Introduction

Your answers are for self assessment only, and will not be saved or graded.

If magnetic field B is parallel to the plane in which a loop of area A lies, then the flux is

a. BA

b. $-BA$

c. Zero.

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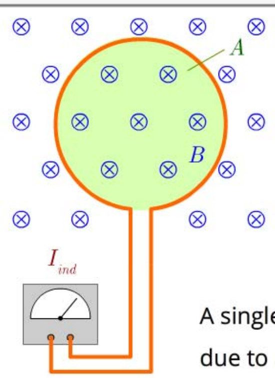
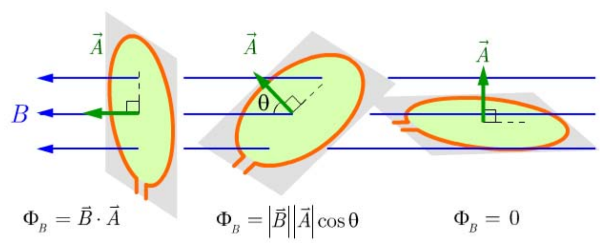
Faraday's Law of Electromagnetic Induction





A single conducting loop has a magnetic flux (Φ_B) through its area, due to an external magnetic field B.

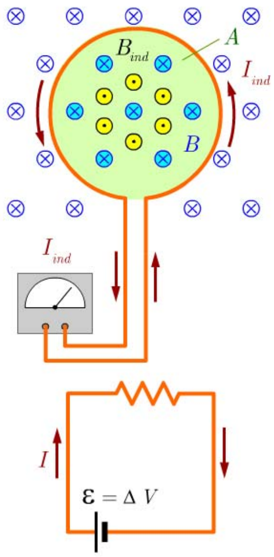
If B is perpendicular to A: $\Phi_B = \vec{B} \cdot \vec{A}$

For a non-uniform field or non-planar area: $\Phi_B = \int \vec{B} \cdot d\vec{A}$

For a uniform field: $\Phi_B = |\vec{B}||\vec{A}| \cos\theta$

Φ_B can be changed by changing shape of A, the strength of the B, or the angle θ between B and A, resulting in an **induced current** in the loop.

Faraday's Law of Electromagnetic Induction (cont'd)



Recall: the nominal voltage generated by a battery, is its electromotive force $\mathcal{E}$.

A change in magnetic flux (Φ_B) in the loop induces an electromotive force (emf, or $\mathcal{E}_{ind}$), which in turn induces a current in the loop.

Faradays law: $$\underbrace{\left|\frac{d\Phi_B}{dt}\right|}_{\text{Rate of change of the magnetic flux}} = \underbrace{\mathcal{E}_{ind} = emf_{ind}}_{\text{Induced electromotive force}}$$

In Lenz's Law there is a negative sign. Lenz's law states that the direction of the magnetic field (created by the induced current) opposes the change in the flux.

Lenz's law: $$\mathcal{E}_{ind} = -\frac{d\Phi_B}{dt}$$

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Consider a loop in the plane of the page, and a uniform external magnetic field pointing into the page (in the $+y$ direction). If the external magnetic field strength increases with time, what will be the direction of the induced magnetic field B_{ind}, and the induced current I_{ind}?

a. ◯ B_{ind} points into the page; I_{ind} travels clockwise.

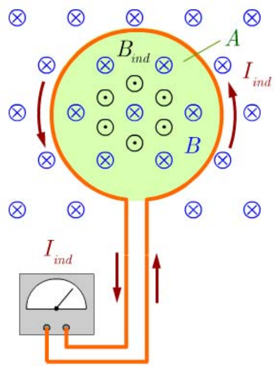
b. ◯ B_{ind} points out of the page; I_{ind} travels clockwise.

c. ◯ B_{ind} points out of the page; I_{ind} travels counter clockwise.

d. ◯ B_{ind} points into the page; I_{ind} travels counter clockwise.

Submit

Schemes for Creating Current



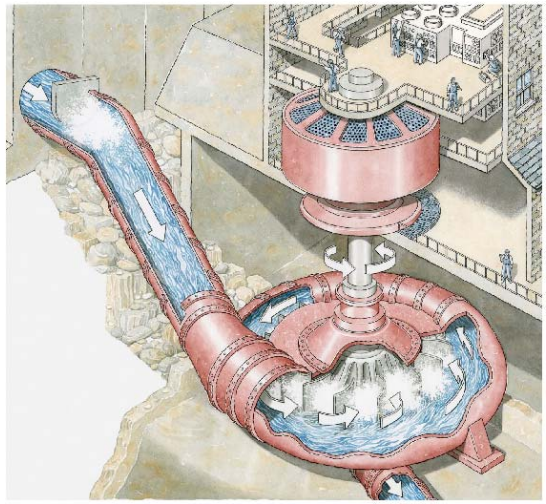


Illustration from Dorling Kindersley/Thinkstock.

Schemes for Creating Current (cont'd)

Photo of Itaipu Dam from iStock/Thinkstock.

Schemes for Creating Current (cont'd)

Photos: turbine blades from Hemera/Thinkstock; wind turbine from iStock/Thinkstock.

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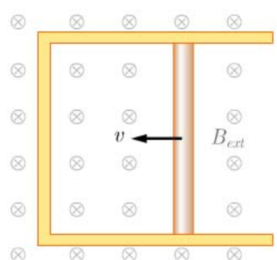
A moveable bar rests on a rectangular C-shaped wire, forming a conducting loop, which sits in an external magnetic field as shown. When you pull the bar to the left, the flux in the loop will change and cause an induced current in the loop. What direction will the induced current flow?.



a. Clockwise.

b. Counter clockwise.

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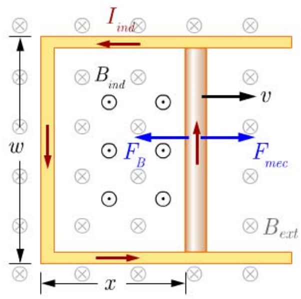
Example Problem

A wire and conducting bar form a rectangular loop in a magnetic field as shown below. The bar moves at a speed v, increasing the area of the loop. What is the the direction and amount of current induced and the power dissipated in the loop?



$$\Phi_B = BA\cos\theta$$

$$\mathcal{E}_{ind} = \frac{d\Phi_B}{dt}$$

Recall: if B is perpendicular to v then $\left|\vec{F}\right| = IlB$

To counteract F_B we need to apply F_{mec}.

Power applied: $P_{mec} = \frac{W}{t} = \frac{Fd}{t} = Fv$

Power dissipated in the loop: $P = I_{ind}^2 R$

$$\mathcal{E}_{ind} = \frac{d\Phi_B}{dt} = \frac{d}{dt}BA\overset{=1}{\boxed{\cos\theta}} = \frac{d}{dt}\left(Bwx\right) = Bw\frac{x}{t} = Bwv$$

$$I_{ind} = \frac{\mathcal{E}_{ind}}{R} = \frac{Bwv}{R}$$

Power dissipated in the loop: $P = I_{ind}^2 R = B^2 w^2 v^2 R$

Does power applied = power dissipated?

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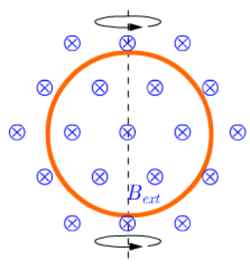
A conducting loop sits in the plane of the page where there is an external magnetic field pointing into the page. If the loop turns along its vertical axis to the right as shown, what is the direction of the current induced in the loop?

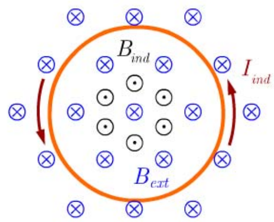


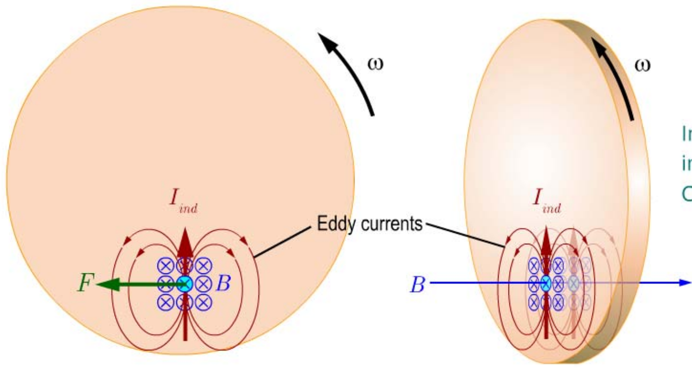
a. ○ Clockwise.

b. ○ Counter clockwise.

Submit

Eddy Currents





Magnetic Induction and Eddy Currents Demonstration