Please write down the critical steps to your answer in each problem. You can choose to provide your answers in English or Chinese.

Problem 1 (15 points)

Consider a flow field given by:

$$\bar{V} = \begin{pmatrix} 5yt \\ -5xt \\ 3xy \end{pmatrix}$$

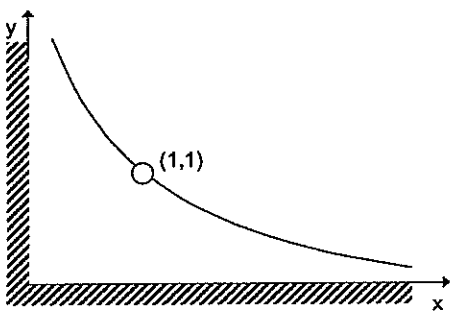
a) Is this a steady or unsteady flow? Explain why. (5 points)

b) Could this be an incompressible fluid? Explain why. (5 points)

c) Is the flow field rotational or irrotational? If rotational, calculate the components of vorticity. (5 points)

Problem 2 (20 points)

Consider the incompressible, two-dimensional flow between the boundaries shown below. The potential function for this problem may be written as $\Phi = x^2 - y^2$



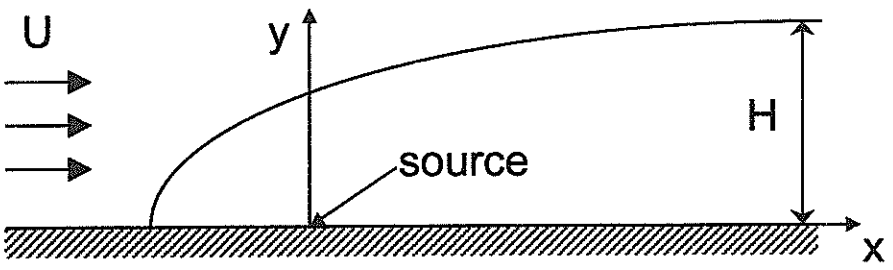
a) Find the corresponding stream function. (6 points)

b) What is the equation of the streamline passing through the point (1,1)? (6 points)

c) What is the discharge q (per unit width into the page) passing between the walls represented by the coordinate system axes and a curved wall represented by the streamline defined in part b)? (8 points)

Problem 3 (20 points)

Wind blowing over a bluff is to be simulated using potential flow theory. A uniform wind, U = 20 m/s, is combined with a source, having a strength of q = 6,000 m^2/s. The resulting flow is sketched below.



a) Develop the complex potential for this flow, and give the potential and stream function. (5 points)

b) Find the stagnation point, and give the equation for the bounding streamline. (5 points)

c) How high is the bluff (H)? (5 points)

d) What is the velocity along the surface of the bluff, directly above the source? (5 points)

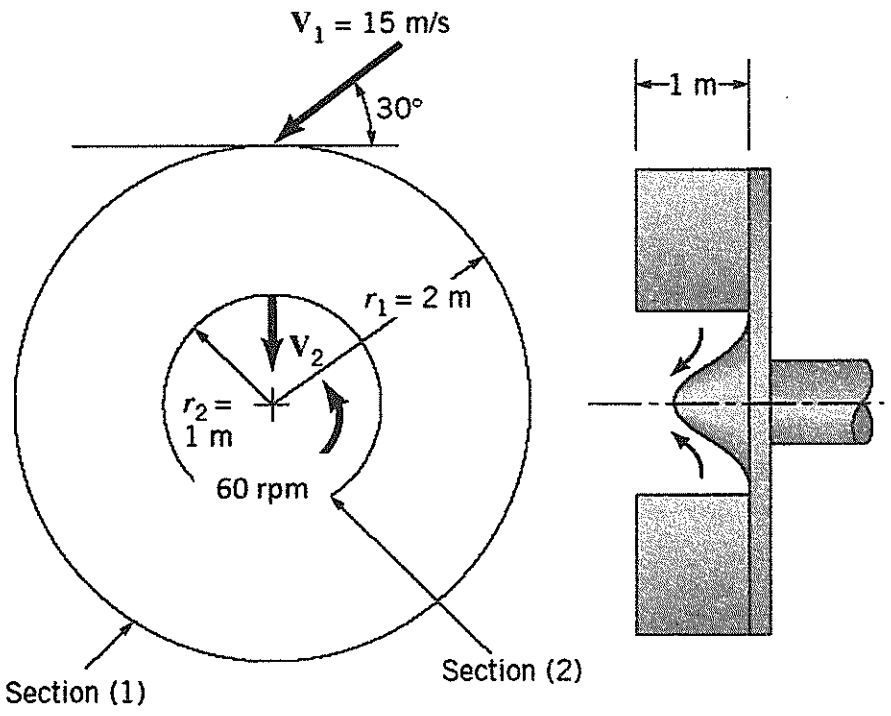
見背面

Problem 4 (16 points)

Assuming that the drag force (D) experienced by an object moving through a fluid is a function of its projected area (A) in the direction of motion, its velocity (V), and the density (ρ) and dynamic viscosity (μ) of the fluid, develop dimensionless groupings that describe the problem.

Problem 5 (20 points)

A water turbine with radial flow has the dimensions shown in the following figure. The absolute entering velocity is 15m/s, and it makes an angle of 30° with the tangent to the rotor. The absolute exit velocity is directed radically inward. The angular speed of the rotor is 60 rpm. Find the power delivered to the shaft of the turbine.



Problem 6 (9 points)

Please answer the following questions briefly.

(a) Describe what is the difference between the Navier-Stokes equations and the Euler equations. (4 points)

(b) Navier-Stokes equations and the mass balance equation (4 differential equations) can be solved for 4 unknowns for fluids as a function of space and time. Can you describe these four unknowns? (5 points)

試題隨卷繳回