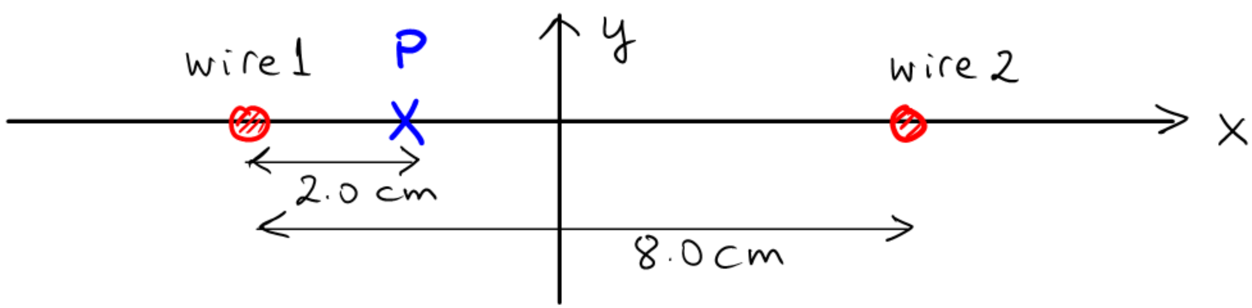
PhysicsTutor

Magnetic field

Giambattista 19.71

Problem:

- Two long straight parallel wires separated by 8.0 cm carry currents of equal magnitude but heading in opposite directions. The wires are shown perpendicular to the page plane (*x*,*y*). Point *P* is 2.0 cm from wire 1, and the magnetic field at *P* is 1.0×10^{-2} T along $-y$.
- Find the current in wire 1 and its direction.



Relevant ideas:

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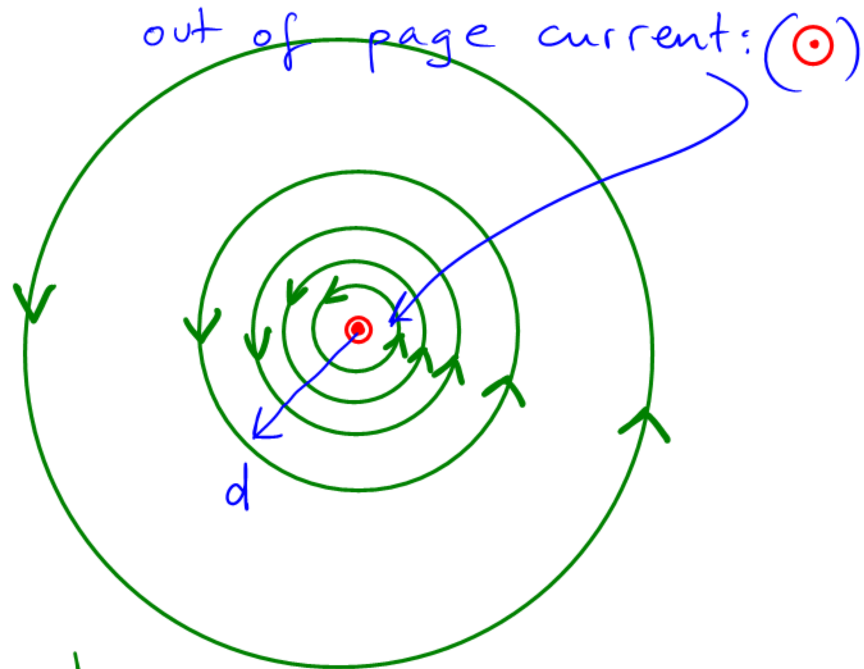
- A long current-carrying wire is surrounded by a magnetic field whose strength drops as 1/d.

$$B = \frac{\mu_0 I}{2\pi d}$$

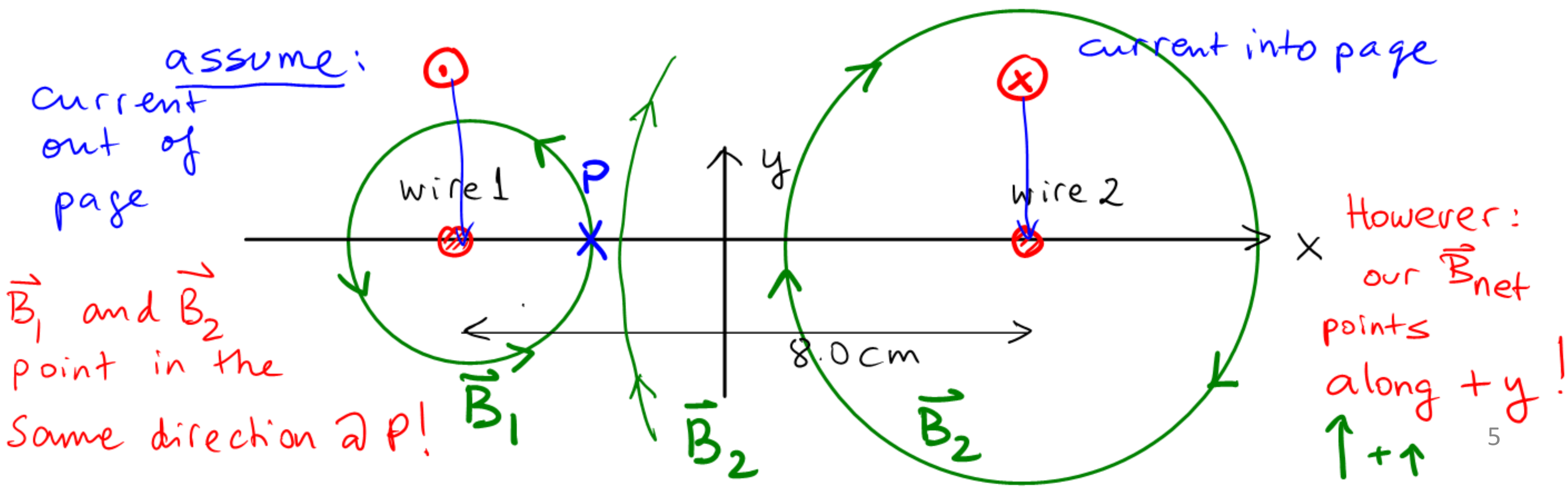
strength of B falls off with distance d



Spacing of field lines grows with d.

Relevant ideas:

- A long current-carrying wire is surrounded by a magnetic field whose strength drops as 1/d.
- The field lines are circles about the wire. Use the Right-Hand rule to find the direction of $\mathbf{B}_i$ at P for wires i = 1,2.



Relevant ideas:

- A long current-carrying wire is surrounded by a magnetic field whose strength drops as 1/d.
- The field lines are circles about the wire. Use the Right-Hand rule to find the direction of $\mathbf{B}_i$ at P for wires i = 1,2. Do they add or subtract?
- The net magnetic field is caused by the closer current in wire 1, but also has a contribution from wire 2.

Equations associated with ideas:

$$B = \frac{\mu_0 I}{2\pi d} \; ; \quad B_1 = \frac{\mu_0 I_1}{2\pi d_1} \; ; \quad B_2 = \frac{\mu_0 I_2}{2\pi d_2}$$

counter-propagating currents at P_1 / P_2 :
(anti-parallel)

$$B_{net} = B_1 + B_2 \quad @ \; P$$

Fields would partially cancel if P was to the left of wire 1 !

Strategy

Strategy

- Use the simple right-hand rule to figure out that the fields from wire 1 and wire 2 add at *P*.

$$B_{net} = \frac{\mu_0}{2\pi} I \left(\frac{1}{d_1} + \frac{1}{d_2} \right)$$

Strategy

- Use the simple right-hand rule to figure out that the fields from wire 1 and wire 2 add at *P*.
- The direction of the net magnetic field is along -*y*. This means current 1 is into the page, and current 2 is out of the page.

opposite to what was assumed for the figure.

Strategy

- Use the simple right-hand rule to figure out that the fields from wire 1 and wire 2 add at P.
- The direction of the net magnetic field is along $-y$. This means current 1 is into the page, and current 2 is out of the page.
- In the formula for the net field isolate the current strength I, and solve for it.

Strategy

- Use the simple right-hand rule to figure out that the fields from wire 1 and wire 2 add at *P*.
- The direction of the net magnetic field is along -*y*. This means current 1 is into the page, and current 2 is out of the page.
- In the formula for the net field isolate the current strength *I*, and solve for it.
- Q: what if *P* was to the left of wire 1?

Solution

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- $B_{net} = \frac{\mu_0}{2\pi} I \left(\frac{1}{d_1} + \frac{1}{d_2} \right) \therefore B_{net} = \frac{\mu_0}{2\pi} I \left(\frac{d_1 d_2}{d_1 + d_2} \right)$ ______________________________

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- $\therefore I = \frac{2\pi}{\mu_0} B_{net} \frac{d_1 d_2}{d_1 + d_2} = \frac{2\pi \cdot 1.0 \times 10^{-2} \cdot 2.0 \cdot 6.0 \times 10^{-4}}{4\pi \cdot 10^{-7} \cdot 8.0 \times 10^{-2}}$ A

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- $I = 0.75 \cdot 10^{3}$ A $= 750$ A

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- $I = 0.75 \cdot 10^{3} A = 750 A$
- current 1 is into the page