University Physics, 13/e

Young/Freedman

Chapter 28 Problem-Solving Strategy

Problem-Solving Strategy 28.1 Magnetic-Field Calculations

IDENTIFY *the relevant concepts:* The Biot–Savart law [Eqs. (28.5) and (28.6)] allows you to calculate the magnetic field at a field point *P* due to a current-carrying wire of any shape. The idea is to calculate the field element $d\vec{B}$ at *P* due to a representative current element in the wire and integrate all such field elements to find the field $\vec{B}$ at *P*.

SET UP *the problem* using the following steps:

1. Make a diagram showing a representative current element and the field point *P*.
2. Draw the current element $d\vec{l}$, being careful that it points in the direction of the current.
3. Draw the unit vector $\hat{r}$ directed *from* the current element (the source point) to *P*.
4. Identify the target variable (usually $\vec{B}$).

EXECUTE *the solution* as follows:

1. Use Eq. (28.5) or (28.6) to express the magnetic field $d\vec{B}$ at *P* from the representative current element.
2. Add up all the $d\vec{B}$'s to find the total field at point *P*. In some situations the $d\vec{B}$'s at point *P* have the same direction for all the current elements; then the magnitude of the total $\vec{B}$ field is the sum of the magnitudes of the $d\vec{B}$'s. But often the $d\vec{B}$'s have different directions for different current elements. Then you have to set up a coordinate system and represent each $d\vec{B}$ in terms of its components. The integral for the total $\vec{B}$ is then expressed in terms of an integral for each component.
3. Sometimes you can use the symmetry of the situation to prove that one component of $\vec{B}$ must vanish. Always be alert for ways to use symmetry to simplify the problem.
4. Look for ways to use the principle of superposition of magnetic fields. Later in this chapter we'll determine the fields produced by certain simple conductor shapes; if you encounter a conductor of a complex shape that can be represented as a combination of these simple shapes, you can use

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superposition to find the field of the complex shape. Examples include a rectangular loop and a semicircle with straight line segments on both sides.

EVALUATE *your answer:* Often your answer will be a mathematical expression for $\vec{\boldsymbol{B}}$ as a function of the position of the field point. Check the answer by examining its behavior in as many limits as you can.

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