Problem 1: Uniform Flow

Visualize the streamlines of a uniform flow along the x-axis. The stream function for this flow is given as:

$$\psi = Uy,$$

where U is the velocity magnitude. Simulate and plot the streamlines.

—

Problem 2: Radial Source Flow

Visualize the streamlines for a source located at the origin in a 2D flow. The stream function is:

$$\psi = \frac{m}{2\pi}\theta,$$

where $m > 0$ is the strength of the source. Simulate and observe radial streamlines.

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Problem 3: Equipotential Lines for Uniform Flow

Visualize the equipotential lines for a uniform flow along the x-axis. The velocity potential is given by:

$$\phi = Ux,$$

where U is the uniform flow velocity.

—

Problem 4: Flow Due to a Sink

Visualize the streamlines for a sink located at the origin in 2D flow. The stream function is:

$$\psi = -\frac{m}{2\pi}\theta,$$

where $m > 0$ is the strength of the sink. Observe inward radial streamlines.

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Problem 5: Flow Around a Doublet

Simulate the flow field for a doublet at the origin in 2D. The stream and equipotential functions for the doublet are:

$$\psi = -\frac{\mu \sin\theta}{2\pi r}, \quad \phi = -\frac{\mu \cos\theta}{2\pi r},$$

where $\mu > 0$ is the strength of the doublet. Plot the streamlines and equipotential lines.

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Problem 6: Flow Around a Cylinder

Visualize the flow field around a stationary cylinder in a uniform flow. The stream function is given by:

$$\psi = Ur\sin\theta\left(1 - \frac{a^2}{r^2}\right),$$

where U is the uniform flow velocity, a is the radius of the cylinder, and (r, θ) are polar coordinates.

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Problem 7: Stagnation Point Flow

Simulate the flow near a stagnation point, where the velocity reduces to zero. The stream function is:

$$\psi = \frac{a}{2}(x^2 - y^2),$$

where $a > 0$ determines the strength of the stagnation flow. Visualize hyperbolic streamlines.

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Problem 8: Combined Source and Uniform Flow

Simulate the flow field resulting from the superposition of a uniform flow and a source at the origin. The stream function is:

$$\psi = Uy + \frac{m}{2\pi}\theta,$$

where U is the uniform velocity and $m > 0$ is the source strength. Plot the resulting streamlines.

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Problem 9: Pathlines in a Simple Flow

Determine the pathlines of a fluid particle in a velocity field defined by:

$$u = x, \quad v = -y.$$

Solve the differential equations for the pathlines:

$$\frac{dx}{dt} = u, \quad \frac{dy}{dt} = v,$$

and plot the trajectories of fluid particles starting at different initial points.

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Problem 10: Streamlines for a Source and Sink Pair

Simulate the streamlines for a source and sink pair located symmetrically about the origin. The stream function is:

$$\psi = \frac{m}{2\pi} \ln \frac{r_1}{r_2},$$

where r_1 and r_2 are the distances of a point from the source and sink, respectively, and $m > 0$ is the strength.