Useful (engineering) fluid unreality vs. useless (Science) explanative realism



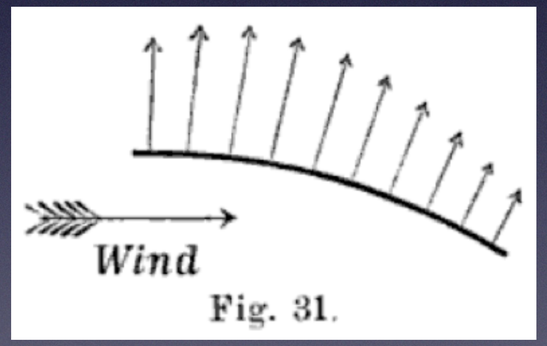
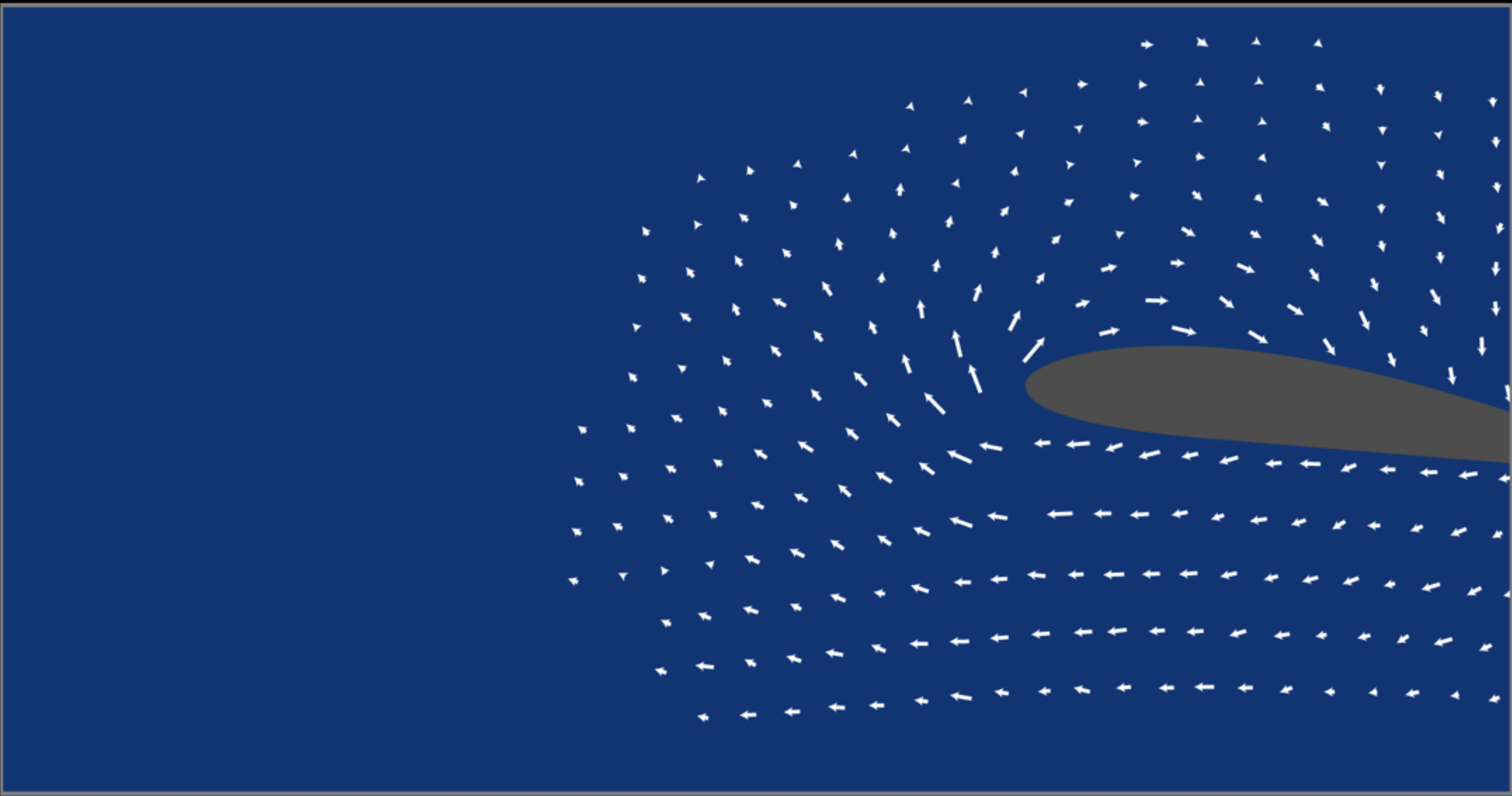
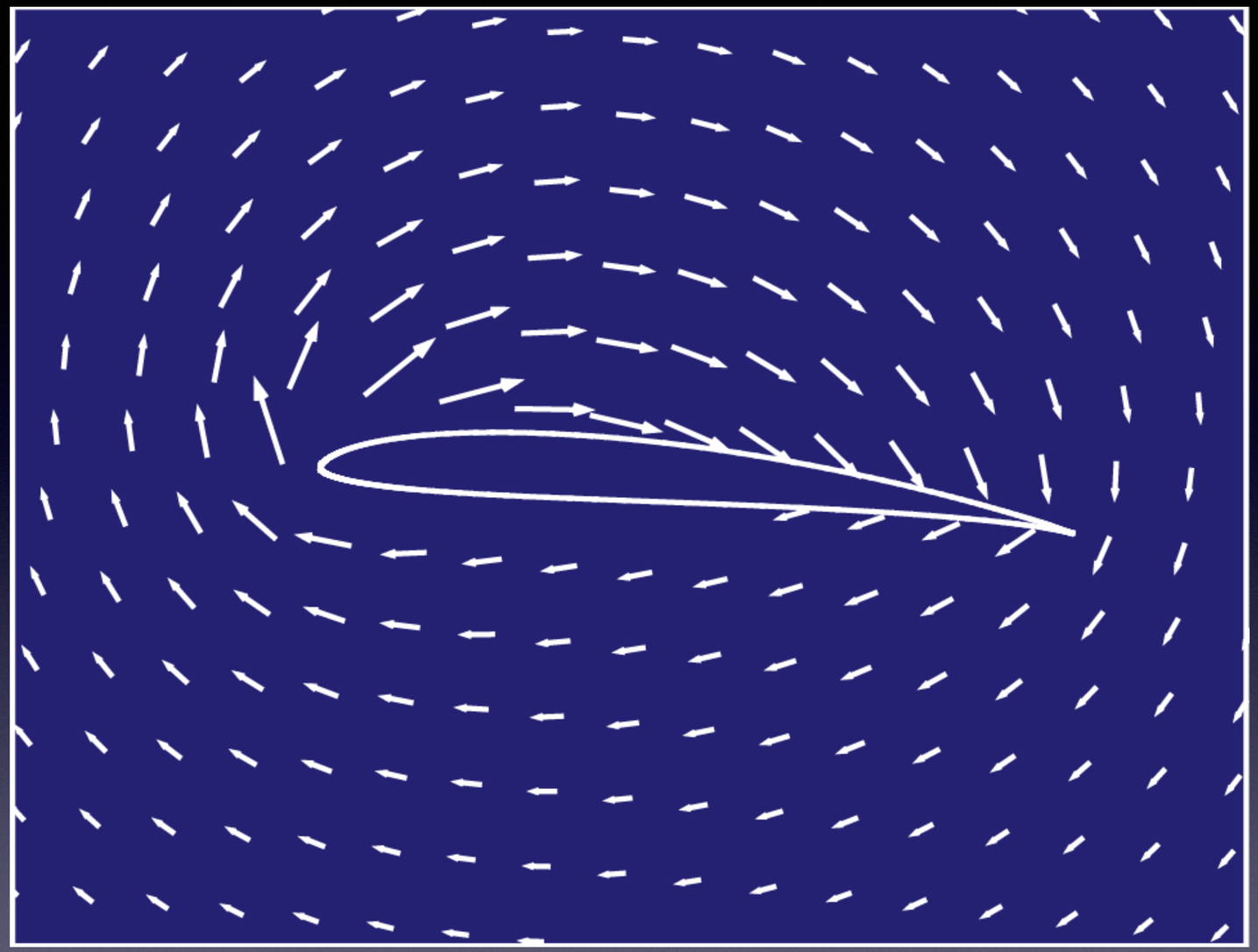


Fig. 31.

From the lift (veer) of curve balls to wing lift engineering.
The 1897 pan-of-water experiment that showed how aero engineering equations modeled on a bogus idea still yield accurate results. Otto Lilienthal's centrifugal lift.
The incomplete translation of Newton's second law into symbolic equation form.
A Heisenberg principle for fluids.

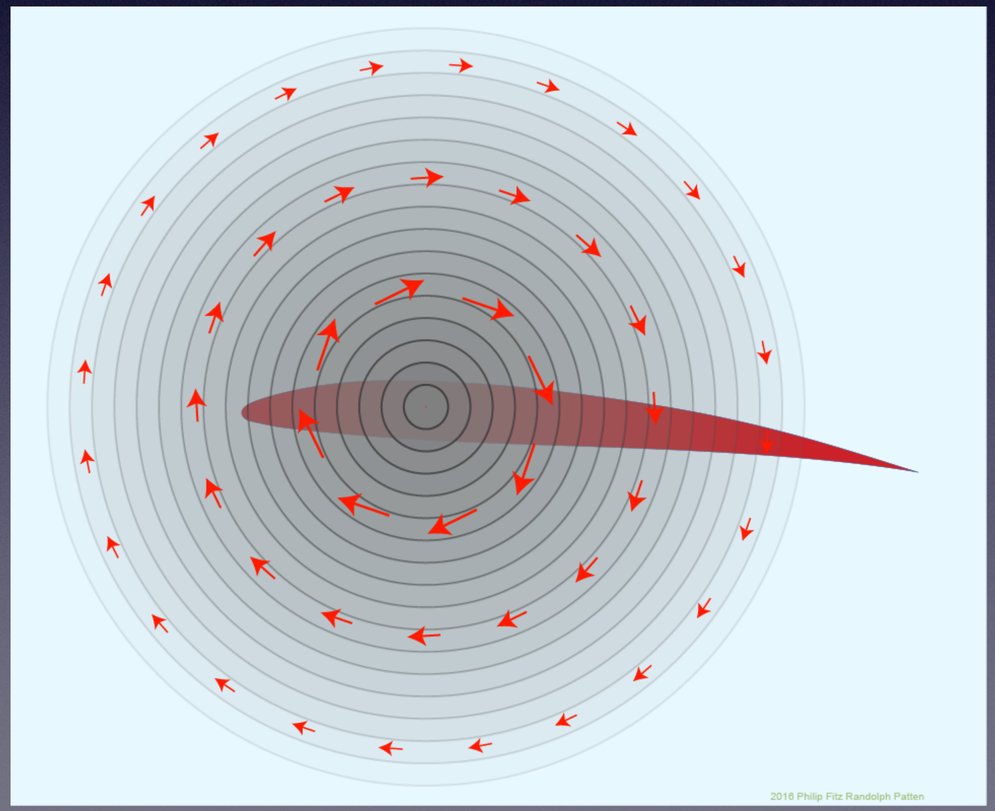




The actual ‘circulation’ component of a wing’s flow field is too complex to be mathematically tractable.

So aero engineers substitute an ideal vortex as a simplified model of wing ‘circulation.’

Why does this yield accurate results?

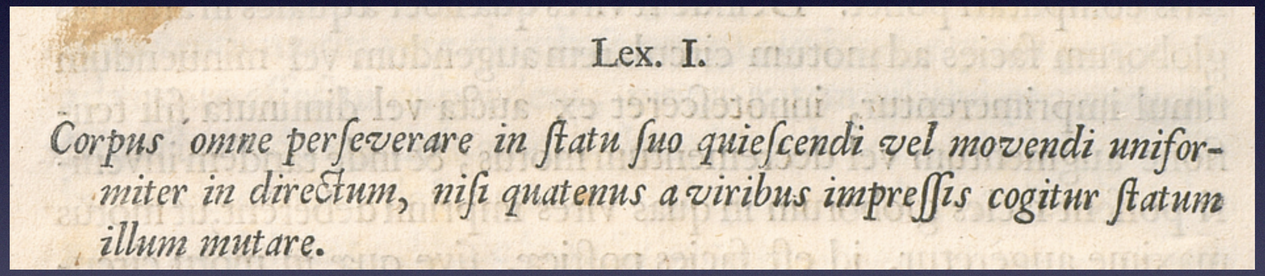


Causality
The equal sign trap
⇒ bad explanations through history.

And to avoide the tediouse repetition of these words: is equalle to: I will settle as I doe often in woorke use, a paire of paralleles, of Gemowe (or twin) lines of one lengthe, thus ======, because noe 2 thynges can be moare equalle.
–Robert Recorde, *The Whetstone of Witte, 1557.*

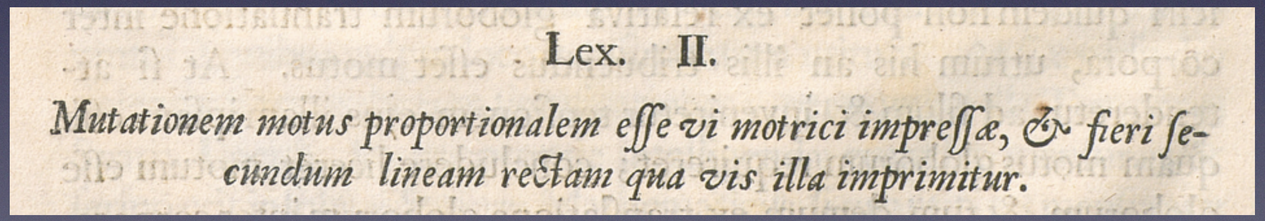
Newton didn't use the equal sign. Newton didn't write F = ma.
F = ma was an incomplete translation of Newton's Latin Law 2,
first in 1716 by Jacob Hermann
and in the 1740s by Leonhard Euler.

Newton's written Laws were explicitly *causal.* A force *causes* a change in "motion."
The equal sign leaves out that causality



Lex. I.

Corpus omne perſeverare in ſtatu ſuo quieſcendi vel movendi uniformiter in directum, niſi quatenus a viribus impreſſis cogitur ſtatum illum mutare.



Lex. II.

Mutationem motus proportionalem eſſe vi motrici impreſſæ, & fieri ſecundum lineam rectam qua vis illa imprimitur.

–Newton, *Principia, 1st edition,1687*

Law 1
Every body perseveres in its state of moving uniformly straight forward ***except insofar as it is compelled to change*** **its state by forces impressed.**

Law 2
A change in motion [momentum] is ***proportional*** *to the motive force impressed and takes place along the straight line in which that* ***force is impressed…***

Newton's Law 2
accurately symbolically translated:

$F \Rightarrow ma$

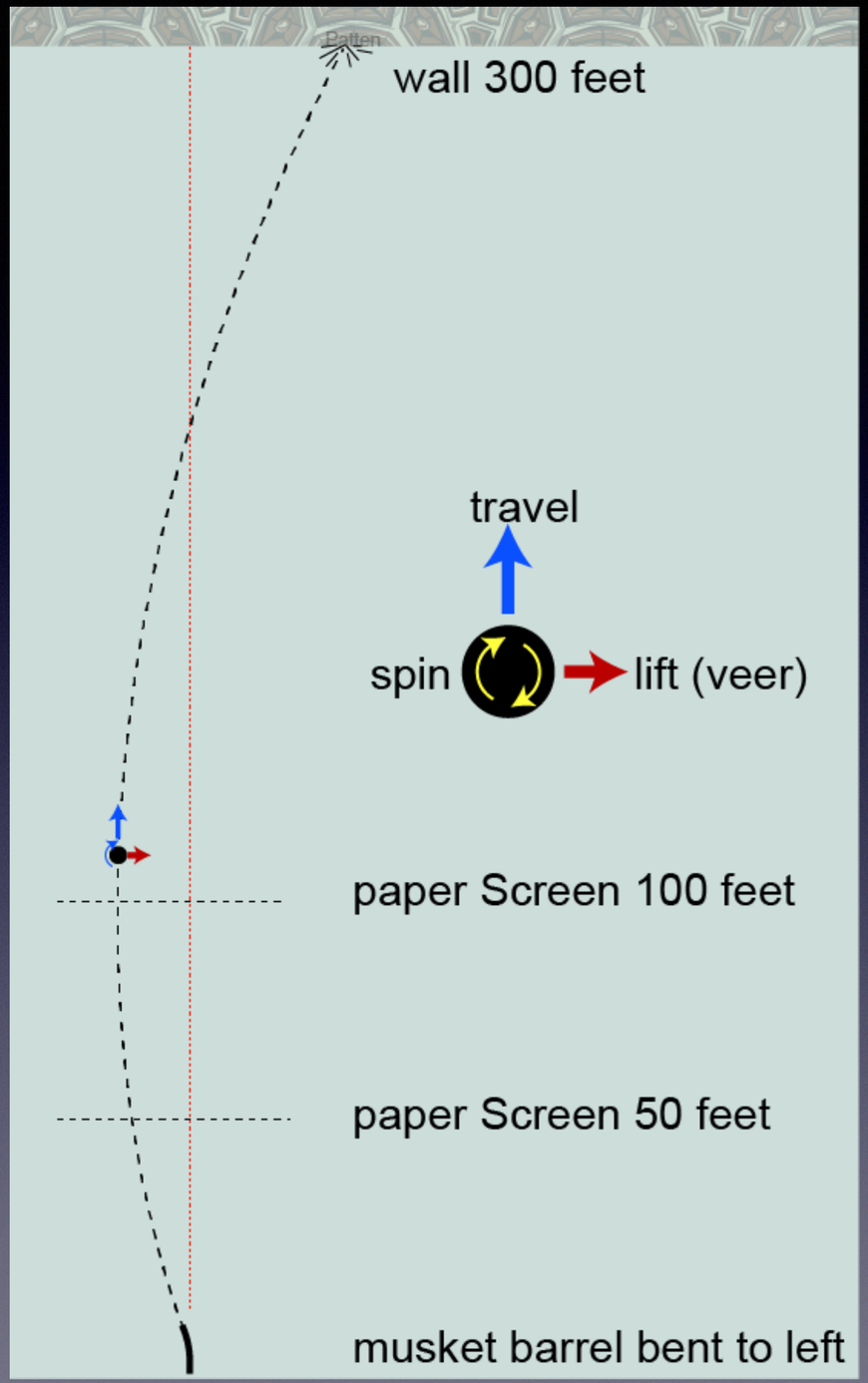
$F \Rightarrow m\Delta v$

Origins of wing lift engineering: curving tennis balls

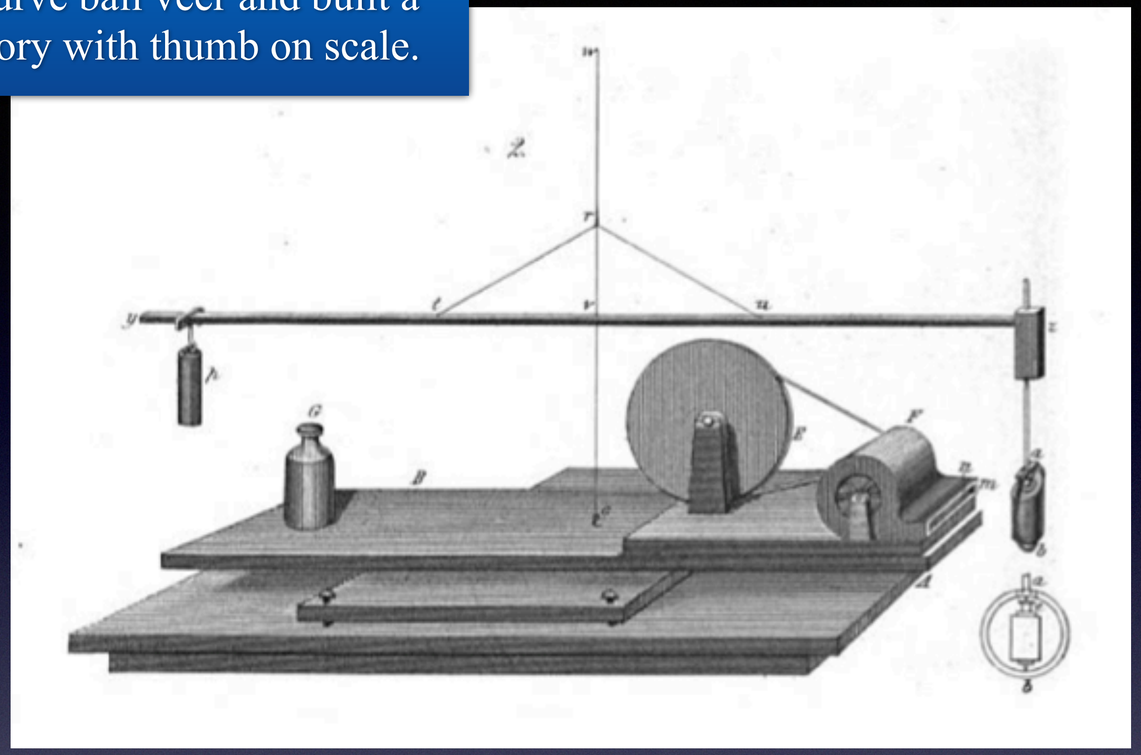
I had often seen a Tennis-ball, struck with an oblique racket, describe such a curve line. For, a circular as well as a progressive motion being communicated to it by that stroak, its parts on that side, where the motions conspire, must press and beat the contiguous Air more violently than on the other; and there excite a reluctancy and reaction of the Air proportionably greater.
–Isaac Newton, "Letter on Light," 1671.
(Abandoned refraction theory, that light bends like curving tennis balls.)

Benjamin Robins,
New Principles of Gunnery, 1742.

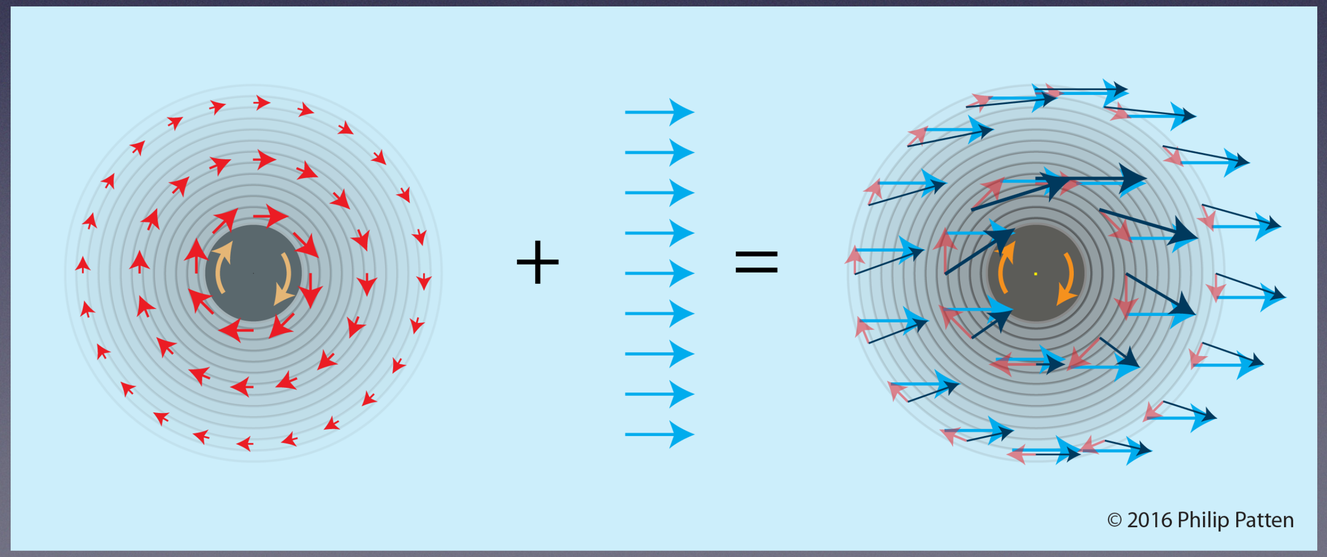
Leonhard Euler, superb mathematician with little physical aptitude, didn't believe in Newton's viscosity and quashed Robins' experimental veer results, for a century.



Gustav Magnus, 1858, verified Robins' curve ball veer and built a bogus theory with thumb on scale.



The false theory that made good aero engineering. How could that be?



False: Gustav Magnus, 1858, says that a "rotatory flow" and a linear flow from his fan add.

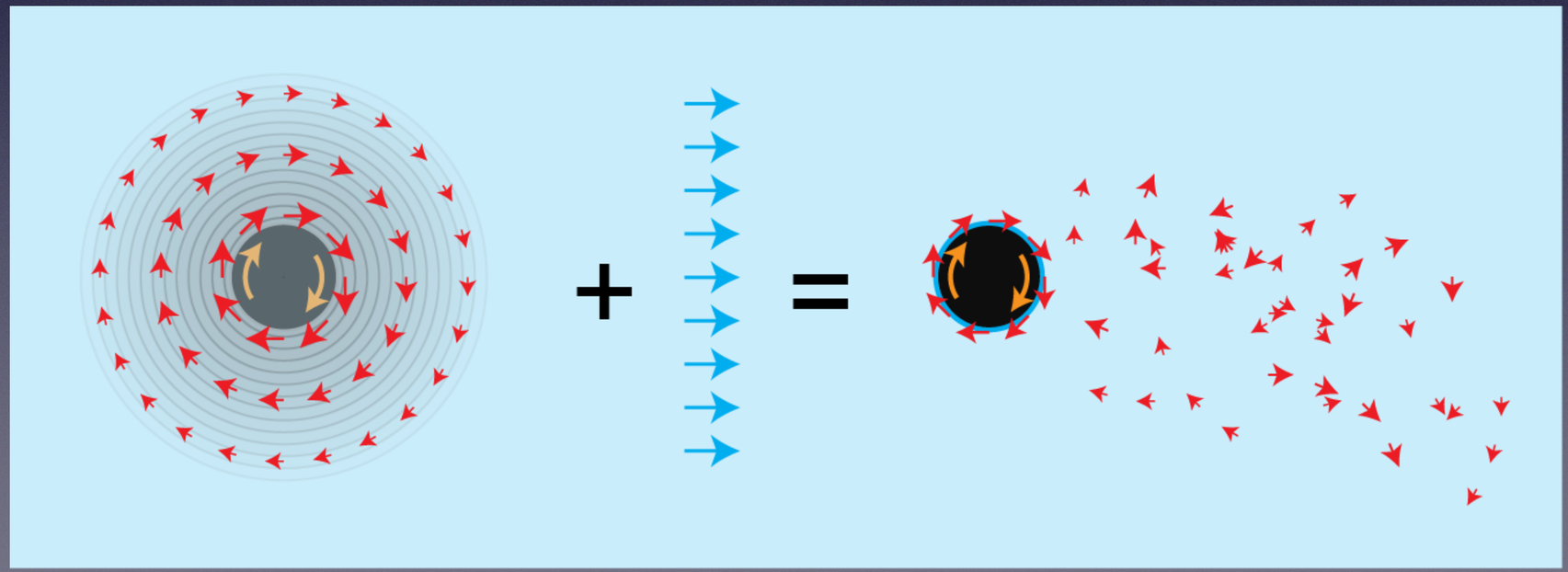
Then he used a backwards Bernoulli interpretation to say faster flows would make lower pressures.

Totally bogus, but eventually it would yield accurate wing lift and drag predictions!

Flaws



Actual:



Frederick William Lanchester's 1907 correct explanation of spinning ball lift: Differential flow attachment makes unequal centrifuging of pressures.

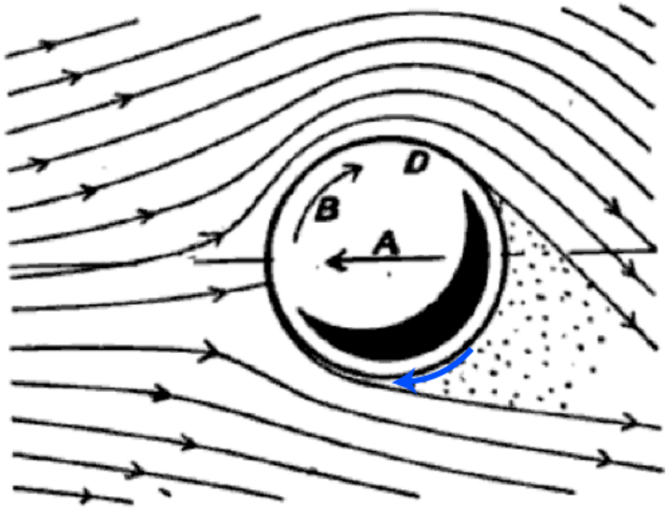
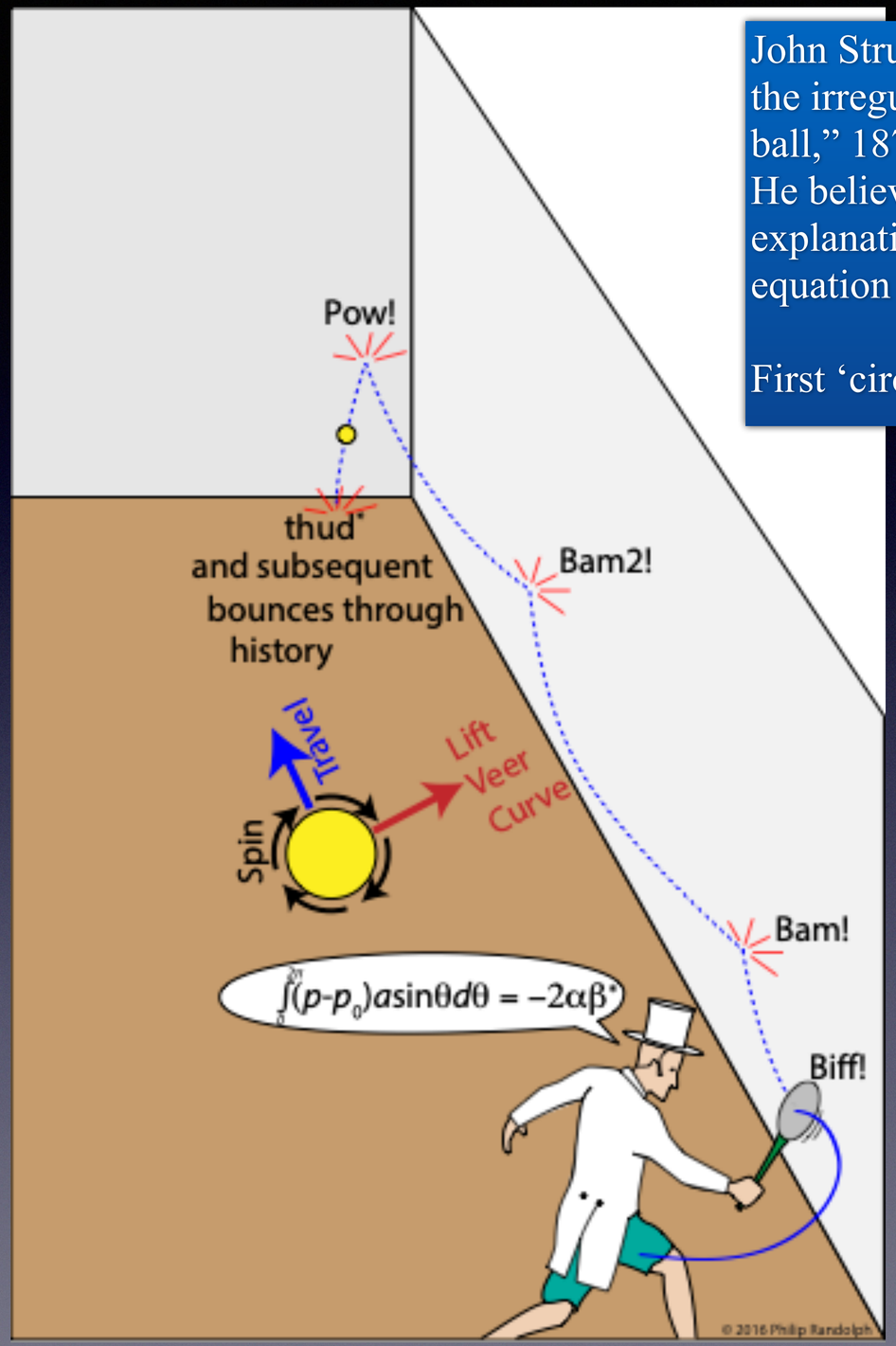


FIG. 22.

FWL: [boundary layer] and flow in the same direction keep upper flows attached.

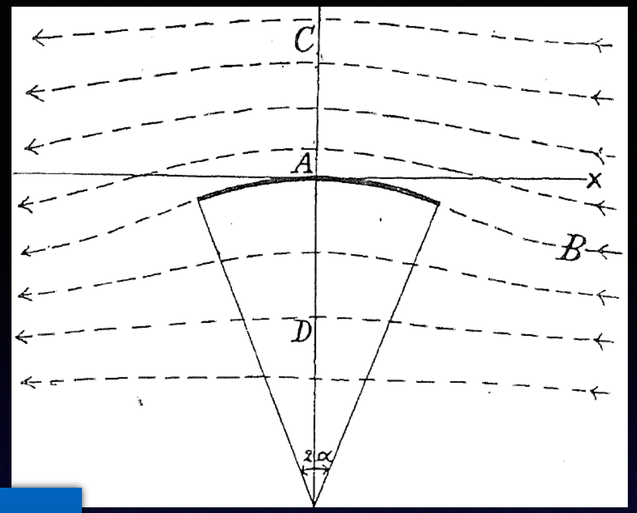
FWL: [boundary layer] "pumps air in" causing flow separation.
Newton: "beats the contiguous air."

Lanchester asserted that the longer curve atop centrifuged lowered pressures there.
The milder lower curve doesn't change pressures too much from ambient.

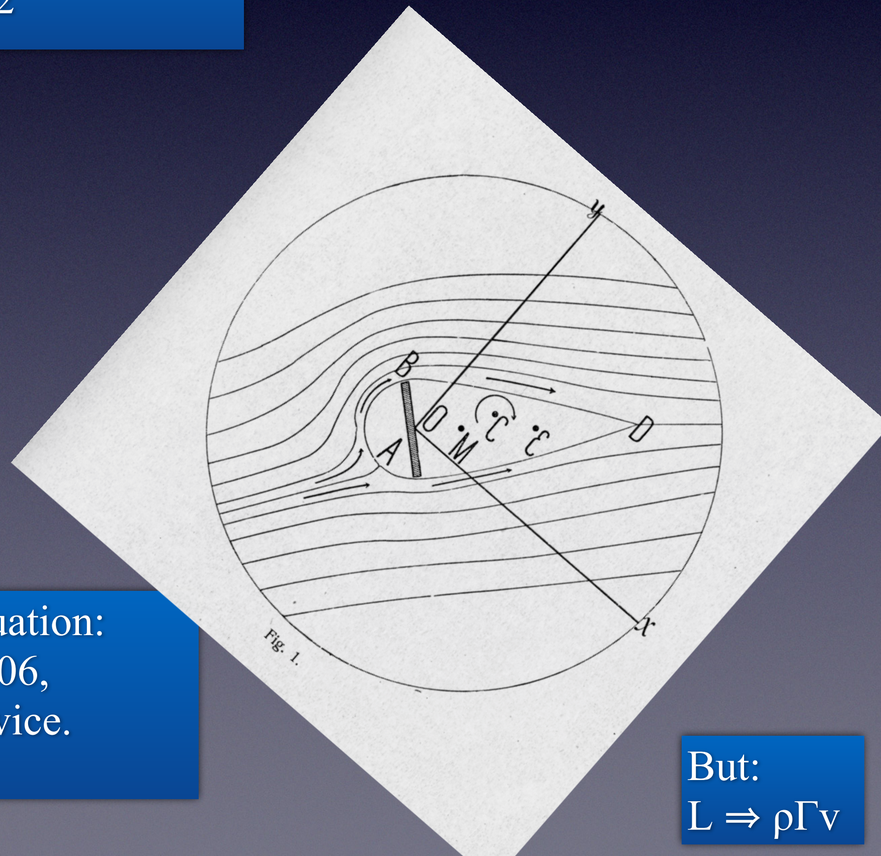


John Strutt Lord Rayleigh, "On the irregular flight of a tennis ball," 1877.
He believes Magnus' bogus explanation and writes a correct equation for spinning ball lift.

First 'circulation' lift equation!



2nd 'circulation lift equation: Wilhelm Kutte, 1902

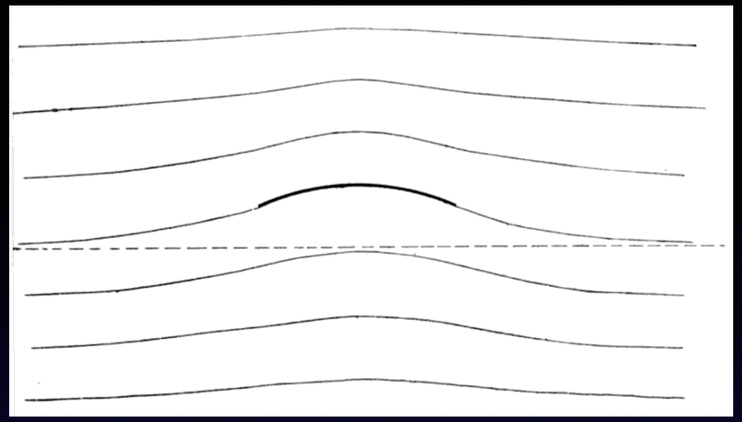


3rd 'circulation lift equation: Nikolai Joukowski, 1906, for a spinning vane device.

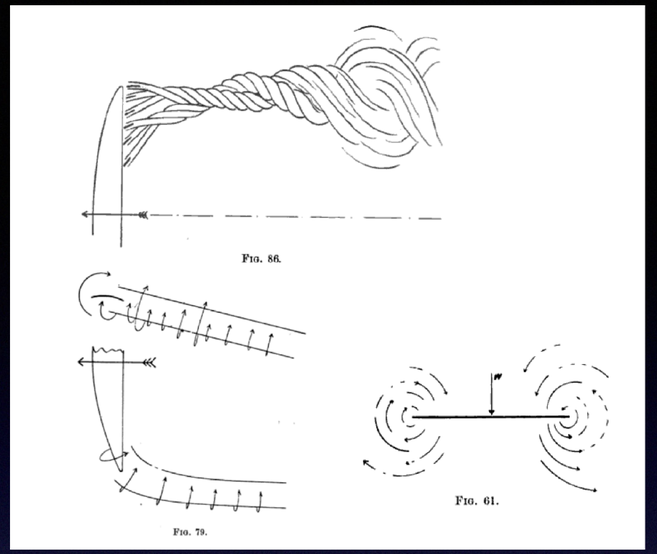
$L = \rho\Gamma v$

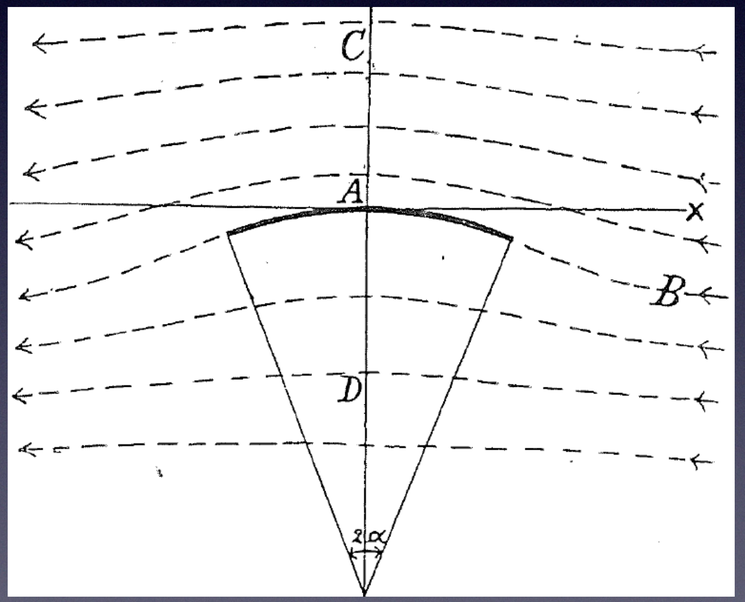
But:

$L \Rightarrow \rho\Gamma v$

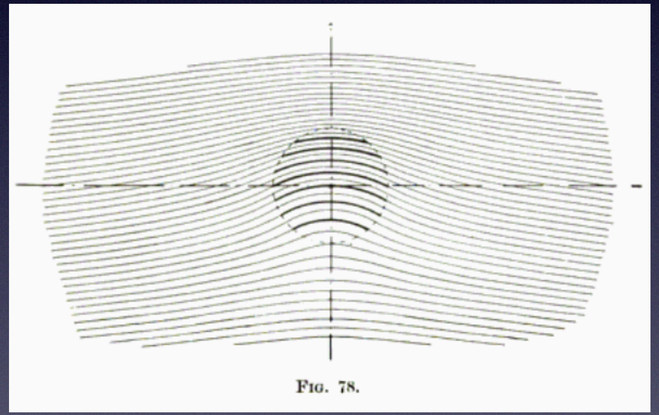


1894, 1897, published in 1907,
Frederick William Lanchester's
"supporting wave."
That's his superb wave theory of lift.

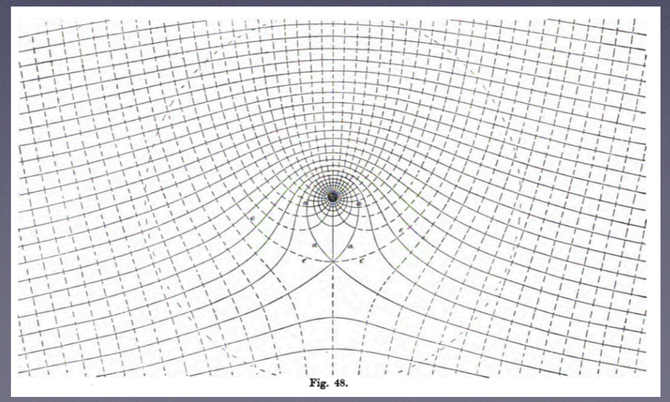




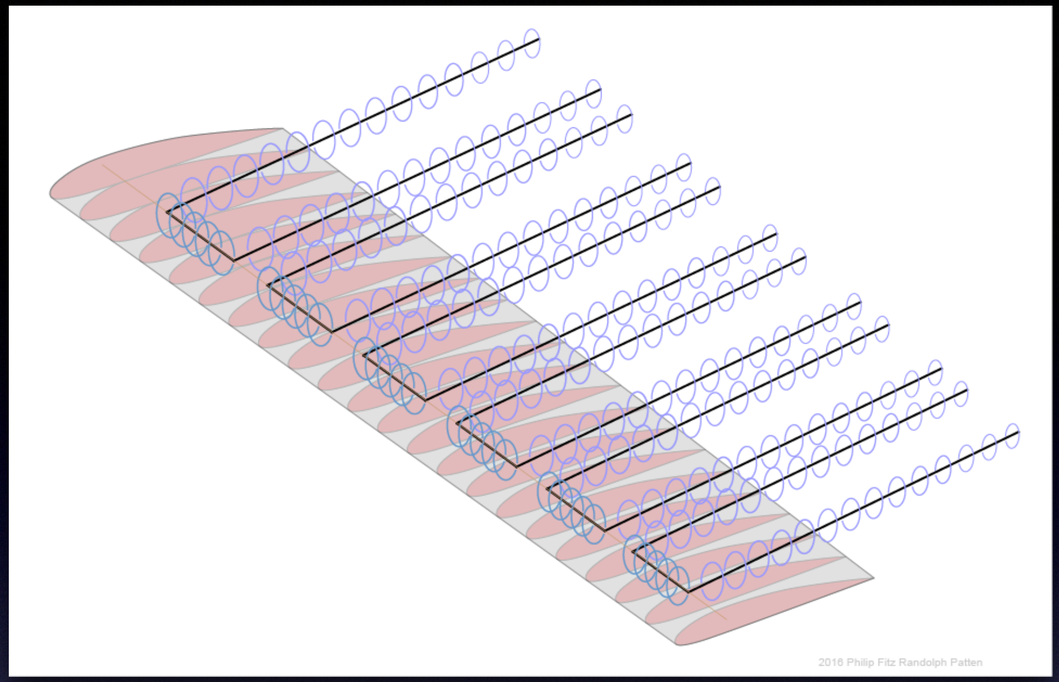
1902: Wilhelm Kutte uses a mathematical 'circulation' term to model the curve of flows over a 1/12 arc Lilienthal airfoil.
1910: Kutta says the concept of 'circulation around a wing' was Lanchester's.

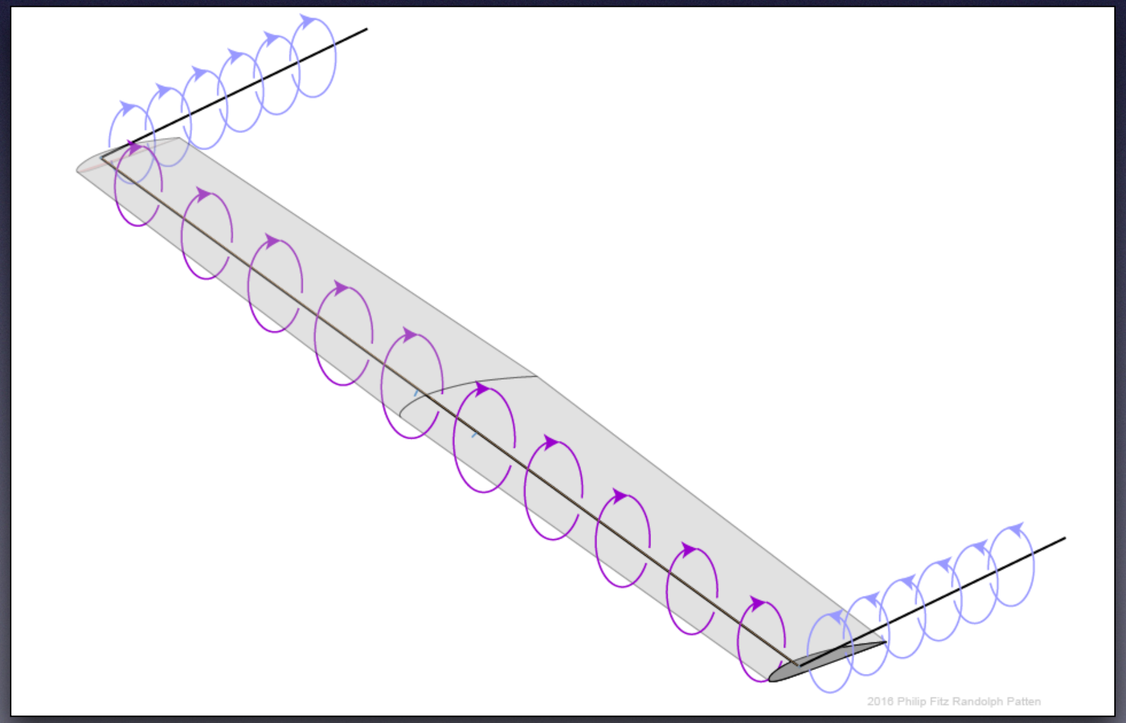


1908: Frederick William Lanchester shows Ludwig Prandtl diagrams of trailing vortices plus 'circulation' making the 'horseshoe vortex system. The lower diagrams are "superpositions" of circular flows on linear flows making lift.

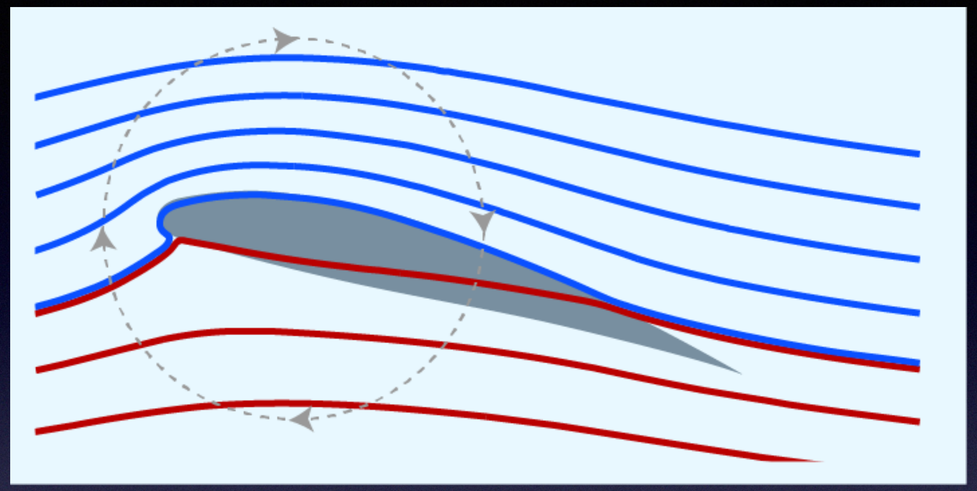


WWI years: Ludwig Prandtl develops Lanchester's 'horseshoe vortex system' into the dominant wing engineering methodology of the 20th century.



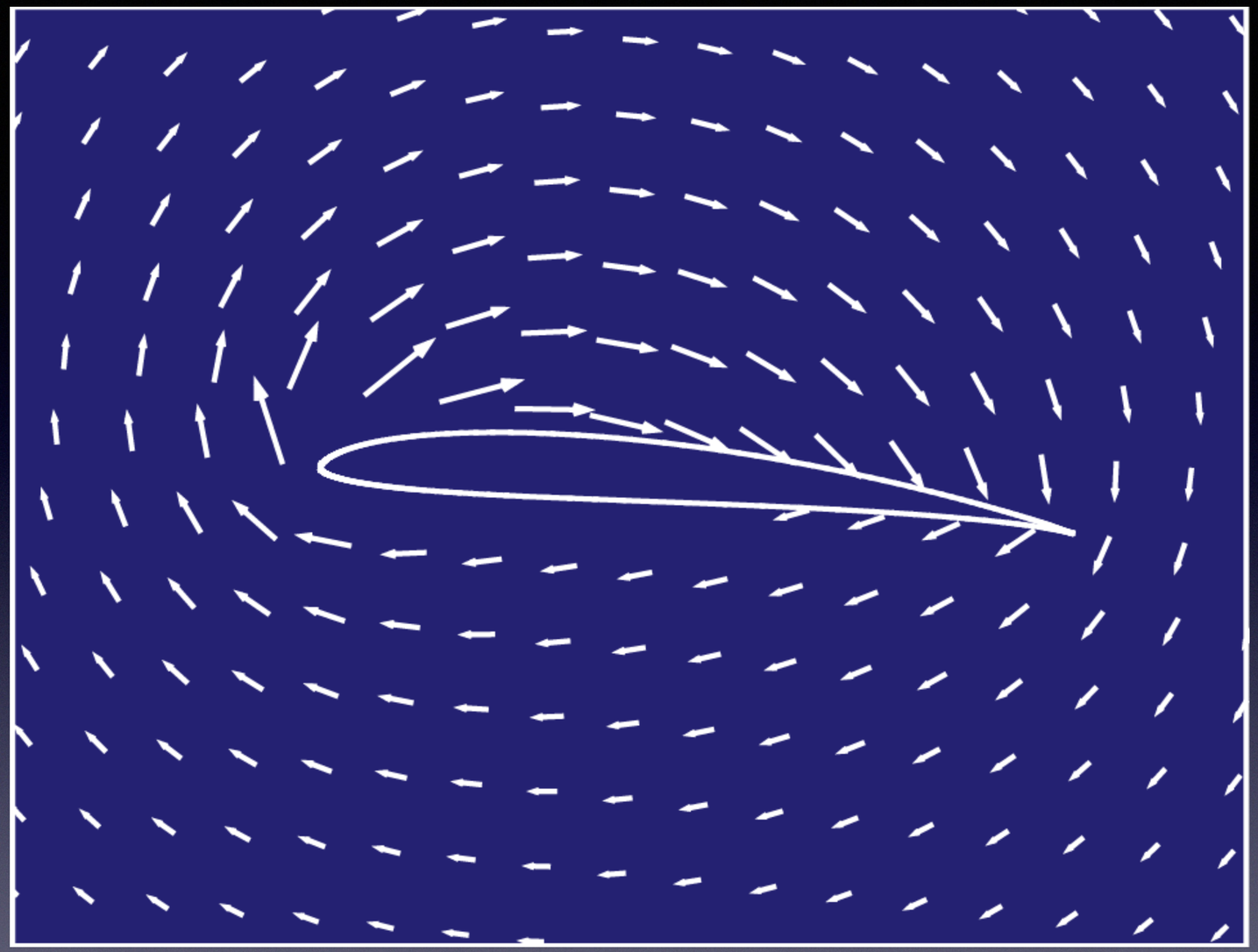


Early predictions of lift were about 25% high. So to get accurate results Germany's #2 aerodynamicist under Prandtl mathematically moved the rear stagnation point to forward and on top of the wing.



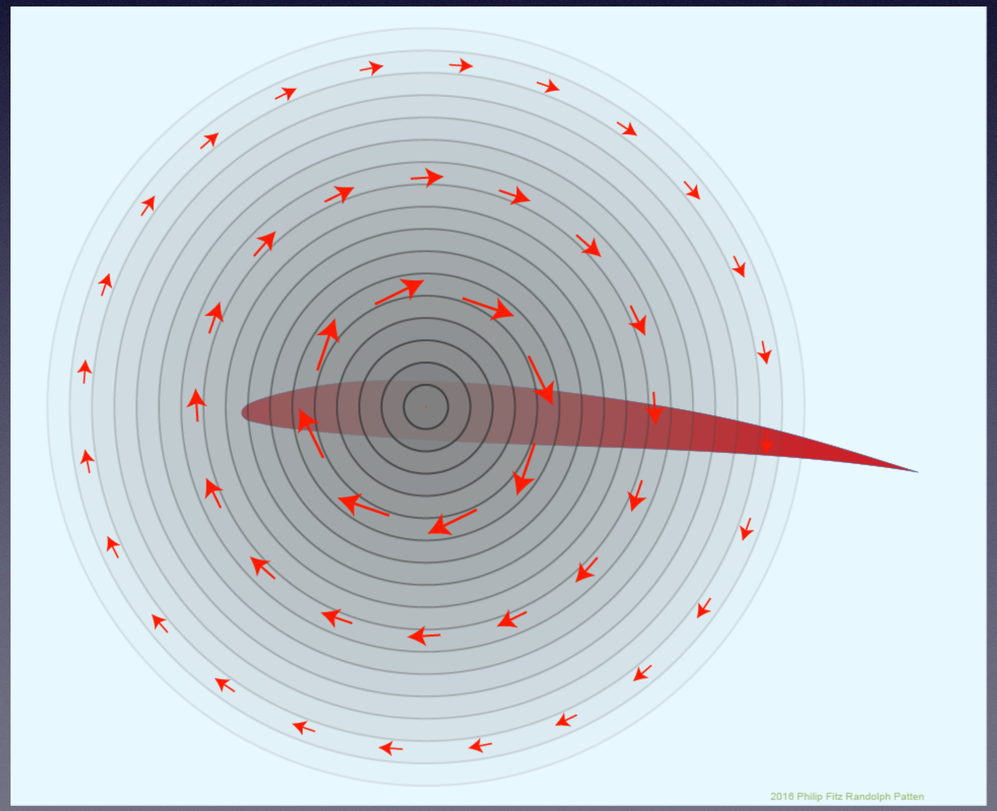
Since perfect fluid theory is known to be unrealistic from the outset, said Betz,
one more piece of unreality hardly matters. The entire approach [inviscid fluid, circulation] is an artifice…
–Albert Betz, 1915, from David Bloor's, *The Enigma of the Aerofoil: Rival Theories in Aerodynamics, 1909-1930.*

Predictions did get highly accurate.
But wing engineering methodologies are such a kluge of fictional ideal vortices, simplified models, approximations, wind tunnel calibrations, coefficients of lift and drag for similar shapes by Reynolds numbers, and a bit of physics, that it couldn't yield good explanations.
Good explanations come from qualitative interpretations of the pure physics equations of fluid dynamics.
Heisenberg principle of aerodynamics: You can't be quantitative and explanative at the same time.
That's quantitative aero engineering vs. explanative qualitative fluid science.



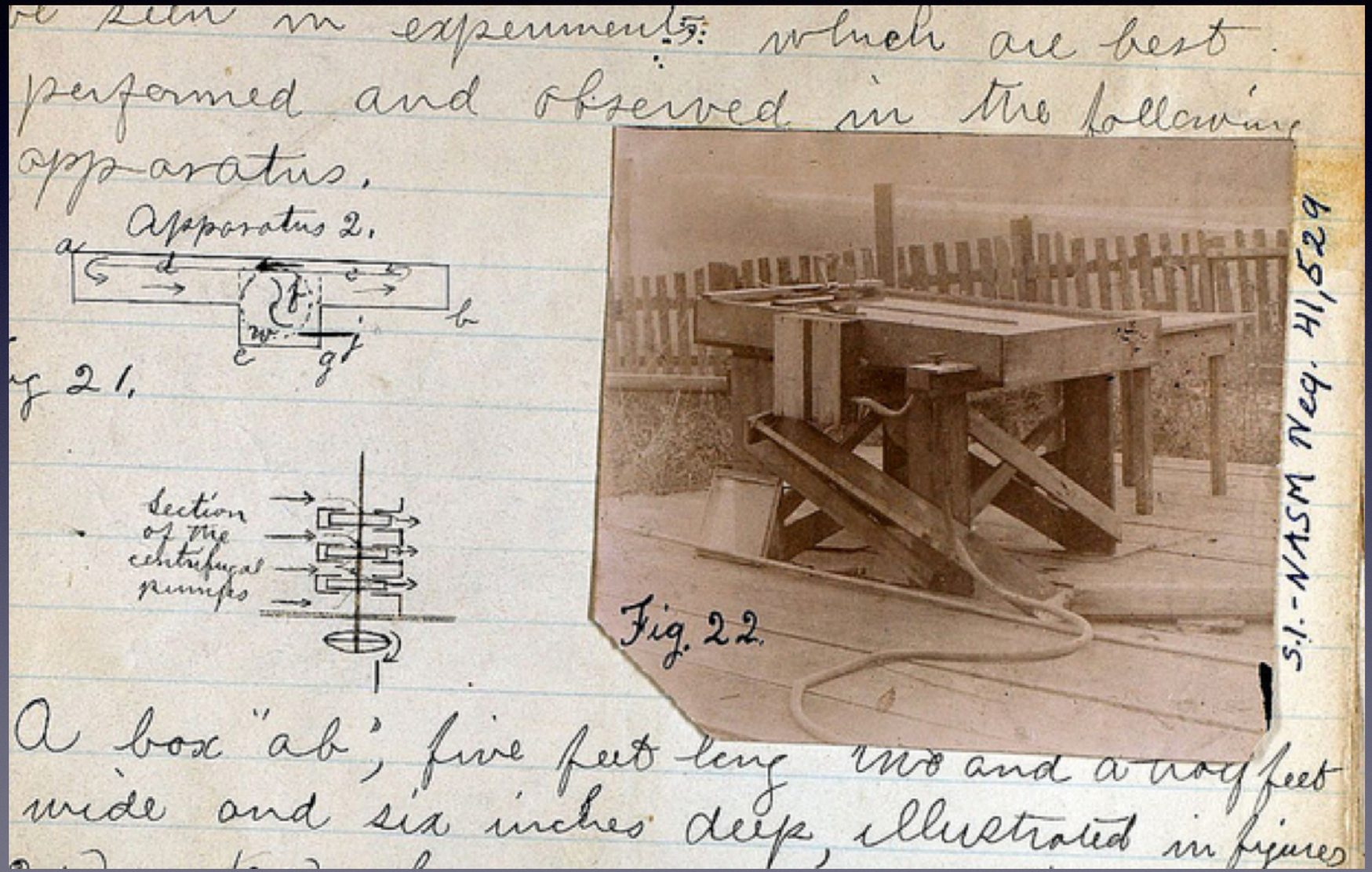
Intractable reality

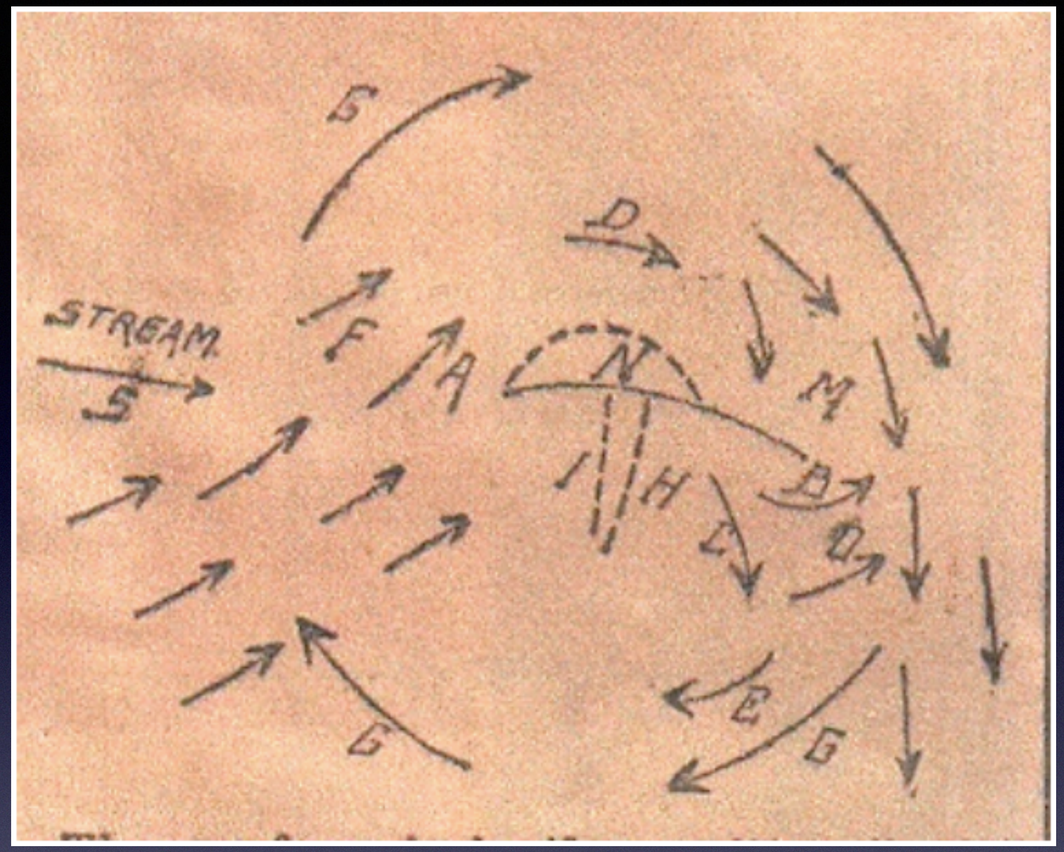
Tractable unreality!
Bogus simplified model that still works.
v = k/r
Why does this yield accurate results?



The pan of water experiment which showed why a false vortex model of ‘circulation’ could make good engineering results

John Jacob Montgomery’s ‘water table’

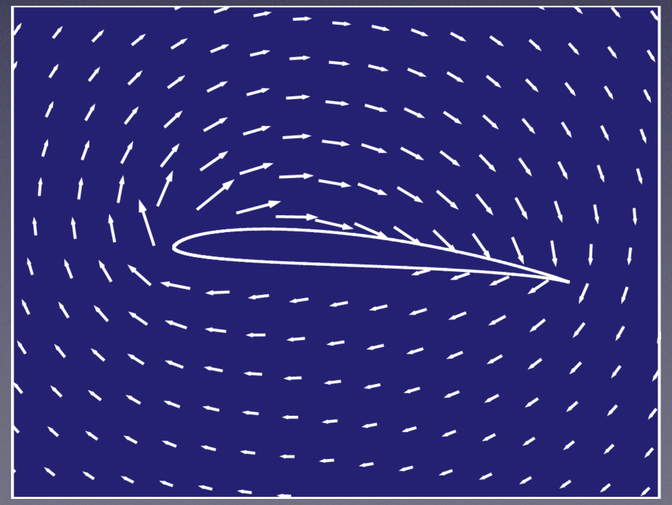


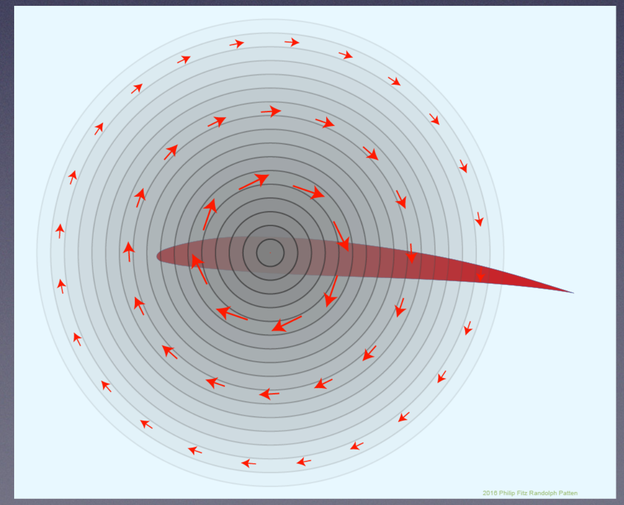


First experimental discovery of wing ‘circulation,’ by John Jacob Montgomery.
Published in the 1897 Los Angeles Herald and in 1905 in Scientific American.

Montgomery dragged an airfoil section across a pan of water, and suddenly removed it. A vortex formed with the same rotational angular momentum as the more complex flow field around the airfoil.

An ideal vortex, $v = k/r$, is mathematically simple and can approximately substitute for the intractably complex flow field around a wing as long as they have similar rotational angular momentums, circulation.’





But! Nobody listened to John Jacob Montgomery.
Besides, he was qualitative rather than quantitative.

The quantitative equivalent:

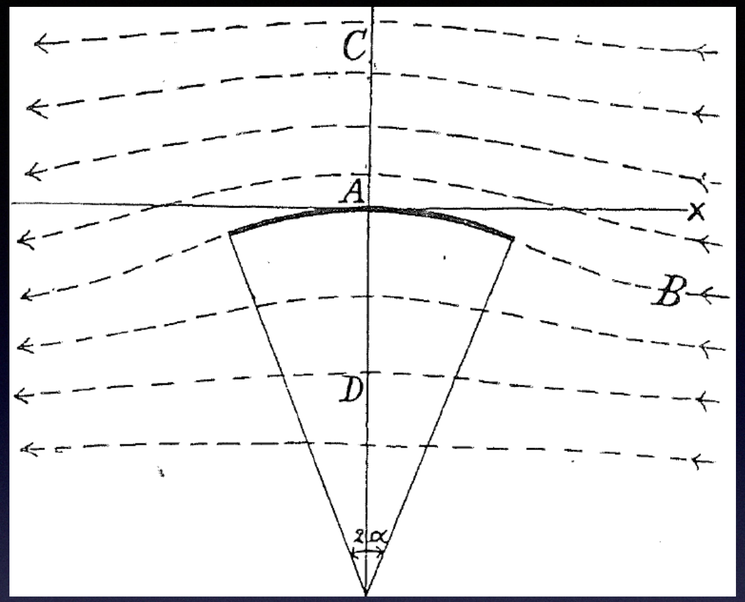
Wilhelm Kutte, 1902: The Kutta condition:

A correct value for ‘circulation’ is found when flows are mathematically determined to flow smoothly off the trailing edge. (Don’t they always?)

Kutta imposed a circulation term on a linear flow and drew an ‘airfoil’ that would conform.

Mathy. Formed the quantitative basis for ‘circulation lift.’

But the Kutta condition is less explanative than JJM’s pan-of-water experiment.



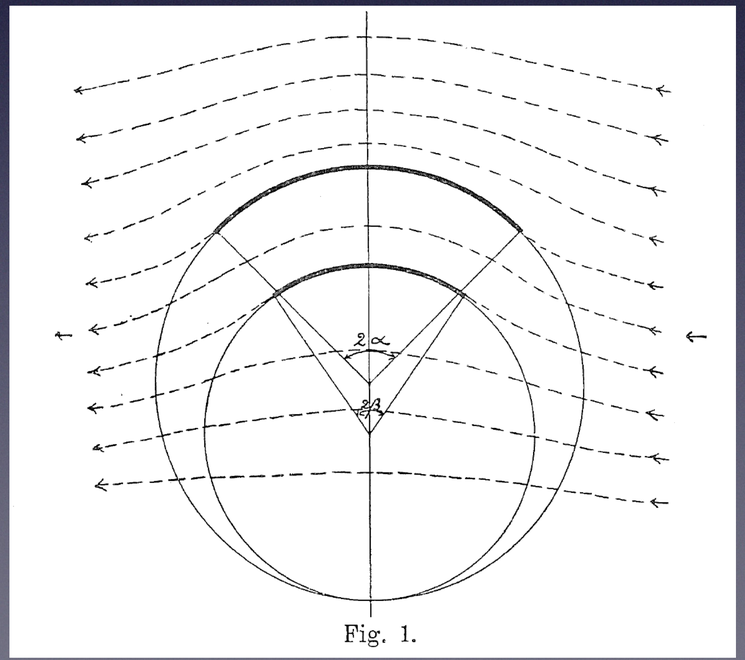


Fig. 1.

Centrifuging of pressure gradients makes lift.
Circulation doesn't make lift. Lift creates actual 'circulation.'
But what is centrifuging of pressure gradients?

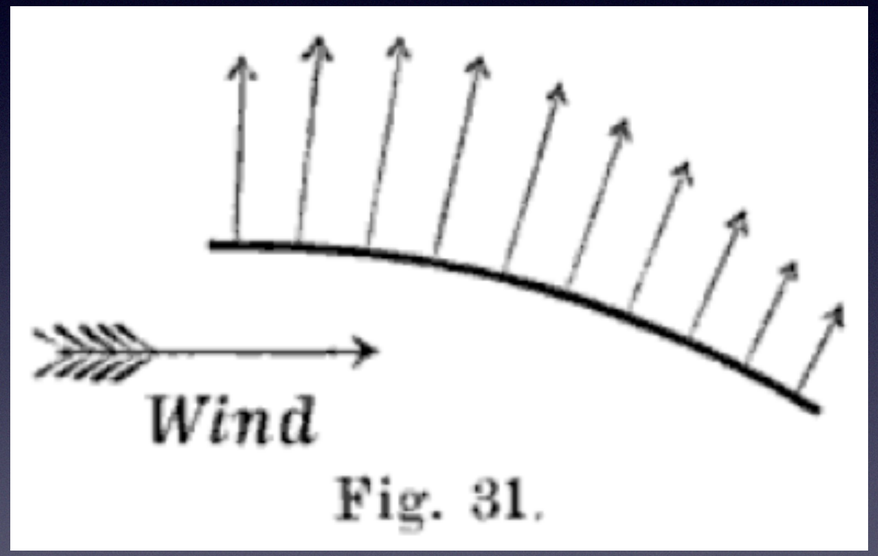


Fig. 31.

Otto Lilienthal, 1889, *Birdflight as the Basis of Aviation*

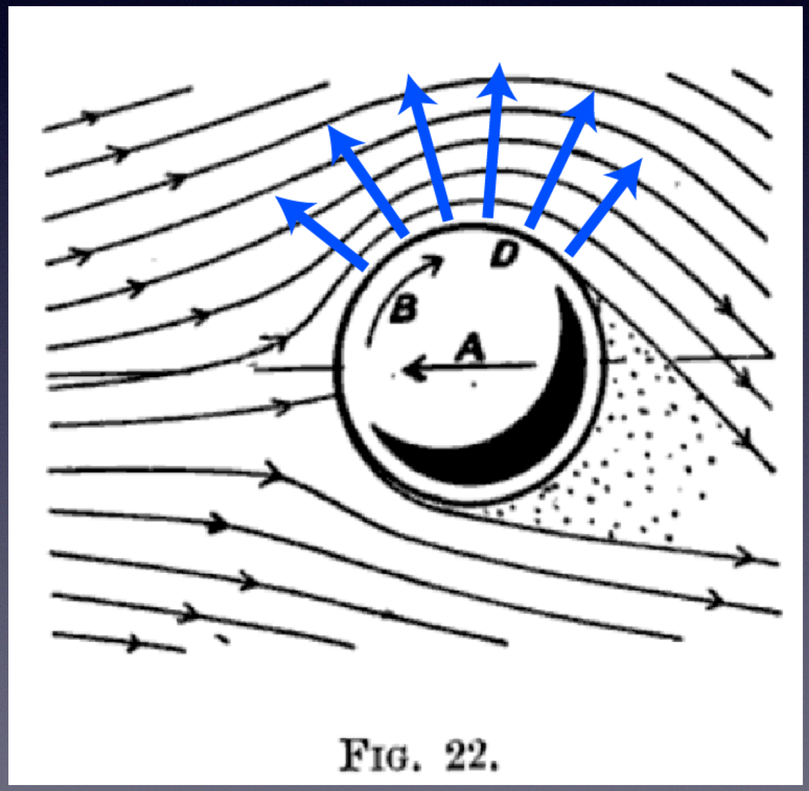


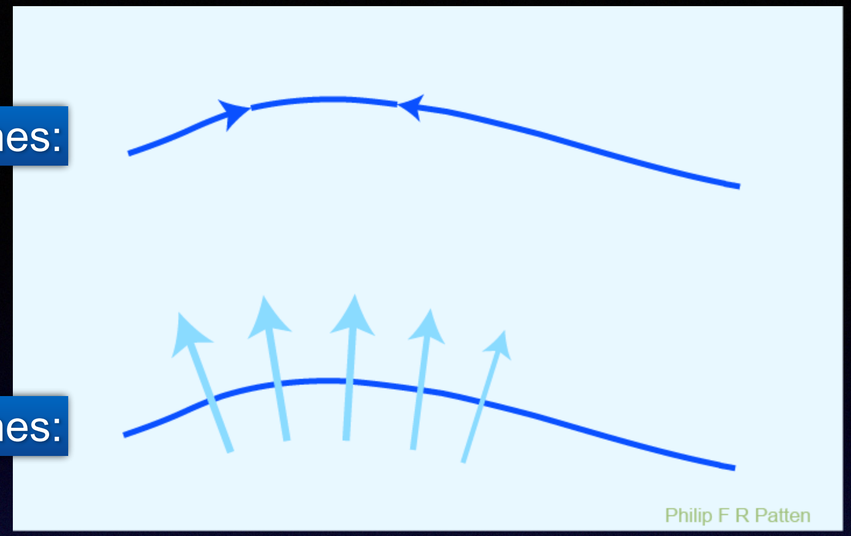
FIG. 22.

Frederick William Lanchester, 1907, *Aerodynamics*

1752, Leonhard Euler derives the fundamental inviscid equations of fluid dynamics.

It just said, “Forces happen in three dimensions:”

along streamlines:



across streamlines:

and sideways.

Simplest form:

$$\begin{cases} u\dfrac{\partial u}{\partial s} = -\dfrac{1}{\rho}\dfrac{\partial p}{\partial s} \\ \dfrac{u^2}{R} = -\dfrac{1}{\rho}\dfrac{\partial p}{\partial n} \\ 0 = -\dfrac{1}{\rho}\dfrac{\partial p}{\partial b} \end{cases}$$

along streamlines, pressures exchange for velocities — the Bernoulli equation

across streamlines, curving flows centrifuge pressure gradients

spanwise flows

Bernoulli equation

$\frac{1}{2}\rho v^2 + p = \text{constant}$

acausal form made trouble, useful

$(p_1 - p_2) \Rightarrow -\frac{1}{2}\rho (v_1^2 - v_2^2)$

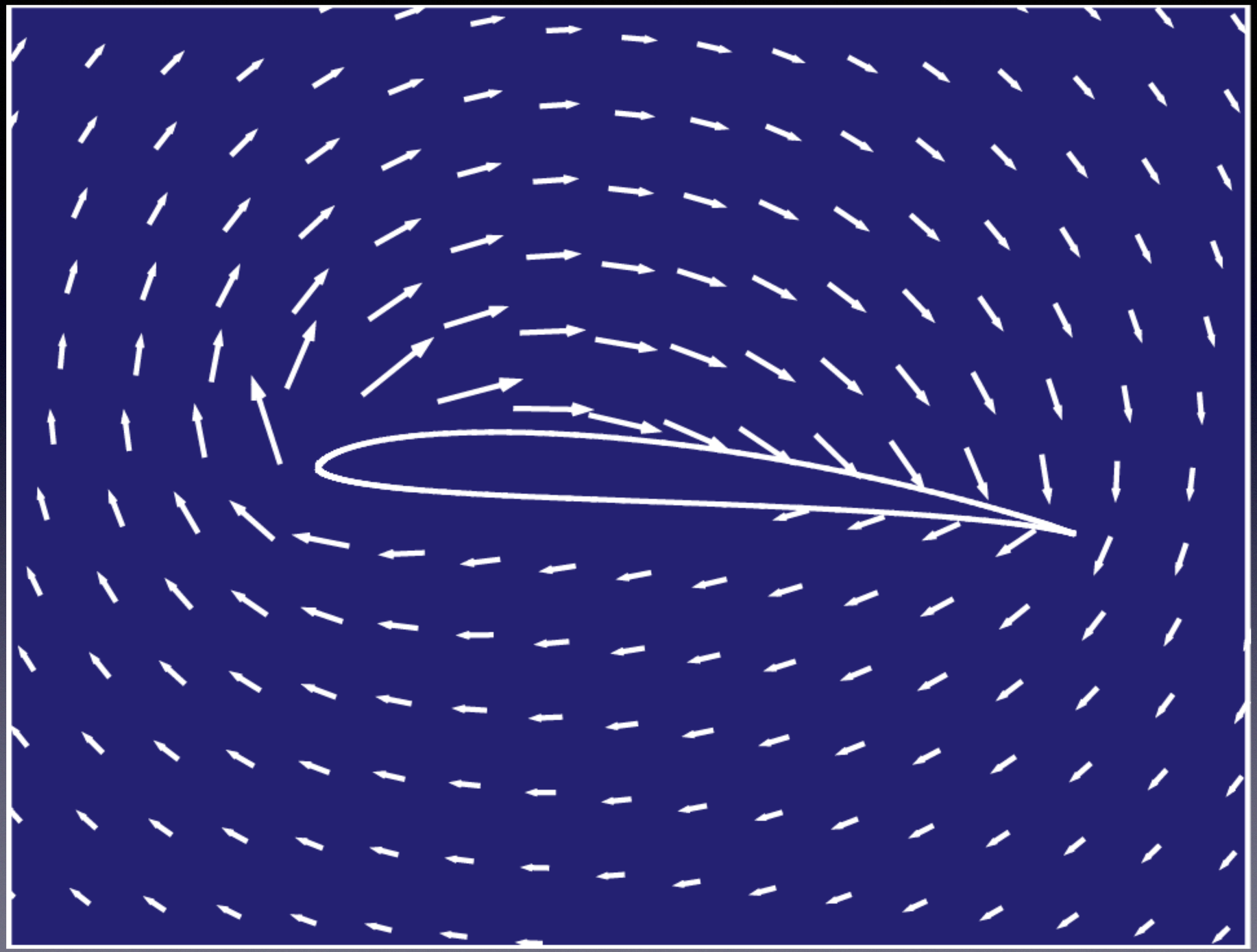
causal form

$dp/dz = \rho v^2/r$

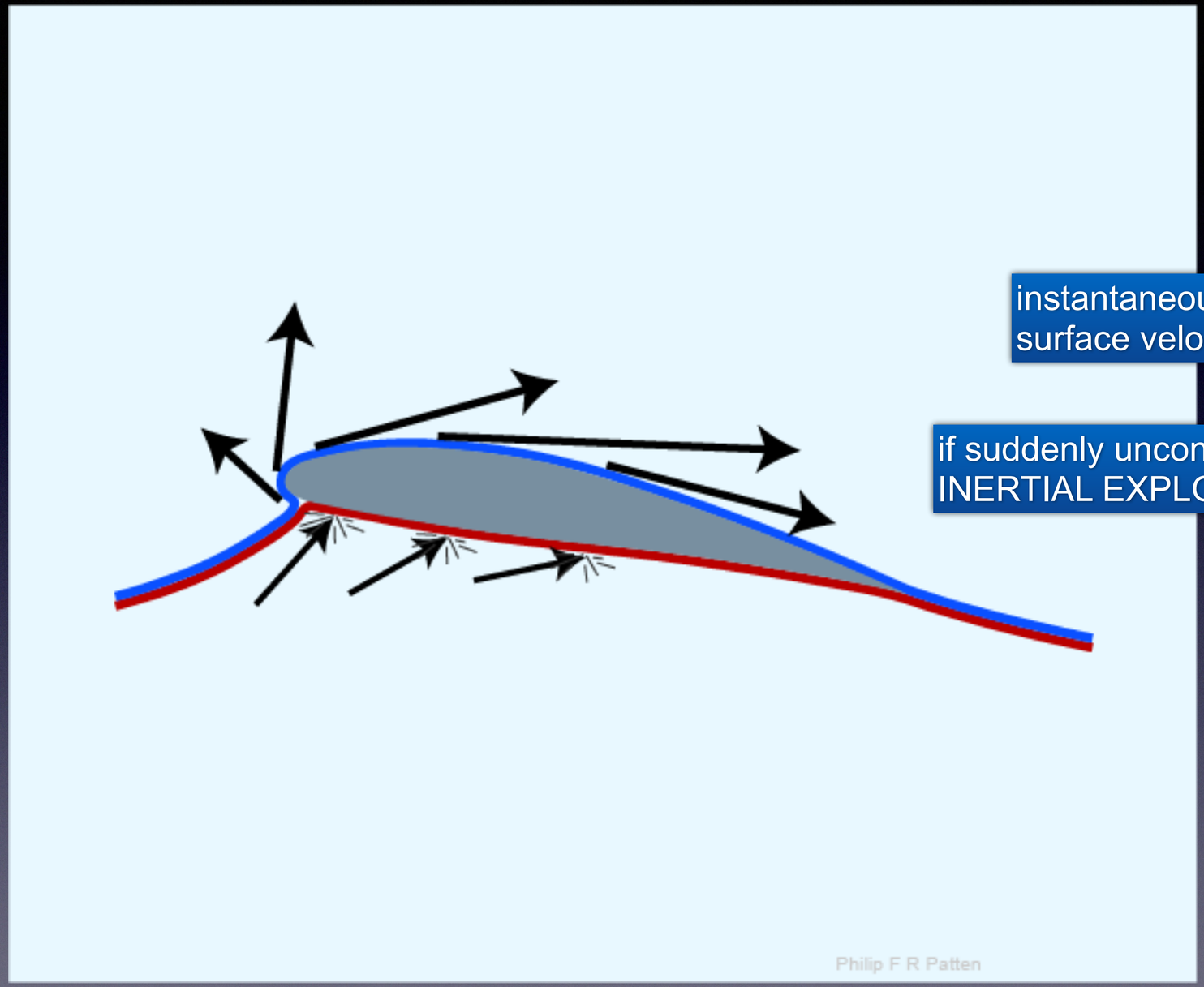
$\rho v^2/r \Rightarrow dp/dz$

- Simple centrifugal equation!
- The density and velocity of a curving flow centrifuge a pressure gradient across streamlines.
- Conceptually explanative!
- But it’s unsolvable for complex flow fields around objects that drag or lift.

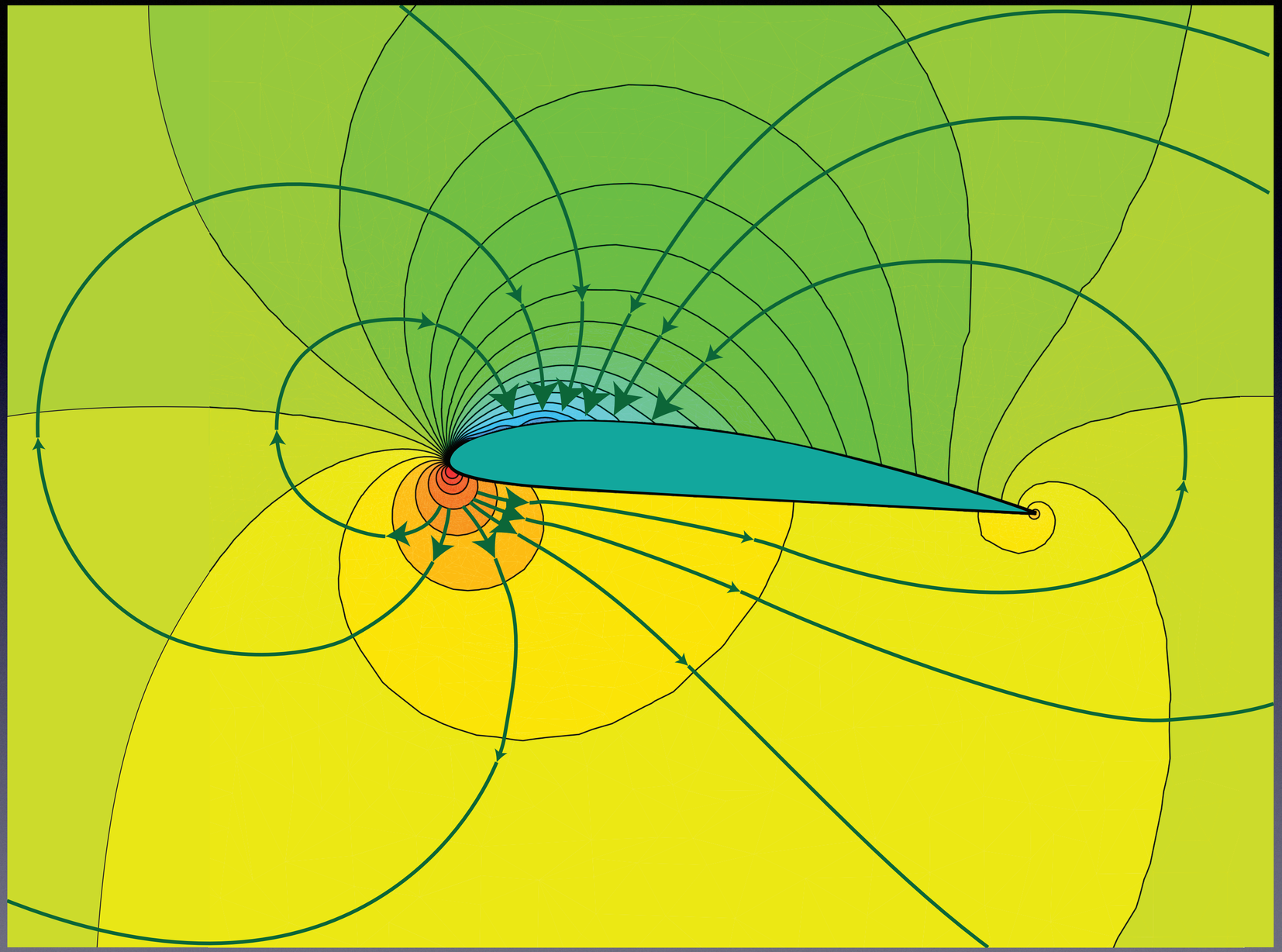
But Euler left out Newton’s viscosity!
1821 - 1845, Navier-Stokes equations just add that air is like very thin honey.

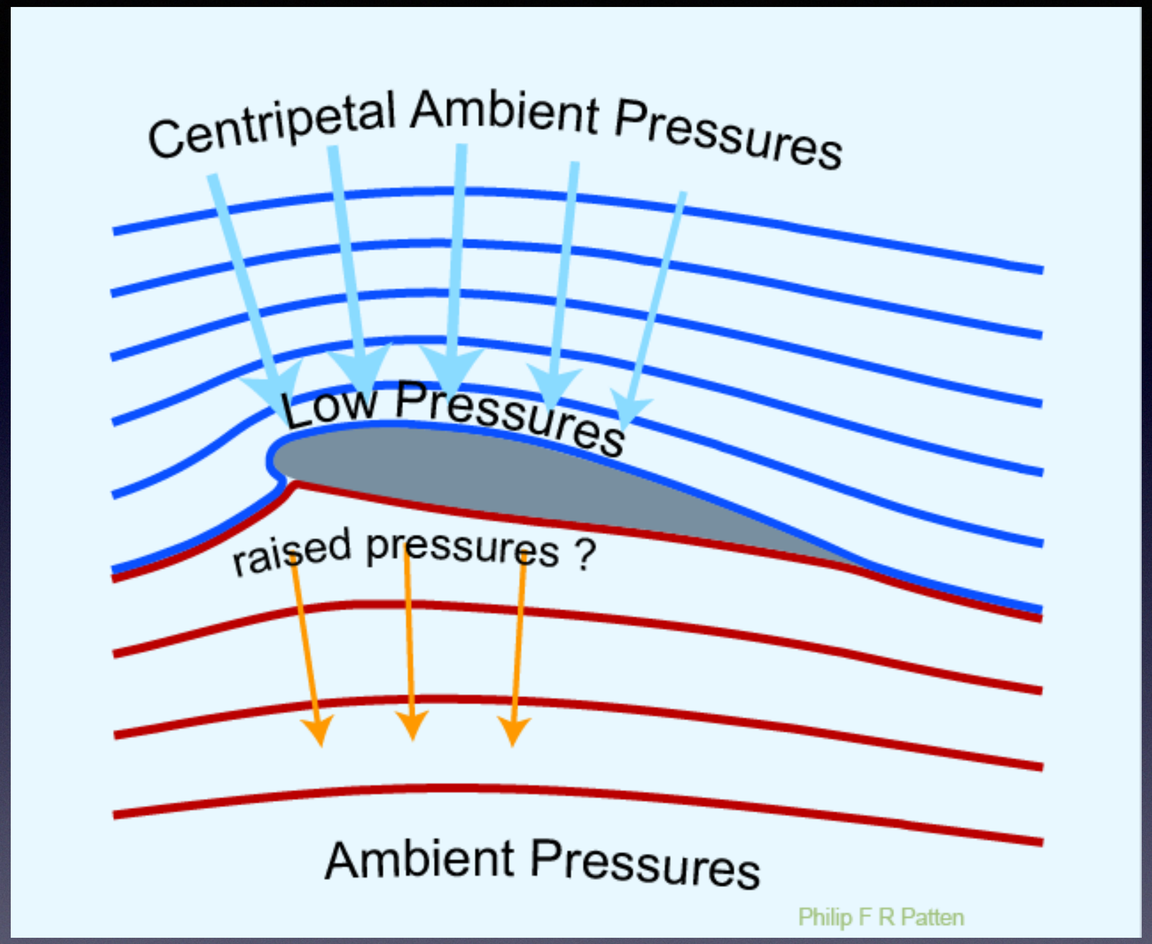


time-lapse movements within air (14.7 psi)



lower pressures are like stirred coffee piling up against the rim of your cup





14.7 psi bends streamlines down toward surface.

Pressure energy gets partly used in bending.

If it all gets used up overcoming flow inertia, that's cavitation.

So why does pressure get used up
bending flows downward
toward the wing's upper surface?

F = ma

m = F/a

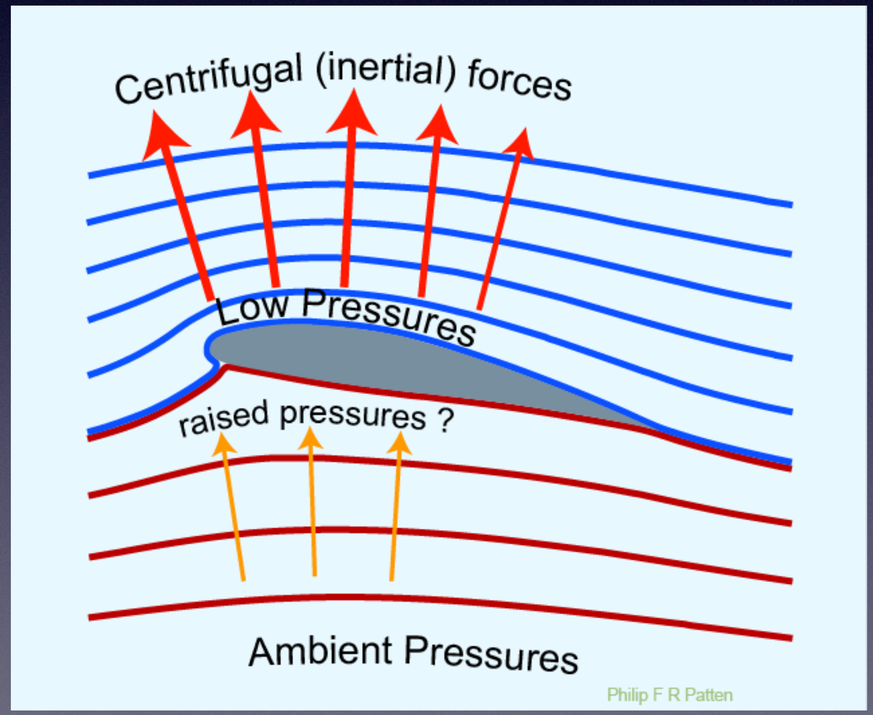
Mass is not matter. Mass is a property of matter.
Mass is the force required for acceleration.
Mass is inertia, quantified.

Inertia is the resistance of mass to acceleration.

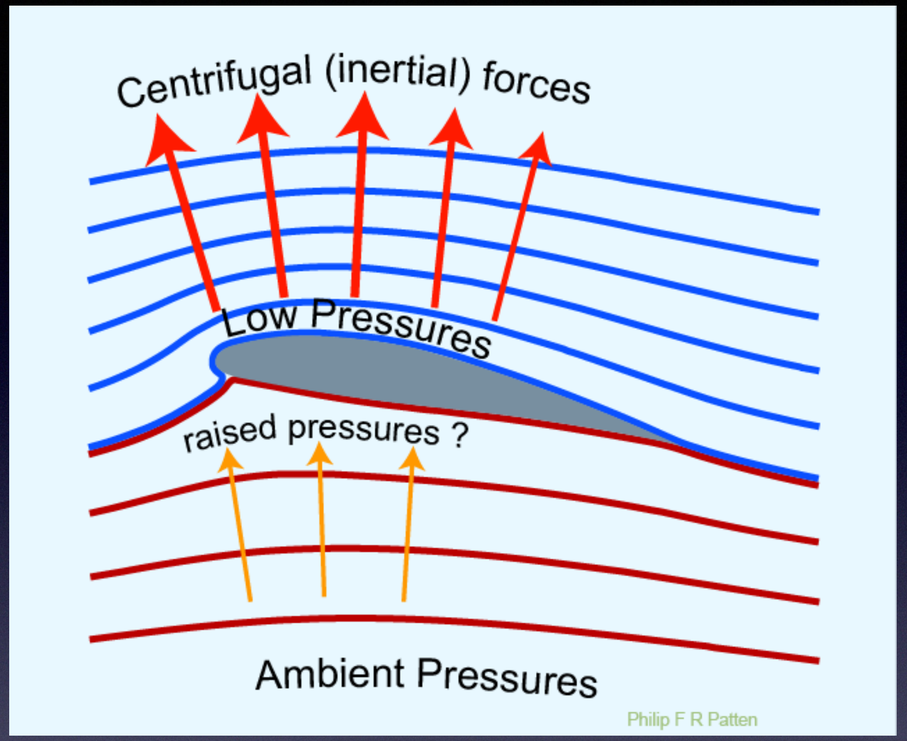
Flows inertially resist being bent by centripetal pressure forces.
So it takes force to bend them.
Force x the distance of bending is Work, energy.
Pressure energy is used in bending flows.

The inertial resistance in a curving pattern
to centripetal forces (in their curving pattern)
is centrifuging.

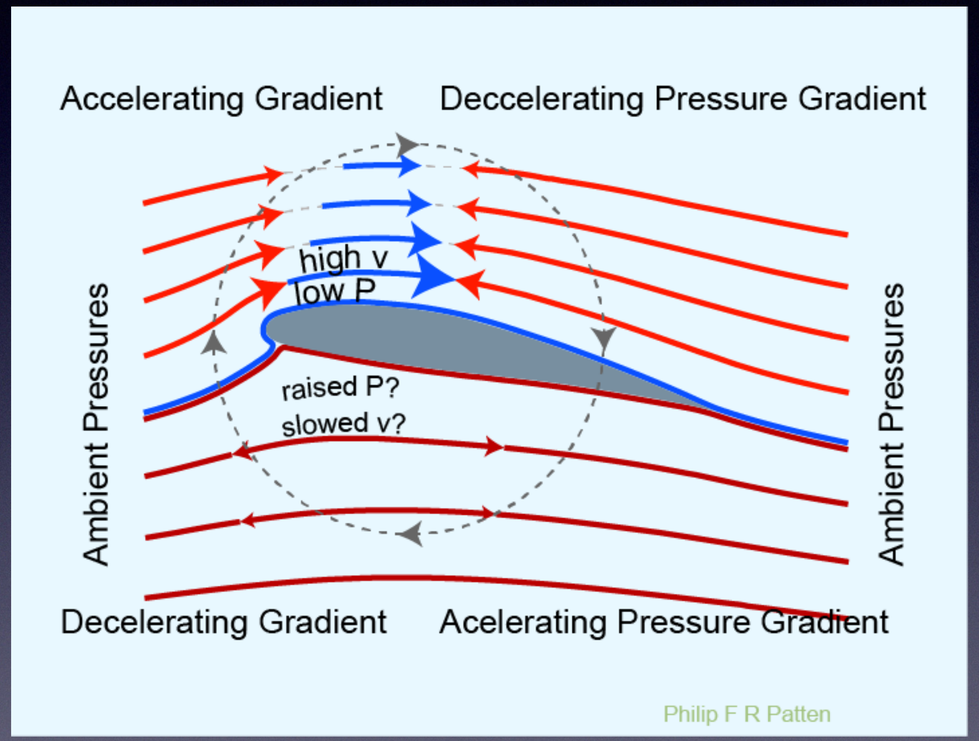
Lift is from the centrifuging of pressure gradients.



Centrifuged lift makes circulation.

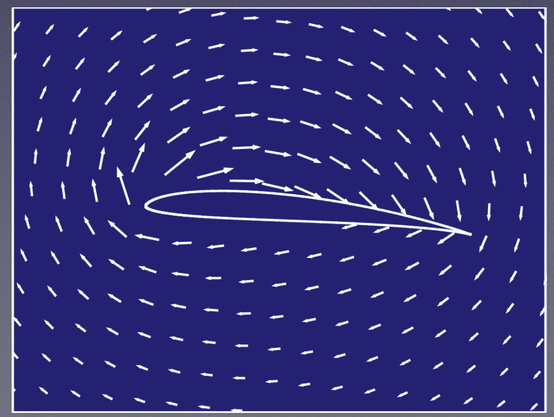


Causally first: centrifugal lift!
creates local pressures.
That makes pressure gradients
along streamlines:



Causally second: Pressure gradients along streamlines create velocities along streamlines.
That's the Bernoulli exchange of pressures for velocities.

⇒



Quantitatively unsolvable!

$$\begin{cases} u\dfrac{\partial u}{\partial s} = -\dfrac{1}{\rho}\dfrac{\partial p}{\partial s} \\ \dfrac{u^2}{R} = -\dfrac{1}{\rho}\dfrac{\partial p}{\partial n} \\ 0 = -\dfrac{1}{\rho}\dfrac{\partial p}{\partial b} \end{cases}$$

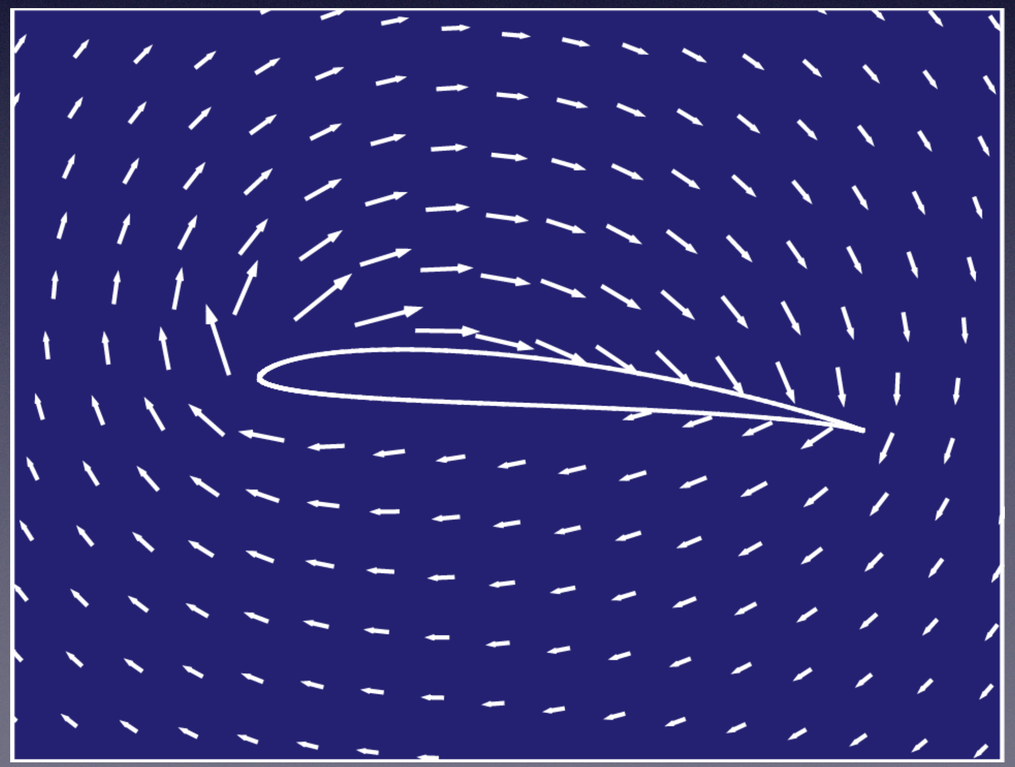
across streamlines, curving flows centrifuge pressure gradients

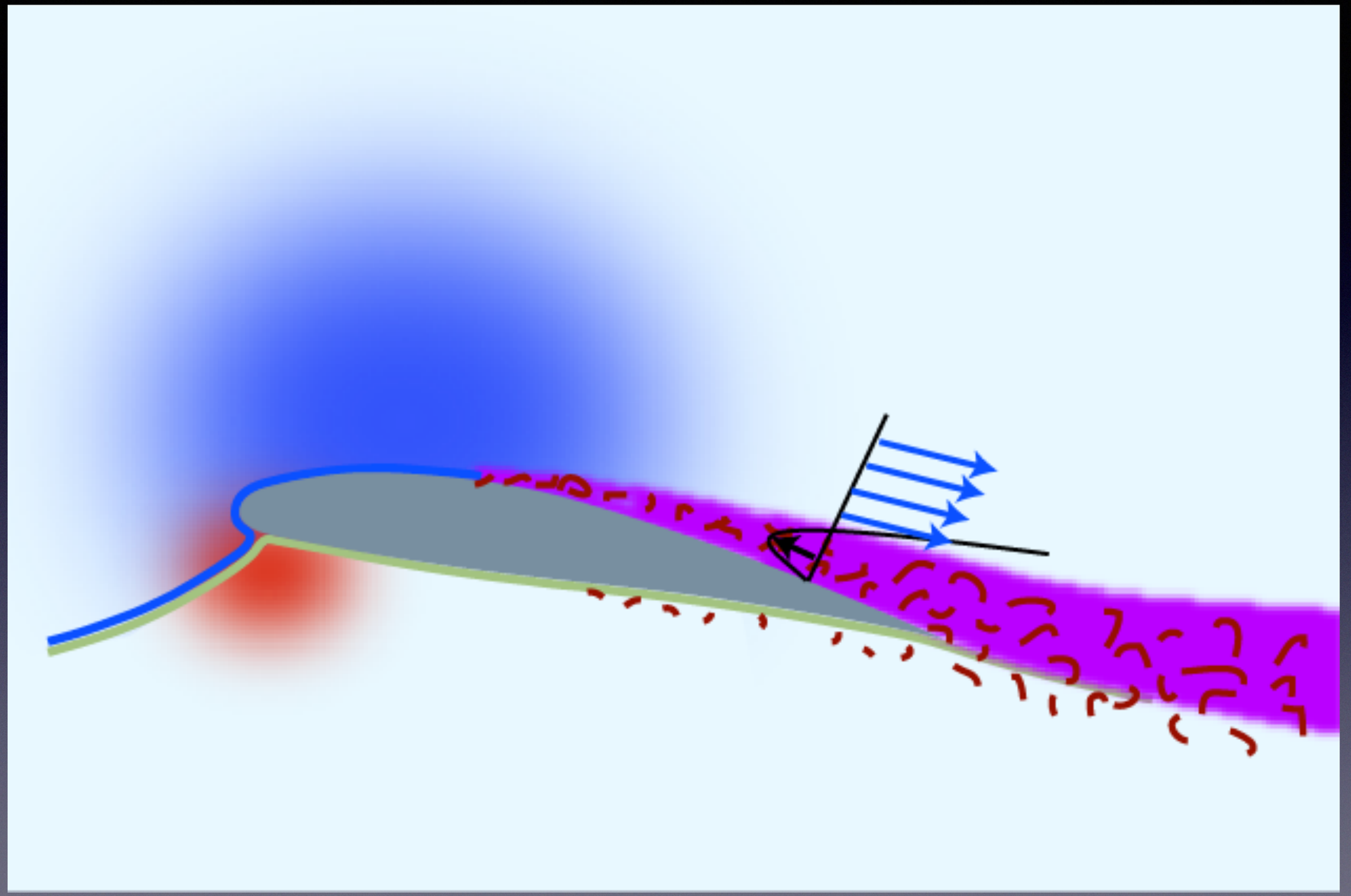
Euler centrifugal pressure gradient equation, 1752!

$dp/dz = \rho v^2/r$

$\rho v^2/r \Rightarrow dp/dz$

for complex flow fields





Viscosity, bother