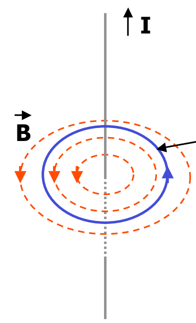
News

- Quiz #3 next Mon, 4/11, 10AM
- Exp MF, Pset 8 due Fri, 4/8
- Review in class, Fri, 4/8 10AM
- No evening review
- Tutoring session, Sun, 3-8PM

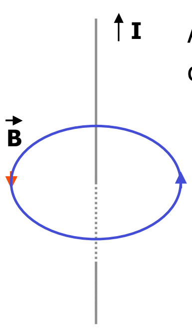
Ampere's Law



- Ampere's idea:
  Relate Field $\vec{B}$ to its Source: I
  Closed Line instead of closed surface!

$$\oint_L \vec{B} \cdot d\vec{l} = \mu_0 \, I_{encl}$$

Ampere's Law



Ampere's Law helps because we can choose integration path!

$$\oint_L \vec{B} \cdot d\vec{l} =$$
$$B \oint_L d\vec{l} =$$
$$B \; 2\pi \; r = \mu_0 I_{encl}$$
$$\Rightarrow \; B = \mu_0 \frac{I}{2\pi r}$$

Faradays Law

$$\Phi_B = \int_A \vec{B} \cdot d\vec{A}$$

Magnetic Flux
(usually, A not closed surface)

$$\xi_{ind} = -\frac{d\Phi_B}{dt}$$

<u>Faradays Law</u>

$$\Rightarrow I_{ind} = \frac{\xi_{ind}}{R}$$

Faradays Law

- Φ_B can change because
  - |B| changes
  - Angle between $\vec{B}$ and $\vec{A}$ changes
  - |A| (size of circuit in B) changes

Lenz' Rule

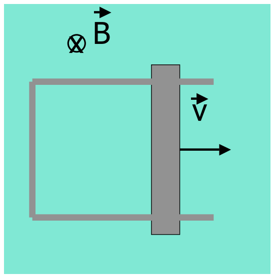
$$\xi_{ind} = -\frac{d\Phi_B}{dt}$$
$$\Rightarrow I_{ind} = \frac{\xi_{ind}}{R}$$

<u>Lenz' Rule:</u>

Sign of I_{ind} such that it opposes the flux change that generated it

Use of Faradays Law

- To find direction of I_{ind}:
  - Determine Φ_B
  - Does $|\Phi_B|$ increase or decrease?
  - Find sign of I_{ind} using Lenz' rule



Lenz' Rule

Field of I_{ind} DOES NOT necessarily oppose Φ_B

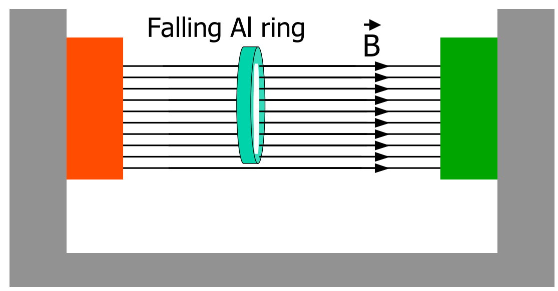
Field of I_{ind} DOES oppose change of Φ_B (= $d\Phi_B/dt$)

Lenz' Rule redux

In most cases:

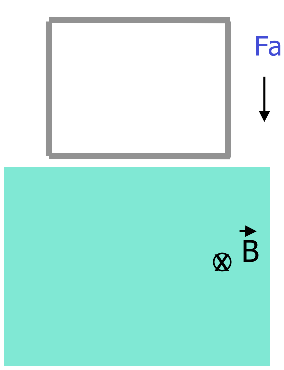
- **If $|\Phi_B|$ increases:**
  $B(I_{ind})$ opposite direction to B_{ext}
- **If $|\Phi_B|$ decreases:**
  $B(I_{ind})$ same direction as B_{ext}

My favorite Demo

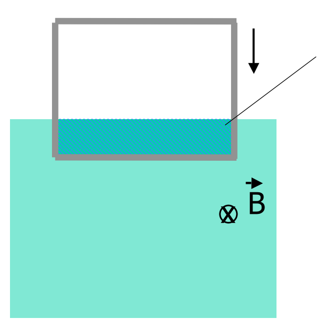


- Falling Al ring is slowed down in B-Field

Falling conducting loop

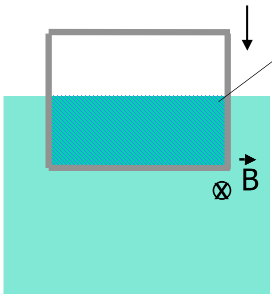


Uniform magnetic field



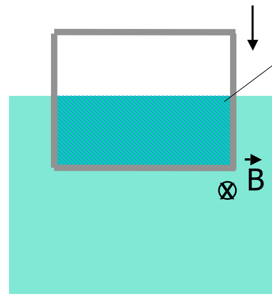
Area A

$\Phi_B = B A$



Area A

$\Phi_B = B\,A$

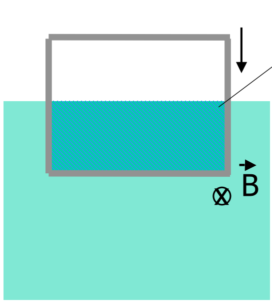


Area A

$\Phi_B = B\,A$

Q: Is $d|\Phi_B|/dt$

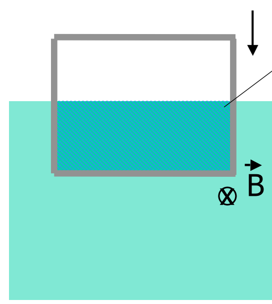
- **> 0**
- **=0**
- **<0**



Area A

$\Phi_B = B\,A$

$d|\Phi_B|/dt = d/dt(B\,A)$
$= B\,dA/dt$

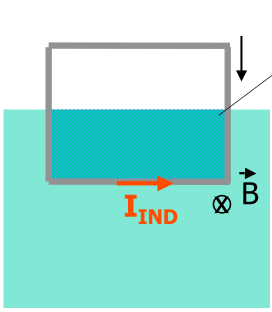


Area A

$\Phi_B = B\,A$

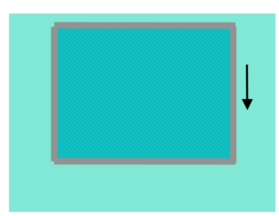
Q: Is I_{IND}

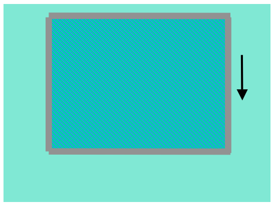
- **Clockwise**
- **Counter-clockwise**
- **Zero**



Area A

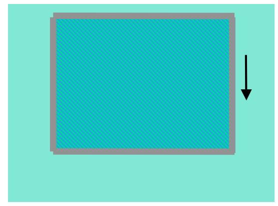
$\Phi_B = B\,A$





Q: Is $d|\Phi_B|/dt$

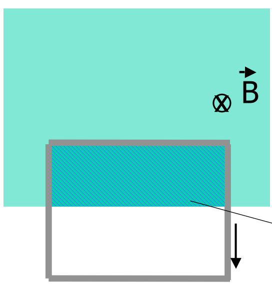
- **> 0**
- **=0**
- **<0**



$\Phi_B = B\,A$

$d\Phi_B/dt = 0$

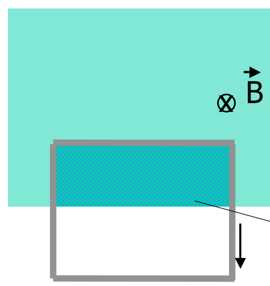
-> $I_{IND} = 0$



Area A

Q: Is $d|\Phi_B|/dt$

- **> 0**
- **=0**
- **<0**



Area A

Q: Is I_{IND}

- **Clockwise**
- **Counter-clockwise**
- **Zero**