Current Balance*

Object

To verify the magnetic force formula for two parallel current carrying wires.

Theory

Two infinitely long parallel straight wires, each carrying a current i, exert a magnetic force on each other. The magnitude of this force per unit length is:

$$\frac{F}{l} = \frac{\mu_0 i^2}{2\pi r},$$

where r is the distance between the wires, l is the length over which the force F is measured and μ_0 ($= 4\pi \times 10^{-7}$ (SI units)) is the permeability of free space. The force is attractive when the currents are in the same direction and repulsive when they are opposite. In reality, the wires cannot be infinite. So, in the lab you shall work with a finite length of wire and see how close the measured force is to the theoretically predicted one.

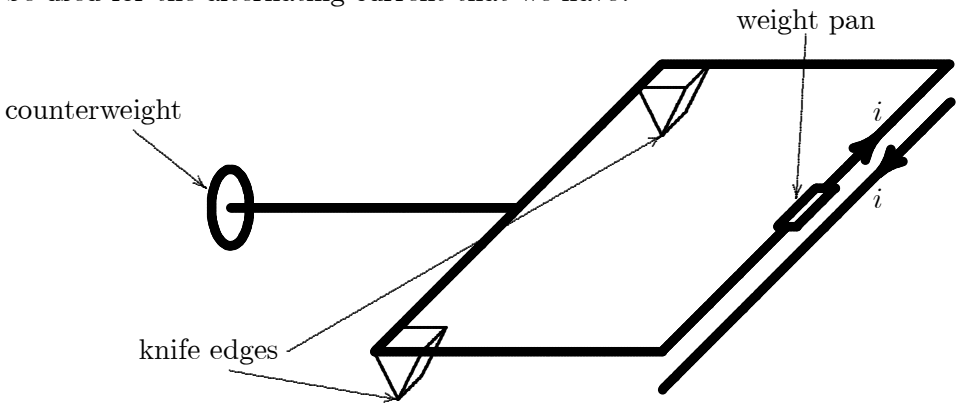
The measurement method

The setup provided has one long wire in a fixed position. A second wire, parallel to the first one, is mounted balanced on a pair of knife edges. A small pan on the second wire can hold small known weights. To locate the balanced position of the wire, a mirror is attached to it. A laser beam reflects off this mirror and forms an illuminated spot on a distant screen. The null position of the spot is marked out with no current in the wires and no weight in the pan. Then a known weight is placed in the pan and the current increased to keep the laser spot in its null position. The two wires are electrically connected in series to maintain the same current in both of them. In the balanced position (laser spot in the null position), the magnetic force of repulsion between the wires equals the known weight placed in the pans†. This would be the measured magnetic force.

The current is measured using an "amp-clamp". This current measuring instrument measures large alternating currents without being inserted in the circuit. The instructor will show you how to use this meter. See if you can guess how it works. Also note that the

†Remember to multiply the mass by the acceleration due to gravity.

force formula used here was derived for constant currents. Does it need modifications to be used for the alternating current that we have?



Some trials

Measure the magnetic force for several values of current. **But do not increase the current beyond 20 amperes and do not let large currents flow in the wires for long durations.** Calculate the magnetic force from the ideal formula given for infinitely long wires and compare with the measured values. This comparison can be done in several ways. One way would be to plot the measured and calculated forces against each other and note how close the curve is to a straight line of slope 1. One may also compute the percentage differences of the measured and the calculated forces for various currents.