Second Semester Examination
2021/2022 Academic Session

July/August 2022

EAH225 – Hydraulics

Duration : 3 hours

Please ensure that this examination paper contains **NINE (9)** printed pages including appendix before you begin the examination.

Instructions: This paper contains **SIX (6)** questions. Answer **FIVE (5)** questions.

All questions **MUST BE** answered on a new page.

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1. (a) Based on Moody Diagram, explain the relationship between friction factor and velocity.

[5 marks]

(b) Determine the discharge of water at 25˚C through a 30 cm diameter cast iron pipe if the head loss is 5.43 m and the length of the pipe is 200 m.

[5 marks]

(c) Determine the elevation of the water surface in Reservoir A if the discharge in the system is 0.25 m^3/s. Pipe (D30) is a steel pipe whereas Pipe (D15) is a HDPE pipe. Given that the value for the coefficient of contraction (K_c) is 0.37 (contraction between pipe D30 and D15).

[10 marks]

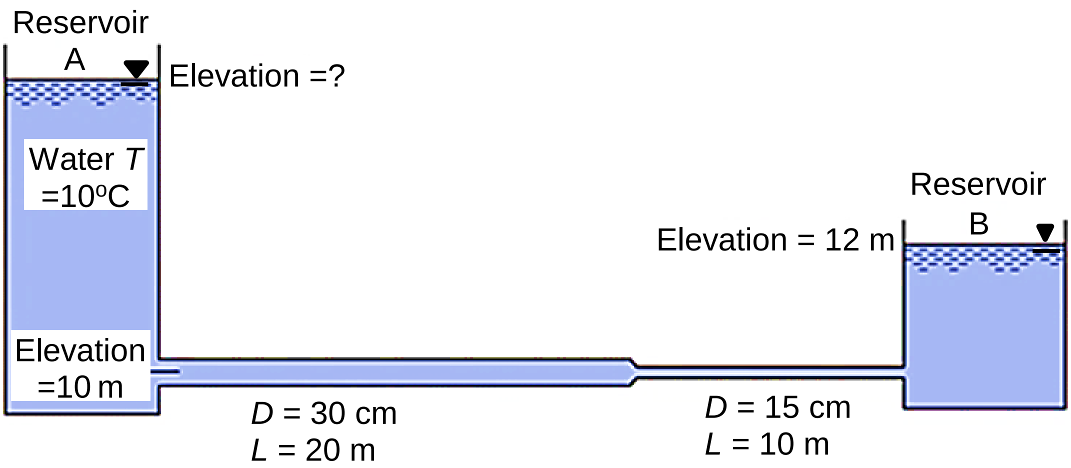

Figure 1

2. (a) Discuss the losses and discharge characteristics between pipe in series and pipe in parallel.

[6 marks]

(b) Water flows from Tank 1 to Tank 2 as shown in **Figure 2**. Determine the discharge in Tank 2 for the pipe characteristic as follows:

- Diameter of the pipe is 20 cm
- Total length of the pipe is 220 m
- A cast-iron pipe is used

[14 marks]

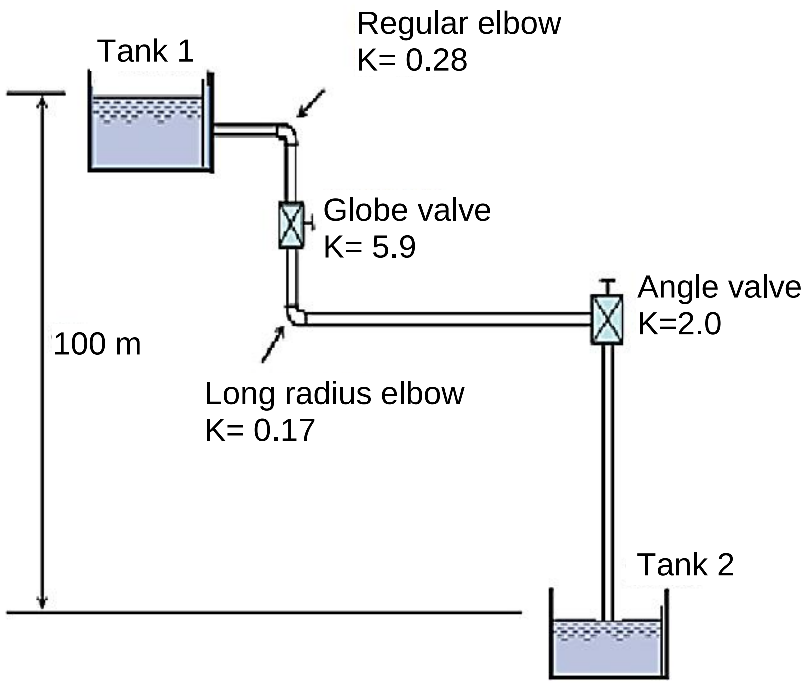

Figure 2

3. (a) Dimensional analysis is a mathematical technique making use of study of dimensions in research work for design and conducting model tests. Explain in detail types of dimensions and give examples for each type.

[10 marks]

(b) The pressure drop in a flow meter in which oil flows at an upstream velocity 0.6 m/s is to be estimated by model studies. A 1:5 scale model using water is used. Determine:

(i) The prototype pressure drop if, the pressure drop in the model is 400 Pa.

(ii) The model discharge If the prototype discharge is 150 L/s. The following values are relevant:

[10 marks]

Table 1

Item	Prototype	Model
Density Viscosity	900 kg/m^3 0.104 Pa.s	998 kg/m^3 1 x 10^{-3} Pa.s

(The Reynolds model law is applicable)

4 (a) With the aid of sketch diagrams, briefly discuss the differences between pump and turbine. Explain **TWO (2)** reasons why pump industry offer several choices of impeller diameter.

[8 marks]

(b) An inward flow reaction of the pump has inlet and outlet diameters of 1.2 m and 0.6 m, respectively. The breadth at inlet is 0.25 m and at outlet is 0.35 m. At a speed of rotation of 250 rpm, the relative velocity at entrance is 3.5 m/s and is radial. Calculate:

(i) Absolute velocity at entrance and the inclination to the tangent of the runner

(ii) Discharge to the pump

(iii) The velocity of flow at the outlet

[12 marks]

5. (a) A float-finished concrete lined trapezoidal channel has a bed width of 3.75 m. It is given that the bed slope is 1 in 1000 and the side slopes are 45°. The discharge running through the channel is 25 m^3/s. Calculate the depth of uniform flow.

[14 marks]

(b) Specific energy provides a measure of the energy relative to the bottom of the channel and provides a useful means to analyze complex flow situations. Sketch and explain specific energy curve for:

(i) Closed sluice gate

(ii) Opened sluice gate

(iii) Drum gate

[6 marks]

6. (a) Consider a rectangular channel with water flowing at an average velocity of 4.35 m/s. The width of the channel is 2.5 m and the depth of the flow is 3.25 m.

Determine:

(i) The types/classification of flow based on Froude no.

(ii) The velocity of the flow at the alternate depth that corresponds to the same specific energy.

Show all of the corresponding values of specific energy, depth and types of flow on the specific energy graph.

[14 marks]

(b) A hydraulic jump occurred as water flows down a spillway of a dam. The velocity of flow at the upstream of the hydraulic jump is 6.5 m/s with a water depth of 0.43 m. Determine the average velocity of the flow downstream of the jump.

[6 marks]

APPENDIX

TABLE 1 – Values for Mannings' Coefficient ***n***

Values for Manning's *n*	
Channel Description	***n***
Glass, copper, plastic, or other smooth surface	0.010
Smooth, unpainted steel, planed wood	0.012
Painted steel or coated cast iron	0.013
Smooth asphalt, common clay drainage tile, trowel-finished concrete, glazed brick	0.013
Uncoated cast iron, black wrought iron pipe, vitrified clay sewer tile	0.014
Brick in cement mortar, float-finished concrete, concrete pipe	0.015
Formed, unfinished concrete, spiral steel pipe	0.017
Smooth earth	0.018
Clean excavated earth	0.022
Corrugated metal storm drain	0.024
Natural channel with stones and weeds	0.030
Natural channel with light brush	0.050
Natural channel with tall grasses and reeds	0.060
Natural channel with heavy brush	0.100

Equivalent Roughness (N_{eq}) – Horton's Method

$$\sum A_i = A = A\frac{\sum\left(n_i^{3/2}P_i\right)}{n^{3/2}P}$$

$$n = \frac{\left(\sum n_i^{3/2}P_i\right)^{2/3}}{P^{2/3}} \qquad (4.35)$$

Equivalent Roughness (N_{eq}) – Total Discharge Method

$$\mathbf{n_{eq}} = \sqrt{\frac{\sum \mathbf{n_i^2\ P_i}}{\sum \mathbf{P_i}}}$$

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$$u = \frac{\pi DN}{60}$$

$$Q = \pi D_1 b_1 V_{f1}$$

$$E = ML^{-1}T^{-2}$$

$$\mu = ML^{-1}T^{-1}$$

Physical Properties of Water (SI Units)[a]

Temperature (°C)	Density, ρ (kg/m³)	Specific Weight[b], γ (kN/m³)	Dynamic Viscosity, μ (N·s/m²)	Kinematic Viscosity, ν (m²/s)	Surface Tension[c], σ (N/m)	Vapor Pressure, p_v [N/m²(abs)]	Speed of Sound[d], c (m/s)
0	999.9	9.806	1.787 E − 3	1.787 E − 6	7.56 E − 2	6.105 E + 2	1403
5	1000.0	9.807	1.519 E − 3	1.519 E − 6	7.49 E − 2	8.722 E + 2	1427
10	999.7	9.804	1.307 E − 3	1.307 E − 6	7.42 E − 2	1.228 E + 3	1447
20	998.2	9.789	1.002 E − 3	1.004 E − 6	7.28 E − 2	2.338 E + 3	1481
30	995.7	9.765	7.975 E − 4	8.009 E − 7	7.12 E − 2	4.243 E + 3	1507
40	992.2	9.731	6.529 E − 4	6.580 E − 7	6.96 E − 2	7.376 E + 3	1526
50	988.1	9.690	5.468 E − 4	5.534 E − 7	6.79 E − 2	1.233 E + 4	1541
60	983.2	9.642	4.665 E − 4	4.745 E − 7	6.62 E − 2	1.992 E + 4	1552
70	977.8	9.589	4.042 E − 4	4.134 E − 7	6.44 E − 2	3.116 E + 4	1555
80	971.8	9.530	3.547 E − 4	3.650 E − 7	6.26 E − 2	4.734 E + 4	1555
90	965.3	9.467	3.147 E − 4	3.260 E − 7	6.08 E − 2	7.010 E + 4	1550
100	958.4	9.399	2.818 E − 4	2.940 E − 7	5.89 E − 2	1.013 E + 5	1543

[a]Based on data from *Handbook of Chemistry and Physics*, 69th Ed., CRC Press, 1988.
[b]Density and specific weight are related through the equation $\gamma = \rho g$. For this table, $g = 9.807\ m/s^2$.
[c]In contact with air.
[d]Based on data from R. D. Blevins, *Applied Fluid Dynamics Handbook*, Van Nostrand Reinhold Co., Inc., New York, 1984.

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Moody Diagram

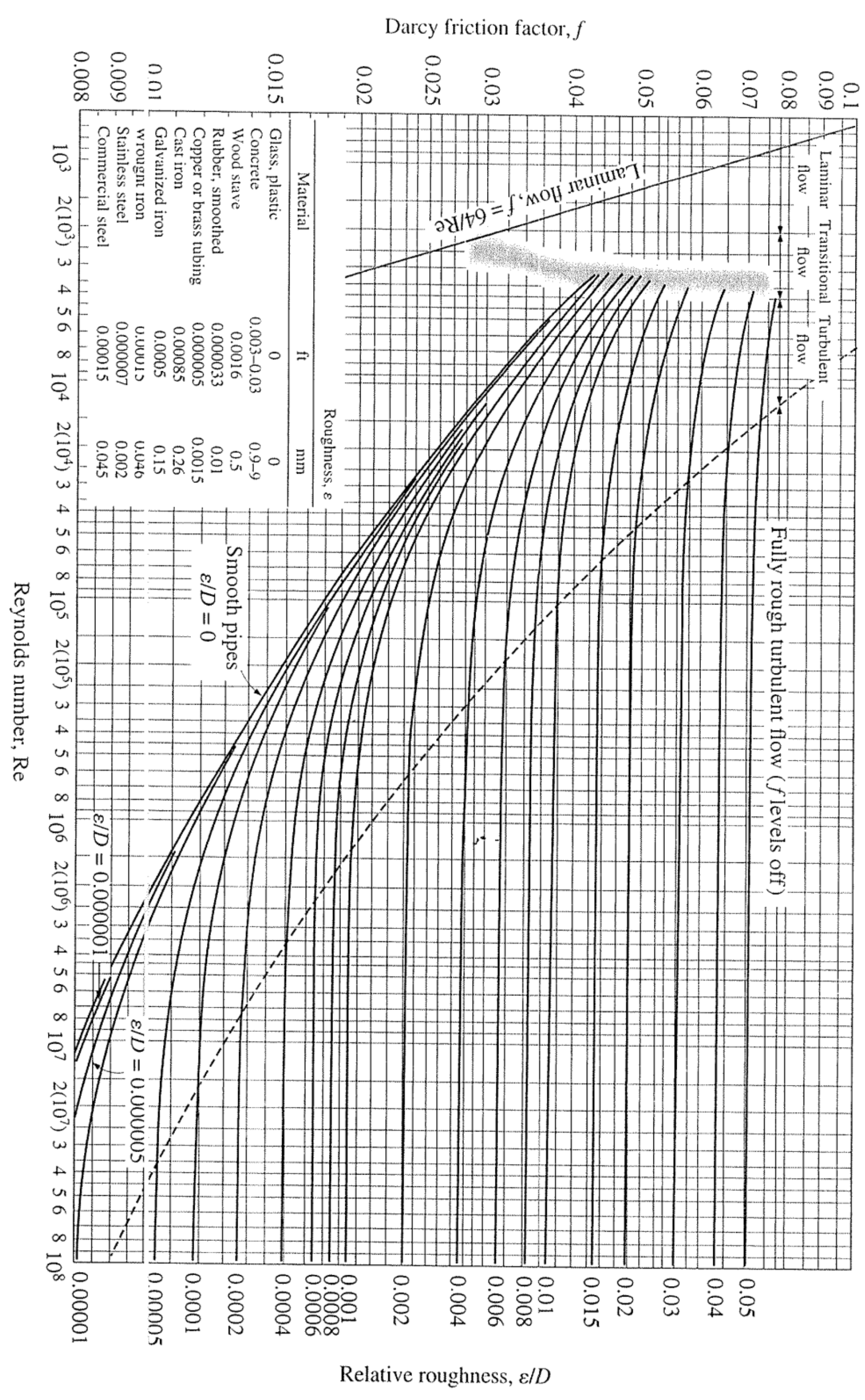

FIGURE A–12

The Moody chart for the friction factor for fully developed flow in circular pipes for use in the head loss relation $h_L = f\frac{L}{D}\frac{V^2}{2g}$. Friction factors in the turbulent flow are evaluated from the Colebrook equation $\frac{1}{\sqrt{f}} = -2\log_{10}\left(\frac{\varepsilon/D}{3.7} + \frac{2.51}{\mathrm{Re}\sqrt{f}}\right)$.

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