Name(s) of the student(s):

Grading:	
Part A:	/ 2
Part B:	/ 4
Part C :	/ 2
Part D:	/ 3
Part E:	/ 2
Bonus:	/ 2
TOTAL:	**/ 13**

Lab on fluid dynamics

Part A: Flow rate and fluid speed

The flow rate Q is the amount of fluid that flows through a pipe in a given amount of time.

Flow rate = Volume of fluid over time (Equation 1)

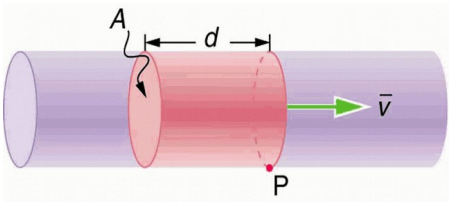


Image: OpenStax, College Physics. OpenStax CNX. 4. Nov. 2016 http://cnx.org/contents/Ax2o07Ul@9.39:g9Jw9bqg@4/Flow-Rate-and-Its-Relation-to- Creative Commons 4.0 License http://creativecommons.org/licenses/by/4.0/

The volume of the highlighted volume in the picture above can be calculated as :

Volume = Cross section Area A times distance d (Equation 2)

The speed v of the fluid is distance d over time. (Equation 3)

Combine equations 1, 2 and 3 to find an equation that relates flow rate to cross section area and speed.

Show your work here:

[1 pt]

Write the result here:

Flow rate = _____

(Equation 4)

[1 pt]

(Call your teacher over to verify your answer before continuing)

Name(s) of the student(s):

Part B: Pipe cross section and fluid speed

1. Open the following simulation: https://phet.colorado.edu/en/simulation/legacy/fluid-pressure-and-flow

On the second tab “Flow” you can change the diameter of a pipe and observe the effect on the fluid speed.

2. Keep the flow rate constant, but change the diameter. Measure diameter and resulting speed for 2 different diameters. (Keep the “predicted flow speed” column empty)

Measurement	Diameter [m]	Cross section area [m^2]	Fluid speed [m/s]	“Predicted flow speed”
Original Pipe	2.0	3.14	1.6	N/a
#1				
#2				

[2 pt]

3. Using your result from part A (equation 4). Try to find an equation that relates the new fluid speed with the original pipe speed, the original cross section area as well as the new cross section area.

Write your hypothesis here:

$$\text{New speed} = \_\_\_\_\_$$

(Equation 5)

[1 pt]

4. Use your hypothesis from above to calculate the predicted flow speed for your measurements #1 and #2.

If the results match your measurements, call the teacher to verify. If not, try another hypothesis. (After about 3 unsuccessful trials, send a spy to another group to get inspiration)

Write your calculations here:

[1 pt]

Name(s) of the student(s):

Part C: Conservation of mechanical energy for fluids

The law of conservation of mechanical energy states that the new mechanical energy (kinetic and potential) is equal to the original mechanical energy (kinetic and potential) plus the energy that was added through work.

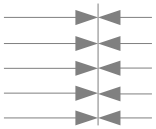
As a formula, this translates to:

$PE_2 + KE_2 = PE_1 + KE_1 + W_{ext}$ or with more detail: $mgh_2 + \frac{1}{2} m v_2^2 = mgh_1 + \frac{1}{2} m v_1^2 + F \cdot d$ (Equation 6)

From the last chapter, you know that density ρ = mass over Volume (capital V) (Equation 7)

If two fluids are pressing on a cross section A from opposite sites, the net force on that cross section is (see Submarine WebWork)

$F = (P_1 - P_2) \cdot A$ (Equation 8)



1. Use equations 7 and 8 to replace the mass and the force in equation 6 and write the result here:

[1 pt]

(Equation 9)

2. Divide your equation 9 by the volume V and simplify as much as you can. Put everything with subscript 2 on the left, and everything with subscript 1 on the right side.

Write the resulting equation here:

(Equation 10)

[1 pt]

(Call your teacher over to verify your answer before continuing)

Name(s) of the student(s):

Part D: Water Tower

1. Go to the third tab “Water Tower” of the simulation

2. Use the pressure gauge and the measuring tape of the simulation as well as your equation 10 to predict the speed at which the water will leave the tower when you open the gate at the bottom.

Show your calculations here:

[1 pt]

Predicted water speed:

[1 pt]

3. Test your prediction by opening the gate.

Measured water speed:

[1 pt]

If the measures speed matches the predicted speed, call your teacher. If not, check your measurements and calculations. (After about 3 unsuccessful trials, send a spy to another group to get inspiration)

Name(s) of the student(s):

Part E:

1. Go back to the second tap with the horizontal pipe. As you have previously observed, a smaller cross section leads to a higher fluid speed.

2. Use your equation 10 to predict the effect of the higher fluid speed on the pressure (assume constant height as the pipe is horizontal):

Put your calculations (without numbers) here:

[1 pt]

Prediction:

If the fluid speed increases, the pressure _____

[1 pt]

Verify your prediction with the simulation.

(Call your teacher over to verify your answer before continuing)

Name(s) of the student(s):

Bonus: [2 pt]

Use the result from part E to explain any other phenomena (no discussed cases) related to your equation 10.