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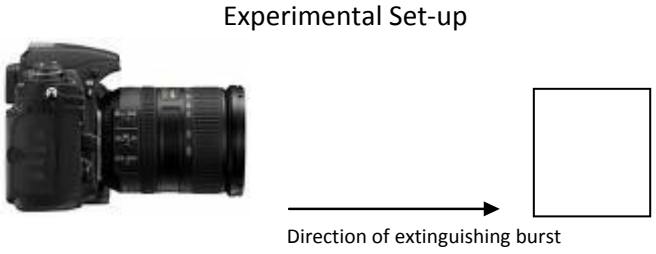
3/1/2009

Group Project 2:
Laminar Flow of Smoke from a Candle

This image was done independently for group project 2. The group had difficulty finding a meeting time so everyone worked independently. This image was meant to show molecular diffusion, especially close to a source of pollution. Several pictures were taken, however this image yielded the most aesthetically pleasing result. Different candles were used, as were different lighting conditions. A small fan was also used to manipulate air flow in many of the unused image.



The observed flow is the result of a candle small household candle being extinguished as gently as possible by blowing parallel to the camera's point of view. The basic flow is molecular diffusion of smoke particles in an open flow room. There are no outside forces on the flow, there was no driving motion by a fan or likewise. The candle is approximately 2.5 inches in diameter. The flow shown was driven by temperature gradients and governed by the ideal gas law, as well as Fick's law of molecular diffusion(1):

$$F = -n_a D \frac{\partial C}{\partial z}$$

F= molecular diffusion flux, na is moles of contaminant, D=molecular diffusion coefficient (cm^2/s), dC is change in concentration and dz is change in height from source

Fick's Law is generally applied in atmospheric measurements, however works on small scales as well. Because the motion is driven by temperature differences (the rising of hot air, falling of cooler) the ideal gas law applies. The stochastic (random) process of diffusion of the smoke can be modeled described by Brownian motion (2) – although this image shows more laminar flow than chaotic, turbulent for which Brownian motion is famous.

Smoke was captured off a wax candle. The air was made as stagnant as possible for the capturing of this photo. The only lighting came from the camera's flash – black cloth was hung behind and under the subject to dull outh any aftereffects and reflection. The flash was on auto, no strobe return detection using red eye reduction. Photoshop was used to increase contrast, using the curves function.

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Camera Info:

Make	Cannon
Model	Cannon Powershot A1000 IS
ISO	80
F Stop	f/3.5
Expose Time	1/60 sec
Focal Length	6.2 mm
Dimensions	3648x2736
Distance from Lens to Object	18 inches
Field of View	3x5 inches

The image effectively reveals laminar flow coming off a source of pollution. I really like the candle, it's a very interesting image with all the melt that has occurred. On that note, I appreciate dust on the candle, which along with the condition of the gives the appearance of age. I love that you can see the shadow of the smoke on the background, but not the shadow of the candle itself as well. For observing how the smoke leaves the candle initially, the image is very effective – however for examinaning the overall behavior of the dispersion, the photo is lacking in height. The makeshift studio used only allowed for so much height and to get the interesting subject, I had to sacrifice getting a view of the overall dispersion. I would like to increase the height and fully track the smoke until dispersal is no longer noticeable.

References:

(1) Jacob, Daniel J. Introduction to Atmospheric Chemistry. Princeton University Press. 1999. P 67
(2) http://en.wikipedia.org/wiki/Brownian_motion