GATE PATHSHALA

Fluid Mechanics and Aerodynamics (Assignment-02)

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March 14, 2025

Total Acceleration, Convective Acceleration, and Angular velocity

Problem 1

For the velocity field:

$$\mathbf{V} = 2xy\hat{i} + 4tz^2\hat{j} - yz\hat{k}$$

find the acceleration, the angular velocity about the z-axis, and the vorticity vector at the point $(2, -1, 1)$ at $t = 2$.

Problem 2

What is the equation of the streamline that passes through the point $(2, -1)$ when $t = 2$ s if the velocity field is given by:

(a) $\mathbf{V} = 2xy\mathbf{i} + y^2t\mathbf{j}$ m/s

(b) $\mathbf{V} = 2y^2\mathbf{i} + xyt\mathbf{j}$ m/s

Problem 3

Write all the non-zero terms of $D\rho/Dt$ for a stratified flow in which:

(a) $\rho = \rho(z)$ and $\mathbf{V} = z(2 - z)\mathbf{i}$

(b) $\rho = \rho(z)$ and $\mathbf{V} = f(x, z)\mathbf{i} + g(x, z)\mathbf{j}$

Problem 4

Decide if each of the following can be modeled as an incompressible flow or a compressible flow:

(a) The take-off and landing of commercial airplanes

(b) The airflow around an automobile

(c) The flow of air in a hurricane

(d) The airflow around a baseball thrown at 100 mi/h

Problem 5

Select the word: **uniform, one-dimensional, two-dimensional, or three-dimensional**, which best describes each of the following flows:

(a) Developed flow in a pipe

(b) Flow of water over a long weir

(c) Flow in a long, straight canal

(d) The flow of exhaust gases exiting a rocket

(e) Flow of blood in an artery

(f) Flow of air around a bullet

(g) Flow of blood in a vein

(h) Flow of air in a tornado

Problem 6

To determine the rate of change of temperature of a fluid particle, we use the material derivative:

$$\frac{DT}{Dt} = \frac{\partial T}{\partial t} + \mathbf{V} \cdot \nabla T$$

Given:

- Velocity field:
$$\mathbf{V} = 2y\mathbf{i} + x\mathbf{j} + t\mathbf{k}$$
- Temperature field:
$$T(x, y, z) = 20xy$$
- Point: $(x, y, z) = (2, 1, -2)$ at $t = 2$

Problem 7

Determine the velocity V in the pipe if the fluid in the pipe of Figure(p7) is:

(a) Atmospheric air and $h = 40$ cm of water

(b) Water and $h = 20$ cm of mercury

(c) Kerosene and $h = 30$ cm of mercury

(d) Gasoline and $h = 80$ cm of water

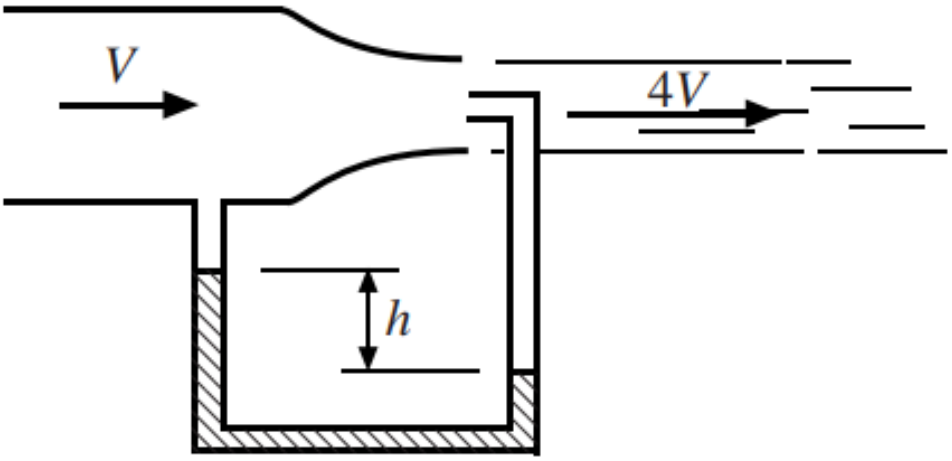

Figure 1: p7

Problem 8

A velocity field is given in cylindrical coordinates as:

$$v_r = \left(4 - \frac{1}{r^2}\right) \sin\theta \quad \text{m/s},$$
$$v_\theta = -\left(4 + \frac{1}{r^2}\right) \cos\theta \quad \text{m/s},$$
$$v_z = 0.$$

Find:

1. The acceleration at the point $(0.6\ \text{m}, 90°)$.
2. The vorticity at the point $(0.6\ \text{m}, 90°)$.