Solutions for Lab Assignment

Solutions

1. **Streamlines for Uniform Flow:**
   The streamlines for a uniform flow with $u = 1, v = 0$ are parallel lines along the x-direction. Use the Python function 'streamplot()' to visualize the uniform flow pattern.

2. **Pathlines for Uniform Flow:**
   The pathline of a particle starting from $(0, 0)$ in a uniform flow $u = 1, v = 0$ is a straight line. The trajectory can be computed as $x(t) = t, y(t) = 0$.

3. **Streamlines for a Vortex:**
   For $u = -y, v = x$, the streamlines are circular around the origin. Use a 2D grid and plot with Python's 'streamplot()' to observe the circular patterns.

4. **Flow Over a Flat Plate:**
   Streamlines for $u = y, v = 0$ are parallel lines spaced increasingly with higher y-values. The flow represents a simple shear flow.

5. **Pathlines in Rotational Flow:**
   Pathlines in $u = -y, v = x$ result in circular trajectories. Numerically integrate the velocity field for initial conditions $(1, 0)$.

6. **Irrotational Source Flow:**
   The velocity field from a source at the origin can be derived as $u = \frac{x}{r^2}, v = \frac{y}{r^2}$. The streamlines radiate outwards from the origin.

7. **Time-Dependent Flow:**
   In $u = t, v = y$, the pathlines are computed as $x(t) = \frac{1}{2}t^2, y(t) = y_0 e^t$. Use numerical methods to integrate the equations.

8. **Vorticity and Irrotationality:**
   The vorticity for $u = x, v = -y$ is zero, confirming the flow is irrotational. Use numerical differentiation to compute $\omega = \frac{\partial v}{\partial x} - \frac{\partial u}{\partial y}$.

9. **Source and Sink Flow:**
   Combine source and sink flows and visualize using their velocity potentials. Streamlines show symmetrical flow connecting the source and sink.

10. **Unsteady Linear Flow:**
    For $u = x\cos(t), v = y\sin(t)$, streamlines evolve dynamically over time. Simulate at different time intervals to observe the patterns.