

Solutions

Original-task marking: M1 method, A1 accuracy, B1 reasoning.

2.1 Measure V (across the capacitor) at known times t after switching. Plot $\ln V$ against t . Gradient $= -1/RC$ and intercept $= \ln V_0$, so a straight line with negative gradient supports the exponential model.

2.2 Any two of: lamp current/supply voltage, since brightness and therefore X change with it; background illumination, since it adds to the sensor reading; alignment/angle of sensor to lamp, since the received fraction depends on it; same sensor and rule position. Physical reason required for each mark pair.

2.3 Record p from the gauge for a series of volumes V read from the syringe scale. Plot p against $1/V$. A straight line through the origin shows pV is constant, so the model holds over the range tested.

3.1 Circuit: battery in series with an ammeter and a variable resistor; voltmeter in parallel with the battery terminals only. Vary the resistance to obtain at least five well-spread current values; record paired I and V . Rearranged model: $V = \varepsilon - Ir$. Plot V vertically against I horizontally. Gradient $= -r$; intercept on the V axis $= \varepsilon$. Switch off between readings to avoid heating the cell.

3.2 With the effective length $l + \delta l$ and a constant δl :

$$T^2 = \frac{4\pi^2}{g}(l + \delta l) = \frac{4\pi^2}{g}l + \frac{4\pi^2}{g}\delta l$$

This is the straight-line form $y = mx + c$: the plot of T^2 against l is straight with gradient $4\pi^2/g$, so $g = 4\pi^2/\text{gradient}$ whatever the length offset. The intercept on the T^2 axis is $(4\pi^2/g)\delta l$, so $\delta l = \text{intercept}/\text{gradient}$ – the graph reveals the systematic length error. Control: same bob and small amplitude. Technique: time many oscillations past a marker at the centre of the swing and divide by the count.

3.3 Measure the background count rate with the source removed and repeat it. Subtract it from every gross rate to get R . Take readings at a series of at least five distances spread over a wide range, each counted for the same long time, repeating each count. Linearise: $R = c(1/d^2)$, so plot R against $1/d^2$ and expect a straight line through the origin, or plot $\lg R$ against $\lg d$ and expect gradient -2 . Confirmation: the line passes through the origin (or gradient -2) within scatter. Safety: hold the source in tongs/holder and point it away from people; minimise handling time and return it to its box immediately, keeping distance.