Description of Pipe Flow

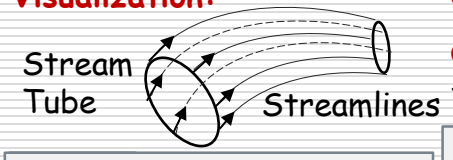
Definitions and Visualization

Questions: What is a streamline? What is a stream tube?

Streamline:

Stream tube:

Visualization:

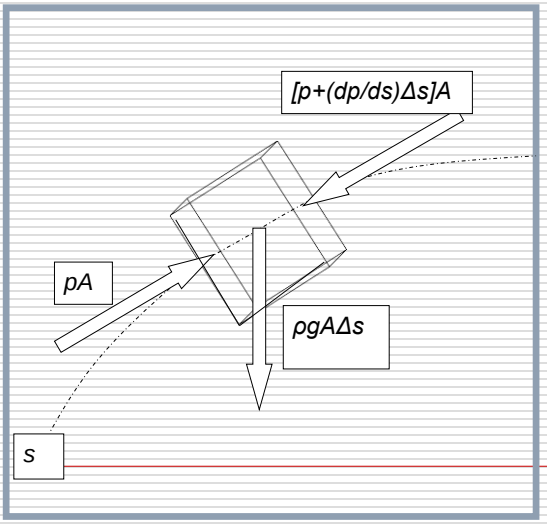


Question: Define steady flow?

Question: Given steady flow, is fluid acceleration possible?

The Bernoulli Equation

(Visualization and Derivation)



A control volume (CV) in a flow field is moving along a streamline. Some forces cause motion, and others resist motion.

1) What forces are defined and what forces are missing?

The Bernoulli Equation

(Visualization and Derivation – cont.)

Applying Newton's 2nd Law ($\sum F = ma$) on CV along streamline:

$-(dP/ds)A\Delta s - (dh/ds)(\rho g A\Delta s) - (\rho A\Delta s)\, a_s = 0$; Note:  +

2) What does the 1st term represent? …the 2nd term? …the 3rd term?

3) Recall that acceleration of a fluid can be expressed as: $V(dV/ds) + dV/dt$ What kind of acceleration is the 1st term? … the 2nd term?

Assuming steady flow ($dV/dt = 0$) and substituting for acceleration:

$-(dP/ds)A\Delta s - (dh/ds)(\rho g A\Delta s) - (\rho A\Delta s)\, V(dV/ds) = 0$; or

The Bernoulli Equation

(Importance: Hydraulic analysis and design.)

$(dP/ds) + \gamma(dh/ds) + \rho V(dV/ds) = 0$; and integrating yields

$\gamma h + P + (1/2)\rho V^2 =$ constant along streamline; or

$h + P/\gamma + V^2/2g =$ constant along streamline **(4th Key Eq'n)**

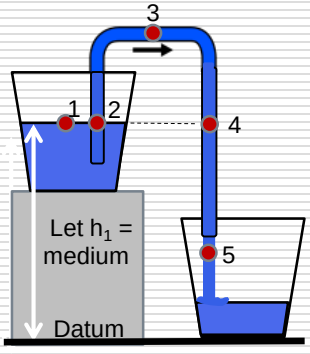
4) What do the 3 terms in Bernoulli's equation represent?

5) What are the units? Are they units of energy?

6) What are the 4 assumptions in using Bernoulli's equation?

The Bernoulli Equation

(Example Problem - Conceptual)



Five points are shown in the siphon flow field. Determine the "3" energy levels of all five points qualitatively (i.e., high, medium, low, or zero).

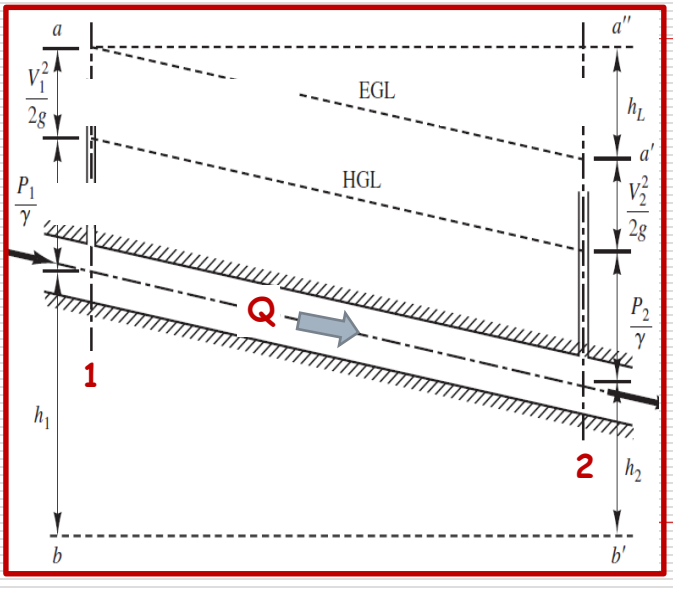
Note: Total energy does not change if losses are ignored.

Energy Levels ?

Point	h	P/γ	$V^2/2g$	Total Energy
1				
2				
3				
4				
5				

The Energy Equation

(Description and Visualization)



From the pipe flow schematic:

1) Identify the three energy components from Bernoulli's equation.

2) What is the new energy component that has appeared?

The Energy Equation

(Description and Visualization)

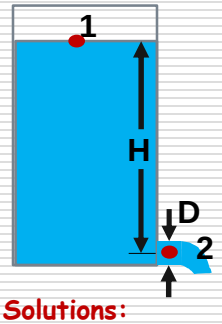
3) Write the equation that would result when you balance energy from location "1" to "2" on the previous slide:

4) What types of losses are encountered in pipe flow? What pipe and fluid properties contribute to friction loss?

Note: Darcy-Weisbach is a semi-empirical equation and dimensionally equivalent to the terms in the energy equation (i.e., feet or meters).

Bernoulli and the Energy Equation

(Example Problems – Solve on White Board)



1) Given H = 1.8m & D = 0.2m, find the flow rate Through the hole in the open top container assuming an inviscid fluid (i.e., no losses).

2) Also determine the head losses through the tank outlet if the exit velocity were 5.20 m/sec.

Solutions:

Homework Problems: