

Magnetic flux, Faraday's law and Lenz's law

AP Physics 2 (algebra-based) · Lab

Name: _____ Date: _____ Class: _____

How does the speed of a magnet affect the voltage induced in a coil? By dropping a magnet through a coil from different heights and recording the voltage pulse, you can test Faraday's law with a simple stack of equipment and see how flux change connects to speed.

Level: AP Physics 2 (algebra-based) · **Curriculum:** AP P2 Unit 12

Aim

Investigate how the peak emf induced in a coil depends on the speed of a magnet falling through it, and compare the results with Faraday's law.

Equipment

- coil of about 500 turns on a plastic former
- strong cylindrical magnet that fits inside a plastic tube
- plastic tube about 60 cm long, clamped vertically through the coil
- voltage sensor and data logger (or oscilloscope with a voltage-input app)
- metre rule, soft cloth or foam for the landing

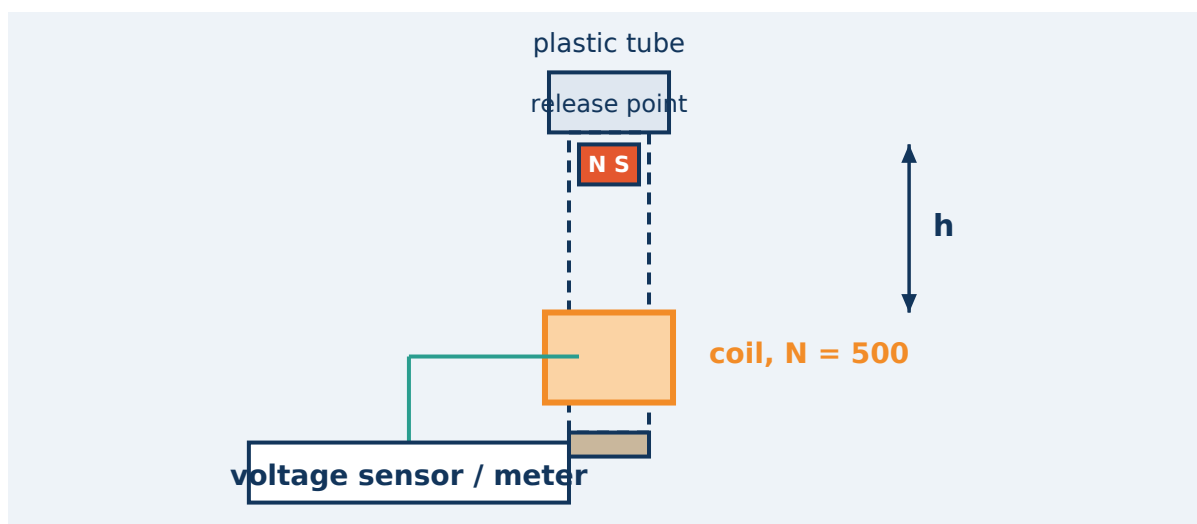
Safety

Safety

Strong magnets can pinch fingers and damage phones or cards. Catch the falling magnet on a soft pad, and keep the magnet away from anyone with a pacemaker.

Method

1. Clamp the tube vertically with the coil near its lower end. Place a soft pad under the tube.
2. Connect the coil to the voltage sensor and start recording.
3. Release the magnet from $h = 0.05$ m above the top of the coil. Read the peak emf from the first pulse on the graph.
4. Repeat for $h = 0.10, 0.20, 0.30$ and 0.40 m. Repeat each height three times and use the mean peak value.
5. Calculate $v = \sqrt{2gh}$ as the speed on entering the coil, using $g = 9.81$ m/s².



The coil is connected to a sensor that records the emf pulse as the magnet falls through.

Results

Sample means of three trials, coil of 500 turns:

Drop height h (m)	Speed $v = \sqrt{2gh}$ (m/s)	Peak emf (V)
0.05	0.99	0.21
0.10	1.40	0.30
0.20	1.98	0.42
0.30	2.43	0.52
0.40	2.80	0.59

Analysis questions

Question 1 Entry speed

Calculate the speed for $h = 0.30$ m and explain the assumption in using $v = \sqrt{2gh}$.

Question 2 Graph

Plot the peak emf (y-axis) against v (x-axis). Describe the shape of the graph.

Question 3 Slope of the graph

Calculate the slope using the first and last points and give its unit.

Question 4 Meaning of the result

Explain with Faraday's law why the peak emf is roughly proportional to the speed.

Question 5 Area under a pulse

For one release the area under the emf pulse was $2.1 \times 10^{-3} \text{ V}\cdot\text{s}$. Calculate the flux change through one turn, $\Delta\Phi$.

Question 6 Two pulses

Explain why the recorded emf has a positive pulse followed by a negative pulse as the magnet passes through.

Question 7 Limitations

Give two reasons why the real speed is below $\sqrt{2gh}$ and one way to reduce the effect.