SUPERPOSITION OF BASIC PLANE POTENTIAL FLOWS

Flow around a circular cylinder
The flow around a circular cylinder can be represented by combining a doublet with a uniform flow.

- Combined velocity potential and streamfunction

<table>
<thead>
<tr>
<th>Uniform flow</th>
<th>Doublet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Streamfunction</td>
<td>$\psi = U_y$</td>
</tr>
<tr>
<td>Velocity potential</td>
<td>$\phi = U_x$</td>
</tr>
</tbody>
</table>

Therefore, the combination of a uniform flow and a doublet is expressed in cylindrical coordinates as:

Streamfunction:

Velocity potential:

- Boundary condition
In order to represent a cylinder of radius $a$, the perimeter of the cylinder must be a streamline in the flow. Therefore, the streamfunction must be constant along the perimeter of the cylinder

Streamfunction and velocity potential of flow around a circular cylinder of radius $a$

Streamfunction:

Velocity potential:
• **Velocity field**

The velocity field can be derived using the definition of the streamfunction in cylindrical coordinates:

\[ v_r = \frac{1}{r} \frac{\partial \psi}{\partial \theta} \quad \text{and} \quad v_\theta = -\frac{\partial \psi}{\partial r} \]

\[
\begin{align*}
v_r &= \\
v_\theta &= \\
\end{align*}
\]

Points where the maximum velocity is attained on the surface of the cylinder:

at \( r = a \):

\[
\begin{align*}
v_r &= \\
v_\theta &= \\
\Rightarrow v_\theta \max &= \\
\end{align*}
\]