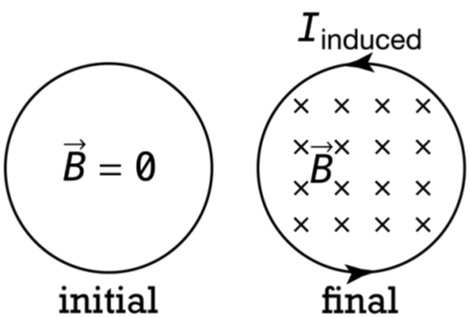
Flipping Physics Lecture Notes:
Lenz's Law
http://www.flippingphysics.com/lenz-law.html

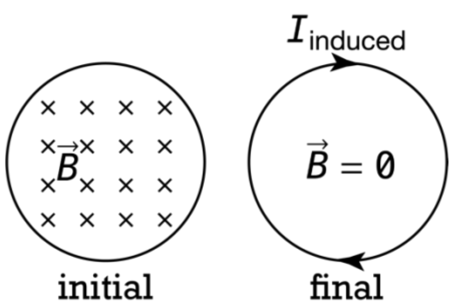
We need to determine the direction of the induced emf caused by a changing magnetic flux. That is shown by removing the absolute value from the equation, which gives us, assuming only one loop:

$$\varepsilon = -\frac{d\Phi_B}{dt}$$

- The negative in this equation means the induced emf is opposite the direction of the change in magnetic flux.
- The direction of the induced emf is called Lenz' law.
    - Yes, the negative added to Faraday's law is called Lenz' law.
    - Lenz' law: The current induced in a circuit due to a change in a magnetic field is directed to oppose the change in magnetic flux and to exert a mechanical force which opposes the motion.
- We use the right-hand rule[1] to determine the direction of the induced emf. Examples below:

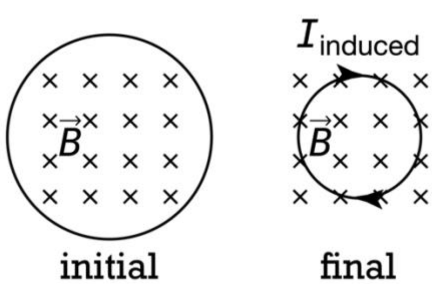


- Zero initial magnetic flux inside the loop.
- Original B field is into the screen and increasing, therefore the original magnetic flux is increasing.
- Induced magnetic field opposes the change in the original magnetic flux and therefore is induced out of the screen to counteract the change in original magnetic flux.
- According to the right-hand rule, fingers curl out of the screen in the direction of the induced magnetic field, thumb points in the direction of the induced current which is counterclockwise.



- Original B field in the loop is into the screen and decreasing, which means the original magnetic flux is decreasing.
- $B_{induced}$ opposes this change in magnetic flux and attempts to maintain the original magnetic flux. Therefore, $B_{induced}$ is into the screen.
- According to the right-hand rule, fingers curl into the screen in the direction of the induced magnetic field, thumb points in the direction of the induced current which is clockwise.

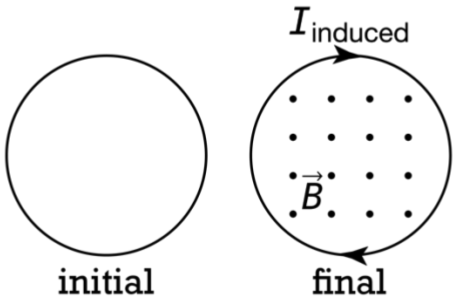
Note: Magnetic flux is a dot product, so magnetic flux is a scalar. So, the induced magnetic flux does not have a direction, however, the induced magnetic field does have a direction and the direction of the induced magnetic field in the plane of the loop is always normal to the loop in which the induced current is created.



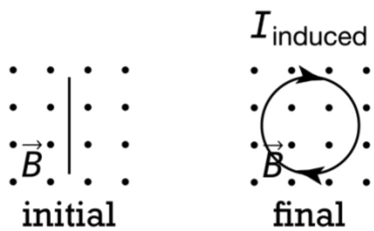
- Original B field inside the loop is into the screen and the area is decreasing which means the original magnetic flux is decreasing.
- $B_{induced}$ opposes this change in magnetic flux and produces a magnetic field to maintain the original magnetic flux. Therefore, $B_{induced}$ is into the screen.
- According to the right-hand rule, fingers curl into the screen in the direction of the induced magnetic field, thumb points in the direction of the induced current which is clockwise.

[1] This is the "alternate" right-hand rule with the thumb pointing in the direction of the current in the wire and fingers curling in the direction of the magnetic field created by the current in the wire.

(The next example was cut out of the video, however, y'all still get to enjoy it here!)

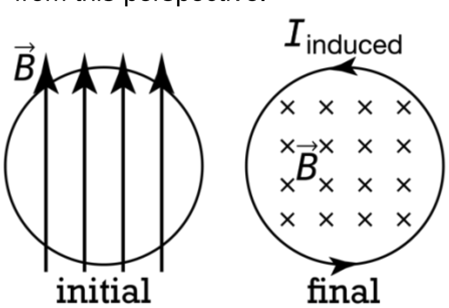


- There is no original B field so no original magnetic flux. The B field is increasing out of the screen so the original magnetic flux is increasing.
- $B_{induced}$ opposes this change in magnetic flux and produces a magnetic field to maintain the original magnetic flux. Therefore, $B_{induced}$ is into the screen.
- According to the right-hand rule, fingers curl into the screen in the direction of the induced magnetic field, thumb points in the direction of the induced current which is counterclockwise.

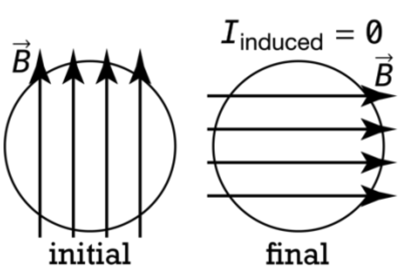


- B field is originally parallel to the loop, so there is zero original magnetic flux through the loop. Loop turns to cause the area of the loop to now be normal to the B field which is out of the screen. So, the original magnetic flux is increasing.
- $B_{induced}$ opposes this change in magnetic flux and produces a magnetic field to maintain the original magnetic flux. Therefore, $B_{induced}$ is into the screen.
- According to the right-hand rule, fingers curl into the screen in the direction of the induced magnetic field, thumb points in the direction of the induced current which is clockwise.

Note: No matter which way the loop is turned, the change in the magnetic flux through the loop is the same and the induced magnetic field is into the screen caused by the induced current which is clockwise from this perspective.



- B field is originally parallel to the loop, so there is no original magnetic flux. B field turns to now be into the screen. So, the original magnetic flux is increasing.
- $B_{induced}$ opposes this change in magnetic flux and produces a magnetic field to maintain the original magnetic flux. Therefore, $B_{induced}$ is out of the screen.
- According to the right-hand rule, fingers curl out of the screen in the direction of the induced magnetic field, thumb points in the direction of the induced current which is counterclockwise.



- B field is originally parallel to the loop, so there is no original magnetic flux. B field turns to now be … still parallel to the loop. So, the magnetic flux through the loop is still zero.
- No change in the magnetic flux means there is no induced current. ▯