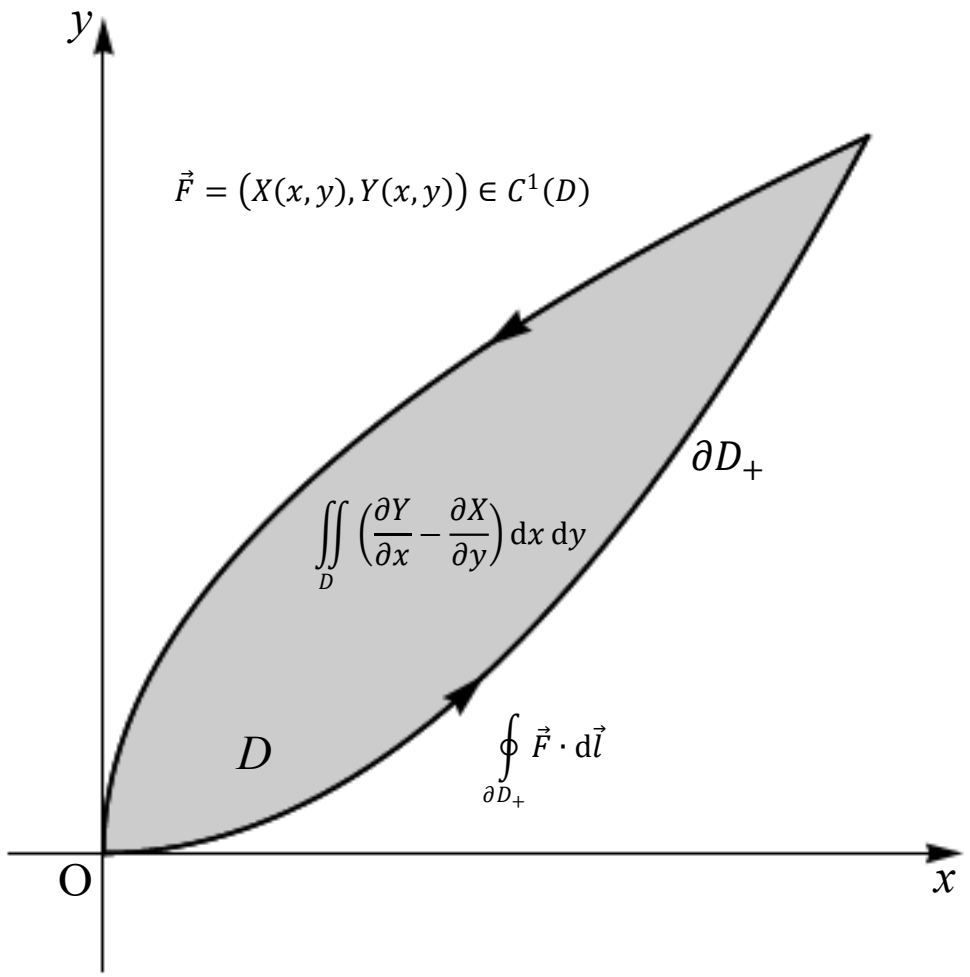

$$\oint_{\partial D_+} \vec{F} \cdot \mathrm{d}\vec{l} = \oint_{\partial D_+} (X, Y) \cdot (\mathrm{d}x, \mathrm{d}y) = \oint_{\partial D_+} X\mathrm{d}x + Y\mathrm{d}y$$

$$= \iint_D \left(\frac{\partial Y}{\partial x} - \frac{\partial X}{\partial y}\right) \mathrm{d}x\,\mathrm{d}y = \iint_D \left(\vec{\nabla} \times \vec{F}\right) \cdot \left(\vec{k}\mathrm{d}x\mathrm{d}y\right)$$

$$= \iint_D \left(\vec{\nabla} \times \vec{F}\right) \cdot \left(\vec{k}\mathrm{d}S\right) = \iint_D \left(\vec{\nabla} \times \vec{F}\right) \cdot \mathrm{d}\vec{S}$$