King Abdullah University of Science and Technology

KAUST

CS 247 – Scientific Visualization
Lecture 22: Vector / Flow Visualization, Pt. 1

Markus Hadwiger, KAUST

Reading Assignment #11 (until Apr 16)

Read (required):

- Real-Time Volume Graphics, Chapter 10
  (Transfer Functions Reloaded)
- Paper:

  Joe Kniss, Gordon Kindlmann, Charles Hansen,

  Multidimensional Transfer Functions for Interactive Volume Rendering,
  IEEE Transactions on Visualization and Comp. Graph. (TVCG) 2002

  `https://ieeexplore.ieee.org/document/1021579`

Read (optional):

- Real-Time Volume Graphics, Chapter 14
  (Non-Photorealistic and Illustrative Techniques)

Online Demos and Info

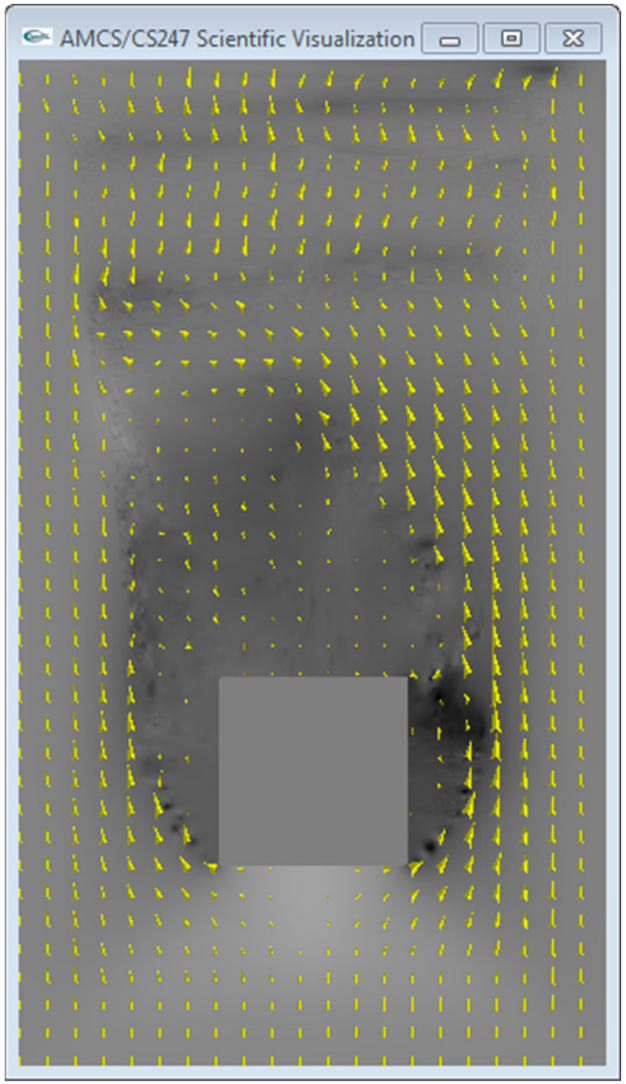
Numerical ODE integration methods (Euler vs. Runge Kutta, etc.)

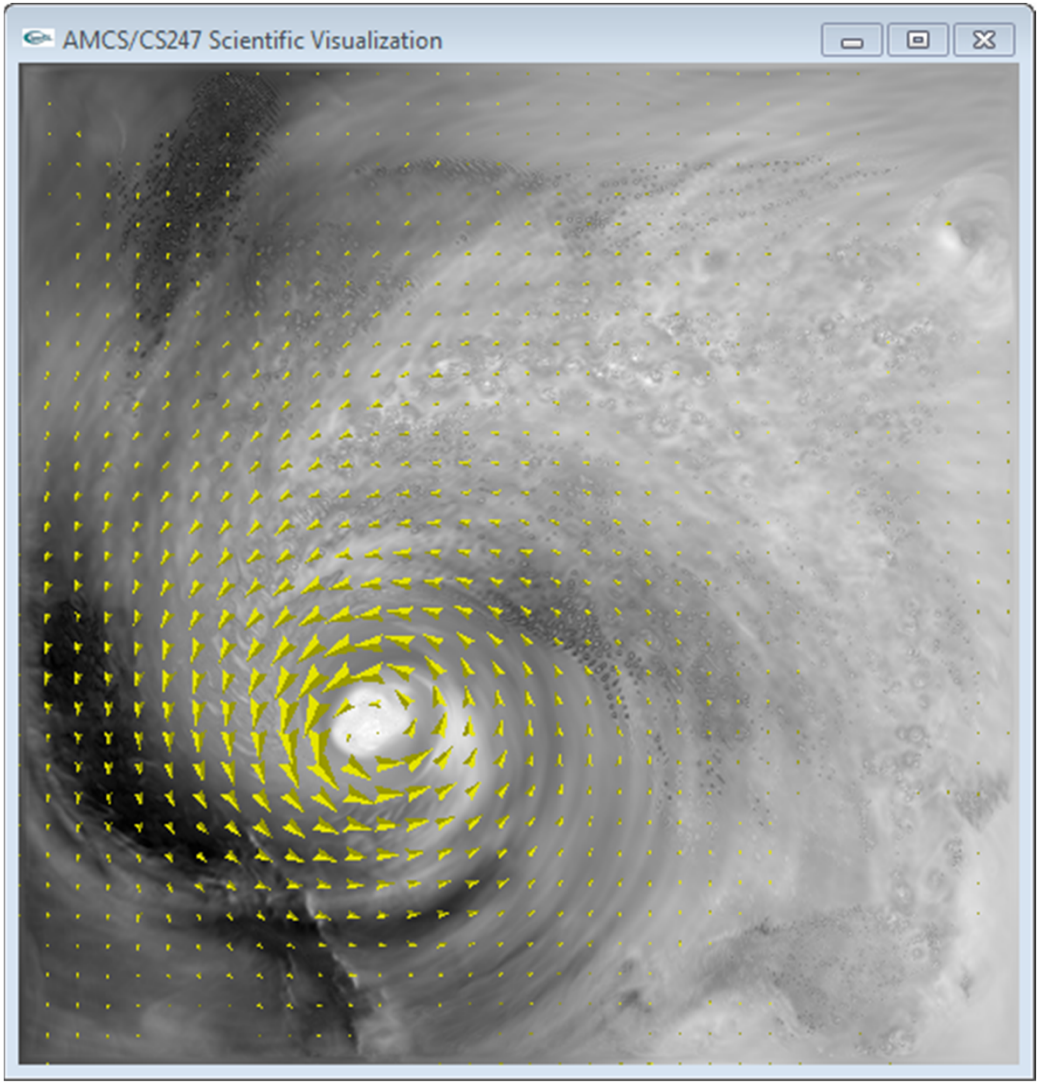
https://demonstrations.wolfram.com/NumericalMethodsForDifferentialEquations/

Flow visualization concepts

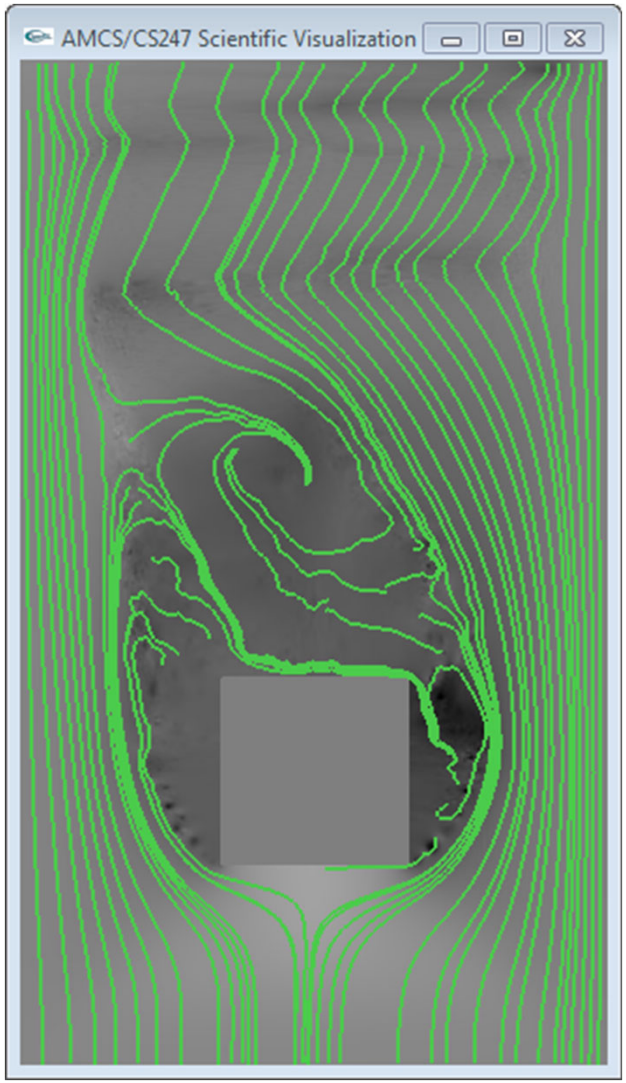
https://www3.nd.edu/~cwang11/flowvis.html

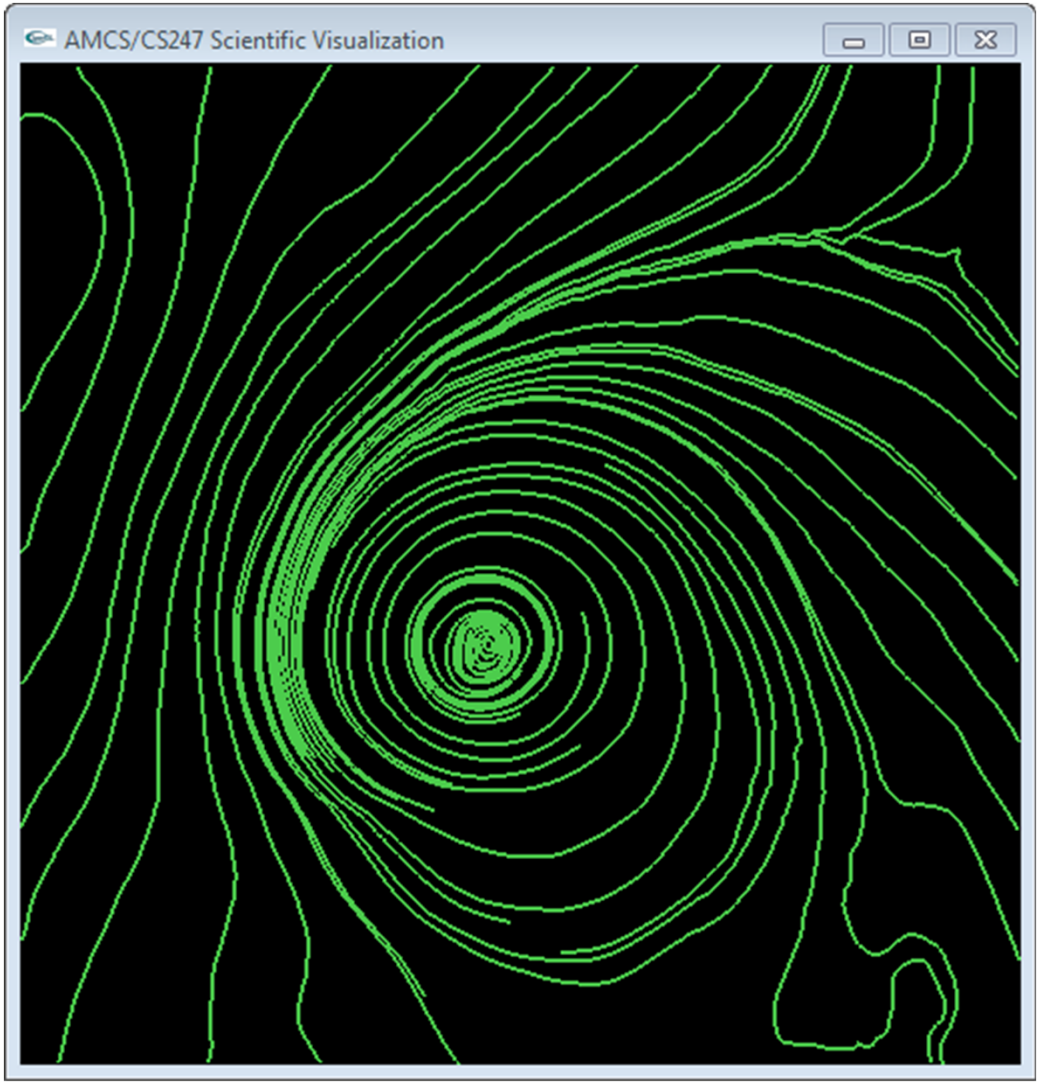
Programming Assignment #5: Flow Vis 1



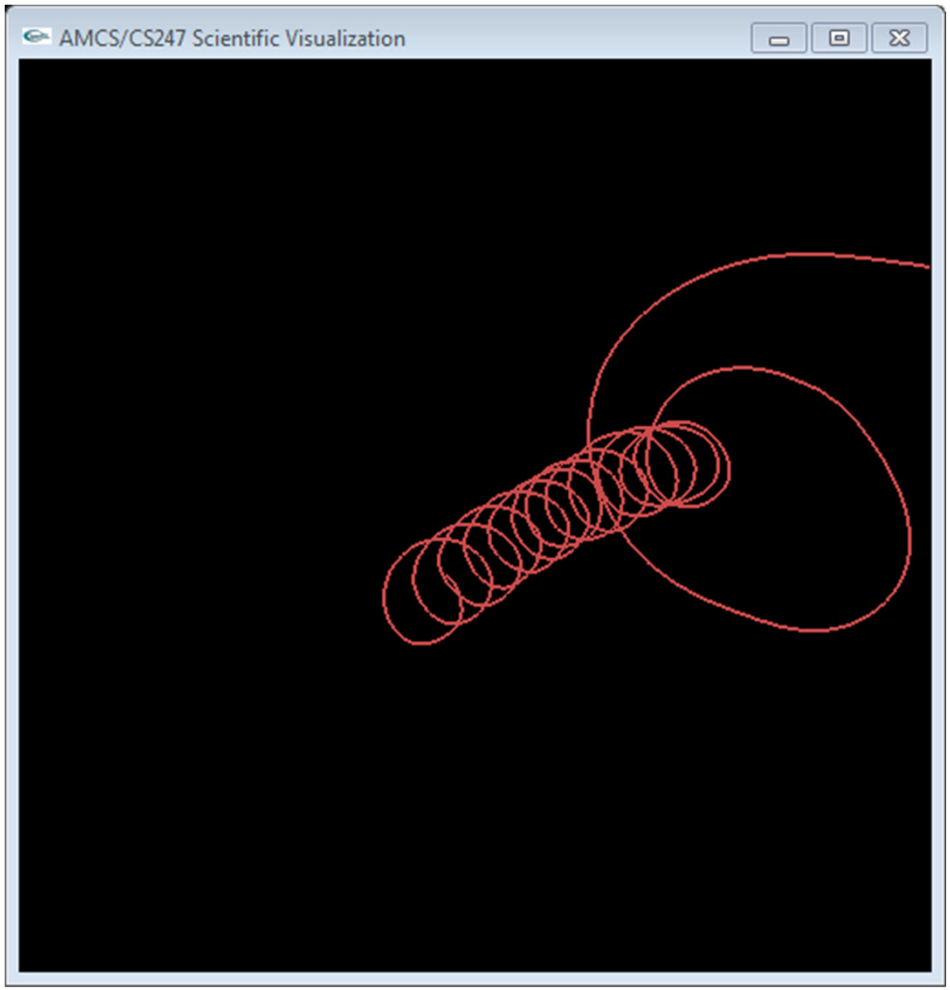


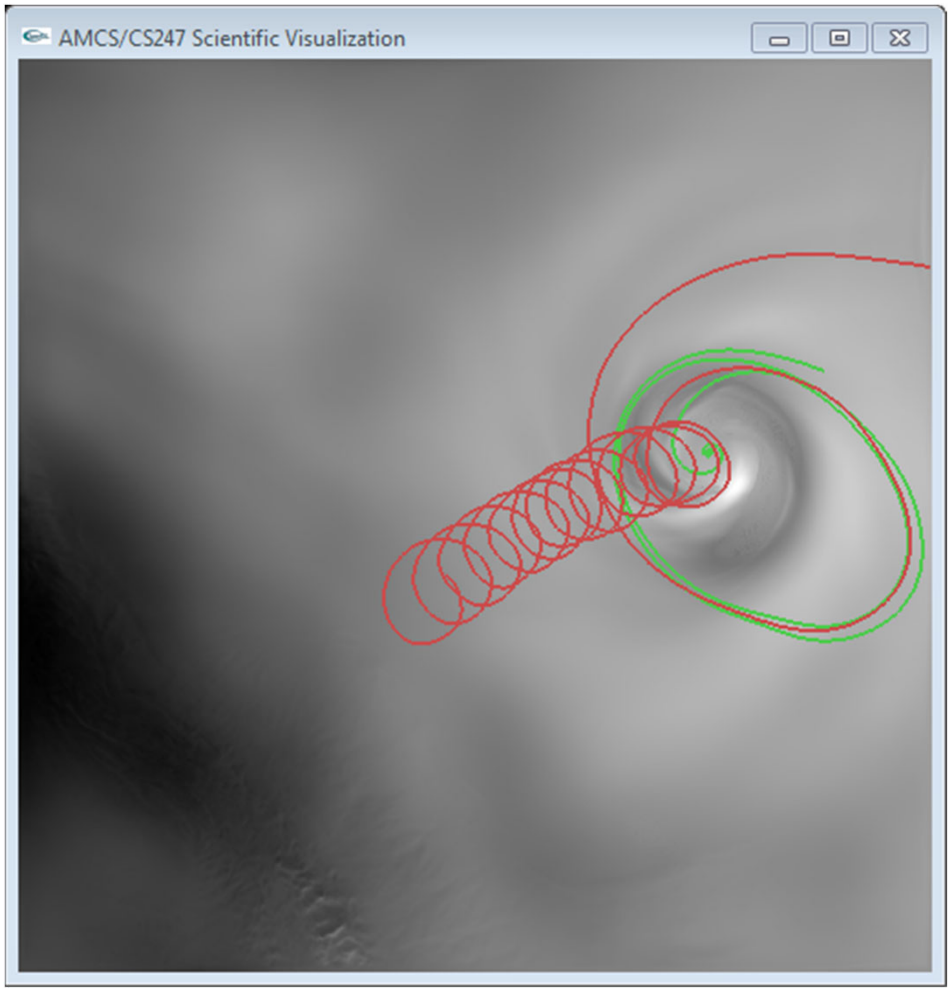
Programming Assignment #5: Flow Vis 1





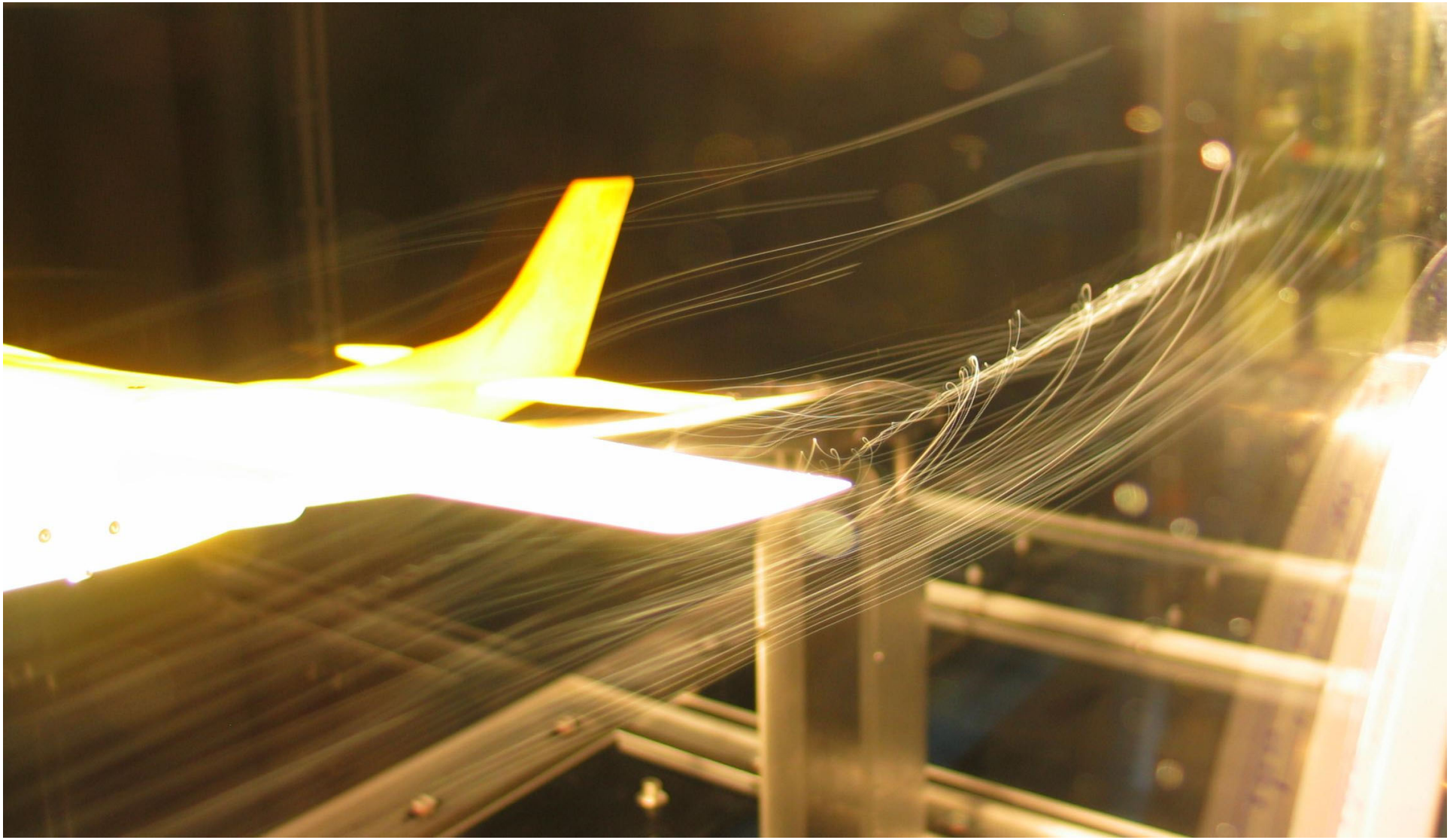
Programming Assignment #5: Flow Vis 1





Vector Fields: Motivation

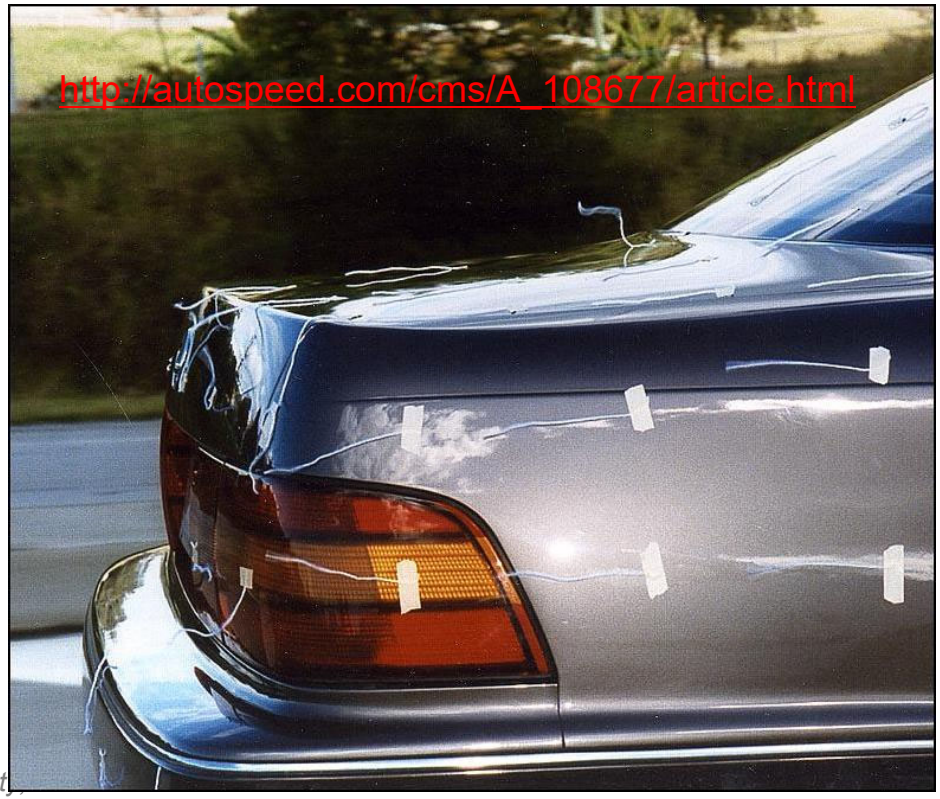
Smoke angel
A C-17 Globemaster III from the 14th Airlift Squadron, Charleston Air Force Base, S.C. flies off after releasing flares over the Atlantic Ocean near Charleston, S.C., during a training mission on Tuesday, May 16, 2006. The "smoke angel" is caused by the vortex from the engines.
(U.S. Air Force photo/Tech. Sgt. Russell E. Cooley IV)



A wind tunnel model of a Cessna 182 showing a wingtip vortex.
Tested in the RPI (Rensselaer Polytechnic Institute) Subsonic Wind Tunnel.
By Ben FrantzDale (2007).

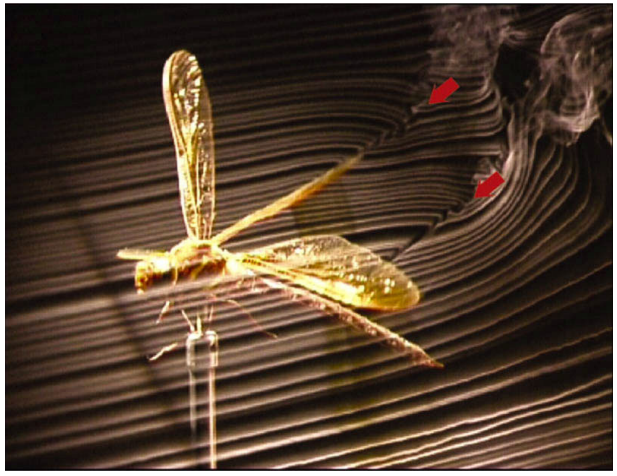

http://autospeed.com/cms/A_108677/article.html

wool tufts


http://autospeed.com/cms/A_108677/article.html

smoke injection

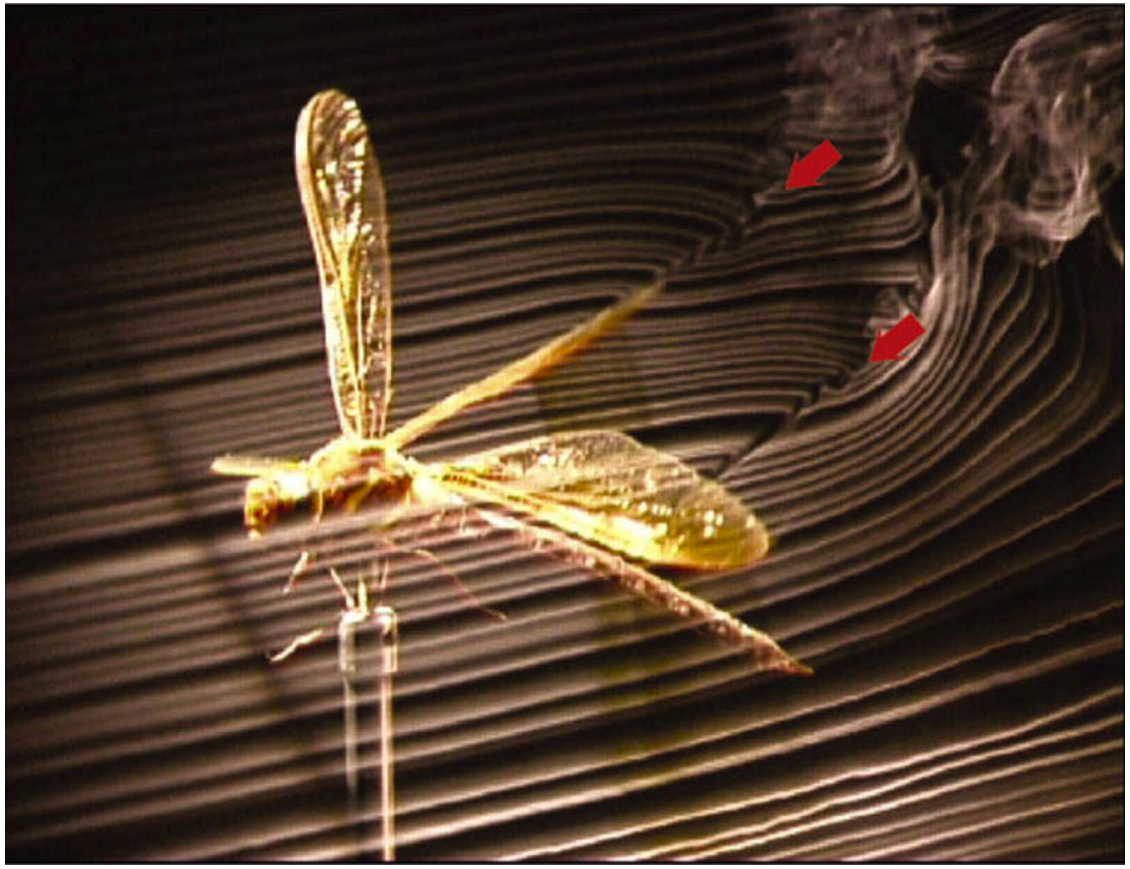
http://autospeed.com/cms/A_108677/article.html smoke nozzles



[NASA, J. Exp. Biol.]

http://autospeed.com/cms/A_108677/article.html smoke nozzles

Smoke injection

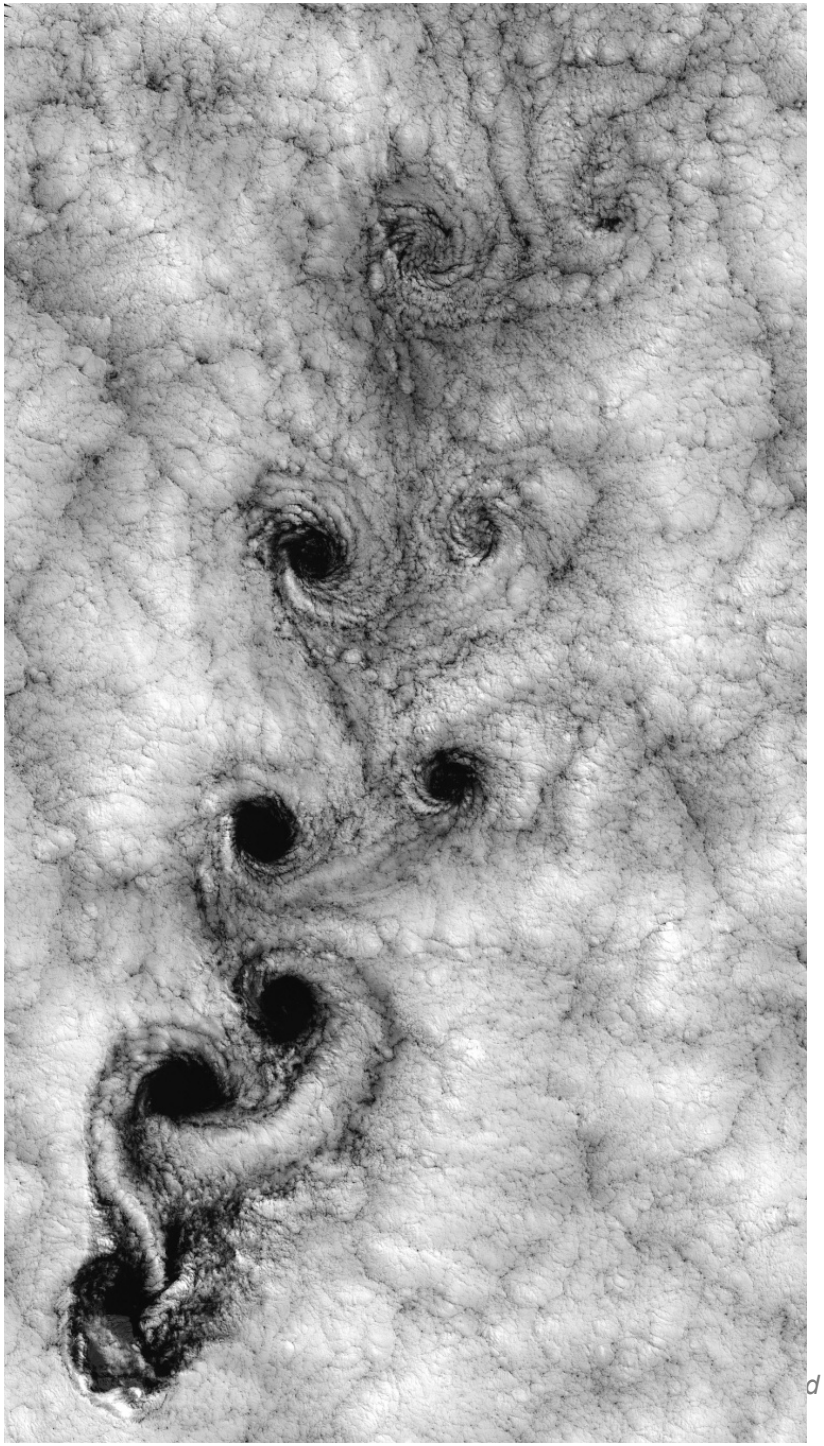


A. L. R. Thomas, G. K. Taylor, R. B. Srygley, R. L. Nudds, and R. J. Bomphrey. Dragonfly flight: free-flight and tethered flow visualizations reveal a diverse array of unsteady lift-generating mechanisms, controlled primarily via angle of attack. J Exp Biol, 207(24):4299–4323, 2004.

http://de.wikipedia.org/wiki/Bild:Airplane_vortex_edit.jpg

Smoke injection

http://www-me.ccny.cuny.edu/research/aerolab/facilities/images/wt2.jpg



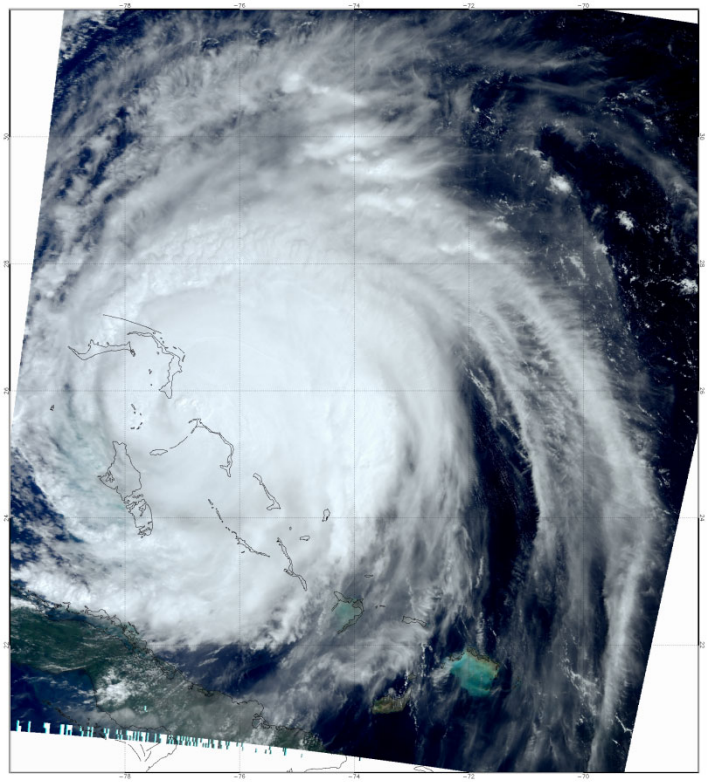
Clouds (satellite image)

Juan Fernandez Islands

http://de.wikipedia.org/wiki/Bild:Vortex-street-1.jpg

Clouds (satellite image)

http://daac.gsfc.nasa.gov/gallery/frances/



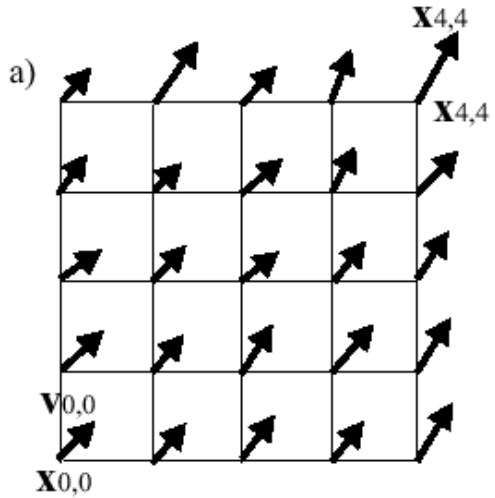
- **Vortex/ Vortex core lines**
  - There is no exact definition of vortices
  - capturing some swirling behavior

Vector Fields

Each vector is usually thought of as a velocity vector

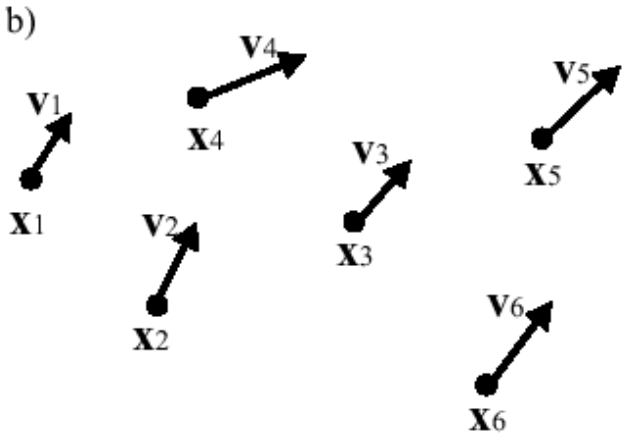
- Example for actual velocity: fluid flow
- But also force fields, etc. (e.g., electrostatic field)

Eulerian specification:



vectors given at grid points
(grid points do not move)

Lagrangian specification:

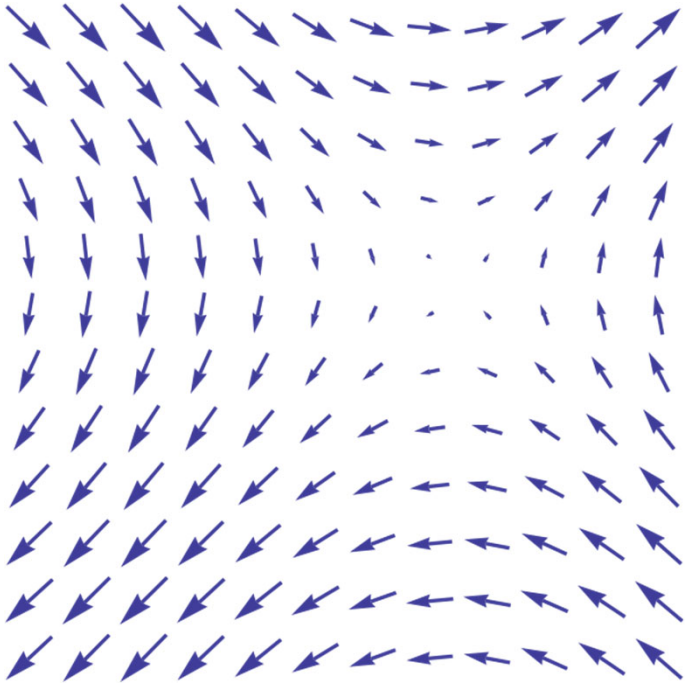


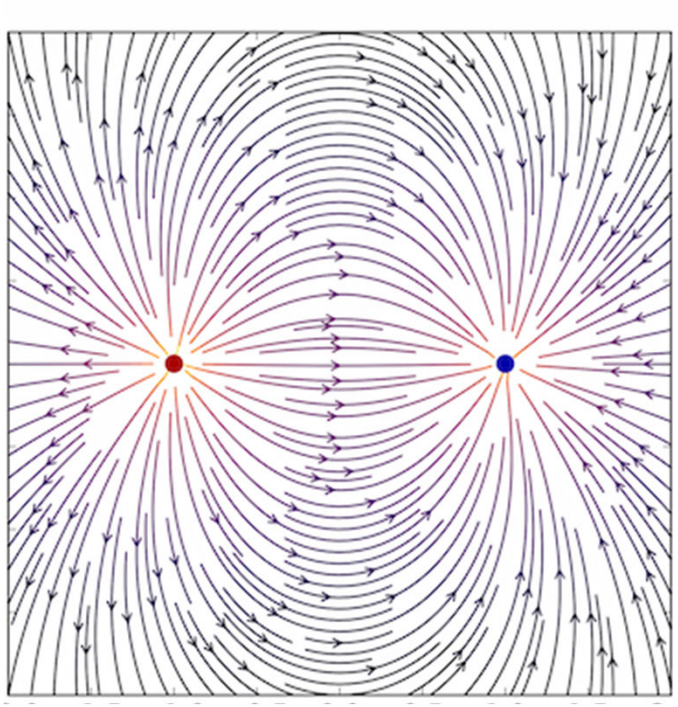
vectors given at particle positions
(particle positions do move)

Vector Fields

Each vector is usually thought of as a velocity vector

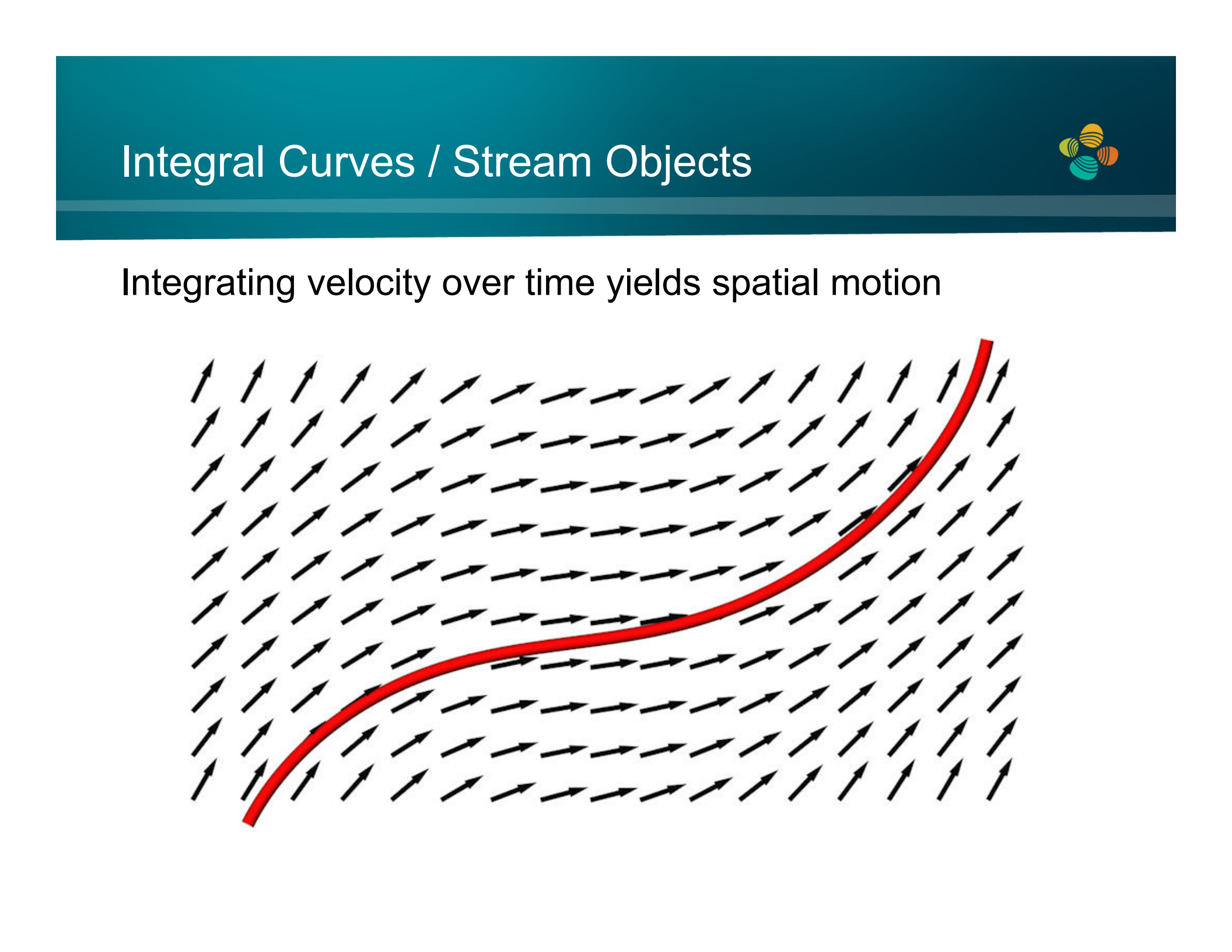
- Example for actual velocity: fluid flow
- But also force fields, etc. (e.g., electrostatic field)





images from wikipedia

Integral Curves / Stream Objects



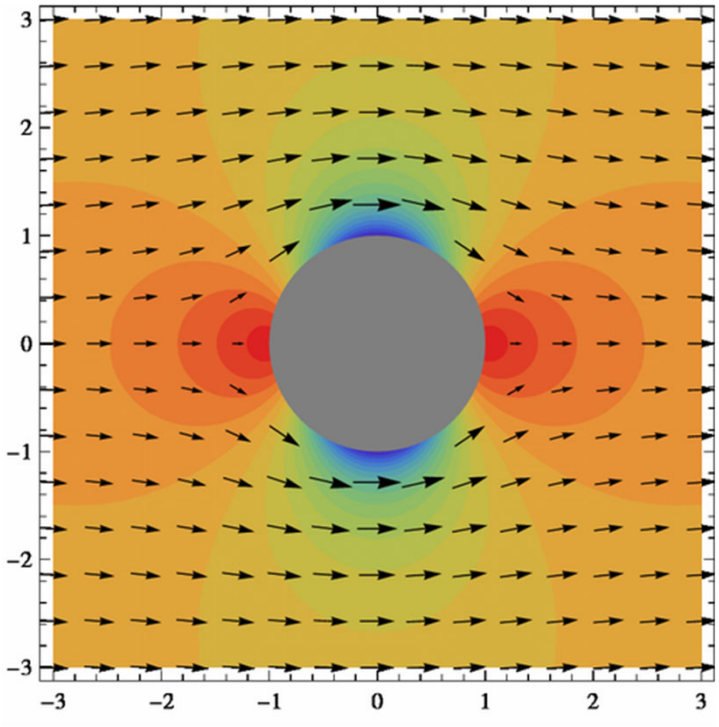
Integrating velocity over time yields spatial motion

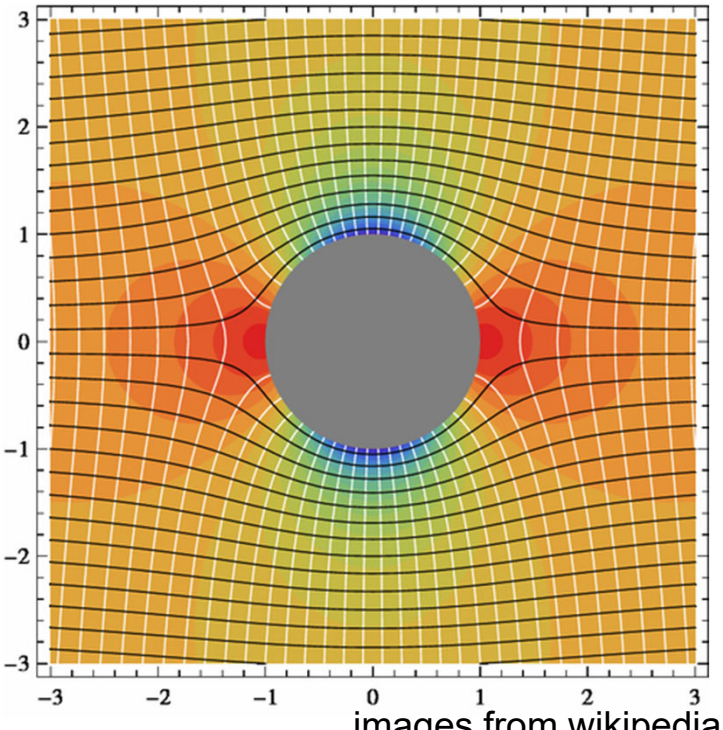
Flow Field Example (1)

Potential flow around a circular cylinder

`https://en.wikipedia.org/wiki/Potential_flow_around_a_circular_cylinder`

Inviscid, incompressible flow that is irrotational (curl-free) and can be modeled as the gradient of a scalar function called the (scalar) velocity potential





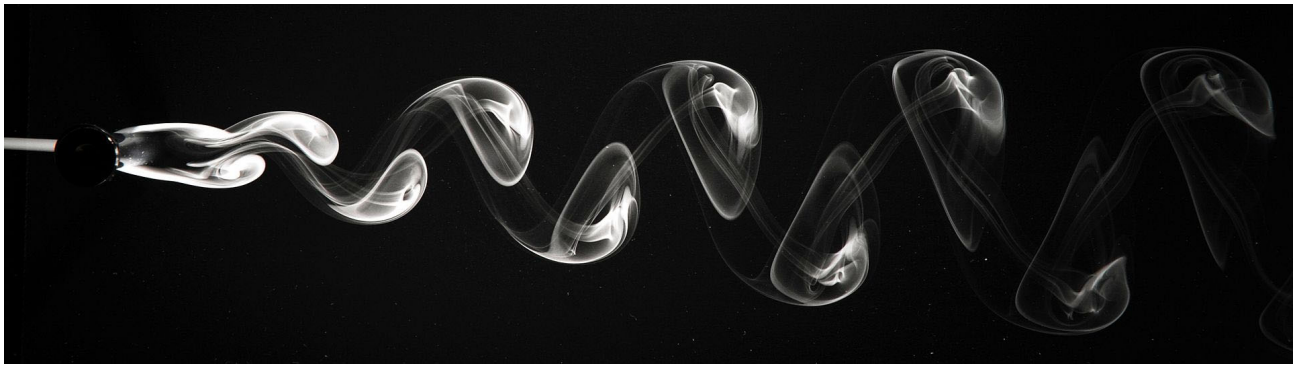
images from wikipedia

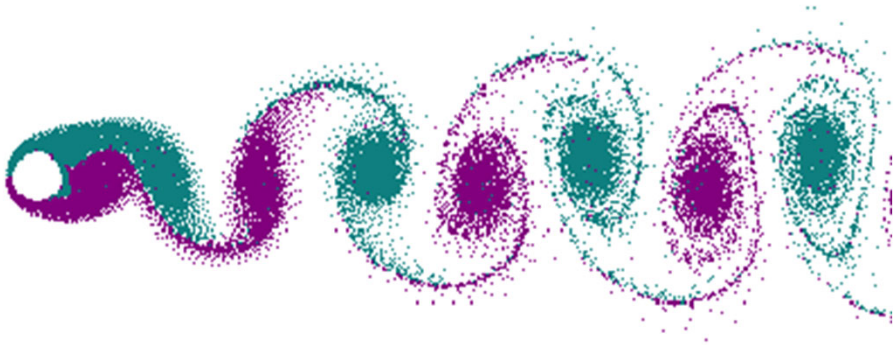
Flow Field Example (2)

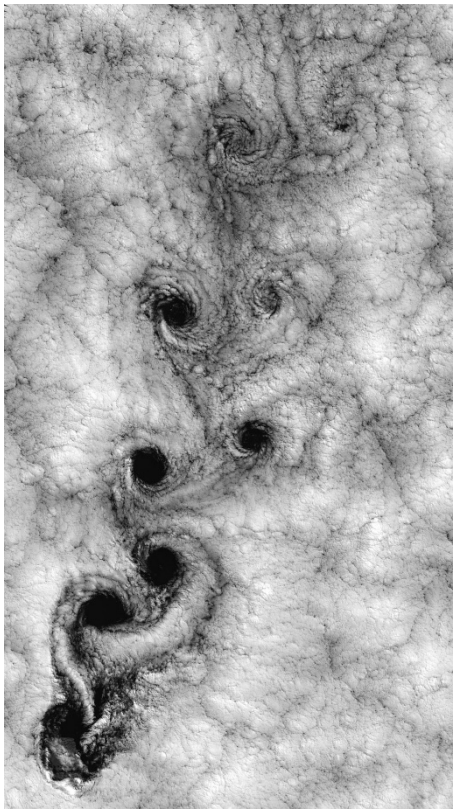
Depending on Reynolds number, turbulence will develop

Example: von Kármán vortex street: vortex shedding

https://en.wikipedia.org/wiki/Karman_vortex_street







images from wikipedia

Thank you.

Thanks for material

- Helwig Hauser
- Eduard Gröller
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- Philipp Muigg
- Christof Rezk-Salama