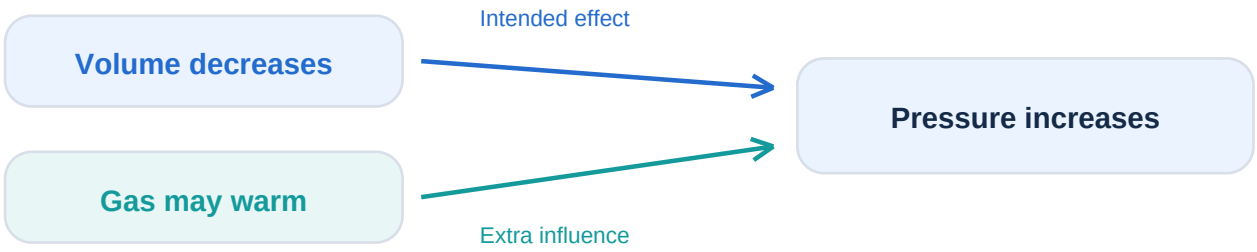
LESSON 6.1.3
Controlling Variables
in Complex Experiments

A result can change for more than one reason. Isolate the relationship you want to test by controlling other influences and recording checks that reveal drift.

EXAMPLE: COMPRESSING A GAS



1. IDENTIFY	Independent: what you deliberately vary. Dependent: what you measure. Controls: other quantities that can affect that measurement.
2. EXPLAIN	Use the physical model to say why each control matters. A variable that changes along with the independent variable can confound the result.
3. MAINTAIN	Give an action: clamp a distance, regulate temperature, use the same component, or wait for equilibrium. "Keep constant" alone is incomplete.
4. VERIFY	Measure the control where possible and define an acceptable range. Record drift; investigate whether it could explain the observed effect.

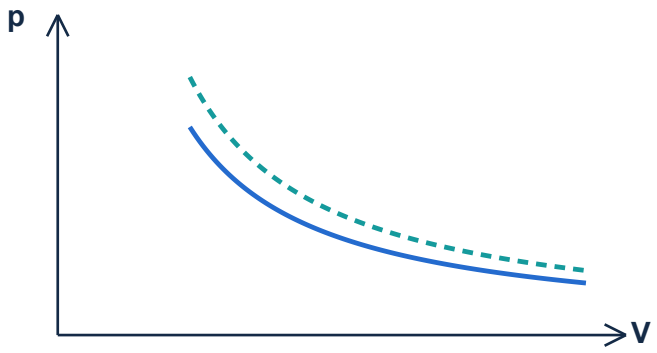
A control variable is not the same as a control or reference run. The variable is a condition to hold fixed; a reference run checks the apparatus or background response.

Curriculum: Pearson IAL Physics, Unit 6 planning and evaluation, pp. 39-40.

1 Gas pressure: control T and amount

Investigate how absolute pressure p depends on total gas volume V. Keep the amount of gas n and its absolute temperature T constant.

SAME AMOUNT OF GAS; DIFFERENT TEMPERATURES



Solid blue: fixed lower temperature.

Dashed teal: fixed higher temperature.

Schematic curves; axes not to scale

$$pV = nRT \qquad \text{at fixed } n, T: \; p = \frac{nRT}{V}$$

Plot p against 1/V: the ideal model predicts a straight line with gradient nRT. A pressure change caused by warming is not evidence for the volume relationship alone.

TEMPERATURE T	Compress slowly; pause at each setting for thermal equilibrium. Use a stable room or suitable water bath and check temperature and pressure have stabilised.
GAS AMOUNT n	Keep the same sealed sample. Check seals and look for pressure drift at fixed volume after thermal equilibration; repair leaks before collecting data.
VOLUME AND PRESSURE	Include fixed tubing/sensor volume in total V. Use absolute pressure, not gauge pressure alone; check the pressure sensor against a reference.

WORKED CONTROL FAILURE

At fixed n and V, warming from 293 K to 303 K raises p by:

$$\frac{303 - 293}{293} \times 100\% = 3.4\%$$

Physics: OpenStax University Physics 2, §2.1. Stay within apparatus pressure ratings.

2 Control the model, then test for drift

Use the equation to identify hidden influences. Keep the measurement procedure consistent as well as the physical apparatus.

A. MAGNETIC FORCE AGAINST CURRENT

$$F = BIL \sin \theta$$

Vary the measured current I; record force F. Keep B, the effective wire length L and the angle θ fixed.

How: clamp the wire and magnets, mark the length inside the uniform field, and set the wire at 90° to B. Use short readings and cooling intervals to limit heating and movement.

Check: record actual current at each force reading; inspect alignment and repeat a reference current. A constant supply-voltage setting does not guarantee constant current.

B. SPRING PERIOD AGAINST MASS

$$T^2 = \frac{4\pi^2}{k} m$$

For the ideal mass-spring model, vary total oscillating mass m and measure period T. Use the same spring so k stays fixed; keep the support rigid and motion vertical.

Release without a push from the same small displacement. Time the same number of complete cycles at the same marker and direction. Stay within the elastic range.

Ideal SHM has amplitude-independent period. Small, consistent amplitudes help real apparatus remain in that regime; account for hanger and effective spring mass when needed.

WHEN PERFECT CONTROL IS NOT POSSIBLE

Monitor the changing condition. Repeat a reference setting between trials to detect drift; if safe and practical, vary trial order so elapsed time is not tied to the independent variable. Neither approach removes drift by itself.

Choose control tolerances from their effect: for a gas at fixed n and V, ±1 K near 300 K changes p by about ±0.33%. Compare this with the pressure effect you are trying to resolve. Repeats do not repair a confounded design.

Physics references: OpenStax, magnetic force (Vol. 2 §11.4) and SHM (Vol. 1 §15.1).

Next: 6.2.1 Log graphs and testing relationships.