



$$\begin{aligned}
 \oint_{\partial D_+} \vec{F} \cdot d\vec{l} &= \oint_{\partial D_+} (X, Y) \cdot (dx, dy) = \oint_{\partial D_+} X dx + Y dy \\
 &= \iint_D \left(\frac{\partial Y}{\partial x} - \frac{\partial X}{\partial y} \right) dx dy = \iint_D (\vec{\nabla} \times \vec{F}) \cdot (\vec{k} dx dy) \\
 &= \iint_D (\vec{\nabla} \times \vec{F}) \cdot (\vec{k} dS) = \iint_D (\vec{\nabla} \times \vec{F}) \cdot d\vec{S}
 \end{aligned}$$