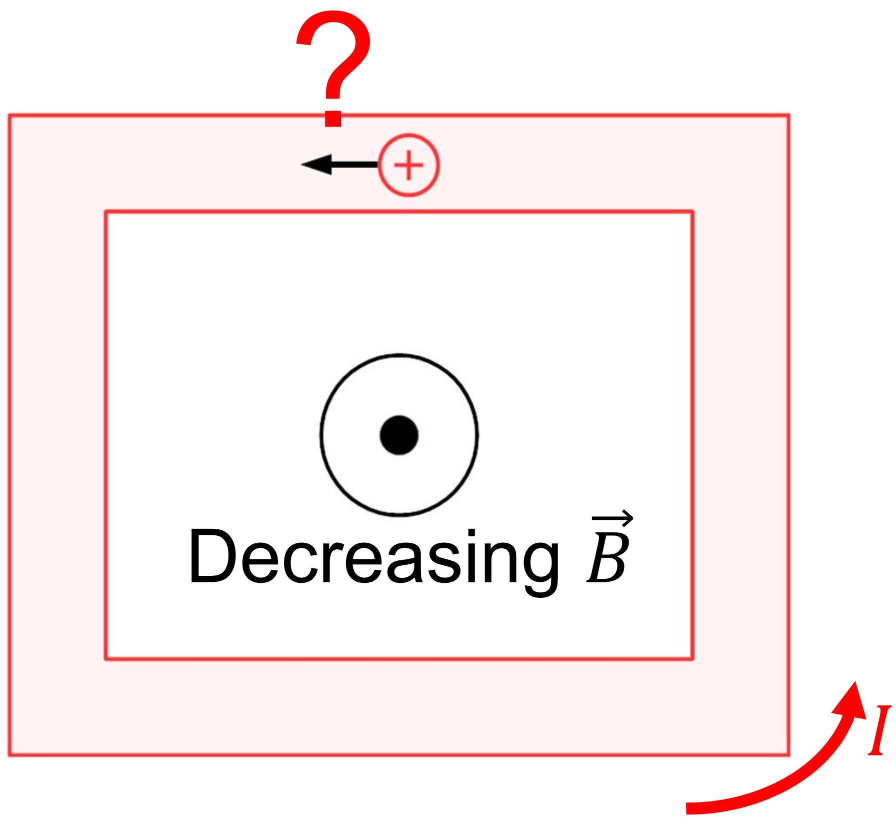
Induced Electric Fields

$$\mathcal{E} = -\frac{d\Phi_B}{dt}$$

What drives the charges in an induced current?



Induced Electric Fields

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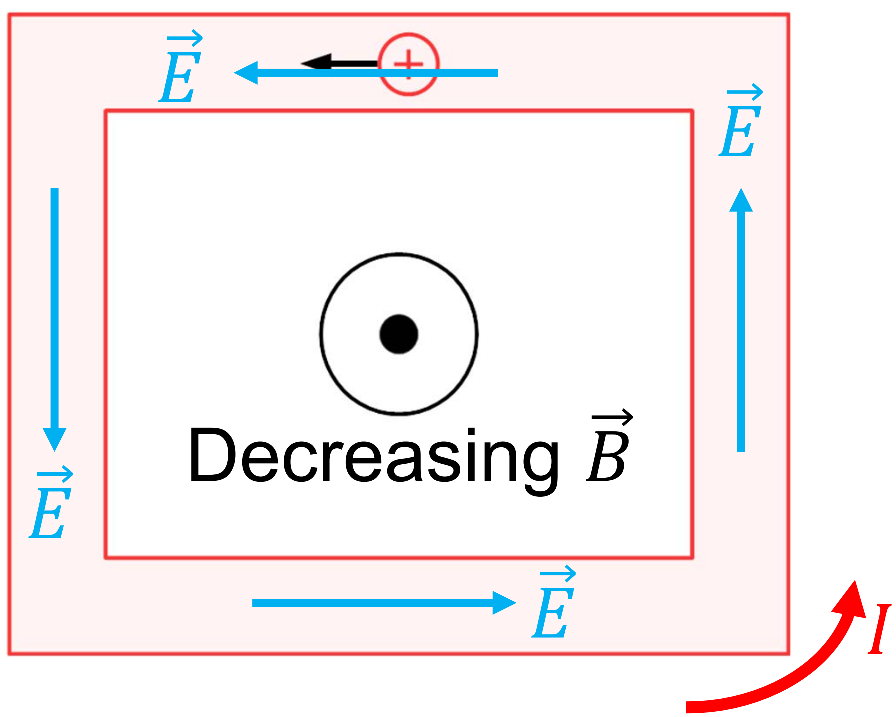
What drives the charges in an induced current?

Magnetic force does not do work.
($\vec{F}_B \perp \vec{v}$)

Must be an electric force.



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For a changing magnetic flux,

$$W = \oint \vec{F}_E \cdot d\vec{s} = q \oint \vec{E} \cdot d\vec{s} = -q\frac{d\Phi_B}{dt} \neq 0$$

Thus, the electric force is not a conservative force?

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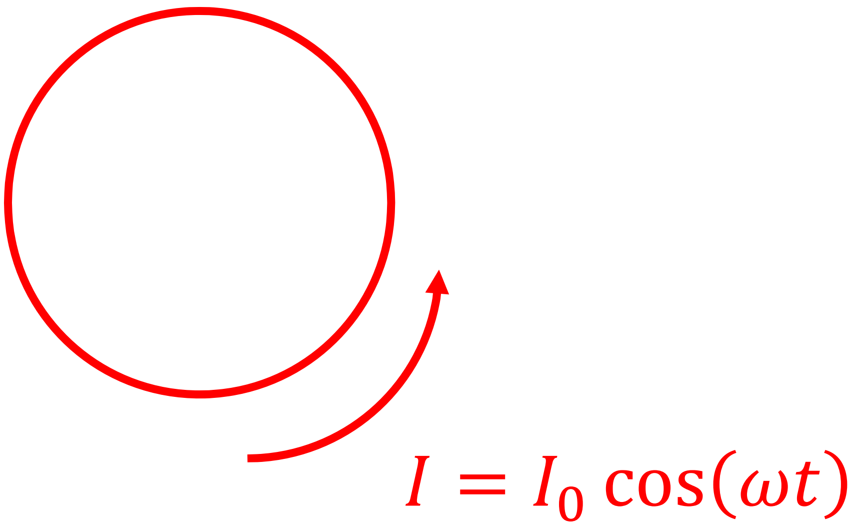
Thus, the electric force is not a conservative force?

$$\vec{E}_T = \vec{E}_{\text{Coulomb}} + \vec{E}_{\text{Nonconservative}}$$

There is no ΔV associated with the induced $\vec{E}$.

Example: Determine the induced electric field in a solenoid that is connected to an AC power supply. The solenoid has length, L, number of turns, N, and radius, R.



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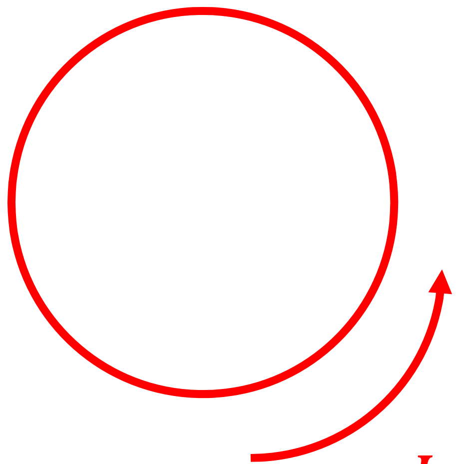


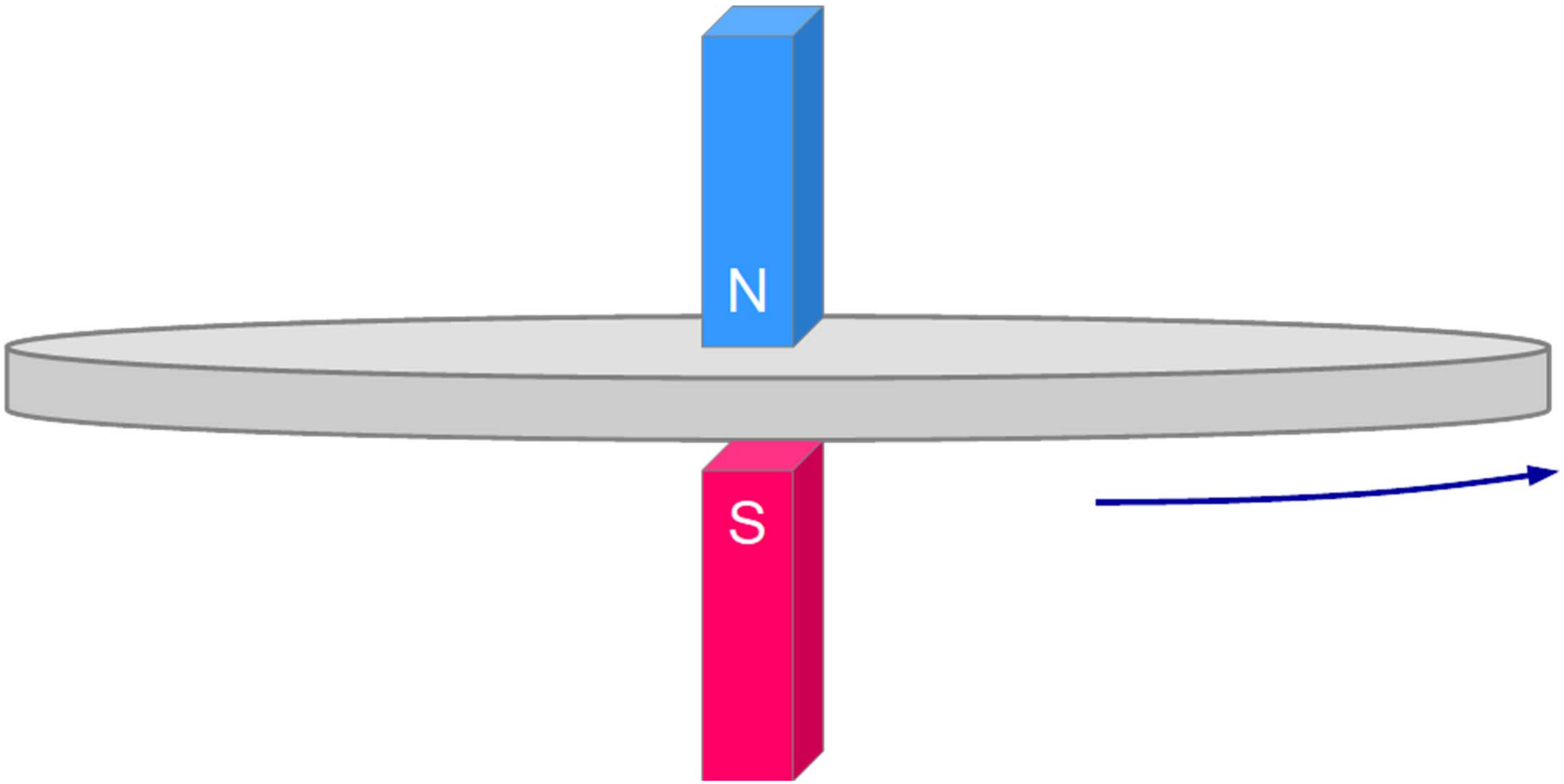
$I = I_0 \cos(\omega t)$

Direction of field lines is the same direction as current would be if there were a conducting loop present.
Determine the direction by pretending there is a wire loop and applying Lenz's Law.

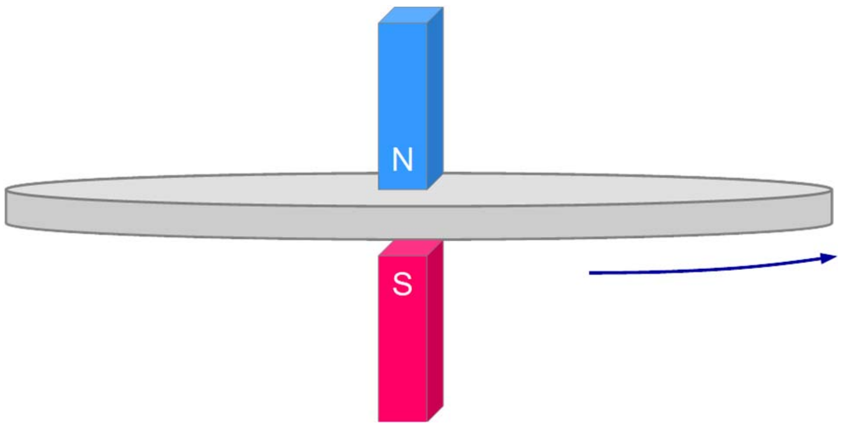
Applications of Induction

- Guitar pick ups
- Alternators
- Generators
- Transformers
- Induction stove
- Eddy brakes

Eddy Brakes

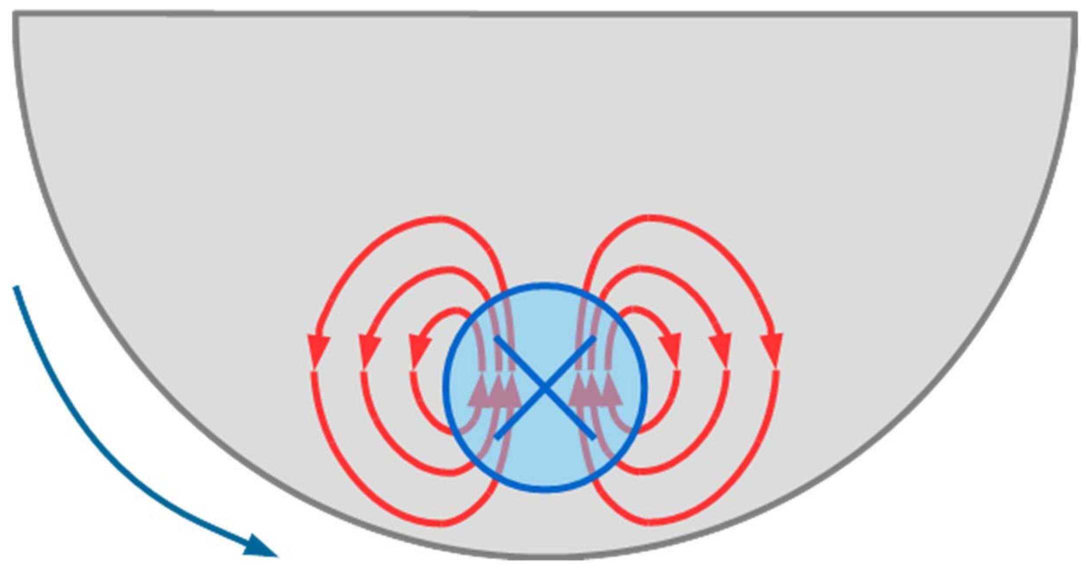


Eddy Brakes

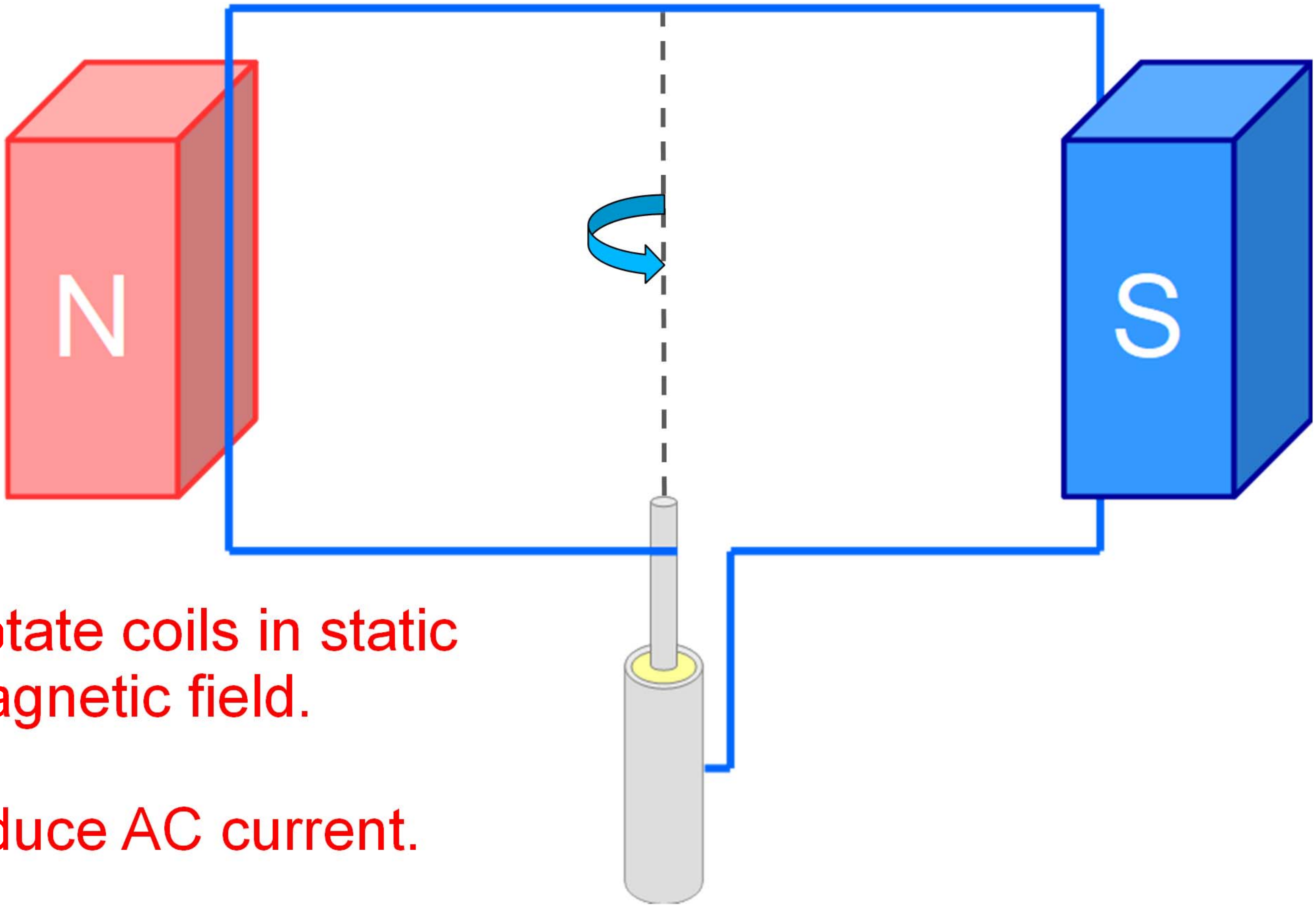


Side View

Top View



Generators and Alternators



Rotate coils in static magnetic field.

Induce AC current.

Gauss's Law

$\oint \vec{E} \cdot d\vec{A} = \frac{q_{\text{enc}}}{\epsilon_0}$ Charges produce $\vec{E}$

Ampere's Law

$\oint \vec{B} \cdot d\vec{s} = \mu_0 I_{\text{enc}}$ Moving charges produce $\vec{B}$

Faraday's Law

$\oint \vec{E} \cdot d\vec{s} = -\frac{d\Phi_B}{dt}$ Changing Φ_B produces $\vec{E}$

Gauss's Law

$$\oint \vec{E} \cdot d\vec{A} = \frac{q_{\text{enc}}}{\epsilon_0}$$ Charges produce $\vec{E}$

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Faraday's Law

$$\oint \vec{E} \cdot d\vec{s} = -\frac{d\Phi_B}{dt}$$ Changing Φ_B produces $\vec{E}$

Ampere-Maxwell Law

$$\oint \vec{B} \cdot d\vec{s} = \mu_0 I_{\text{enc}} + \mu_0 \epsilon_0 \frac{d\Phi_E}{dt}$$

Moving charges produce $\vec{B}$
Changing Φ_E produces $\vec{B}$

Example: Determine the magnetic field in a circular parallel plate capacitor as it discharges through an RC circuit.