# Serrata Current Balance

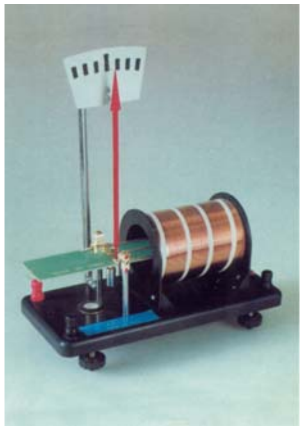
**Current Balance:** It is the object of this experiment to determine how the *magnitude* of the magnetic field near the centre of a long solenoid varies with the current in the solenoid.

### Apparatue Required

**current balance,** P.S.S.C. type
**solenoid**
**2 power supplies,** 0–12 V, 6 A, D.C. (continuously variable OR in 2 V steps)
*1035411 M or R Power Supplies can be used*
**2 ammeters,** 0–10 A, D.C. *(Cat No. 1040008)*
**2 rheostats,** 15 ohm, 5 A *(Cat No. 1052907)*
**connecting leads**

**Note:**
It is possible to do this experiment with only one of the power supplies.

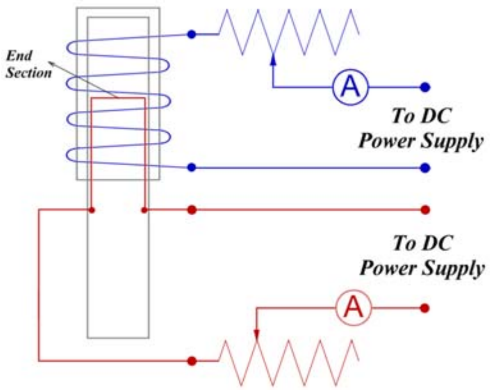
To calculate the values of the magnetic field strength, the relationship $B = \frac{F}{Il}$ is used, where $F$ is the force on a current element, the current element being the product of the current $I$ and length $l$ of the conductor in the field. As indicated by equation this *defines* the magnetic field strength.



Cat No. 1052036

## The Experiment:

The current balance consists of a U-shaped loop of copper wire attached to an insulating blade which fits neatly into the solenoid.




Measure the length of the *end* section of the wire loop and then balance the blade on the two conducting supports, so that this end section is at the centre of the solenoid. (Final balance is achieved by adjusting the nut at the end opposite the wire loop.) Connect the conducting supports in series with a rheostat and ammeter to the 0–12 V D.C. power supply.
The loop is connected to the conducting supports and forms part of the electric circuit.

Cat No. 1052020


Slowly increase the value of the D.C. supply and adjust the sliding contact on the rheostat so that there is a current of 3 A in the circuit. Readjust the balance if necessary but do not alter the settings for the rest of the experiment. Switch off the current.

Now connect the solenoid in series with the other rheostat and ammeter to the second D.C. power supply.

**Note:**
*It is possible to use the same D.C. supply as for the loop circuit but in this case any variation in current for either the loop or the solenoid circuit will have to be made by adjusting one of the two rheostats since the voltage remains at one setting.*

Adjust the sliding contact of the rheostat (and if you have a second power supply slowly increase its value) until you have a current of 1 A in the solenoid circuit. Switch on the loop circuit. What do you notice?

The sides of the loop are parallel to the magnetic field produced by the current in the solenoid, and thus do not experience a force. However the end of the loop, being perpendicular to the magnetic field at the centre of the solenoid, experiences a force either upwards or downwards depending on the direction of the current in the loop. If the force is upwards so that the balancing nut outside the solenoid swings downward, change the direction of the current in the loop, but check that its value remains at 3 A. (Do not forget to change the connections to the ammeter as well.)

To balance the loop, a small wire mass is added to the blade at the nut end. The balance is so designed that this mass is exactly the same distance from the balancing supports as is the loop at the other end. Thus when balance is achieved the gravitational force on the wire (its *weight*) is exactly equal to the magnetic force on the loop.

The length of wire used to balance the loop is proportional to the mass of the wire and hence to the force on the loop. Also the force on the loop is proportional to the magnetic field strength in the solenoid (for a given length and current in the loop, since $B = F/Il$). Thus *the length of wire required to balance the loop can be used as a measure of the magnetic field strength at the centre of the solenoid.*

Measure and record in the space below the length of wire required to balance the loop with currents in the solenoid varying in steps of 0.5 A from 1 A up to 4.5 A.

Plot a graph of length of wire *vs* current in the solenoid and thus determine a relationship between the magnetic field at the centre of the solenoid and the current in the solenoid.

### Questions:

1. Determine the directions of the current in both the solenoid and loop circuits. Are the right hand rules that you have learnt consistent with:
(a) the statement that there are no magnetic forces on the sides of the loop element inside the solenoid?
(b) the direction of deflection of the end of the loop in the solenoid?
2. The magnetic field strength at the centre of the solenoid is given by the relationship $B = \frac{F}{Il}$ (i.e., the force per unit current element). Given the length density of the wire mass by your teacher, use your graph to determine the strength of the magnetic field at the centre of the solenoid when the current in the solenoid is 2.5 A.
3. Would it be possible to use steel wire for the current loop on the blade rather than copper wire? Explain your answer.