Review - Key Hydraulic Equations

(Review from the last two classes.)

Mean Velocity: $V =$

Continuity: $A_1(V_1) =$

Momentum: $\sum F =$ (or Impulse-Momentum)

Bernoulli: $h_1 + P_1/\gamma + V_1^2/2g =$

Energy: $h_1 + P_1/\gamma + V_1^2/2g =$

Darcy-Weisbach: $h_f =$ → f: Moody Diagram*

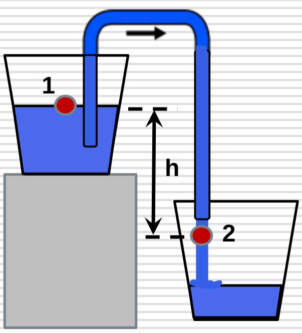
You can solve most pipe flow problems with these eqn's!

*Note: *e/D* = relative roughness; $N_R = (DV\rho)/\mu = (VD)/\nu$

In-Class Siphon Experiment

Bernoulli's Equation

Let's test the validity of the Bernoulli Equation.



Does Q_B (Bernoulli) = Q_m (measured)?

Questions:

1) How would we obtain the experimental flow rate?

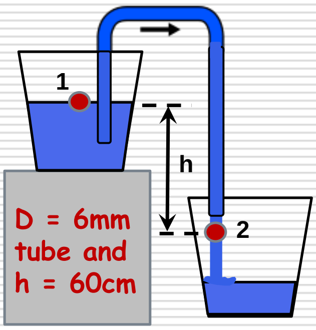
2) How would we obtain the Bernoulli flow rate?

3) What 2 points to find Q? Resulting eq'n? Data needed?

In-Class Siphon Experiment

Bernoulli's Equation

Perform the experiment and compare results.



Does Q_B (Bernoulli) = Q_m (measured)?

Q_m = 2 liters/(75 sec) = 0.0267 L/s

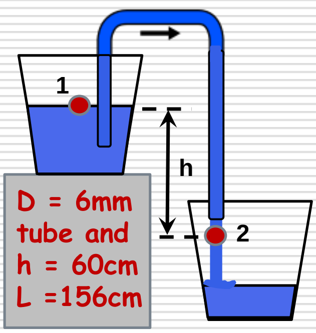
Bernoulli Calculations:

Why don't the flow rates compare closely? Perform the calculations a second time with the modifications* you think are necessary.

In-Class Siphon Experiment

Bernoulli's Equation

Perform the experiment and compare results.



Does Q_B (Bernoulli) = Q_m (measured)?

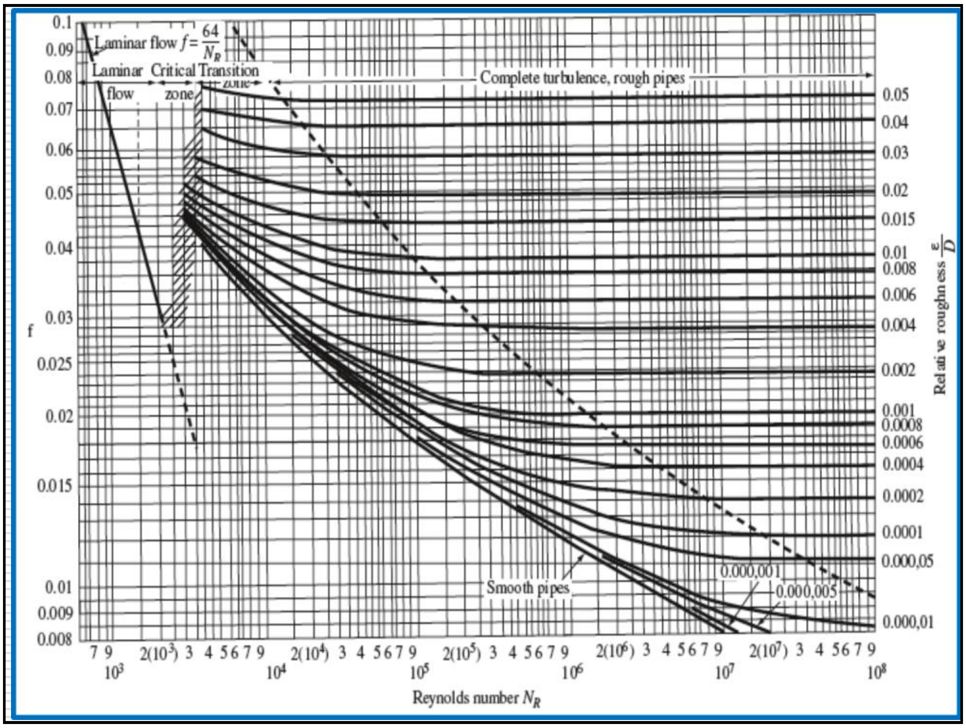
Q_m = 2 liters/(75 sec) = 0.0267 L/s

Energy Equation Calculations:

$h = V^2/2g + f(L/D)V^2/2g = V^2/2g[1 + f(L/D)]$

Moody Diagram for f (next slide):

Better!! Can we improve the results?



Friction Factors for Various Types of Flows (Review)

The Darcy-Weisbach Equation

$$h_f = f(L/D)(V^2/2g)$$

Determination of the Friction Factor

- Laminar Flow:
- Turbulent Flow:
- Complete Turbulence:
- Turb. (smooth pipe):

Pipe Flow Problems (Iterative Solution)

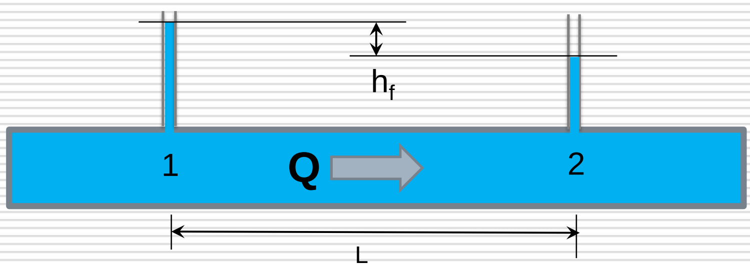
(Example Problems – Solve on White Board)

Determine the flow rate (L/sec) in a 4-cm-diameter copper pipe. The pressure at point A is 210 kPa, and the pressure at point B is 180 kPa. The elevation at A is 90 cm higher than point B and the two points are separated by 91.9 meters of pipeline. Assume no minor losses and water @ 10° C.

Solution:

Other Friction Loss Formulas

- Background: Popular formulas based on experiments.
- Empirical formulas - not dimensionally consistent (must use units established for formulas in experiments).
- Applicable only to conditions and ranges of experiments.



What are the vertical tubes? What do they measure? Sketch the HGL.

MANNING'S EQUATION

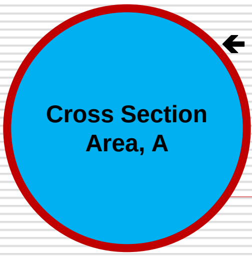
$V = (1.49/n)\, R_h^{2/3}\, S^{1/2}$

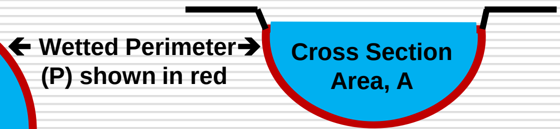
Define the variables? R_h = [ ] Where is h_f?

Is the equation dimensionally consistent?

n ➔ Table 3.3 based on pipe material.

("n" is between [ ] for most pipes)





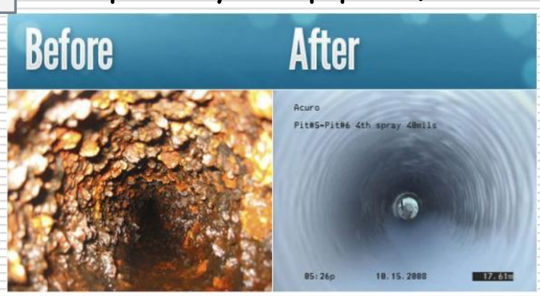
Note: This equation is often used for open channel flow.

The Hazen-Williams Formula

$V = 1.318\, C_{HW}\, R_h^{0.63}\, S^{0.54}$

Define the variables. Where is h_f ? Units?
C_{HW} ➔ Table 3.2 based on pipe material (usually between [ ] except very old pipes !)

Pipe cleaning and lining projects will increase pipe flow and pressure.



Pipe Tuberculation and Lining

http://www.ci.wilmington.de.us

Homework Problems: