Magnetic Field of a Helmholtz Coil*

Object

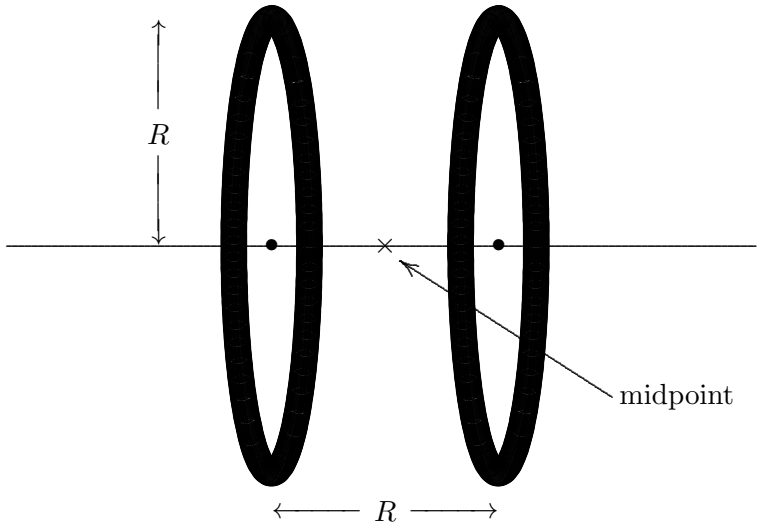
To study the magnetic field due to a Helmholtz coil.

Theory

A Helmholtz coil is a pair of circular loops of current carrying wire that are placed in parallel planes with the line joining the two centers being perpendicular to the planes (see figure below). The two loops have the same radius R. The distance between the centers of the loops is also R. Usually, each loop is made of multiple turns of wire. The number of turns n and the current I in each turn is the same for both loops. Historically, this arrangement has been used to produce a practically uniform magnetic field near the midpoint between the two centers. The uniformity of the field can be proved from theory. But we shall not do that here. Also from theory, it can be shown that the magnitude of that uniform field is,

$$B = \frac{8\mu_0 nI}{5\sqrt{5}R}$$

where $\mu_0 = 4\pi \times 10^{-7}$ Tm/A.



The measurement method

The magnetic field magnitude B can be measured using a probe that is interfaced to its dedicated computer software. Th above formula can be experimentally tested by measuring B at the midpoint

for a range of values for I and plotting a B vs. I graph. The slope of this graph should be as given by the above formula:

$$\text{Slope} = \frac{8\mu_0 n}{5\sqrt{5}R}$$

Plotting multiple magnetic field lines will give a pictorial account of the uniformity of the field. The magnitude of the field will be seen to be almost constant in the region where the field lines are straight and parallel.

COVID compromise

Due to COVID, we shall do a computer simulated version of this experiment. On starting the simulation, one sees the two coils in edge view. So, they appear as two vertical lines. This gives a better view of the magnetic field they produce. The mouse pointer is at the location of the simulated magnetic field probe. As it is moved, it shows the direction of the magnetic field at that point with a blue arrow. The meter at the top right hand corner shows the magnitude of the field. Bringing the mouse pointer at the midpoint, displays the field magnitude at that point. This measurement can be recorded for a range of values of current. The current value can be changed using the "Enter data" menu item in the "File" menu. Then a graph of current vs. magnetic field can be plotted. The fitted slope to this graph can then be compared to the theoretical slope as given above. The number of turns n and the radius R of the coil are also found in the "Enter data" menu item.

To draw a magnetic field line, click the mouse pointer at any point to register the magnetic field at that point. It will show up as a fixed red arrow. Then move the mouse pointer to the tip of this red arrow and click again. This will register another red arrow connected tail-to-tip to the previous one. By continuing this process, you can produce a series of red arrows connected tail-to-tip. This is a magnetic field line. If a field point is incorrectly registered, you can erase it by choosing "Erase last point" from the "File" menu. You can draw multiple field lines by starting at different points on the screen. You can then notice that the field lines are practically straight and parallel in the neighborhood of the midpoint.