044

The Open University of Sri Lanka
Faculty of Engineering Technology

Study Programme	: Bachelor of Science (Honours) in Engineering
Name of the Examination	: Final Examination
Course Code and Title	: **DMX5206 – Applied Fluid Dynamics II**
Academic Year	: 2023/24
Date	: February 10, 2025
Time	: 09.30 – 12.30
Duration	: 3 hours

General Instructions

1. Read all the instructions carefully before answering the questions.
2. This question paper consists of five (5) questions. All questions carry equal marks.
3. Answer **all** questions.
4. Take acceleration due to gravity as **9.81 N/kg** and the density of water as **1000 kg/m^3** respectively where necessary.

Q1.

a) Develop a general equation for the continuity for three-dimensional flow of a compressible fluid.

b) Hence show that the continuity equation for incompressible two-dimensional flow is given by,

$$\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}=0$$

c) Show that the velocity field V is describes an incompressible flow.

$$V=(x^2-y^2+t)i-(2xy-t)j$$

d) Calculate the velocity and the acceleration at P(1,1) at t=1sec in the flow field V.

Q2.

a) What are the conditions that must be satisfied for a flow to be a "**potential flow**" field?

Consider a two-dimensional flow field consisting of a uniform flow ***(U_∞)*** and a point sink of strength ***(Q)*** at ***$P(x_k,y_k)$*** as shown in the Figure Q2.

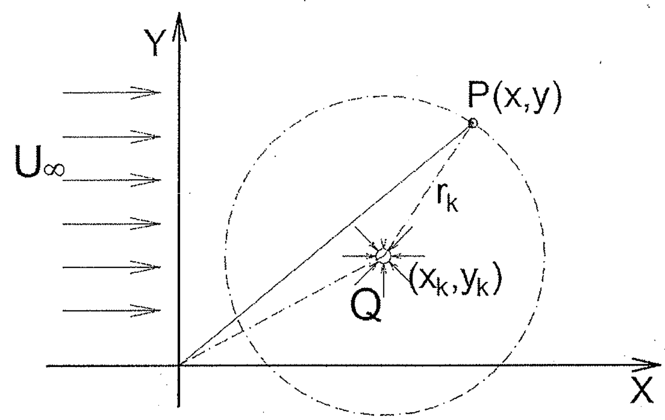

Figure Q2.

b) Show that the resultant stream function and velocity potential for this flow field are given by,

$$\varphi(x,y) = U_\infty y - \frac{Q\theta_k}{2\pi}$$

and

$$\phi(x,y) = U_\infty x - \frac{Q}{2\pi} ln(r_k)$$

Where

$$r_k = \sqrt{(x-x_k)^2 + (y-y_k)^2}$$

$$\theta_k = tan^{-1}\left(\frac{y-y_k}{x-x_k}\right)$$

c) Find the expressions for the velocity components for X and Y directions.

Q3.

a) Write down the Bernoulli's equation for a compressible flow undergoing an isothermal process.

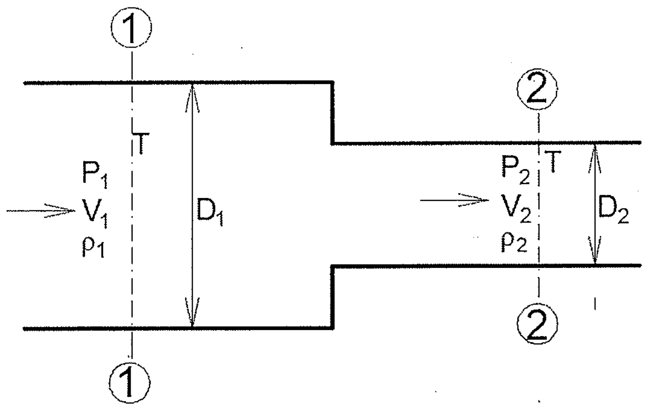

Figure Q3

b) A gas is flowing isothermally through a horizontal pipe as shown in the Figure Q3. Show that,

$$\frac{P_1}{\rho_1} log_e \left[\frac{P_1}{P_2}\right] = \frac{[V_2^2 - V_1^2]}{2}$$

Where,

P_1, P_2 absolute pressure at section 1 and 2 respectively

V_1, V_2 velocity of the flow at section 1 and 2 respectively

ρ_1: density of the gas at section 1

c) Calculate the velocities at section 1 (V_1) and section 2 (V_2), using the values provided in Table Q3.

D1 (cm)	*D2(cm)*	*P1 (N/cm²)*	*P2 (N/cm²)*	*R (Nm/kgK)*	*T ⁰C*
12	6	60	25	287	5

Table Q3.

Q4.

The velocity distribution of a laminar boudary layer over a flat plate is approximated by the polynomial,

$$\frac{u}{U_\infty} = a + b\left(\frac{y}{\delta}\right) + c\left(\frac{y}{\delta}\right)^2 + d\left(\frac{y}{\delta}\right)^3$$

a) By applying the boudary conditions, show that the velocity profile simplifies to,

$$\frac{u}{U_\infty} = \frac{3}{2}\left(\frac{y}{\delta}\right) - \frac{1}{2}\left(\frac{y}{\delta}\right)^3$$

b) Discuss the significance of momentum thickness in analyzing boundary layer behavior.

c) Determine the momoentum thickness Θ in terms of boundary layer thickness (δ) for the simplified velocity profile.

Q5.

a) Write down a brief explanation of dynamic similitude in the context of model studies.

b) Draw a schematic diagram of an airfoil.

c) An airfoil with a chord length of 2m and a span of 15m is placed in a wind tunnel where the airflow has a velocity of 80 m/s. The air has a density of 1.25 kg/m³, and the airfoil is set at an angle of attack of 6°. The coefficients of drag and lift corresponding to the given angle of attack are 0.03 and 0.5, respectively.

I. Find the lift force and drag force on the airfoil.

II. Hence, find the weight of the airfoil and the power required to drive it

Lift force L and drag force D are given by,

$$L = \frac{1}{2} C_L \rho A U_\infty^2$$

$$D = \frac{1}{2} C_D \rho A U_\infty^2$$

==================== End of Paper ====================