University of Ruhuna- Faculty of Technology

Bachelor of Engineering Technology Honours
Level 4 (Semester 2) Examination, December 2023
Academic year 2021/2022

Course Unit: ENT4232 Fluid Dynamics and Machinery **Duration: 2 hours**

First page must be allocated to rubric/instructions to candidate of the question paper.

- Answer all **Four (04)** questions.
- University approved calculators are allowed.
- The total mark allocated is 60.
- g = gravitational acceleration 9.81 m/s^2
- Density of water 1000 kgm^{-3}

Q1. A 6 cm diameter horizontal water pipe expands gradually to a 9 cm diameter pipe as shown in Figure Q1. The walls of the expansion section are angles 10° from the axis ($K_L = 0.133$). The average velocity and pressure of water before the expansion section are 7 ms^{-1} and 150 kPa, respectively. Determine the head loss in the expansion section and the pressure in the larger diameter pipe.

(15 marks)

Figure Q1

Q2. Water flows at a rate 4 liters per minute in a circular pipe of 40 mm diameter and 750 m laid horizontal. Dynamic viscosity of water equal to 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 provided compute the head loss due to pipe friction.

(15 marks)

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

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

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

(01 mark)

c) The rotation of the fluid element about the x, y and z axes are denoted as ω_x, ω_y, and ω_z respectively.

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

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)

d) 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).

(01 mark)

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

(02 marks)

f) i) Sketch the streamline represented by $\psi = x^2 + y^2$ showing the direction of flow.

(04 marks)

ii) find the velocity and its direction at (1,1). (02 marks)

Q4. Consider the following equation to present the location vector of the fluid particles at a given time.

$$R = [8xt]i + [5zt^2]j - [2xt]k$$

a) Find the **velocity functions** of a fluid particle. (02 marks)

b) Find the **acceleration functions** of a fluid particle. (06 marks)

c) Using the derived velocity and acceleration functions, Find the **velocity** and **acceleration vectors** of fluid particles when location coordinate (R_1) is $(x, y, z) \equiv (0,1,1)$ at $t = 1$ s.

(04 marks)

d) Find the **velocity** and **acceleration** vectors of fluid particles at $t = 0$ s and $t = 1$ s using calculated velocity and acceleration vectors in part **(c)**. Consider the location coordinate (R_0) of a fluid particle is $(x, y, z) \equiv (0,0,0)$ at $t = 0$ s and location coordinate (R_1) is $(x, y, z) \equiv (0,1,1)$ at $t = 1$ s. Mark the R_0 *and* R_1 in the *X*-*Y* Cartesian plane with relevant scale and mark clearly the velocity and acceleration vectors in that plane. (You can use two *X*-*Y* planes to show the velocity and acceleration separately).

(03 marks)

*** End of the Examination Paper***

Annex

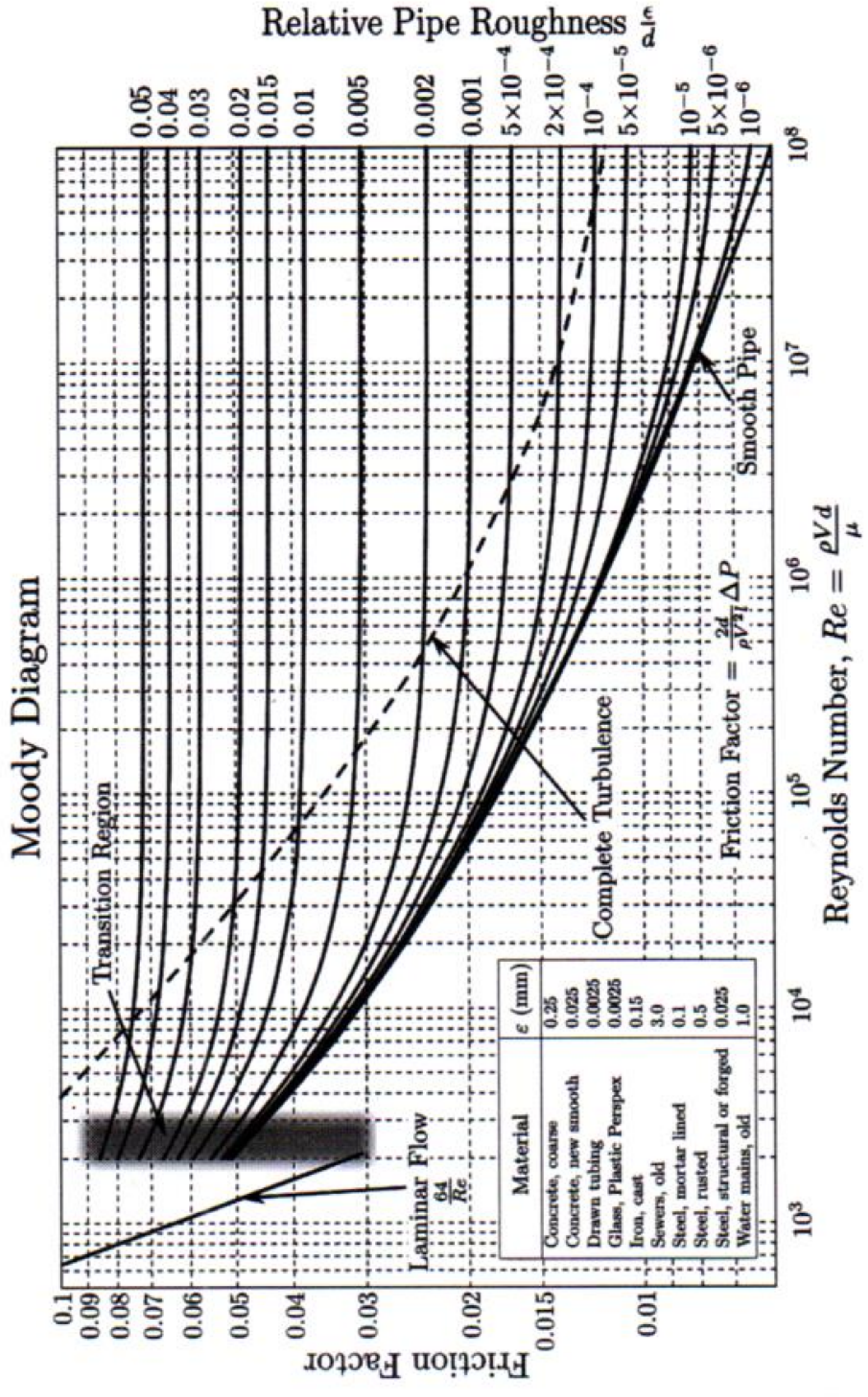

Figure 02