

Faraday's law, inductors and LR circuits

AP Physics C (Mechanics and E&M, calculus-based) · Lab answers

Model answers use the sample results from the table. Your own gradient will depend on your coil and magnet, but the proportional trend should be the same.

Level: AP Physics C (Mechanics and E&M, calculus-based) · **Curriculum:** AP PC:E&M Unit 13

Question 1 Speed at the coil

$v = \sqrt{2 \times 9.81 \times h}$: **0.99, 1.40, 1.98, 2.43, 2.80 m/s** for 5, 10, 20, 30, 40 cm.

Question 2 Graph

The points lie close to a straight line through (or very near) the origin, so ϵ is **directly proportional to v** .

Question 3 Gradient

The best-fit line has gradient about **39 mV per m/s** (units $\text{mV}\cdot\text{s/m}$, equivalent to $3.9 \times 10^{-2} \text{ V}\cdot\text{s/m}$).

Question 4 Link to Faraday's law

The flux linkage through the coil changes as the magnet moves. A faster magnet changes the flux over a shorter time, so $d\Phi/dt$, and therefore ϵ , increases in proportion. **$\epsilon \propto v$** .

Question 5 Sources of error

Air resistance and friction with the tube reduce the speed, and eddy-current braking in the coil also slows the magnet. The true v is **lower than $\sqrt{2gh}$** .

Question 6 Uncertainty

At 5 cm: $3/37 \times 100 = 8\%$. At 40 cm: $3/108 \times 100 = 2.8\%$. The uncertainty is **about 8 % and 2.8 %**: the same absolute spread matters more for small signals.

Question 7 Improvement

Use a pair of light gates to measure the speed directly, and integrate the logged emf over time to find the flux change $\Delta\Phi = (1/N)\int \epsilon dt$. Then **compare the integral with the flux change expected from the magnet's field**.