Interactive Visual Report 3 - MCEN 5151

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1 Initial and Final Photos

Figure 1: Unedited Photo

Figure 2: Processed Image

2 Background

Above is a man, slowly engulfed in a paint emulsion as he is surrounded by, frankly, overgrown hands. A melancholic expression sits upon his visage - perhaps an expression of ennui, as if being surrounded by a paint cloud is no novel event for him. Whatever the case, this image was a fun experimentation of setting and color. With a needle (sourced from a diabetic), a syringe, some paint, a fish tank, the figurines, and a dream, we created a display which both managed to capture a partial truth of the human condition, and some beautiful flow effects. While I can try analyze and define our

subject's expression of discontent, I will likely make it further attempting to describe the flow pictured. I will leave the green man in his suit of despair, and instead inspect his hat of paint.

3 Physics of the Flow

As I am sure you have never seen before, I will attempt to calculate the Reynolds number of the orange paint in this image. Truly the most useful dimensionless number, the Reynolds number will help the reader characterize this (obviously turbulent) flow.

To begin, we will look at the equation to calculate Reynolds number:

$$\mathrm{Re} = \frac{\rho v d}{\mu} = \frac{v d}{\upsilon} \tag{1}$$

Where ρ is the density, v is the velocity of the flow, d is the characteristic length-scale of the flow, and μ is the kinematic viscosity. As seen above, the dynamic viscosity υ can be used in order to eliminate the density from the equation. Looking at multiple images, side by side, the velocity of the flow can be calculated first. Between two images in my camera's memory, a chosen point on the fluid moves an estimated $0.005\,\mathrm{m}$. With a shutter speed of $\frac{1}{500}$, it can be calculated that the fluid has a speed of:

$$v = \frac{0.005\,\mathrm{m}}{0.002\,\mathrm{s}} = 2.5\,\mathrm{m\,s^{-1}}$$

Equipped with the speed of this flow, we are oh-so close to calculating the all-important number of Reynold. Next, we will find the density, and decide the characteristic length-scale. After consulting the all-mighty internet...

Alright, my search turned up fruitless. I am going to rely on some tactful guesswork to come up with a value for ρ. While the paint itself was a fair bit denser than water, it was mixed with a hearty amount of water before it was shot into the, well, water. So, this being considered, I decree $\rho \approx 1100\,\mathrm{kg/m^3}$.

With this *formidable* barrier overcome, we are on the highway to Reynolds-Number-Ville. While I am already in the business of determining whatever parameters I see fit, I might as well decide that the dynamic length scale d is roughly $0.025\,\mathrm{m}$

Lastly, the viscosity is estimated to be nearly 1.3 times that of water at 20 degrees Celsius. If the reader would like to know why, consult the paragraph above. For now, $\mu = 1.3 * (0.000\,001\,\mathrm{m^2/s})$.

Finally, we may calculate our all important number:

$$\mathrm{Re} = \frac{1100\,\mathrm{kg/m^3} \cdot 0.025\,\mathrm{m} \cdot 2.5\,\mathrm{m\,s^{-1}}}{0.000\,001\,3\,\mathrm{m^2/s}} = 5200000 \tag{2}$$

This is well within the turbulent region, as to be expected. That is all the analysis I will put forwards. I will do the field of fluid dynamics no more injustice in this paper.

4 Experiment Setup

This experiment notably requires a fish tank, a syringe, some paint, and an odd assortment of figurines. It helps to own a camera, as well. Lastly, it might help to have access to water. Any extra lighting will also prove beneficial. The tank was filled with water, and the figurines were placed in a *desirable* pattern within the tank. Mix the paint with some water until it is nearly the consistency of the water itself.

With our lenses pointed at the figure of contagious despair, a teammate shot ink over his head. From there, it was a mere matter of capturing the best shot. We repeated the process a number of times until the desired effect was reached. A high ISO and fast shutter speed was essential for capturing the clarity and crisp vorticies of the paint. This was a relatively easy experiment to set up.

5 Photographic Technique

The basic specifications and camera settings are listed in the table below. The shutter speed was kept high in tandem with the ISO. This was in an effort to minimize the motion blur of the paint.

Camera Setting	**Value**
Aperture	f/5.6
Exposure Time (s)	1/2000 = .0005
ISO	3200
Raw Resolution (Width x Height)	6000 x 4000
Camera/Lens Model	Canon Rebel T1i, Sigma 18-250mm f/6.5
Distance From Object to Lens (m)	1m
Lens Focal Length (mm)	78mm

Calculation can be done to calculate the field of view of the camera. The 35mm equivalent of the Canon T1i can be calculated knowing the focal length, sensor size, and aperture used. The 35mm focal equivalent of the Canon at that focal length was 128mm. The sensor on the Canon Rebel T1i has dimensions of 22.3×14.9mm, with a sensor diagonal width of nearly 26.8mm. Knowing this information, the horizontal angle of view can be calculated even though there is no direct way to determine a length-scale from information in the image.

$$\text{Horizontal Angle of View} = 2\arctan\left(\frac{\text{Sensor Size}}{2 \cdot \text{Focal Length}}\right) = 12^\circ$$

Knowing this angle, coupled with the distance from the camera to the plane of focus ($d \approx 1\,\text{m}$), the field of view can be calculated as well:

$$\text{Horizontal Field of View} = 2\tan\left(\frac{\text{Horizontal Angle of View}}{2}\right) \times d \approx 0.21\,\text{m}$$

And thus ends my calculation for this section. I think all of these values are correct, if not close? I guess there is some level of credence the viewer must find within the paper, and the magnitude of said truth is dependant upon the person, rather than the paper itself. Why try? The Nihilists were right.

Let's speak to the processing. The image was quite dark, and quite grainy. From it's RAW format, I messed with the RBG curve until I found a pleasing brightness. I also applied a denoising and demosaicing filter to the image, in order to reduce some of the artifacts created by the high ISO.

6 Intended Image Ideals, and the Inevitable Shortcomings

Whether it was good or bad, we have done a job determining the flow surrounding our depressed friend. I think most of my discontent with this image is a product of the technology I own and nothing else. I would require a camera with a nicer sensor, a higher ISO, and a faster shutter speed to eliminate my issues with the image. I had quite a bit of fun making this image, and props to my peers for helping put the experiment together. Thank you for once again tolerating a paper wrought with my idiocy. Goodnight, and God bless America.