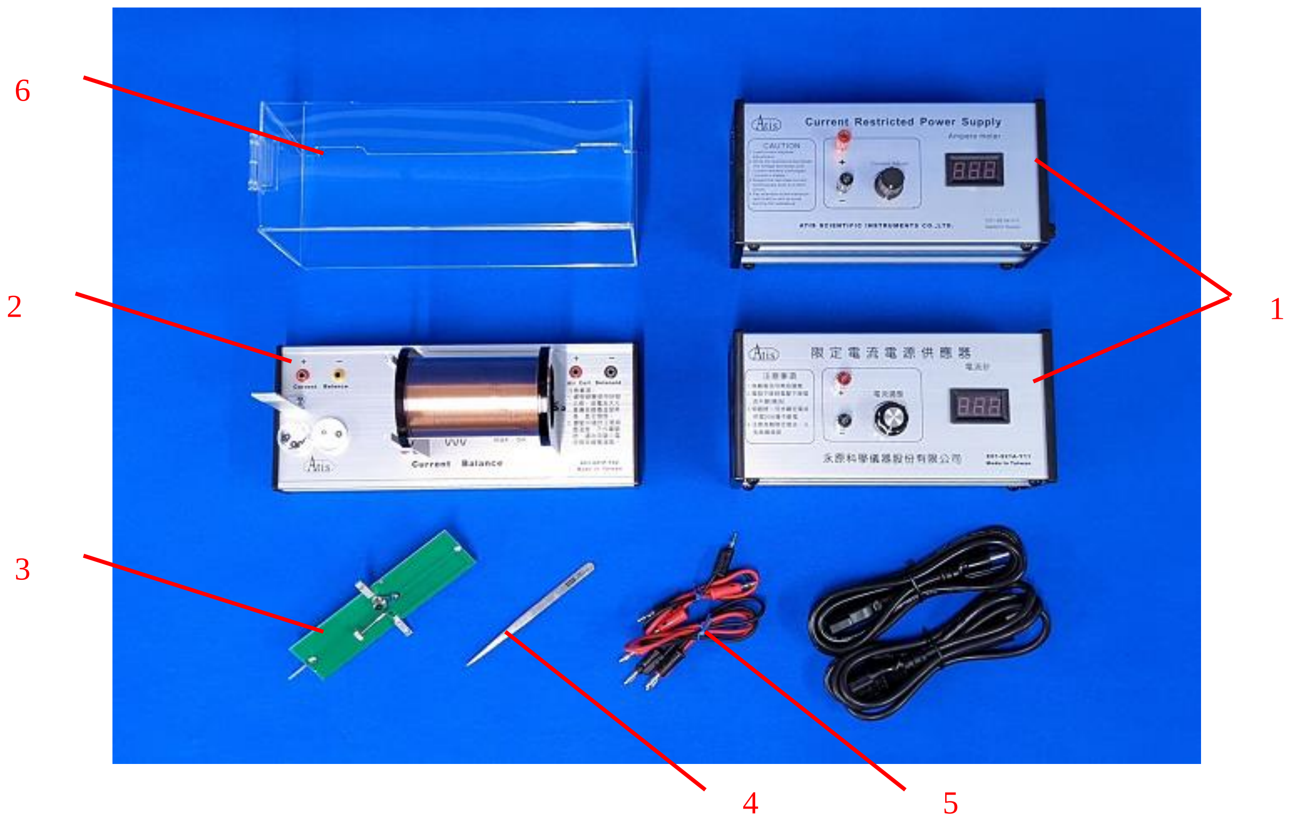
Current Balance Experiment

1. Purpose

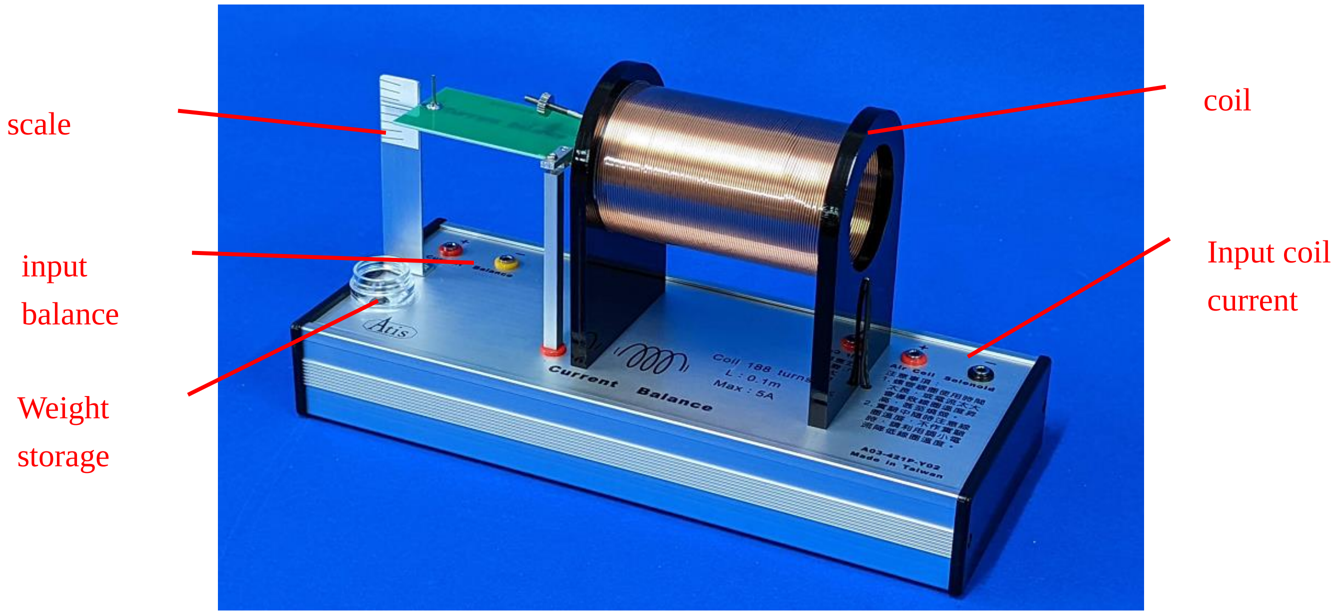
Use the current balance to measure the mass of weights, the current of the balance and the current of solenoid for calculating the magnetic field strength and observe the relationship between the solenoid current and the magnetic field.

2. Experimental tool:

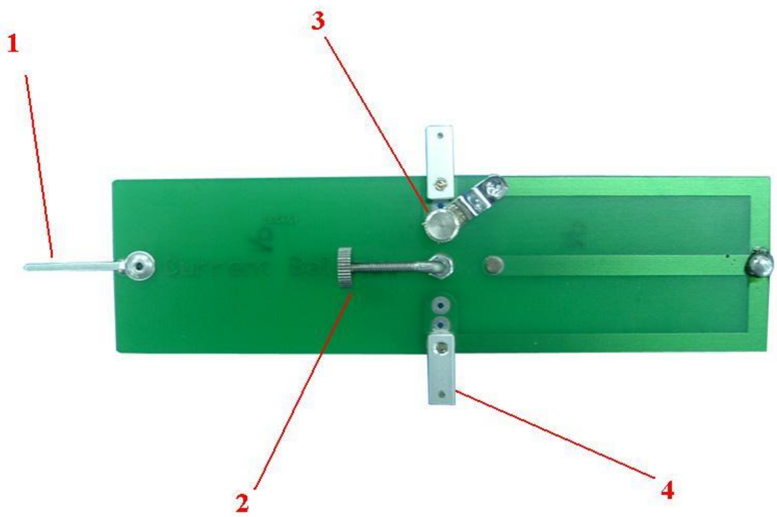


No.	Item	QTY	No.	Item	QTY
1	Limited Current Power Supply (5A)	2	4	tweezers	1
2	Screw-tube balance base	2	5	wire	4
3	current balance	1	6	Windproof Cover	1

Item 2 : Screw-tube balance base



Item 3: current balance



1. Balance pointer	2. Zero calibration screw	3. Line length knob
4. balance pivot		

3. Experimental principle

In 1819, Oersted discovered the deflection of a compass needle near a current-carrying wire. After that, Ampère discovered that electric current makes electricity when flows through a circuit. From the experiment, he found the relationship of the magnetic force F of the length λ, current i of a wire in the magnetic field B

$$F = I\lambda B\sin\theta \tag{1}$$

The θ is the angle between two sides of the current and the magnetic field. From the above equation, we know that when the current-carrying wire is perpendicular to the magnetic field, the magnetic force will be the strongest. When the two are parallel, the magnetic force will be zero. And the direction of the current-carrying wire is perpendicular to the direction of the magnetic field and the current. So the above equation can be rewritten as the following cross product. It shows the magnitude and direction of the magnetic force in a magnetic field.

$$\vec{F} = I \times \vec{\lambda} \times \vec{B} \tag{2}$$

The direction of the $\vec{\lambda}$ in the formula is the direction of the current, and its magnitude is the length of the wire in the magnetic field. The direction of the magnetic force can be known from the result of the mathematical outer product of vectors. In the above two equations, the unit of current is Ampere (A), the unit of wire length is meter (m), the unit of magnetic field is Tesla (T), and the unit of magnetic force is Newton (N). This experiment uses a current balance to measure the magnitude of the solenoid magnetic field. The structure of the current balance is shown in **Figure 1.**

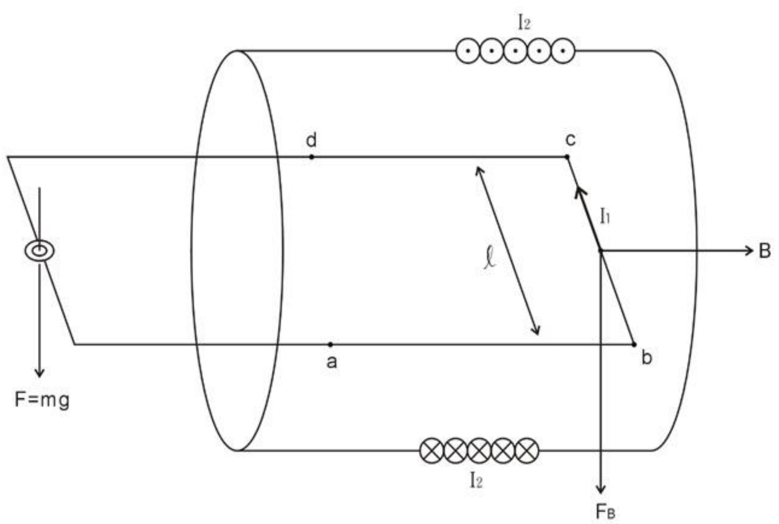


Figure 1.

As shown in **Figure 2,** when the current balance is inclined, the wire is perpendicular to the magnetic field, so $F = I_1 \lambda B$, the magnitude of magnetic forces of $\overline{ab}$ and $\overline{cd}$ is equal and opposite. So the two forces cancel each other, only the force of $\overline{bc}$ acts on the current balance.

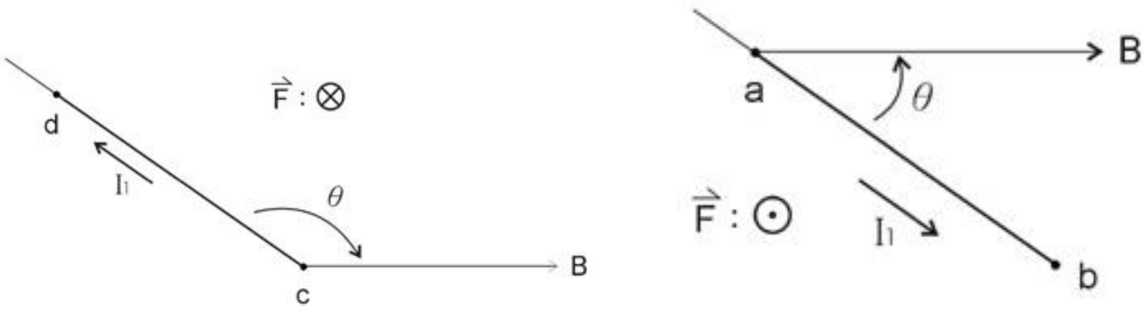


Figure 2

When the current balance is balanced, the force of the weight on the left is equal to the force of the wire, so $F = F_B$

$$mg = I_1 \lambda B$$

We obtain

$$B = \frac{mg}{I_1 \lambda} \qquad (3)$$

The unit of current I_1 is ampere (A), the unit of wire length λ is meter (m), the unit of magnetic B field is Tesla (T), the unit of mass is kilogram (kg), and the acceleration of gravity is 9.8m/ s^2.

In addition to the above method, the magnetic field of the solenoid can also be obtained by the solenoid current. The relational expression is:

$$B = u_0 \, n \, I_2 \qquad (4)$$

Among them, the unit of magnetic B field is Tesla (T), $u_0 = 4\pi \times 10^{-7}$ N/ A^2 is the vacuum permeability constant (permeability of free space), n is the number of turns of the coil length of one meter, and the unit of current I_2 is ampere (A).

In this experiment, the balance is used to measure the experimental magnetic B field in the solenoid, and the relationship between the experimental magnetic field $B = \frac{mg}{I_1 \lambda}$, the theoretical magnetic field $B = u_0 \, n \, I_2$ and the coil current I_2 is observed and compared.

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