Lenz's Law

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Faraday's law tells you that there will be an induced emf in a circuit if the magnetic flux it is linking changes. Faraday's law also tells you the magnitude of the induced emf. But Lenz's Law tells you the direction of the emf:

Lenz's Law: A changing magnetic flux induces an emf that produces a current which sets up a magnetic field that ***tends to oppose whatever produced the change***.

Coils and loops do not like any change in the magnetic flux they are linking, and they will try to produce an emf or current to counteract the change imposed on them. Note that the net result is that they usually would not be successful - the change in the magnetic flux still takes place. This tendency to oppose the change is why there is a minus sign in Faraday's Law.

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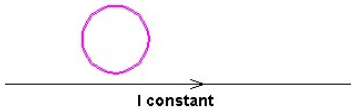
Lenz's Law example 1

A wire loop is located near a long straight current-carrying wire. The current in the wire is directed to the right. With the current held constant in the long straight wire, the loop is moved up, away from the wire. In what direction is the induced current in the loop?

1. The induced current is clockwise.
2. The induced current is counter-clockwise.
3. There is no induced current.



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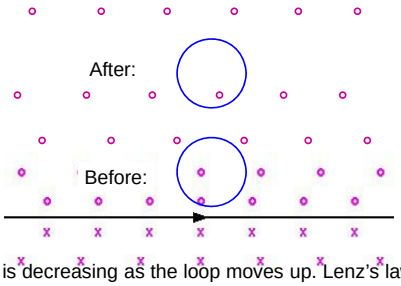
Lenz's Law example 1



The flux is decreasing as the loop moves up. Lenz's law says that a current should flow in the loop to oppose the change. This can be achieved if the current is counter-clockwise since that will produce magnetic fluxes going out of the screen and reduce the amount of decrease in flux as the loop moves up.

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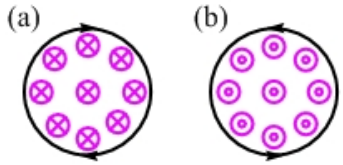
A pictorial approach to Lenz's Law

An easy way to approach Lenz's Law situations, to figure out the direction of an induced current, is to draw a set of three pictures, which we will discuss below.

First, let's review the direction of the magnetic field produced inside a loop when the current is (a) clockwise and (b) anti-clockwise.



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A pictorial approach to Lenz's Law

Example: A wire loop in the plane of the page is in a uniform magnetic field directed into the page. Over some time interval the field is doubled. What direction is the induced current in the loop while the field is changing?

Step 1: Draw a "Before" picture, showing the field passing through the loop before the change takes place.

Step 2: Draw an "After" picture, showing the field passing through the loop after the change.

Step 3: Draw a "To Oppose" picture, showing the direction of the field the loop creates to oppose the change.

Step 4: Use the right-hand rule to determine which way the induced current goes in the loop to create that field.

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Step 3: Draw a "To Oppose" picture, showing the direction of the field the loop creates to oppose the change.

Step 4: Use the right-hand rule to determine which way the induced current goes in the loop to create that field.

One field line is enough for the To Oppose picture - that's enough to determine the direction of the induced current.

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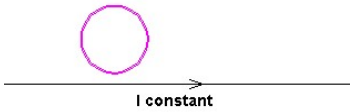

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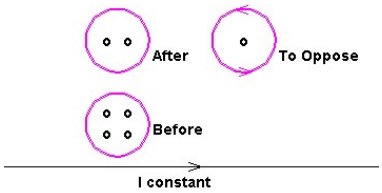
Lenz's Law example 1

The flux through the loop decreases, so the loop tries to add field lines that are directed out of the page to oppose the change. The induced current must go counter-clockwise to produced the required field.



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