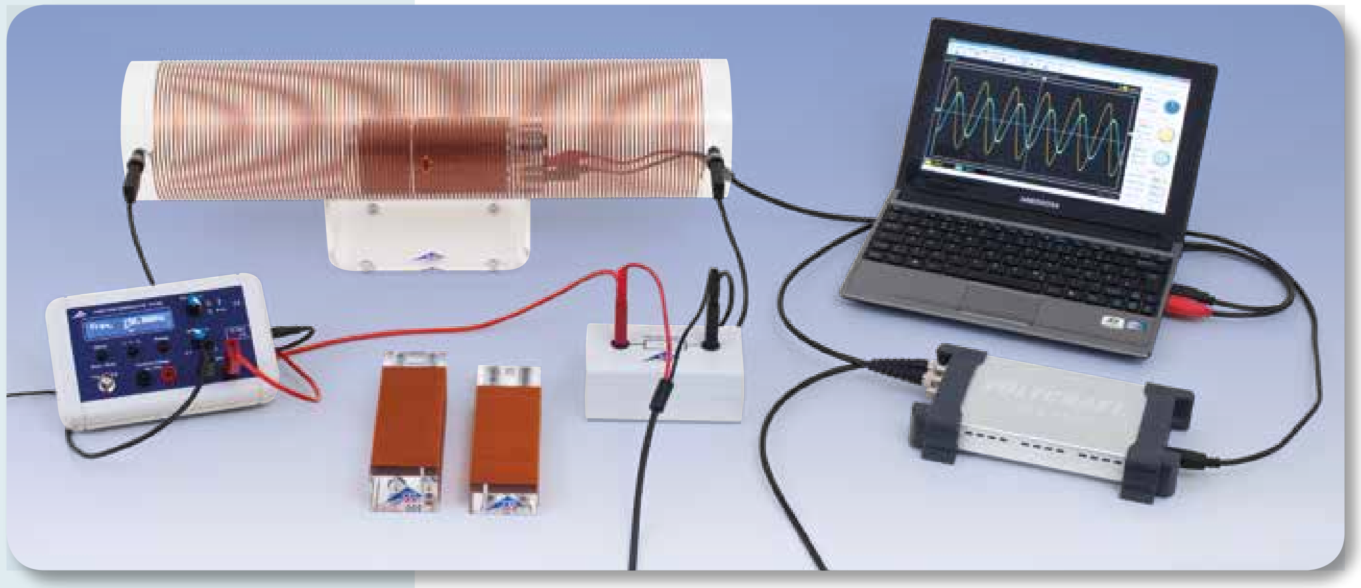
# INDUCTION THROUGH A VARYING MAGNETIC FIELD



## EXPERIMENT PROCEDURE

- **Measure the induced voltage as a function of the number of turns *N* of the induction coil.**
- **Measure the induced voltage as a function of the cross-sectional area *A* of the induction coil.**
- **Measure the induced voltage as a function of the amplitude $I_0$ of the alternating current applied for induction.**
- **Measure the induced voltage as a function of the frequency *f* of the alternating current applied for induction.**
- **Measure the induced voltage as a function of the waveform of the alternating current applied for induction.**

You can find technical information about the equipment at 3bscientific.com

## OBJECTIVE

**Measuring the voltage induced in an induction coil**

## SUMMARY

If a closed conductor loop with *N* windings is located in a cylinder coil through which an alternating current flows, then an electrical voltage is induced by the variable magnetic flux through the conductor loop. This induction voltage is dependent on the number of windings and the cross-sectional area of the conductor loop as well as the frequency, amplitude and waveform of alternating current applied to the field coil. These dependencies are explored and compared with the principle theory.

## REQUIRED APPARATUS

| Quantity | Description | Number |
|---|---|---|
| 1 | Set of 3 Induction Coils | 1000590 |
| 1 | Field Coil 120 mm | 1000592 |
| 1 | Stand for Cylindrical Coils | 1000964 |
| 1 | Precision Resistor 1 Ω | 1009843 |
| 1 | Function Generator FG 100 (230 V, 50/60 Hz) | 1009957 or |
| | Function Generator FG 100 (115 V, 50/60 Hz) | 1009956 |
| 1 | USB Oscilloscope 2x50 MHz | 1017264 |
| 2 | HF Patch Cord, BNC/4 mm Plug | 1002748 |
| 1 | Pair of Safety Experiment Leads, 75 cm, black | 1002849 |
| 1 | Pair of Safety Experimental Leads, 75 cm, red/blue | 1017718 |





UE3040300

## BASIC PRINCIPLES

**Every change in the magnetic flux through a closed conductor loop with *N* turns induces an electrical voltage in said loop. Such a variation is evoked, for example, if the conductor loop is located in a cylinder coil which has alternating current flowing through it.**

According to Faraday's law of induction the following applies for an induced voltage dependent on rate of change:

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

The magnetic flux Φ through an area *A* is given by:

(2) $$\Phi = B \cdot A$$

*B*: Magnetic flux density

if the magnetic flux density *B* permeates the area *A* perpendicularly. Consequently, from Equation (1) we obtain:

(3) $$U(t) = -N \cdot A \cdot \frac{dB}{dt}(t).$$

The field coil generates the following magnetic flux density in the conductor loop:

(4) $$B = \mu_0 \cdot \frac{N_F}{L_F} \cdot I$$

$\mu_0 = 4_\pi \cdot 10^{-7}$ N/A²: Vacuum permeability, $N_F$: Number of turns in the field coil, $L_F$: Length of the field coil, *I*: Current flowing through the field coil

Accordingly, from Equation (3) we arrive at:

(5) $$U(t) = -\mu_0 \cdot N \cdot A \cdot \frac{N_F}{L_F} \cdot \frac{dI}{dt}(t).$$

In the experiment a function generator is used first to apply a sinusoidal signal to the field coil. The amplitude $I_0$ of the current *I*(*t*) is determined by the field coil with the aid of a resistor connected in series between the coil and generator. The amplitude $U_0$ of the induced voltage *U*(*t*) is measured as a function of the number of windings *N* and cross-sectional area *A* of the induction coils as well as the frequency *f* of the sinusoidal signal and the amplitude $I_0$ of the current flowing through the field coil.
Besides the sinusoidal signal, a triangular and a square-wave signal are also applied to the field coil for an induced voltage on a coil with fixed number of turns and cross-sectional area as well as a constant frequency, and from these measurements screen shots are made for each.

## EVALUATION

For sinusoidal current:

$$I = I(t) = I_0 \cdot \sin(2 \cdot \pi \cdot f \cdot t),$$

the following applies:

$$U(t) = U_0 \cdot \left[-\cos(2 \cdot \pi \cdot f \cdot t)\right]$$

with:

$$U_0 = 2 \cdot \pi \cdot \mu_0 \cdot \frac{N_F}{L_F} \cdot N \cdot A \cdot I_0 \cdot f.$$

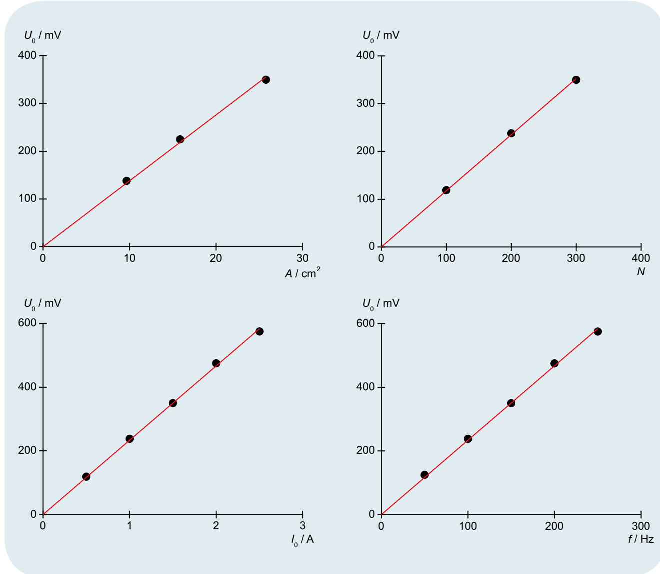



Fig. 1: Amplitude of the induced voltage as a function of the number of turns and the cross-sectional area of the induction coil as well as the amplitude of the current flowing through the field coil and the frequency of the sinusoidal signal applied to the field coil.

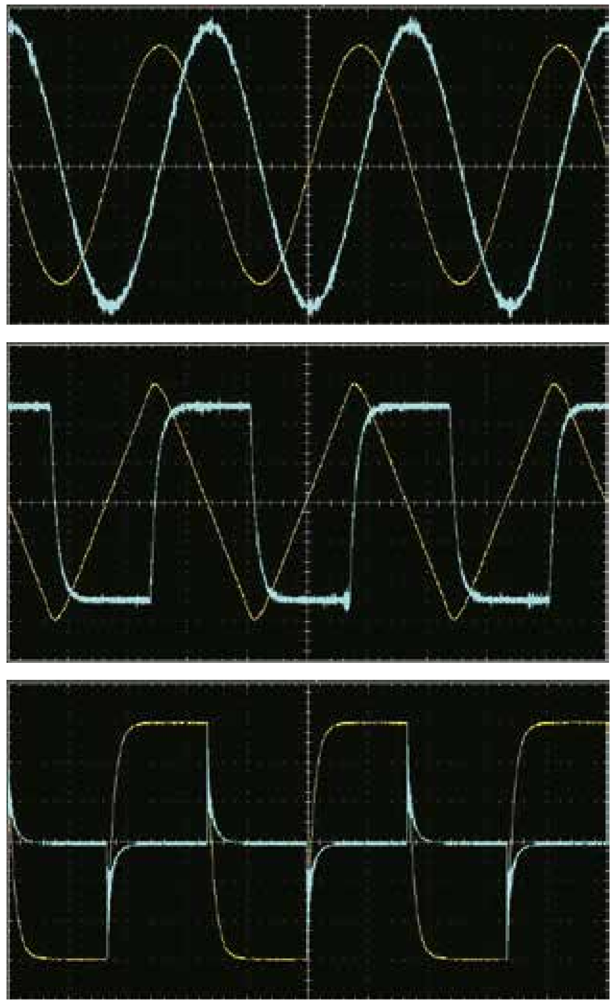


Fig. 2: Screen shots of the characteristics of the induced voltage as a function of time for a sinusoidal (top left), triangular (top right) and square-wave signal (bottom) applied to the field coil