# Bernoulli Flow Uphill and Downhill Lab

*Separate pressure height and speed changes*

Name _____ Period _____ Date _____

Compare uphill and downhill flow, then change flow rate. Linearize a pressure comparison that includes both height and speed, and determine liquid density.

**Time 50 minutes • Open buildphysics.com/?experiment=fluid-bernoulli-height**

### Model and measurements

The flow is steady and incompressible without energy loss. Keep the elevated pipe geometry and the zero-height level unchanged; g = 9.8 m/s².

$$P + \frac{1}{2}\rho v^2 + \rho g y = constant$$

For Part B, Station A is 1 and Station C is 2. Read height y above the zero level. Convert pressure to Pa for calculations: 1 kPa = 1,000 Pa.

### Predict before running

If two sections have equal area but different heights, which should have the greater pressure? Predict and explain.

### Part A Compare heights and speeds

1. Keep Middle section height at 2.60 m and Outlet area at 0.030 m². In Properties → Elevated pipe, set Reference pressure to 100,000 Pa. Set Q to 0.080 m³/s.

2. Select Stations A, B, and C in Properties. Read Height above zero level, Speed, and Absolute pressure from Live values.

3. Record the three stations while paused. Keep these station positions unchanged.

| Station | Height y (m) | Speed v (m/s) | Pressure P (kPa) |
|---|---|---|---|
| A | | | |
| B | | | |
| C | | | |

A1. Compare A and B using speed, height, and pressure. Then explain why speed also matters in the B-to-C comparison.

A2. How can the flow speed stay constant while pressure decreases along an uphill section?

## Part B  Design and collect

Suggested time 16 minutes

**Investigation question  How are pressure and squared-speed changes related when the two stations also differ in height?**

Choose at least five Volume flow rates from 0.040 to 0.120 $m^3/s$, spread across the range. Keep pipe geometry, station positions, and Reference pressure unchanged.

B1. Identify the independent and dependent variables.

B2. What will you keep constant? How will you do this?

B3. List your settings. Why is this set useful?

B4. How will you obtain matching pressure and speed pairs at Stations A and C?

B5. Write a procedure another group could follow.

Read Area once at Stations A and C. Use their Part A heights. Record both pressures and speeds for each flow rate while paused.

**Record your measurements**

$A_1$ = _____ $m^2$  $A_2$ = _____ $m^2$  $y_1$ = _____ m  $y_2$ = _____ m

| Trial | Q ($m^3/s$) | $v_1$ (m/s) | $v_2$ (m/s) | $P_1$ (kPa) | $P_2$ (kPa) |
|---|---|---|---|---|---|
| 1 | | | | | |
| 2 | | | | | |
| 3 | | | | | |
| 4 | | | | | |
| 5 | | | | | |
| Extra | | | | | |

## Part C  Build and analyze a linear graph

Suggested time 14 minutes

C1. The relationship is $P_2 - P_1 = \frac{\rho}{2}({v_1}^2 - {v_2}^2) - \rho g(y_2 - y_1)$. How does the fixed height difference affect this pressure comparison?

C2. Choose quantities for a straight-line graph. Label the table with your choices and units, and calculate the transformed values.

| Trial | _____ Units _____ | _____ Units _____ |
|---|---|---|
| 1 | | |
| 2 | | |
| 3 | | |
| 4 | | |
| 5 | | |
| Extra | | |

C3. Plot your transformed data and draw a best-fit line. Label both axes with quantities and units.



C4. Find slope and units using two separated points on your fitted line. Determine liquid density and interpret the intercept.

## Part D  Explain and predict

Suggested time 8 minutes

D1. A student claims, “All pressure change between A and C comes from their height difference.” Evaluate the claim using two flow rates.

D2. Does your graph support Bernoulli’s relationship? Compare inferred density with 1,000 kg/m³ and discuss the intercept.

D3. Choose an unused Q within your range. Use Q/A at each station and your fit to predict $P_2$. Set Q and measure $P_2$. Compare.

| New Q ($m^3/s$) | Predicted $P_2$ (Pa) | Measured $P_2$ (Pa) |
|---|---|---|
| | | |

Comparison