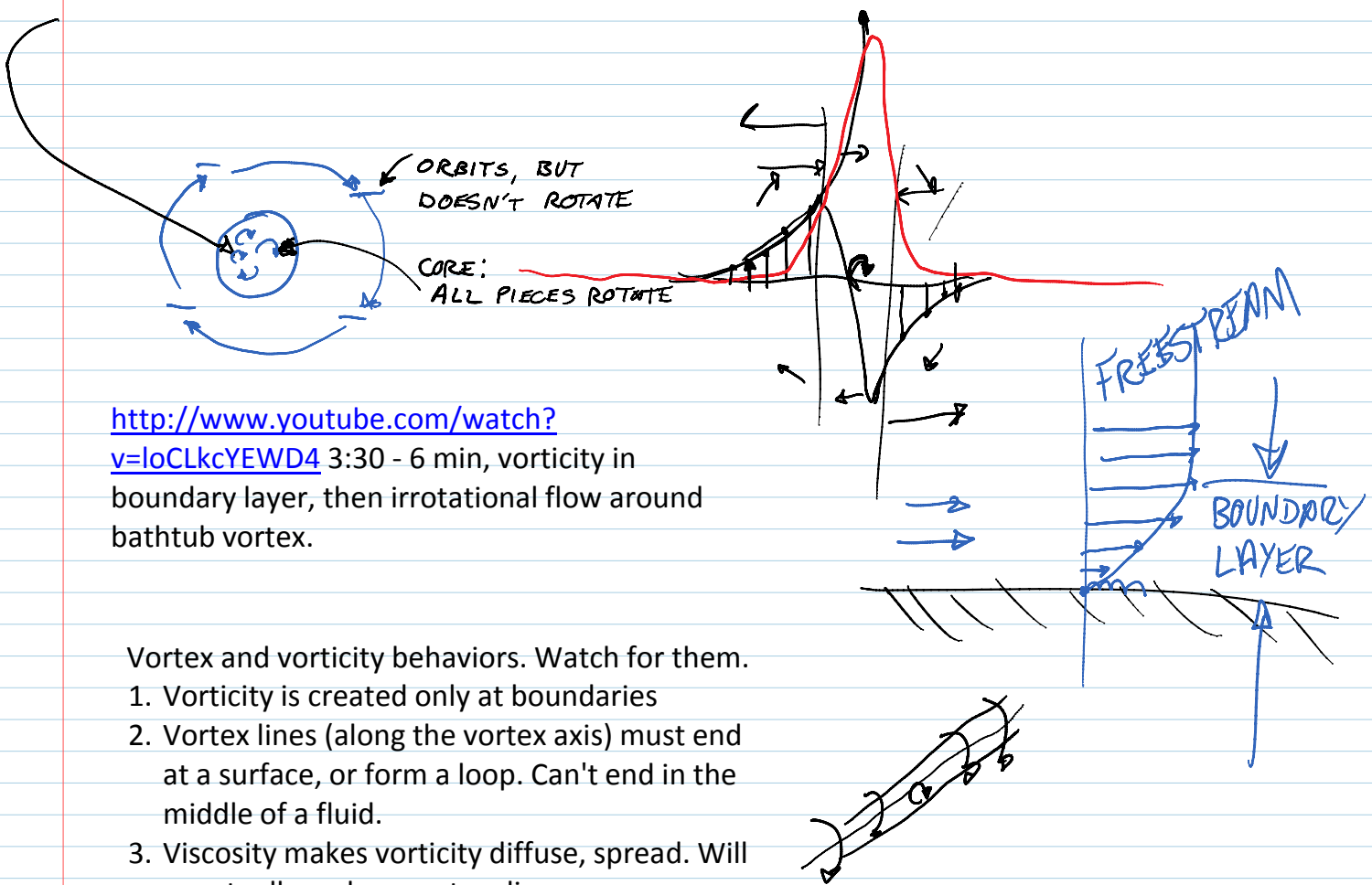
11.Vorticity-Resolution1

Monday, March 05, 2012
11:53 PM

- D2L is working again; proceed with uploads.
- Upload your edited image to D2L dropbox. Upload your image to your discussion AFTER it's been critiqued in class.
- Today: VORTICITY and Resolution

Vorticity = rotation of a fluid element around its own middle
Vortical fluid = fluid with vorticity
Vortex = Vortical fluid (vortex core), often surrounded by irrotational (non-vortical) fluid



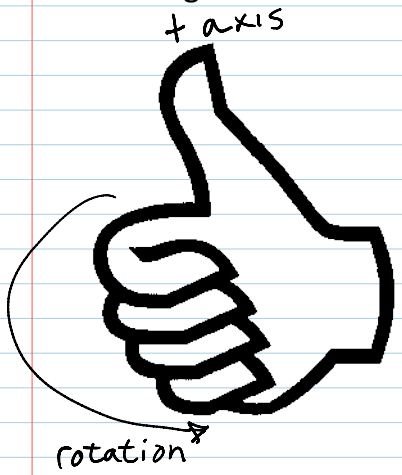
http://www.youtube.com/watch?v=loCLkcYEWD4 3:30 - 6 min, vorticity in boundary layer, then irrotational flow around bathtub vortex.

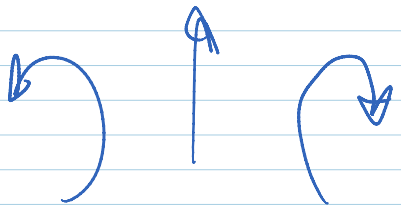
Vortex and vorticity behaviors. Watch for them.

1. Vorticity is created only at boundaries
2. Vortex lines (along the vortex axis) must end at a surface, or form a loop. Can't end in the middle of a fluid.
3. Viscosity makes vorticity diffuse, spread. Will eventually make a vortex die.

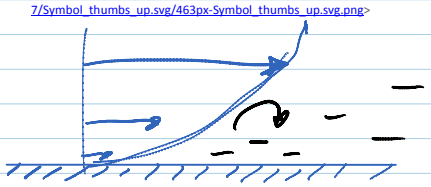
Math& physics references:
Panton, Ronald L. *Incompressible Flow*. 3rd ed. Wiley, 2005. New edition will have FV image in it.
Batchelor, G. K. *An Introduction to Fluid Dynamics*. Cambridge University Press, 2000.

Use right-hand rule to keep track of vorticity

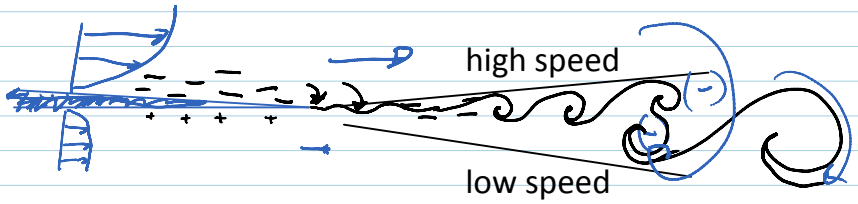




Pasted from
<http://upload.wikimedia.org/wikipedia/commons/thumb/8/87/Symbol_thumbs_up.svg/463px-Symbol_thumbs_up.svg.png>



Boundary layer. Vorticity (negative)
is generated at the wall, diffuses outward
via viscosity

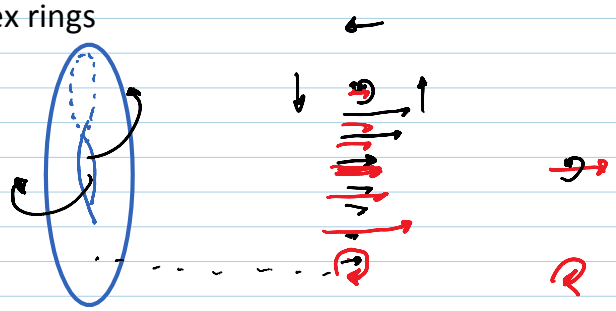


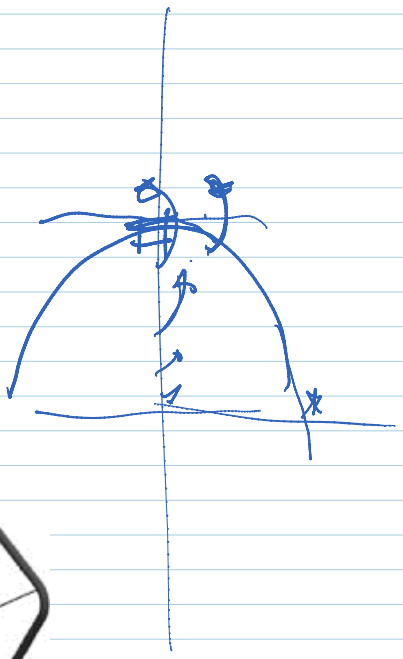
Shear layer. Vortex sheet is unstable,
rolls up into vortexes (Kelvin-Helmholtz instability), which then pair and form larger vortexes. This is how shear layers grow. *Hydrodynamic stability theory* can predict initial roll-up frequency, spacing.

Ref: Drazin, P. G., and W. H. Reid. *Hydrodynamic Stability*. 2nd ed. Cambridge University Press, 2004.

4. Like-sign vortexes pair, unlike vortexes cancel.

Vortex rings

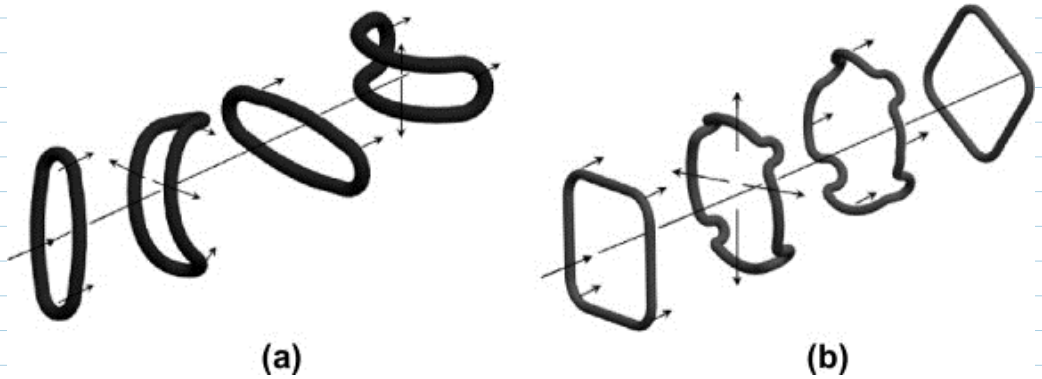




Self-induction: each part of the ring tries to get the rest of the ring to rotate around it. Net result: every part of the ring moves forward the same.

Strength of the self induction goes up as ring curvature tightens: small rings go faster

Elliptic rings: high curvature parts move ahead, increasing curvature on the straighter parts, which then speed up.



Zare-Behtash, H., N. Gongora-Orozco, and K. Kontis. "Effect of Primary Jet Geometry on Ejector Performance: A Cold-flow Investigation." *International Journal of Heat and Fluid Flow* 32, no. 3 (June 2011): 596–607. doi:10.1016/j.ijheatfluidflow.2011.02.013.

Major axis becomes the minor = axis switching.
Up to 7 switches have been seen.

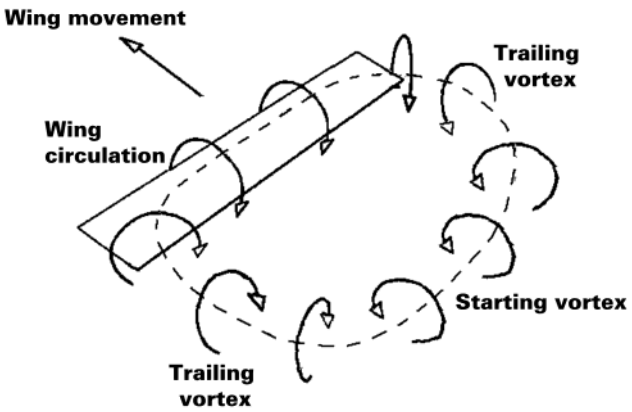
Other interesting vortex ring behaviors:

http://www.youtube.com/watch?v=j3wJal_AggY
Very short and fast example

http://www.youtube.com/watch?v=mHyTOcfF99o Extraordinary vortex

rings. Leapfrogging doesn't show net motion. Has dolphins.

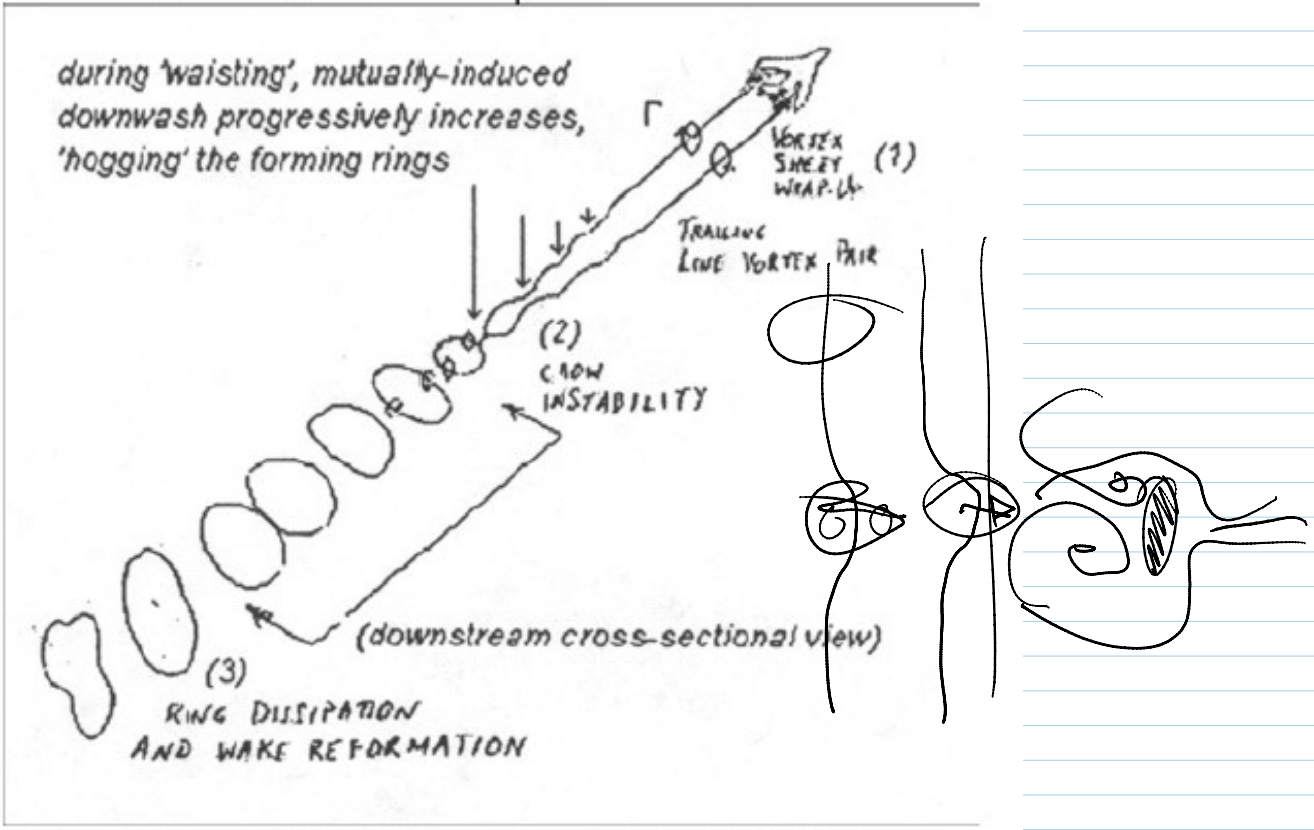
Contrails are long parallel vortexes. Loop forms starting with takeoff, ends on landing



http://www.regenpress.com/

The Crow Instability Process

'An instant flurry would likely be the GO trigger to commence reactive control inputs.'



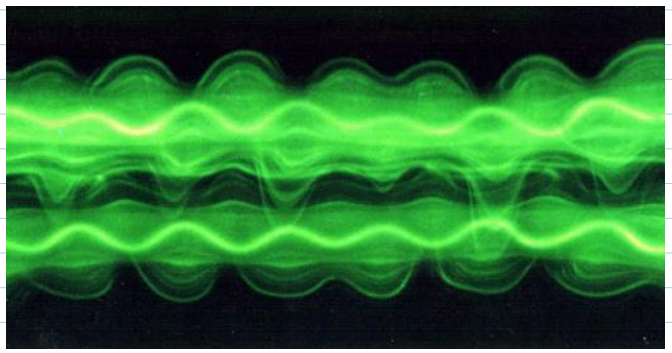
A trailing pair of wake vortices can merge into a series of vortex segments inclined more or less vertically. Hence, upon climb-out, a following aircraft at two-minute takeoff separation could encounter a preceding wake which is not a stable vortex pair, but which is in a state of breakdown or transition. *Source: Brown, in NTSB Docket No. SA-522, Exhibit 2-X, Aug. 2002*

http://www.iasa-intl.com/folders/the068event/587crows-1_files/crowinstab-1.jpg

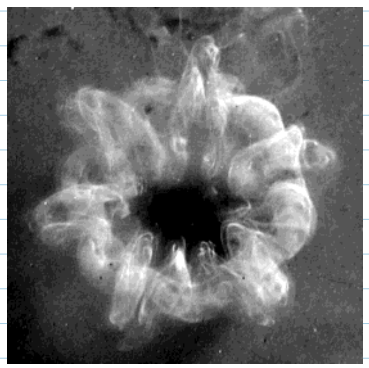
Crow instability

http://upload.wikimedia.org/wikipedia/commons/thumb/0/05/Contrail_with_crow_instability.jpg/200px-Contrail_with_crow_instability.jpg

Crow (1970) and Widnall et al (1974)



http://www.efluids.com/efluids/gallery/gallery_pages/pair_instability_page.jsp



Widnall instability

http://iopscience.iop.org/1873-7005/44/1/015501/article Collision of vortex ring and granular layer

http://www.flamingtornado.com/ Fire art by Nate Smith

BLEVE: Boiling Liquid Vapor Explosion

BLEVE (Boiling Liquid Expanding Vapor Explosion) Demonstration - How It Happens Training Video, 2009. http://www.youtube.com/watch?v=UM0jtD_OWLU&feature=youtube_gdata_player.

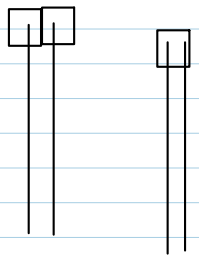
Resolution

Can two adjacent things be resolved?

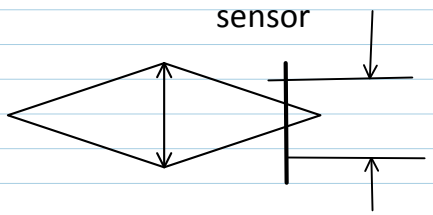
Resolution = minimum distance between two objects for them to be recognized as separate.
Applies to objects (spatial resolution) and events (temporal or time resolution)

Spatial resolution can be DEGRADED by

- Bad focus
- Rastering, pixelation
- Diffraction effects
- Low contrast
- Compression artifact (in jpegs)
- Motion blur



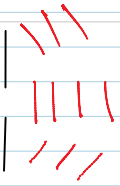
- Bad focus: is circle of confusion > pixel?



- Diffraction effects if lens aperture or pixel size < λ wavelength of light

λ >d
woofers

λ < d
tweeters,
Beamy
effect



from interference effects

Example : http://www.luminous-landscape.com/tutorials/understanding-series/u-diffraction.shtml. Moral of the story: high f number has better depth of field, but sharpness

can be defeated by diffraction effects.

Current sensor sizes range 35 - 3 mm. For 3k px wide, 1 pixel = 10 -1 μm. Red λ = 0.7 μm. Pretty close!

"Canon Develops 35 Mm Full-frame CMOS Sensor for Video Capture." Accessed March 5, 2013. http://www.opli.net/magazine/imaging/2013/canon_35_mm_full_frame_CMOS.aspx.