Measuring the force acting on current-carrying conductors in a homogeneous magnetic field – Recording with CASSY (P 3.3.3.2)

P 3.3.3

Effects of force in a magnetic field

P 3.3.3.1 Measuring the force acting on current-carrying conductors in the field of a horseshoe magnet

P 3.3.3.2 CASSY-S Measuring the force acting on current-carrying conductors in a homogeneous magnetic field – Recording with CASSY

P 3.3.3.3 CASSY-S Measuring the force acting on current-carrying conductors in the magnetic field of an air coil – Recording with CASSY

P 3.3.3.4 Basic measurements for the electrodynamic definition of the ampere

Cat. No.	Description	P 3.3.3.1 (a)	P 3.3.3.1 (b)	P 3.3.3.2	P 3.3.3.3	P 3.3.3.4 (a)	P 3.3.3.4 (b)
510 22	Large horse-shoe magnet, with yoke	1	1				
562 11	U-core with yoke			1			
562 14	Coil with 500 turns			2			
562 25	Pole-shoe yoke			1			
314 265	Support for conductor loops	1	1	1	1	1	1
516 34	Conductor loops for force measurement	1	1	1	1		
516 244	Field coil, diameter 120 mm				1		
516 249	Stand for coils and tubes				1		
516 33	Set of conductors for Ampere definition					1	1
516 31	Vertically adjustable stand					1	1
521 55	Current source, DC, $I = 20$ A, e. g. High current power supply	1	1	1	1	1	1
521 501	Current source, DC, $I = 5$ A, e.g. AC/DC power supply 0....15 V			1	1		
531 835	Universal Measuring Instrument Physics	1				1	
524 009	Mobile-CASSY		1				1
524 010USB	Sensor CASSY			1	1		
524 060	Force sensor S, ± 1 N	1	1	1	1	1	1
524 043	Sensor box - 30 Amperes			1	1		
524 200	CASSY Lab			1	1		
300 02	Stand base, V-shape, 20 cm	1	1	1	1	1	1
300 42	Stand rod, 47 cm	1	1	1	1	1	1
301 01	Leybold multiclamp	1	1	1	1	1	1
501 26	Connecting lead, Ø 2,5 mm², 50 cm, blue			2	1	1	1
501 30	Connecting lead, Ø 2.5 mm², 100 cm, red	1	1	2	2	1	1
501 31	Connecting lead, Ø 2.5 mm², 100 cm, blue	1	1	2	2	1	1
	additionally required: PC with Windows 95/NT or higher			1	1		

To measure the force acting on a current-carrying conductor in a magnetic field, conductor loops are attached to a force sensor. The force sensor contains two bending elements arranged in parallel with four strain gauges connected in a bridge configuration; their resistance changes in proportion to the force when a strain is applied. The force sensor is connected to a newton meter, or alternatively to the CASSY computer interface device via a bridge box. When using CASSY a 30 ampere box is recommended for current measurement.

In the first experiment, the conductor loops are placed in the magnetic field of a horseshoe magnet. This experiment measures the force F as a function of the current I, the conductor length s and the angle α between the magnetic field and the conductor, and reveals the relationship

$$F = I \cdot s \cdot B \sin \alpha$$

In the second experiment, a homogeneous magnetic field is generated using an electromagnet with U-core and pole-piece attachment. This experiment measures the force F as a function of the current I. The measurement results for various conductor lengths s are compiled and evaluated in a graph.

The third experiment uses an air coil to generate the magnetic field. The magnetic field is calculated from the coil parameters and compared with the values obtained from the force measurement.

The object of the fourth experiment is the electrodynamic definition of the ampere. Here, the current is defined on the basis of the force exerted between two parallel conductors of infinite length which carry an identical current. When r represents the distance between the two conductors, the force per unit of length of the conductor is:

$$\frac{F}{s} = \mu_0 \cdot \frac{I_2}{2\pi \cdot r}$$

This experiment uses two conductors approx. 30 cm long, placed just a few millimeters apart. The forces F are measured as a function of the different current levels I and distances r.