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| **Magnetic Field from Two Wires** |
| **Learning Goal:** To understand how to use the principle of superposition in conjunction with the Biot-Savart (or Ampere's) law.  From the Biot-Savart law, it can be calculated that the magnitude of the magnetic field due to a long straight wire is given by  B_{\rm wire}=\frac{\mu_0 I}{2\pi d},  where mu_0(\!=\!4\pi \times 10^{-7}\; \rm T \cdot m/A) is the permeability constant, Iis the current in the wire, and dis the distance from the wire to the location at which the magnitude of the magnetic field is being calculated.  The same result can be obtained from Ampere's law as well.    The direction of vector B_veccan be found using the *right-hand rule*. (Take care in applying the right-hand rule. Many students mistakenly use their left hand while applying the right-hand rule since those who use their right hand for writing sometimes automatically use their "pencil-free hand" to determine the direction of B_vec.)  In this problem, you will be asked to calculate the magnetic field due to a set of two wires with antiparallel currents as shown in the diagram http://session.masteringphysics.com/problemAsset/1004684/21/189576A.jpg. Each of the wires carries a current of magnitude I. The current in wire 1 is directed out of the page and that in wire 2 is directed into the page. The distance between the wires is 2d. The *x* axis is perpendicular to the line connecting the wires and is equidistant from the wires.  As you answer the questions posed here, try to look for a pattern in your answers.   |  |  | | --- | --- | | Part A |  | | Which of the vectors best represents the direction of the magnetic field created at point K (see the diagram in the problem introduction) by wire 1 *alone*?  **Enter the number of the vector with the appropriate direction. http://session.masteringphysics.com/problemAsset/1004684/21/189576B.jpg**   |  |  |  |  |  | | --- | --- | --- | --- | --- | | ANSWER: | |  |  |  | | --- | --- | --- | |  | **3** ***Correct*** |  | | | | | Part B |  | | Which of the vectors best represents the direction of the magnetic field created at point K by wire 2 *alone*?  **Enter the number of the vector with the appropriate direction. http://session.masteringphysics.com/problemAsset/1004684/21/189576B.jpg**   |  |  |  |  |  | | --- | --- | --- | --- | --- | | ANSWER: | |  |  |  | | --- | --- | --- | |  | **3** ***Correct*** |  | | | |  |  |  | | --- | --- | | Part C |  | | Which of these vectors best represents the direction of the *net* magnetic field created at point K by *both* wires?  **Enter the number of the vector with the appropriate direction. http://session.masteringphysics.com/problemAsset/1004684/21/189576B.jpg**   |  |  |  |  |  | | --- | --- | --- | --- | --- | | ANSWER: | |  |  |  | | --- | --- | --- | |  | **3** ***Correct*** |  | | | | | Part D |  | | Find the magnitude of the magnetic field B_1Kcreated at point K by wire 1.  **Express your answer in terms of I, d, and appropriate constants.**   |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | | ANSWER: | |  |  |  |  |  | | --- | --- | --- | --- | --- | |  | B_1K = | **\frac{{\mu}_{0}I}{2{\pi}d}** ***Correct*** |  |  | |   Of course, B_{\rm 2K}=B_{\rm 1K}because point K is equidistant from the wires. | |  |  |  | | --- | --- | | Part E |  | | Find the magnitude of the *net* magnetic field B_Kcreated at point K by both wires.  **Express your answer in terms of I, d, and appropriate constants.**   |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | | ANSWER: | |  |  |  |  |  | | --- | --- | --- | --- | --- | |  | B_K = | **\frac{{\mu}_{0}I}{{\pi}d}** ***Correct*** |  |  | |   This result is fairly obvious because of the symmetry of the problem: At point K, the two wires each contribute equally to the magnetic field. At points L and M you should also consider the symmetry of the problem. However, be careful! The vectors will add up in a more complex way. | | | Part F |  | | Point L is located a distance d\sqrt 2from the midpoint between the two wires. Find the magnitude of the magnetic field B_1Lcreated at point L by wire 1.   |  |  | | --- | --- | | Hint F.1 | **How to approach the problem** | | ***Hint not displayed*** | |   **Express your answer in terms of I, d, and appropriate constants.**   |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | | ANSWER: | |  |  |  |  |  | | --- | --- | --- | --- | --- | |  | B_1L = | **\frac{{\mu}_{0}I}{2{\pi}d\sqrt{3}}** ***Correct*** |  |  | | | |  |  |  | | --- | --- | | Part G |  | | Point L is located a distance d\sqrt 2from the midpoint between the two wires. Find the magnitude of the *net* magnetic field B_Lcreated at point L by both wires.   |  |  | | --- | --- | | Hint G.1 | **How to approach the problem** | | ***Hint not displayed*** | | | Hint G.2 | **Find the direction of the magnetic field due to wire 1** | | ***Hint not displayed*** | |  |  |  | | --- | --- | | Hint G.3 | **Find the direction of the magnetic field due to wire 2** | | ***Hint not displayed*** | | | Hint G.4 | **Find the direction of the net magnetic field** | | ***Hint not displayed*** | |  |  |  | | --- | --- | | Hint G.5 | **Angle between magnetic field due to wire 1 and the *x* axis** | | ***Hint not displayed*** | | | Hint G.6 | **Find the angle between magnetic field due to wire 1 and the *x* axis** | | ***Hint not displayed*** | |  |  |  | | --- | --- | | Hint G.7 | **Net magnetic field** | | ***Hint not displayed*** | |   **Express your answer in terms of I, d, and appropriate constants.**   |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | | ANSWER: | |  |  |  |  |  | | --- | --- | --- | --- | --- | |  | B_L = | **\frac{{\mu}_{0}I}{3{\pi}d}** ***Correct*** |  |  | | | | | Part H |  | | Point M is located a distance 2dfrom the midpoint between the two wires. Find the magnitude of the magnetic field B_1Mcreated at point M by wire 1.  **Express your answer in terms of I, d, and appropriate constants.**   |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | | ANSWER: | |  |  |  |  |  | | --- | --- | --- | --- | --- | |  | B_1M = | **\frac{{\mu}_{0}I}{2{\pi}d\sqrt{5}}** ***Correct*** |  |  | | | |  |  |  | | --- | --- | | Part I |  | | Find the magnitude of the *net* magnetic field B_Mcreated at point M by both wires.   |  |  | | --- | --- | | Hint I.1 | **How to approach the problem** | | ***Hint not displayed*** | | | Hint I.2 | **Find the direction of the magnetic field due to wire 1** | | ***Hint not displayed*** | |  |  |  | | --- | --- | | Hint I.3 | **Find the direction of the net magnetic field** | | ***Hint not displayed*** | | | Hint I.4 | **Angle between magnetic field due to wire 1 and the *x* axis** | | ***Hint not displayed*** | |  |  |  | | --- | --- | | Hint I.5 | **Find the angle between magnetic field due to wire 1 and the *x* axis** | | ***Hint not displayed*** | | | Hint I.6 | **Net magnetic field** | | ***Hint not displayed*** | |   **Express your answer in terms of I, d, and appropriate constants.**   |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | | ANSWER: | |  |  |  |  |  | | --- | --- | --- | --- | --- | |  | B_M = | **\frac{{\mu}_{0}I}{5{\pi}d}** ***Correct*** |  |  | | | | | Part J |  | | Finally, consider point X (not shown in the diagram) located on the *x* axis very far away in the positive *x* direction. Which of the vectors best represents the direction of the magnetic field created at point X by wire 1 *alone*?  **Enter the number of the vector with the appropriate direction. http://session.masteringphysics.com/problemAsset/1004684/21/189576B.jpg**   |  |  |  |  |  | | --- | --- | --- | --- | --- | | ANSWER: | |  |  |  | | --- | --- | --- | |  | ***Answer not displayed*** |  | | | |  |  |  | | --- | --- | | Part K |  | | Which of the vectors best represents the direction of the magnetic field created at point X by wire 2 *alone*?  **Enter the number of the vector with the appropriate direction. http://session.masteringphysics.com/problemAsset/1004684/21/189576B.jpg**   |  |  |  |  |  | | --- | --- | --- | --- | --- | | ANSWER: | |  |  |  | | --- | --- | --- | |  | ***Answer not displayed*** |  | | | | |

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| **Problem 33.8** |
| |  |  | | --- | --- | | Part A |  | | What current is needed to generate the magnetic field strength of 5.0\times 10^{-5}\;{\rm T}at a point 2.3 cm from a long, straight wire?  **Express your answer using two significant figures.**   |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | | ANSWER: | |  |  |  |  |  | | --- | --- | --- | --- | --- | |  | I = | **5.8** ***Correct*** | {\rm A} |  | | | | | Part B |  | | What current is needed to generate the magnetic field strength of 5.0\times 10^{-3}\;{\rm T}at a point 2.3 cm from a long, straight wire?  **Express your answer using two significant figures.**   |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | | ANSWER: | |  |  |  |  |  | | --- | --- | --- | --- | --- | |  | I = | **580** ***Correct*** | {\rm A} |  | | | |  |  |  | | --- | --- | | Part C |  | | What current is needed to generate the magnetic field strength of 1.0\;{\rm T}at a point 2.3 cm from a long, straight wire?  **Express your answer using two significant figures.**   |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | | ANSWER: | |  |  |  |  |  | | --- | --- | --- | --- | --- | |  | I = | ***Answer not displayed*** | {\rm A} |  | | | | | Part D |  | | What current is needed to generate the magnetic field strength of 10\;{\rm T}at a point 2.3 cm from a long, straight wire?  **Express your answer using two significant figures.**   |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | | ANSWER: | |  |  |  |  |  | | --- | --- | --- | --- | --- | |  | I = | ***Answer not displayed*** | {\rm A} |  | | | | |