The Dam Break

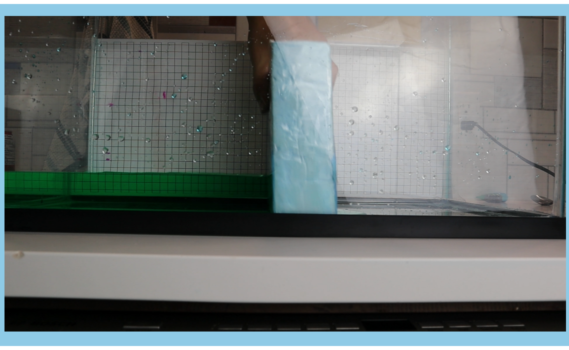
Note: This is not a full project, just the outline of an idea. Use it as a starting point, but go further, be more complete and careful.
You're expected to do your own literature search on the topic.
Ask questions, find the answers.

Description: A dam holds back water at a certain height but "breaks" instantaneously. The resulting flow can be described using the shallow-water equations and both the height $h(t)$ and fluid speed can be found under that approximation. In this experiment you reproduce a dam break, trace the height of the water as it flows out, and compare with theory. How close does it approximate reality?

References: P. K. Stansby, A. Chegini, and T. C. D. Barnes, *Journal of Fluid Mechanics*, Vol. 374, 1998; J. D. MacMillan, *Introduction to Fluid Dynamics*, §6.3, 2022.

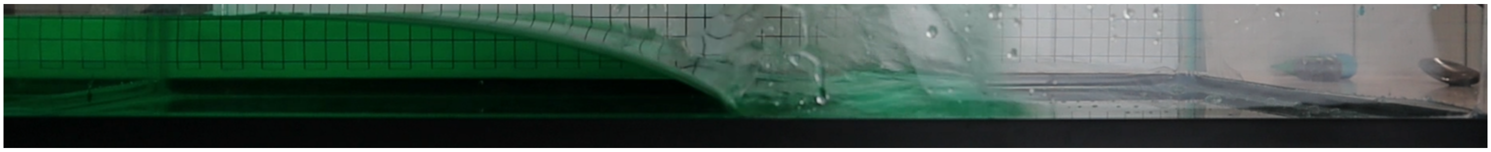
Suggested Materials

Large aquarium tank (or similar)
Material for the dam "wall"
Food colouring
Camera (high speed preferable, but a smart phone will do)
Software to trace curves on video frames (e.g., *WebPlotDigitizer*)



Basic Analysis: The "dam" was removed by quickly pulling up on the barrier, allowing the water (green in the photograph above and below) to flow to the right. The height of the initial water h_0 was measured with a ruler, and the flow was recorded and individual frames were analysed. According to the shallow-water approximation, the height of the surface is given by the equation on the right; this is plotted as the blue region in Figure 1. The surface was traced out by an online plot digitizer and this data is shown as the red line in the figure.

$$h(x,t) = \begin{cases} h_0, & x < -\sqrt{gh_0}t \\ \frac{1}{g}\left[\frac{2}{3}\sqrt{gh_0} - \frac{x}{3t}\right]^2, & -\sqrt{gh_0}t < x < 2\sqrt{gh_0}t \\ 0, & x > 2\sqrt{gh_0}t, \end{cases}$$



Further Work

There are numerous things you can do to extend this basic work; in particular, my analysis was not particularly careful and measurements should be more precise. In addition, can you measure the horizontal velocity u, which is also predicted by theory? Are there variants to the dam break problem that you can replicate? How does changing the depth affect the results? Can you modify the apparatus so that backsplash from the far wall is eliminated? Finally, can you simulate the experiment using smoothed particle hydrodynamic methods and compare with your results?

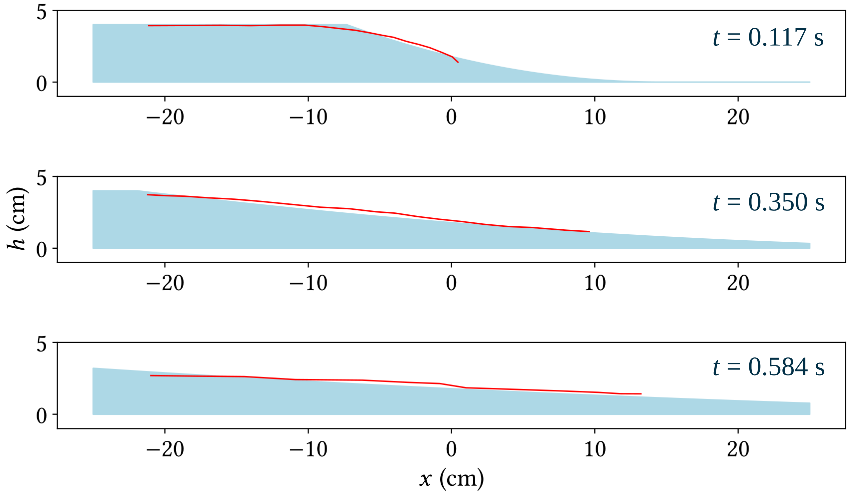


Figure 1 - The height of the water flowing from the dam.