B10 · Extra practice, worked solutions

Fields around currents | Diploma-style set of 8

Easy · B10-X01. A straight wire carries a conventional current out of the page, toward you. At a point to the right of the wire, which way does the magnetic field point?

A. Down the page
B. Up the page
C. Into the page
D. To the right

1. Givens: current out of the page (⊙); the point is to the right of the wire. Question: the field direction there.

2. Point your right thumb out of the page, along the current. Your fingers curl counterclockwise.

3. On the right side of the wire the fingers point up the page, so the field is up the page.

4. Answer: B. Up the page

Easy · B10-X02. Electrons flow east along a wire. What is the direction of the conventional current?

A. West
B. East
C. North
D. There is no conventional current.

1. Givens: electron flow is east. Question: the conventional current direction.

2. Conventional current is the flow of positive charge. Electrons are negative, so the conventional current is opposite to their flow.

3. The conventional current is west.

4. Answer: A. West

Medium · B10-X03. Looking at the right end of a solenoid, the conventional current goes around its coils counterclockwise. Which end of the solenoid is its north pole?

A. The left end, the far end

B. Both ends are north poles.

C. The north pole is in the middle of the solenoid.

D. The right end, the end nearest the viewer

1. Givens: the current is counterclockwise as seen from the right end. Question: which end is north.

2. Right-hand rule for a coil: curl the fingers in the direction of the current. Counterclockwise, as seen by the viewer, makes the thumb point toward the viewer.

3. The thumb points toward the north end, so the right end is the north pole.

4. Answer: D. The right end, the end nearest the viewer

Medium · B10-X04. Which change makes the magnetic field inside a solenoid stronger?

A. Use fewer turns and remove the current
B. Reverse the current only
C. Add more turns per length and put an iron core inside
D. Use a longer wire with the same number of turns per length

1. Givens: a solenoid of fixed size. Question: which change makes the field stronger.

2. The field grows with more turns per length, more current and an iron core.

3. Reversing the current only flips the direction. The field strength does not change.

4. Answer: C. Add more turns per length and put an iron core inside

Challenging · B10-X05. A long horizontal wire lies across the page with conventional current to the right. At a point just below the wire, which way does the magnetic field point?

A. Out of the page
B. Into the page
C. To the right
D. Up the page

1. Givens: current to the right; the point is below the wire. Question: the field direction there.

2. Thumb to the right, along the current. The fingers curl up out of the page above the wire.

3. Below the wire the fingers curl into the page, so the field is into the page.

4. Answer: B. Into the page

Medium · B10-X06. Describe the shape and direction of the magnetic field inside a long solenoid, and compare it with the field outside.

1. Givens: a long solenoid carrying current. Question: describe the field inside and outside.

2. Inside, the field lines are straight, parallel and evenly spaced, so the field is nearly uniform. It points along the axis toward the north end.

3. Outside, the lines curve around from the north end back to the south end, like a bar magnet, and spread out so the field is weak.

Medium · B10-X07. Give two ways to make the field of a straight current-carrying wire stronger at a point near it, and one way to reverse the field.

1. Givens: a straight wire carrying current. Question: two ways to strengthen the field, and one way to reverse it.

2. To strengthen: increase the current, or move closer to the wire. (The field falls off with distance.)

3. To reverse: reverse the direction of the current. The right-hand rule then gives the opposite direction.

Challenging · B10-X08. A compass is placed below a horizontal wire and the needle points north when there is no current. When a current flows, the needle turns. When the current is reversed, the needle turns the other way. Explain both observations.

1. Givens: a compass under a wire; the needle turns when the current flows and turns the other way when it is reversed. Question: why.

2. A current makes a magnetic field around the wire. The compass needle lines up along the combined field of the Earth and the wire, so it turns away from north.

3. Reversing the current reverses the direction of the wire’s field by the right-hand rule, so the needle turns the other way. This shows that the direction of the field depends on the direction of the current.