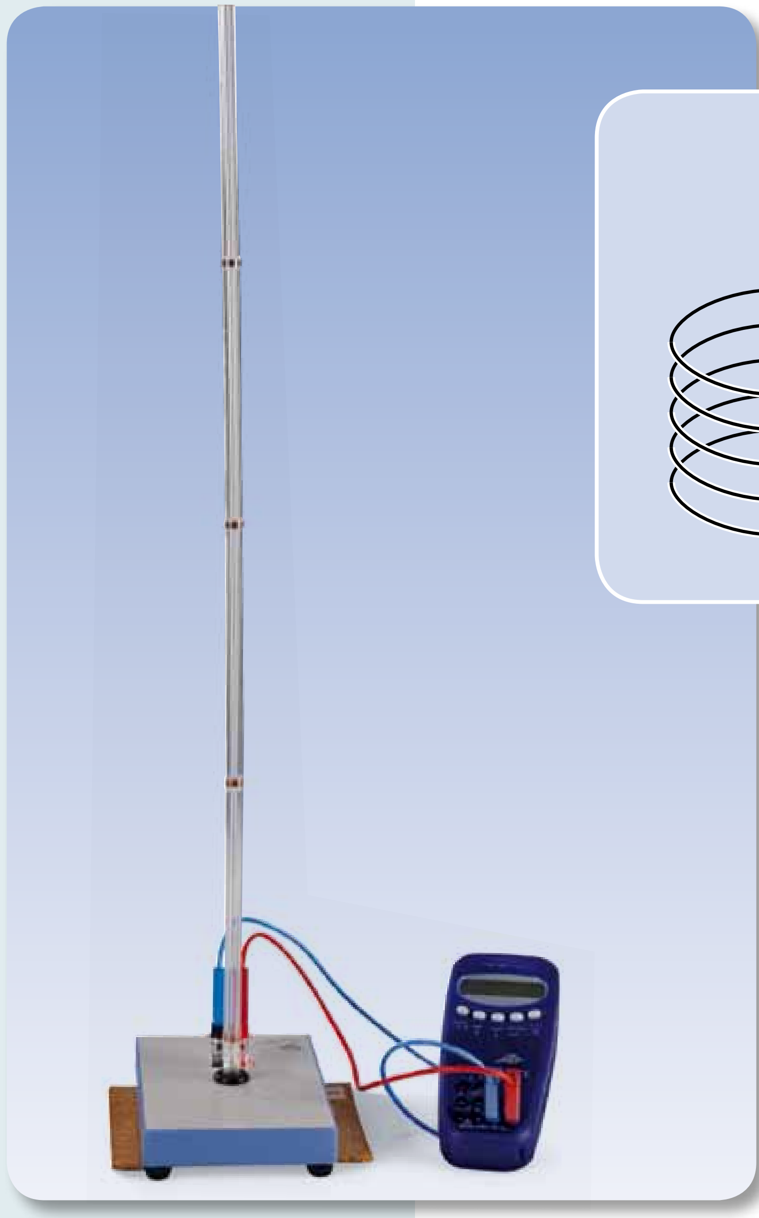
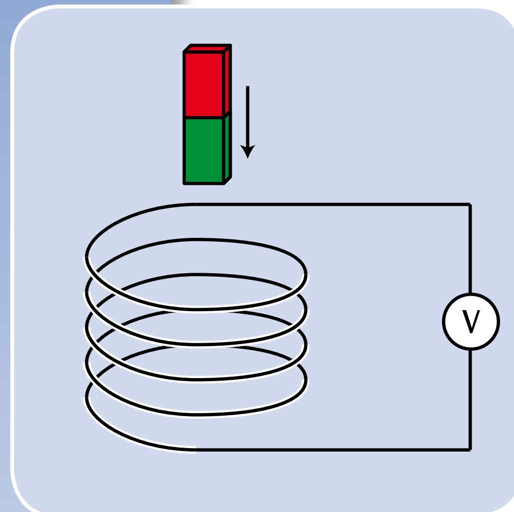
FARADAY'S LAW OF INDUCTION





OBJECTIVE

Generating a voltage pulse in a conducting loop by the motion of a permanent magnet.

SUMMARY

When a permanent bar magnet is allowed to fall in succession through a set of identical induction coils connected in series, a voltage is induced in each of the coils. The voltage amplitude increases from coil to coil as the magnet moves through each coil, as the velocity of the magnet increases steadily. However, the magnetic flux that is calculated by integrating over the observed voltage curve has the same value for all the coils.

EXPERIMENT PROCEDURE

- **Observing the motion of a permanent bar magnet through a set of induction coils connected in series.**
- **Measuring the induced voltage as a function of time.**
- **Calculating the magnetic flux as a function of time.**

REQUIRED APPARATUS

Quantity	Description	Number
1	Tube with 6 Induction Coils	**1001005**
1	3B NET*log*™ (230 V, 50/60 Hz)	1000540
	3B NET*log*™ (115 V, 50/60 Hz)	**1000539**
1	3B NET*lab*™	**1000544**
1	Pair of Safety Experimental Leads, 75cm, red/blue	**1017718**

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BASIC PRINCIPLES

Any change of the magnetic flux through a closed conducting loop induces in it an electrical voltage. Such a change is produced, for example, when a permanent bar magnet moves through a stationary conducting loop.

In this case it is instructive to consider not only the time-dependent induced voltage

(1) $$U(t) = -\frac{d\Phi}{dt}(t)$$

Φ: Magnetic flux

but also its integral over time, viz. the voltage pulse

(2) $$\int_{t_1}^{t_2} U(t)\cdot dt = \Phi(t_1) - \Phi(t_2)$$

This corresponds to the difference between the magnetic flux at the beginning (t_1) and that at the end (t_2) of the observed process.

In the experiment, a permanent bar magnet is allowed to fall through six identical induction coils that are connected in series. The induced voltage is recorded as a function of time (see Fig. 1). The voltage amplitude increases from coil to coil as the magnet moves through each coil, because the velocity of the magnet increases steadily.

The areas under all the positive and negative voltage signals are equal. They correspond to the maximum flux Φ produced by the permanent magnet inside each individual coil.

EVALUATION

The experimental set-up is such that the induced voltage is negative when the magnet is introduced into the coil.

The induced voltage is once again zero when the magnet reaches the centre of the coil, and therefore the magnetic flux has its maximum value at that point. During the subsequent exit phase of the magnet, a positive voltage is induced.

From the voltage measurements, we can calculate the magnetic flux at any point in time t by integration, using Equation 2:

$$\Phi(t) = \Phi(0) - \int_0^t U(t')\cdot dt'$$

The maximum flux reached during the magnet's fall is the same for all the coils, subject to the limitation of the precision of the measurements (see Fig. 2).

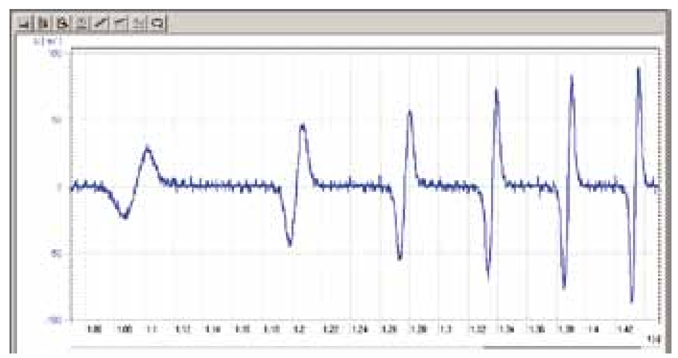

Fig. 1: Induced voltage U as a function of time.

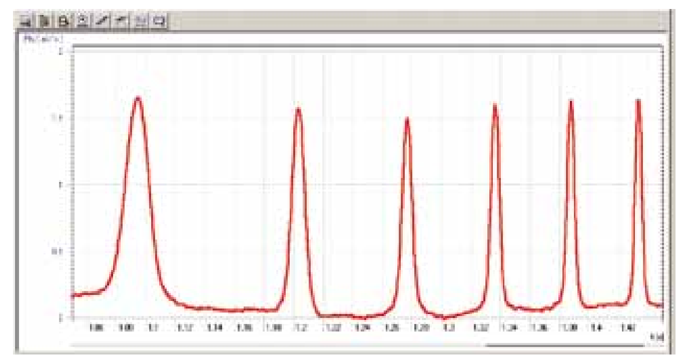

Fig. 2: Magnetic flux Φ as a function of time.