Visualization
– Flow Visualization (Questions)

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Possible Questions

- Given is the following vector field $\boldsymbol{v}(x, y, z) = \left(x - y,\ x^2 - 1,\ x + z\right)^T$. Determine the Jacobian, the divergence, and the curl.

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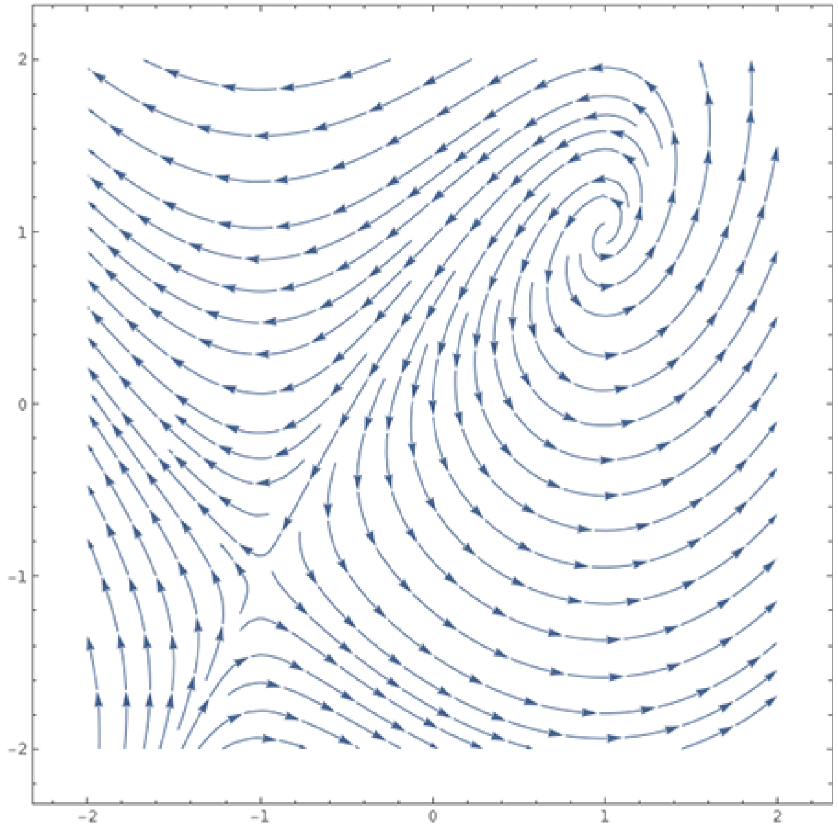
$$\mathbf{J} = \begin{pmatrix} 1 & -1 & 0 \\ 2x & 0 & 0 \\ 1 & 0 & 1 \end{pmatrix}$$

$$div\, \boldsymbol{v}(x, y, z) = 2$$

$$curl\, \boldsymbol{v}(x, y, z) = \begin{pmatrix} 0 \\ -1 \\ 2x + 1 \end{pmatrix}$$



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  - Stream lines:
    - Trajectories of massless particles in a “frozen” (steady) vector field
    - Trajectories of massless particles at one time step
  - Path lines:
    - Trajectories of massless particles in (unsteady/time-varying) flow
    - Follow one particle through time and space

Possible Questions

- Given is the 2D vector field $\boldsymbol{v}(x, y, t) = (-y,\ {}^{x}/_{2})^T$. Perform the Euler integration at $\boldsymbol{x}_0 = \begin{pmatrix} 0 \\ -1 \end{pmatrix}$ with $\Delta t = 0.5$.

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- See lecture

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- Given is the vector field $\boldsymbol{v}(x, y) = \begin{pmatrix} x + y \\ 4x - 2y \end{pmatrix}$, determine the critical point and classify it.

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- $\boldsymbol{v}(x,y) = 0 \ \rightarrow (x,y) = (0{,}0)$
- $\mathbf{J} = \begin{pmatrix} 1 & 1 \\ 4 & -2 \end{pmatrix}$

Compute eigenvalues λ_1, λ_2:

$$\det\left[\begin{pmatrix} 1 & 1 \\ 4 & -2 \end{pmatrix} - \lambda\begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix}\right] = \det\begin{pmatrix} 1-\lambda & 1 \\ 4 & -2-\lambda \end{pmatrix} = \lambda^2 + \lambda - 6$$

→ $\lambda^2 + \lambda - 6 = 0$

→ $\lambda_{1,2} = \frac{-1 \pm \sqrt{1+24}}{2}$

We get real eigenvalues: $\lambda_1 = -3,\ \lambda_2 = 2 \rightarrow$

Saddle point

$\mathrm{Im}(\lambda_{1,2}) = 0$

$\lambda_1\lambda_2 < 0$

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