.

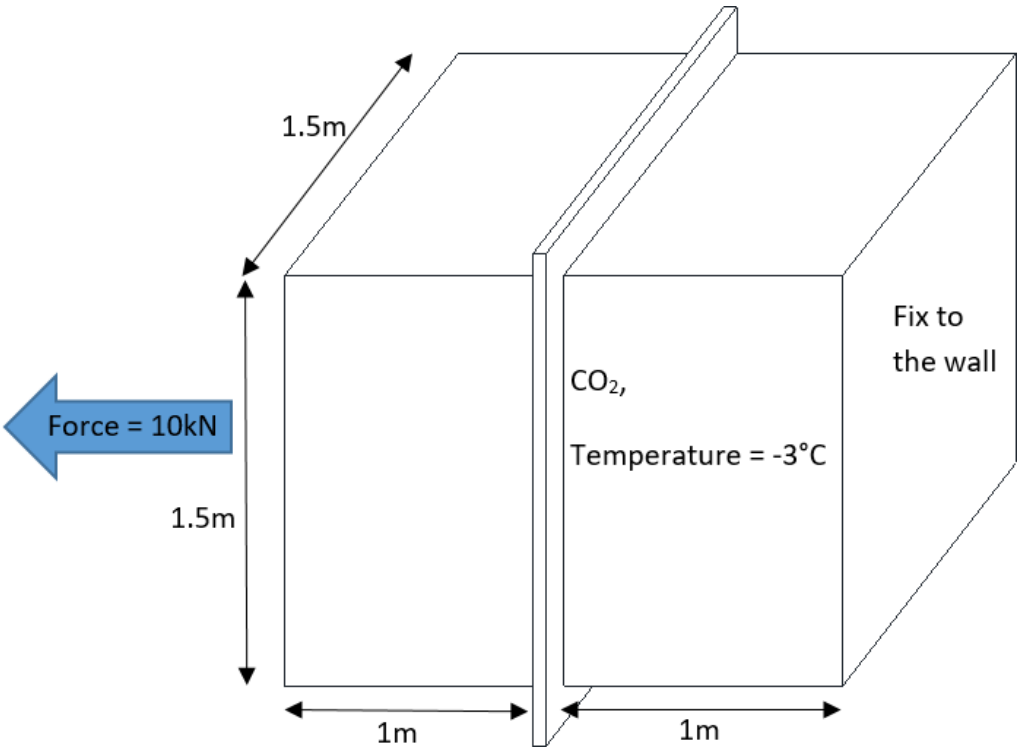

Figure Q1 (a)

(65 marks)

(b) Figure Q1 (b) shows an inclined manometer containing a manometer fluid specific gravity of 0.85, to measure the flow of special fluid with a specific gravity of 0.3 inside a flow tunnel. Calculate the vacuum pressure of the special fluid inside the flow tunnel.

(35 marks)

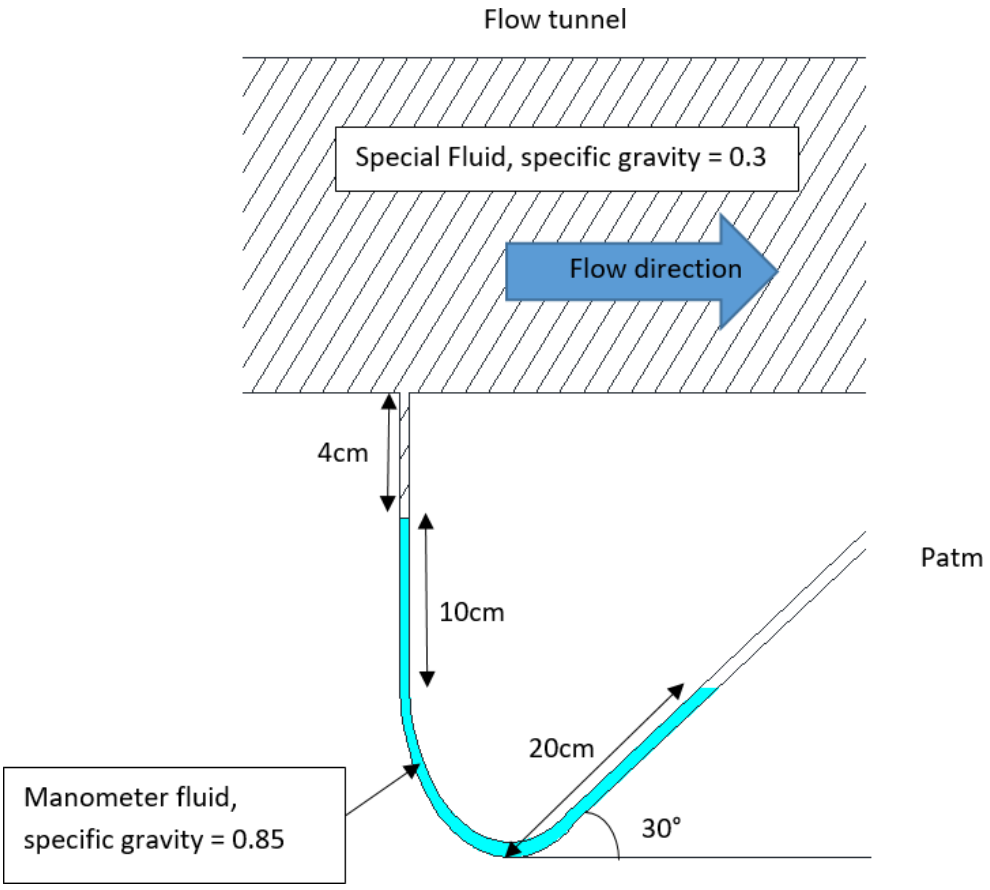

Figure Q1 (b)

2. (a) The water pressure at section 1 in Figure Q2(a) is 70kPa, V_1= 3.7m/s, V_2= 13.7m/s and specific weight of carbon tetrachloride, γ= 17.96kN/m^3.

(i) Calculate the reading on the manometer.
(ii) If the downstream piezometer is replaced with a pitot tube, calculate the manometer reading

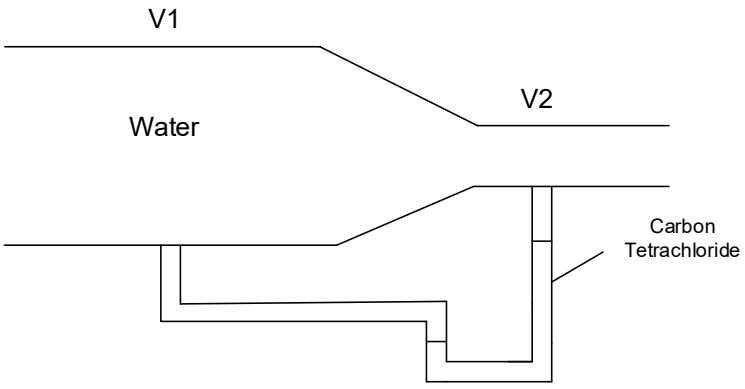

Figure Q2 (a)

(50 marks)

(b) A vertical venturimeter carries a liquid of specific gravity 0.8 and has inlet and throat diameters of 150mm and 75mm respectively. The pressure connection at the throat is 150mm above that at inlet. The actual flow rate is 40 Liter/s and the discharge coefficient is 0.96, calculate:

(i) The pressure different between inlet and throat
(ii) The difference of levels in a vertical U-tube mercury manometer connected between these points, the tube above the mercury being full of liquid. (Take specific gravity of mercury= 13.6)

(50 marks)

3. (a) A two-dimensional flow field is given by u= 2y, v= x. Derive general expression for the velocity and acceleration in the form of x and y.

(40 marks)

(b) The two-dimensional flow is described by the following stream function (in meter-second units):

$$\Psi = x + 2x^2 - 2y^2$$

(i) Proof whether the flow is rotational or irrotational
(ii) Calculate the velocity potential of the flow
(iii) Calculate the piezometric pressure at the point (9, 6), if the piezometric pressure at the point (1, -2) is 4.8kPa and density of 1.12 kg/m^3

(60 marks)

4. (a) Distribution of cooled air in air conditioning system is done by installation of Galvanised Iron (GI) ducting as shown by Figure Q4(a). Air enters a rectangular duct of cross section 20 cm X 30 cm at 1 atm and the temperature of 20 °C. The average velocity of the air inside the ducting is 5.0 m/s. The length of the duct is 15 m. Given, ε for GI = 0.000045 m. Disregarding the entrance effect, calculate:

(i) The pressure drop
(ii) The head loss

Show your work to obtain friction factor value on Moody diagram.

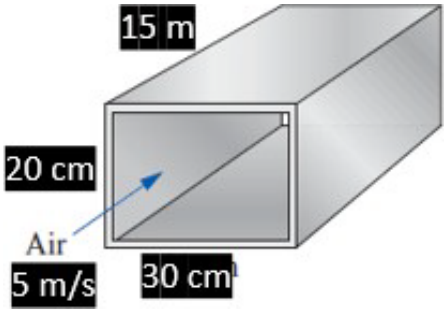

Figure Q4 (a)

(40 marks)

(b) A periodic Karman vortex street is formed when a uniform stream flows over a circular cylinder as shown by Figure Q4(b). The Karman vortex shading frequency, f_k depends on free-speed stream (V), fluid density (ρ), fluid viscosity (μ) and cylinder diameter (D). By using Buckingham π-Theorem, demonstrate a non-dimensional form for the Karman vortex shading frequency. Show all the steps and calculations.

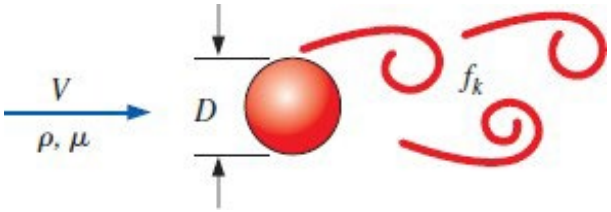

Figure Q4 (b)

(60 marks)

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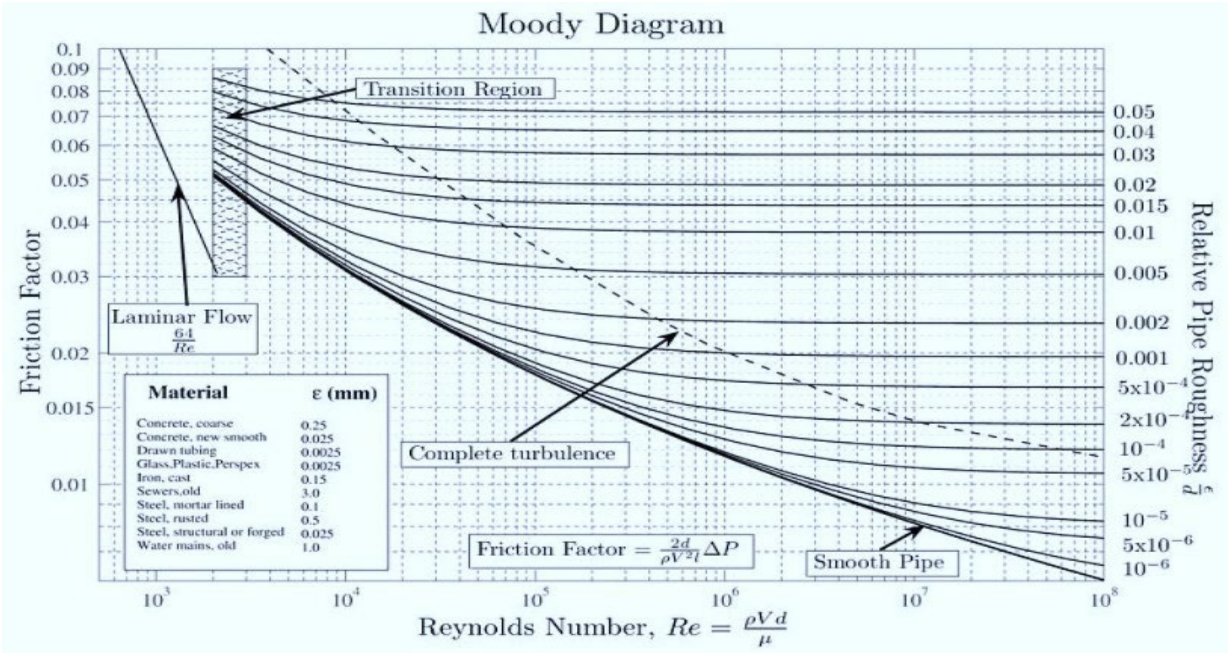
APPENDIX 1


Moody Diagram
Friction Factor
Reynolds Number, $Re = \frac{\rho V d}{\mu}$
Relative Pipe Roughness $\frac{\varepsilon}{d}$
Transition Region
Laminar Flow $\frac{64}{Re}$
Complete turbulence
Friction Factor = $\frac{2d}{\rho V^2 l}\Delta P$
Smooth Pipe
Material ε (mm)
Concrete, coarse 0.25
Concrete, new smooth 0.025
Drawn tubing 0.0025
Glass,Plastic,Perspex 0.0025
Iron, cast 0.15
Sewers,old 3.0
Steel, mortar lined 0.1
Steel, rusted 0.5
Steel, structural or forged 0.025
Water mains, old 1.0

APPENDIX 2

TABLE E.1 Properties of air versus temperature in SI units at standard atmospheric pressure

Temperature T (°C)	Density ρ (kg/m^3)	Specific Weight γ (N/m^3)	Dynamic Viscosity η (Pa·s)	Kinematic Viscosity ν (m^2/s)
−40	1.514	14.85	1.51×10^{-5}	9.98×10^{-6}
−30	1.452	14.24	1.56×10^{-5}	1.08×10^{-5}
−20	1.394	13.67	1.62×10^{-5}	1.16×10^{-5}
−10	1.341	13.15	1.67×10^{-5}	1.24×10^{-5}
0	1.292	12.67	1.72×10^{-5}	1.33×10^{-5}
10	1.247	12.23	1.77×10^{-5}	1.42×10^{-5}
20	1.204	11.81	1.81×10^{-5}	1.51×10^{-5}
30	1.164	11.42	1.86×10^{-5}	1.60×10^{-5}
40	1.127	11.05	1.91×10^{-5}	1.69×10^{-5}
50	1.092	10.71	1.95×10^{-5}	1.79×10^{-5}
60	1.060	10.39	1.99×10^{-5}	1.89×10^{-5}
70	1.029	10.09	2.04×10^{-5}	1.99×10^{-5}
80	0.9995	9.802	2.09×10^{-5}	2.09×10^{-5}
90	0.9720	9.532	2.13×10^{-5}	2.19×10^{-5}
100	0.9459	9.277	2.17×10^{-5}	2.30×10^{-5}
110	0.9213	9.034	2.22×10^{-5}	2.40×10^{-5}
120	0.8978	8.805	2.26×10^{-5}	2.51×10^{-5}

Note: Properties of air for standard conditions at sea level are as follows:

Temperature	15°C
Pressure	101.325 kPa
Density	1.225 kg/m^3
Specific weight	12.01 N/m^3
Dynamic viscosity	1.789×10^{-5} Pa·s
Kinematic viscosity	1.46×10^{-5} m^2/s