Consider the 2-D velocity field $\vec{V} = u\hat{\imath} + v\hat{\jmath}$

$$u = y \qquad\qquad v = x$$

whose hyperbolic-shape streamlines are sketched below. The density ρ is everywhere constant.

a) Evaluate the mass-flow integral

$$I \;=\; \oint \rho\,(\vec{V}\cdot\hat{n})\,dA$$

for the square control volume of side length ℓ shown in the figure.

Hint: First express I as four separate integrals I_1, I_2, I_3, I_4 over each of the four segments of the C.V. boundary. Note that dA is a length in 2-D.

b) Does this flow satisfy the mass conservation law *everywhere*? Explain.