Hydraulic Jumps

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: Hydraulic jumps are easily seen when turning on a faucet in the kitchen sink - when the water hits the flat surface of the sink bottom, it creates an almost perfect circle of outward flow. This flow persists until a certain radius *r* at which point the water surface "jumps" up to a greater height. This phenomenon has been well studied and is an incompressible flow analog of shock wave. In this project you will investigate various aspects of the hydraulic jump, starting with how the flow rate of the faucet affects the size of the circular region.

References: Robert P. Godwin, *Am. J. Phys.*, Vol. 61, No. 9, September 1993; B. L. Blackford, *Am. J. Phys.*, Vol. 64, No. 2, February 1996; Y. Brechet and Z. Neda, *Am. J. Phys.*, Vol. 67, No. 8, August 1999.

Suggested Materials

Sink and faucet
Ruler
Baking sheet (or similar flat surface)
Graduated cylinder
Timer

Basic Analysis: Af The volume flow rate Q was measured for a variety of different flows from the faucet by timing the filling of a measuring cup (V = 250 mL). The flow rate is then $Q = V / \Delta t$. For each flow rate, the diameter of the circular region was measured with a basic ruler. These measurement technqiues had large uncertainties (not estimated here) and other issues. The results are plotted in Figure 1 below, along with a line $r \propto Q^{2/3}$ as suggested by the analysis of Brechet and Neda (1999).

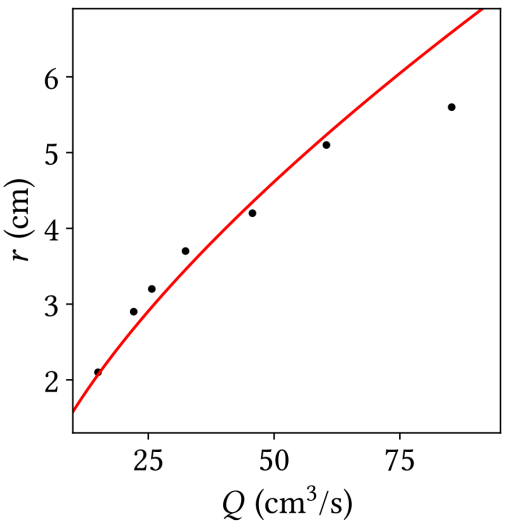

Figure 1 - Radius of circular region for various flow rates. The red line shows the prediction from Brechet and Neda (1999).

Further Work

There's a lot to improve on here and to explore further. Be more careful with your experimental set up - make sure the base is level, make careful measurements (with uncertainties). Do your results agree with the literature? What else affects the radius (e.g., viscosity)?

Can you measure the surface height of the water before and after the jump? What affects the final height?