10/30–Practice Problems and Tutorial on Ampere's Law

Ampere's Law

Ampere's Law in integral form is:

$$\oint \vec{B} \cdot d\vec{\ell} = \mu_0 I_{enc}$$

Learning how to choose an Amperian Loop is a skill we should practice.

1. Imagine there is a constant magnetic field B whose direction is given by the field lines shown below. An Amperian loop is also shown below (dashed lines).

   (a) What is $\int \vec{B} \cdot d\vec{\ell}$ for each side of the loop?

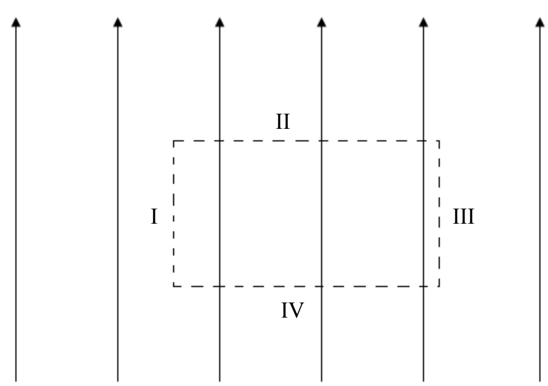
      i. Side I:

      ii. Side II:

      iii. Side III:

      iv. Side IV:

   (b) What is $\oint \vec{B} \cdot d\vec{\ell}$?



2. Now imagine rotating the Amperian loop such that it makes an angle ? with respect to the magnetic field (shown below).

   (a) What is $\int \vec{B} \cdot d\vec{\ell}$ for each side of the loop?

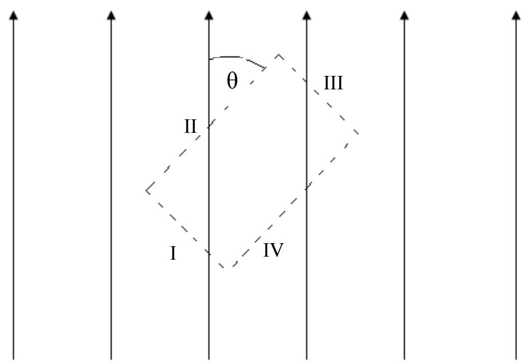
      i. Side I:

      ii. Side II:

      iii. Side III:

      iv. Side IV:

   (b) What is $\oint \vec{B} \cdot d\vec{\ell}$?



3. Compare $\oint \vec{B} \cdot d\vec{\ell}$ for the two previous cases. Do they make sense? Explain.
4. Thinking about Problems 1 and 2:
   (a) Qualitatively explain how your results for questions 1-3 would change if your Amperian loop was a circle instead of a rectangle.
   (b) Why is a rectangular Amperian loop better for this problem than a circular Amperian loop? Explain.
   (c) What sort of situation might you want a circular Amperian loop for and why? Explain the geometry and the direction of the current.
5. If for an Amperian loop, $\oint \vec{B} \cdot d\vec{\ell} = 0$ (not necessarily the one in questions 1 and 2), can you conclude $\vec{B} = 0$? Can you conclude anything about the magnetic field B? Explain.
6. What does it mean if $\oint \vec{B} \cdot d\vec{\ell} \neq 0$? Explain.

After you've done these, try Griffiths' 5.14, 15