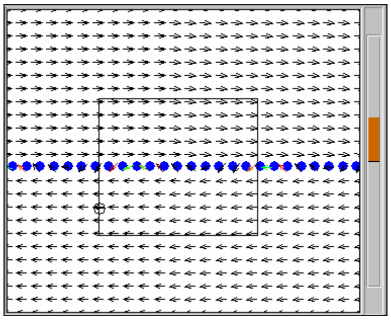
Worksheet for Exploration 28.2: A Plate of Current



Ampere's law states that $\int \mathbf{B} \cdot d\mathbf{l} = \mu_o I$, where the integration is over a closed loop (closed path), d**l** is an element of the path in the direction of the path, μ_o is the permeability of free space ($4\pi \times 10^{-7}$ Tm/A) and I is the total current enclosed in the path **(position is given in millimeters and the magnetic field is given in millitesla 10^{-3} T, so the integral is given in mT mm = 10^{-6} T m)**. To use Ampere's law to calculate the magnetic field, Amperian loops need to mimic the symmetry of the field so that **B** • d**l** is constant over the loop (or sections of the loop).

a. The blue dots represent wires carrying current into or out of the computer screen. In which direction does the current flow in the wires? Explain.
   i. Think about how magnetic fields wrap around a single wire first, then put many wires together.

This animation shows the path integral (the value in table and on the bar graph) as you move the cursor (the circle with cross-hair) around as well as the position of the cursor as you move it. Move the cursor along the top portion of the loop.

b. Is the integral positive or negative? Why? (Hint: d**l** points along the path in the direction you move the dot around the path).
   i. Try moving the cursor along the top from left to right, and then from right to left.

Move the cursor to a corner and re-zero the integral (push the *set integral = 0* button). Now move the cursor along one of the vertical sides of the loop.

c. How does the size of this integral compare with the integral along the top part of the loop? Why? (Hint: what is the direction of **B** along the side and what is the direction of d**l**. So what then is **B** • d**l**?)

d. Do the complete path integral (take the cursor completely around the loop). What is its value?

Path integral=_______

e. From this value, if each wire has the same current, what is the current in one of the wires?

I_{total}=__________

$I_{single\ wire}$=__________

f. From the path integral, what is the magnetic field above the series of wires? (Hint: If we neglect edge effects, $\int \mathbf{B} \cdot d\mathbf{l}$ = BL on the top and bottom of the loop and $\int \mathbf{B} \cdot d\mathbf{l}$ = 0 for the sides.)

$B_{predict}$=__________

g. Compare your calculated value (from the path integral) with the value you measure by click-dragging around the animation. Comment on any differences.

$B_{measured}$=__________

h. Show that the general expression for the magnetic field above or below the series of wires is B = (μ_0/2)(current/length) where the current/length is the current per length across the cross section of the plate (along the x axis in this animation).

i. Verify this expression for this animation.