

## Magnetic Flux and Flux Density

### Purpose

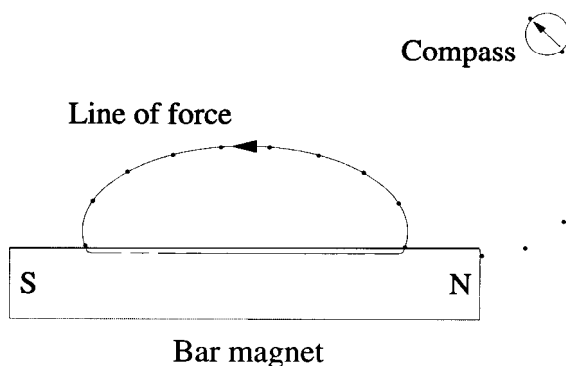
To draw maps of magnetic fields for five different configurations. Each map is to depict both the direction and the relative intensity of the magnetic field at every point.

### Theory

One can *imagine* lines of force, or magnetic flux (or streamlines, if you will) passing through regions of space in the vicinity of magnets. The flux's direction indicates the magnetic field's direction. If a compass were placed on a line of force, its north pole would point along a tangent to the line. The direction of the compass needle at any point in the field is the magnetic field's direction there.

The *SI* unit for  $\Phi_B$ , magnetic flux is the weber (Wb). While magnetic flux is not tangible in the sense that you can see or feel it, nevertheless if you were to move a conductor in a magnetic field so that it cut across 1 weber of flux each second, a potential difference of 1 volt would develop across its ends.

$B$ , the magnetic field intensity, or flux density, is a measure of the flux's concentration in a given region. The *SI* unit for  $B$  is the tesla (T), which describes a flux density of 1 weber of flux per square meter.



### Procedure

The above diagram illustrates Configuration 1: the field around a bar magnet. The bar magnet was placed on a sheet of paper and its outline was traced out. A compass was placed near the north pole of the magnet and a dot was drawn on the paper at the north end of the needle. The compass was then shifted so that its south end was touching the dot and a new dot was drawn at the north end of the needle. This process was continued, shifting the compass each time to draw the next dot, until the compass once again was touching the bar magnet. A smooth curve was then drawn through the dots.

To indicate that the line of force is a closed loop—part of which passes through the magnet, a dashed line was drawn connecting the curve. The diagram on the previous page also shows a second line of force in the process of being mapped. Map at least 6 lines of force on a sheet of paper. Label the paper “Configuration 1: Compass Method.”

A second method to map the magnetic field is to cover the bar magnet with a large piece of cardboard upon which you sprinkle iron filings. If you tap the cardboard gently, the iron filings will form a pattern illustrating the magnetic field. (Iron filings are shaped like tiny needles, each of which acts as a magnet.) Sketch the pattern you observe on a separate sheet of paper and label it “Configuration 1: Iron Filings Method.”

Repeat the above procedures for configurations 2 through 5, using both the compass and the iron filings method to map the magnetic fields. Submit two maps for each configuration, i.e., one map for each method.

Configuration 2: Two bar magnets along a line with their opposite poles facing each other. Separate the poles by approximately 10 cm.

Configuration 3: The same as configuration 2 except that there is an iron washer in the space midway between the poles.

Configuration 4: Two bar magnets along a line with their north poles facing each other. Separate the north poles by approximately 10 cm.

Configuration 5: The magnetic field around a horseshoe magnet.

## Questions

For each of the five configurations, where is the magnetic field intensity greatest? Discuss each case separately.

## Questions Continued

Which of the two methods, using the compass or iron filings, provides a more accurate representation of an individual line of force? Justify your answer.

Have you observed any magnetic flux that intersect? If you have, describe the configuration where the intersections occurred. If you haven't, discuss whether or not magnetic flux can theoretically intersect.

Does magnetic flux penetrate into glass or into copper? Suggest a procedure to determine the answer to this question.