Bernoulli’s Principal in Action

Team 3rd

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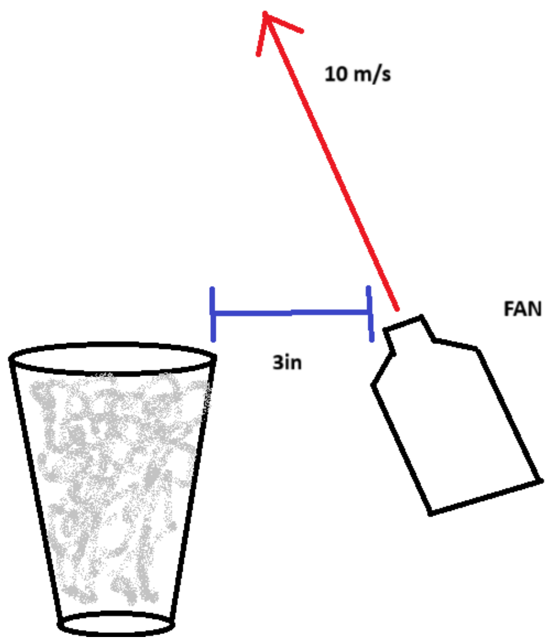
This image's purpose was to visualize how high velocity flow causes a Bernoulli driven pressure drop in the flow that draws in surrounding air. This was done by using stagnant incense smoke that is more dense than air, with a fan positioned to the side of the cup to avoid any direct flow, revealing how a localized low pressure region can draw fluid from nearby. The final image shown in this report captures this event cleanly with a black background to highlight the motion of the smoke.



The flow apparatus consisted of a incense bulb suspended above a clear glass, which was then filled with the dense incense smoke that then stayed stagnant in the class. Once the glass was filled the incense bulb was removed slowly to avoid any air currents that could move the smoke. The glass was around 36 inches tall and 3 inches wide. Then an air fan with a nozzle on it was positioned 3 inches away from the glass pointed upward and a slight angle. It was also level with the top of the glass. The fan with a half inch nozzle diameter emits a flow at around 10 m/s. Once the fan is turned on the high velocity air creates a Bernoulli driven low pressure gradient around the high velocity air, [1]. This pressure gradient then slowly pulls the smoke upward and toward the high velocity air even though it is not in the direct path of the air. The smoke rising out of the glass got shaped into thin filaments that thinned out as they got further from the glass, eventually defusing as they hit the high velocity air. The smoke also seemed to have a slight spiraling action as it got pulled into the stream which has been an observed phenomena with this type of scenario.

Bernoulli equation for pressure drop

$P+½*\rho*v^2+\rho*g*h$ = Constant
$P_1+½*\rho*v_1^2 = P_2+½*\rho*v_2^2$
P_2= 84 kPa (atmospheric pressure at 5,000 feet)
ρ= 1.06 kg/m^3 (room temperature air density)
v_1= 10 m/s (velocity from fan)
v_2= 0 m/s
P_1= unknown (pressure in the high velocity stream)

$P_1+½*\rho*v_1^2 = P_2$
$P_1+ ½*1.06*10^2 = 84,000$
P_1= 83,947 Pa

From this equation of Bernoulli's Principal, ignoring the height difference and assuming a constant air density we see that the fan’s high velocity stream causes a small pressure difference of 53 Pa. This pressure difference is quite small compared to the atmospheric pressure but still creates a pressure gradient strong enough to slowly pull the smoke out of the glass.

Insert Renolds number here

$Re= U*D/\nu$
U= .2 m/s (estimated velocity of smoke)
D= 0.09m (diameter of cup)
ν= $1.5*10^{-5}$ (kinematic viscosity of air)

$Re= (.2)*(0.09)/(1.5*10^{-5})$
Re= 1200

This Renolds number is in the transitional range, which is consistent with the smooth coherent smoke filaments seen in the image, as the smoke gets closer to the stream the Renolds number grows to be turbulent with the higher velocity which causes the smoke to diffuse quickly which is also seen in the image.

The visualization technique is using incense smoke as a tracer for the air currents. A incense bulb that is used for falling smoke fountains was used since this smoke is more dense than air which allowed us to contain the smoke in a glass, and show that there is a force causing an upward movement stronger than the density difference between the smoke and air. The lightning in this setup consisted of a small amount of overhead light from the room and a stronger camera flash. Using a black cloth as a background helped highlight the white smoke and the flash brought more detail in the smoke. The image uses black level correction with some area exposure mapping to darken the background and emphasize the lighter smoke.

This photo was taken with a Canon EOS Rebel T3i

Focal Length: 18 mm
Aperture: f/5.0
ISO: 400
Edited image resolution: 3429x2576
Unedited image resolution: 5202x3464
Edited image size: 9x9 in
Unedited image size: 18x12 in
Camera distance: 12 in

The final image successfully captures the smoke as it's pulled from the glass toward the high velocity air from the fan. I like how the smoke rises in thin smooth strands that show the laminar pulling action that the pressure gradient causes. I wonder if the upward movement is also slightly caused by a viscous force in the air and how much that factors in. The dark black background allows us to focus in these flow physics. One limitation of this image is that the smoke gets faint the further it gets from the glass, missing out on a laminar to turbulent flow transition. At this transition, at the boundary layer there tends to be spiral flows due to the Kelvin-Helmholtz instability Kelvin-Helmholtz instability [2]. This part of the flow would have been very interesting to capture. The intent of this project was to demonstrate the Bernoulli driven attraction of smoke into a fast moving air flow, which was clearly shown in the image, and it shows some more forces that could be at work.

In the future I would use an enclosed box to block external flows. I would also like to find a way to make a larger amount of high density smoke that won't flair up my asthma.

Appendix

Original Image

References

[1] "Bernoulli's Equation," Glenn Research Center | NASA. Accessed: Nov. 30, 2025. [Online]. Available: https://www1.grc.nasa.gov/beginners-guide-to-aeronautics/bernoullis-equation/

[2] N. Sharp, "Smoke Flow Viz," FYFD. Accessed: Nov. 30, 2025. [Online]. Available: https://fyfluiddynamics.com/2012/02/smoke-visualization-illuminated-by-a-laser-sheet/?utm_source=chatgpt.com