Seth Dry – Team First Report

MCEN 5151 September 23rd, 2025

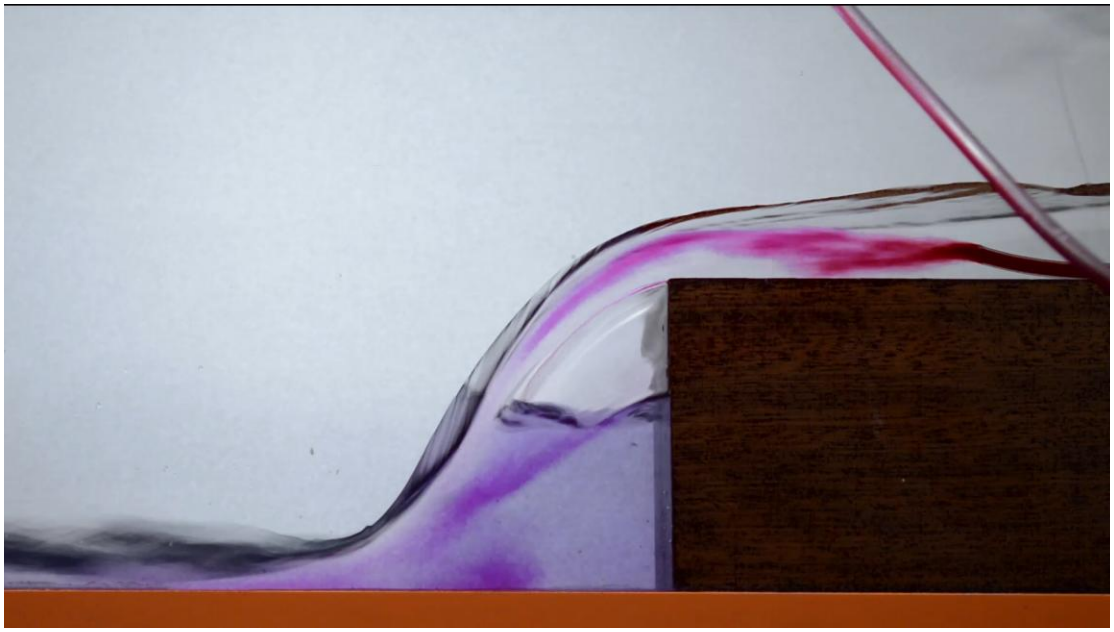

Figure 1 – Still from Final Video

For this second flow visualization assignment I worked with my groupmates Haiying Peng and Iker Acha to create a video showing the flow of water over a weir and the resulting flow phenomena as the water falls over the weir. We used the flume in the CU Boulder ITLL campus lab to create this flow and all three of us helped each other with various aspects of setting up and videographing the flows created in the flume. My intent with this video was to capture the vortex that forms at the downstream base of a weir, which is visible in the final video. I also wanted the visualization to be striking, and for the swirling of the downstream vortex to be the focal point of the image. I think this was moderately successful, the dye was a useful and striking visualization tool, but the diffusion of the dye into the flow did not bring as much focus as I would have liked to the vortex. I am pleased with both the clear visualization of my chosen flow phenomena, as well as the aesthetic quality of the final video.

"A weir is a small dam built across a river to control the upstream water level. Weirs have been used for ages to control the flow of water in streams, rivers, and other water bodies" [What is a Weir, 2019]. The flow over weirs is a long studied and interesting phenomenon, that this visualization modeled in the small scale. In addition to controlling water levels in rivers, weirs can also be used as an effective flow measurement device. The head height over the top of the weir can be correlated to a volumetric flow rate. From Sadegh (2017) the equation for volumetric flow over a rectangular weir is as follows:

$$Q = \frac{2}{3} C L_a \sqrt{2g} h_a^{\frac{3}{2}}$$

Where:

Q = Volumetric Flow Rate

C = Discharge Coefficient

L_a = Adjusted Crest Length, $L_a = L_w + \Delta L$

L_w = Crest Length

g = acceleration due to gravity

h_a = Adjusted Weir Head, $h_a = h + .003$ ft.

h = head height above weir

The variables as applicable to this weir flow are listed in the table below. The head height above the weir was computed using a still frame from the image, where a pixel measurement was made of water above the weir and compared to the known height of the weir. C and ΔL are from Sadegh (2017) Table 1.3.15.

Variable	Value
C	.6215
L_w	.25 ft
ΔL	-.005
L_a	.245 ft
g	32.174 ft/s^2
h	.0775 ft
h_a	.0805 ft

Using these values we get:

$$Q = \left(\frac{2}{3}\right)(.6215)(.245)\left(\sqrt{(2)(32.174)}\right)\left((.0805)^{\frac{3}{2}}\right)$$

$$Q = .0186\ \frac{\text{ft}^3}{\text{s}}$$

This flow rate seems very reasonable for the size of channel we were using during the visualization, and demonstrates how with a very simple device, fairly accurate flow measurements can be made. These measurements are widely used in agriculture and resource management across the world to control water flows.

To capture this video of water over a weir we used the Armfield C4-MKII Multi-Purpose Teaching Flume owned by the CU Boulder ITLL. This device is designed to create repeatable open channel flows and demonstrate the corresponding fluid phenomena. Figure 2 below shows two views of the device while in use.

Figure 2 – Flume

The flume was operated using 0 slope and the maximum flow rate, which is controlled by a valve between the pump and outlet. The obstacle used was a rectangular weir (not shown in figure X) that measured 4 inches high, 3 inchers wide and 13 ¾ inched long with a 90 degree downstream edge. The flume channel was 3 inches wide and 9 7/8 inches deep. To capture the photograph, we attached a white sheet of paper behind the flow area of interest, which was backlit by a desk lamp, the remaining light came from the fluorescent room lights.

Once the appropriate weir was placed in the flume and the flow had reached a steady state, we injected dye into the flume above the weir, you can see the dye injection point in figure 1. The dye was first mixed using a ratio of about ½ bottle of food dye to 60 ml of water. The dye was then drawn into a 60 ml syringe with a length of surgical tubing attached to the end to allow more precise dye placement in the flow. The loaded syringe is shown below in figure X. Using dye to delineate the flow is a particle tracking technique where the mass of dye particles follows the flow, which allows us to see where the flow goes as it passes over the flume. There is also an interesting effect where, as the dye loses concentration, we can see the flow splitting. This is especially prevalent in the vortex where we can see the dye become less intense as the flow is split between the downstream direction and the flow pocket.

Figure 3 – Dye Syringe

The final video was taken using a Nikon model D3200 DSLR camera with a 55mm lens. The field of view of the video is about 14 inches, and the camera is 2.4 feet away from the subject. Using 400 ISO and given the available light, I had easy control over the exposure and chose to use aperture priority mode to set the aperture at f/5.6 which gave an acceptable depth of field for this flow phenomena. This then necessitated a shutter speed of 1/60th of a second which resulted in a final video with no discernable blur. The video was shot at a resolution of 1920x1080 px with a framerate of 30 frames per second. The final video was processed using Davinci Resolve. There is no cropping done to the final video, so the resolution is the same in the final product as listed above. The major change that was made was to clip the video to a length of 13 seconds, down from 58 seconds. This clip shows only the period where there is dye and therefore flow visibility. Otherwise, I used the color correction tools in DaVinci Resolve to increase the saturation of red hues and decrease the saturation of blue hues to give the dye greater contrast to the white background which had blue tones. Figure 4 below shows a still from the unedited video.

Figure 4 – Unedited Frame

All in all, I am very happy with how this flow visualization turned out. I like how the final video gives a good sense of what is happening as water passes over a weir, while still being visually interesting. Weirs are an engineering device that are extremely common, but infrequently visible, and I think shedding some light on this device and its usefulness is a worthwhile endeavor. Even with this simple setup we can see how weirs are able to control and measure flow through an interesting visualization and subsequent calculations.

References

"What is a Weir?," Practical Engineering. Accessed: Oct. 02, 2025. [Online]. Available: https://practical.engineering/blog/2019/3/9/what-is-a-weir

Sadegh, Ali M., and William M. Worek, editors. *Marks' Standard Handbook for Mechanical Engineers, 12th Edition*. McGraw-Hill Education, 2017.