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University of Ruhuna- Faculty of Technology

Bachelor of Engineering Technology Honours
Level 4 (Semester 2) Examination, December 2024
Academic year 2022/2023

Course Unit: ENT4232 Fluid Dynamics and Machinery **Duration: 02 hours**

Instructions to candidates:

- This question paper contains **Four (04)** questions in four (04) pages.
- Use a separate book for answering the questions and each question should start with a new page.
- This examination accounts for 60% of the module assessment.
- This is a close book examination.
- Answer all the questions.
- Each question carries 15 marks. The maximum mark attainable for the sub parts of each question is indicated in the bracket.
- Electronic communication devices are not permitted, only allowed is the calculator approved by the Faculty of Technology, University of Ruhuna.
- g = gravitational acceleration 9.81 m/s^2
- Density of water 1000 kgm^{-3}
- All symbols have their usual meaning.

Q1. The diameter of a pipe reduces abruptly (sudden) from 150 mm to 100 mm. If the pipe carries water at 30 lts/sec, calculate the pressure loss across the contraction. Take coefficient of contraction (CC) as 0.6.

$$h_{concentration} = \left(\left(1/_{cc}\right) - 1\right)^2 \left(V_2^2/_{2g}\right)$$

(15 marks)

Q2. Water flows at a rate of 30 liters per minute in a circular pipe of 40 mm diameter and 750 m horizontal length. Dynamic viscosity of water is 1.14×10^{-3} Nsm^{-2}. The absolute roughness (k) of the internal wall of the pipe is 0.00008 m. Using the Moody diagram given in Fig. 01, compute the head loss due to pipe friction. (Note: The Reynold number more than 4000 is turbulent for the pipe)

(15 marks)

Q3. Answer all the short questions (a) to (g).

a) What are the main **five** characteristics of ideal fluids? (02 marks)

b) What are the **four** basic types of line patterns used to visualize flow fields? (02 marks)

c) What are the **two** approaches used in fluid dynamics to study fluid motion? (02 marks)

d) The particle motion in a fluid flow can be decomposed into **four** fundamental components. What are those four fundamental components?

(02 marks)

e) Name the **four** elementary fluid flow patterns which are categorized according to streamline and velocity geometry of fluid flow.

(02 marks)

f) Define the vorticity (ζ) of fluid and write down the relationships between vorticity and rotation vector (ω) and relationships between vorticity and the velocity vector (V).

(02 marks)

g) The rotation of the fluid element about the x, y and z axes are denoted as ω_x, ω_y, and ω_z respectively. Where u, v and w are velocity vector components in x, y and z directions respectively.

$$\omega_x = \frac{1}{2}\left(\frac{\partial w}{\partial y} - \frac{\partial v}{\partial z}\right); \quad \omega_y = \frac{1}{2}\left(\frac{\partial u}{\partial z} - \frac{\partial w}{\partial x}\right) \quad \omega_z = \frac{1}{2}\left(\frac{\partial v}{\partial x} - \frac{\partial u}{\partial y}\right) \qquad \bar{\omega} = \omega_x \hat{i} + \omega_y \hat{j} + \omega_z \hat{k}$$

These three components can be combined to define the rotation vector (ω) in terms of the velocity vector (V), Write down the relationship between the rotation vector (ω) and the velocity vector (V). (03 marks)

Q4. The general continuity equation that one can get by expanding the vector equation as below,

$$\frac{\partial \rho}{\partial t} + \frac{\partial(\rho u)}{\partial x} + \frac{\partial(\rho v)}{\partial y} + \frac{\partial(\rho w)}{\partial z} = 0$$

The stream function $\{\psi(x, y)\}$ relates to the velocity components in such a way that continuity equation is satisfied. The streamline represented by stream function, $\psi = x^2 + y^2$.

$$u = \frac{\partial \psi}{\partial y} \; and \; v = -\frac{\partial \psi}{\partial x}$$

i) Derive reduced form of the continuity equation for a steady, incompressible, plane, two-dimensional flow.

(02 marks)

ii) Determine the velocity components u and v in two-dimensional steady flow. Hence find the resultant magnitude of velocity (V) and velocity vector ($\bar{V}$) of flow.

(05 marks)

iii) Sketch the streamline represented by stream function, $\psi = x^2 + y^2$ showing the direction of flow.

(05 marks)

iv) Find the velocity (V) and its direction at (0,1). (03 marks)

***** End of the Examination Paper*****

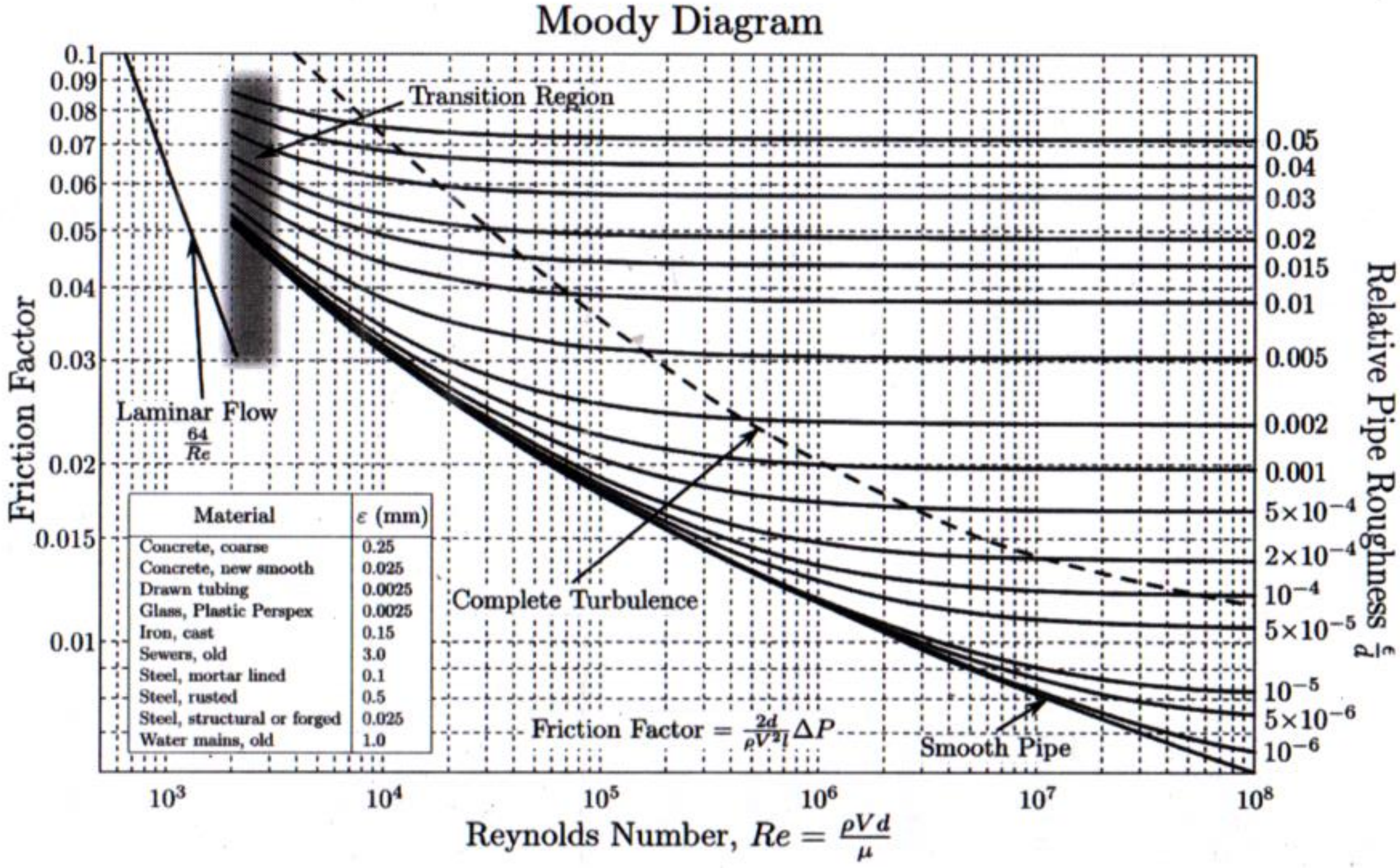

Figure 01: Moody diagram