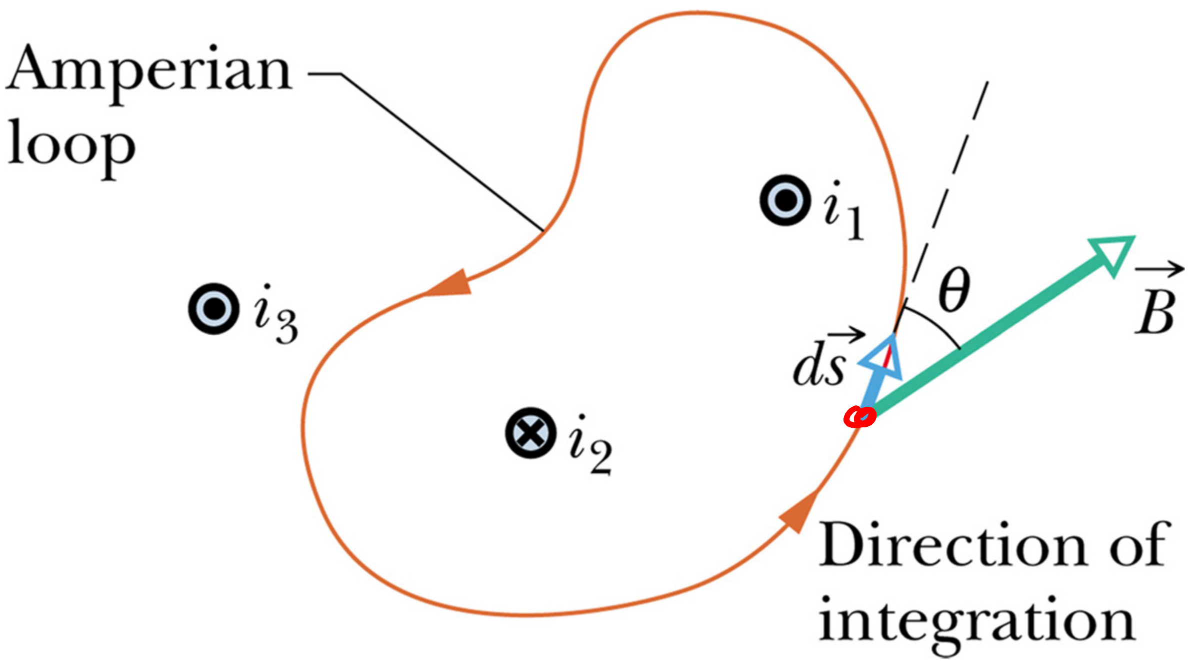
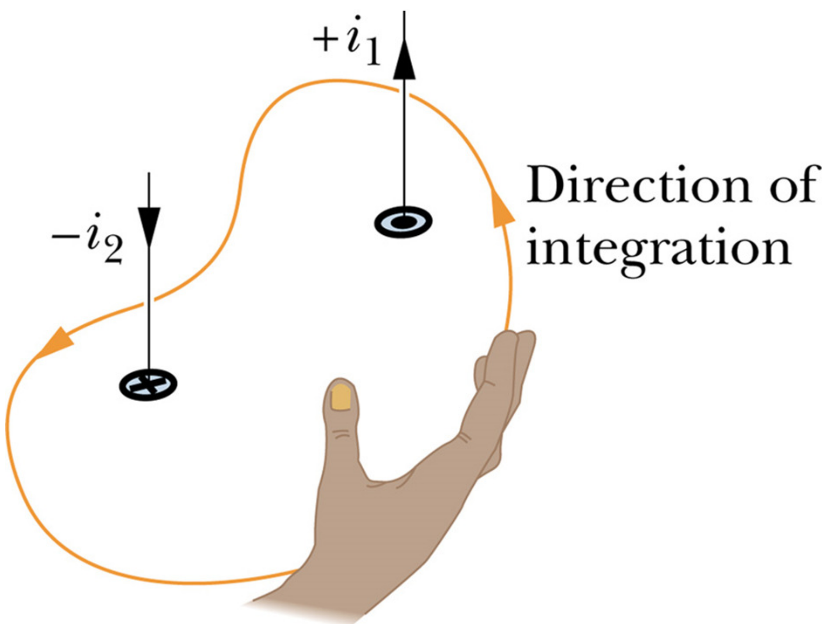
Test on Monday

- Midterm 3, covers chapters 30-32 (magnetic stuff)
  - Yes, that's a Monday. Yes, there's still written HW due then
- Sample test has been online for weeks
  - Try taking it as a test, rather than just reading over the answers
  - One difference – we're not covering "Inductors" in circuits, or permanent magnetism
- You get a sheet of whatever notes you want
  - Same as before



$$\oint \vec{B} \cdot d\vec{s} = \mu_0 i_{enc}$$

Ampere's Law



Which amperian loop (dashed circles) encloses more current?

1. Loop 1
2. Loop 2
3. Both the same
4. Need more data

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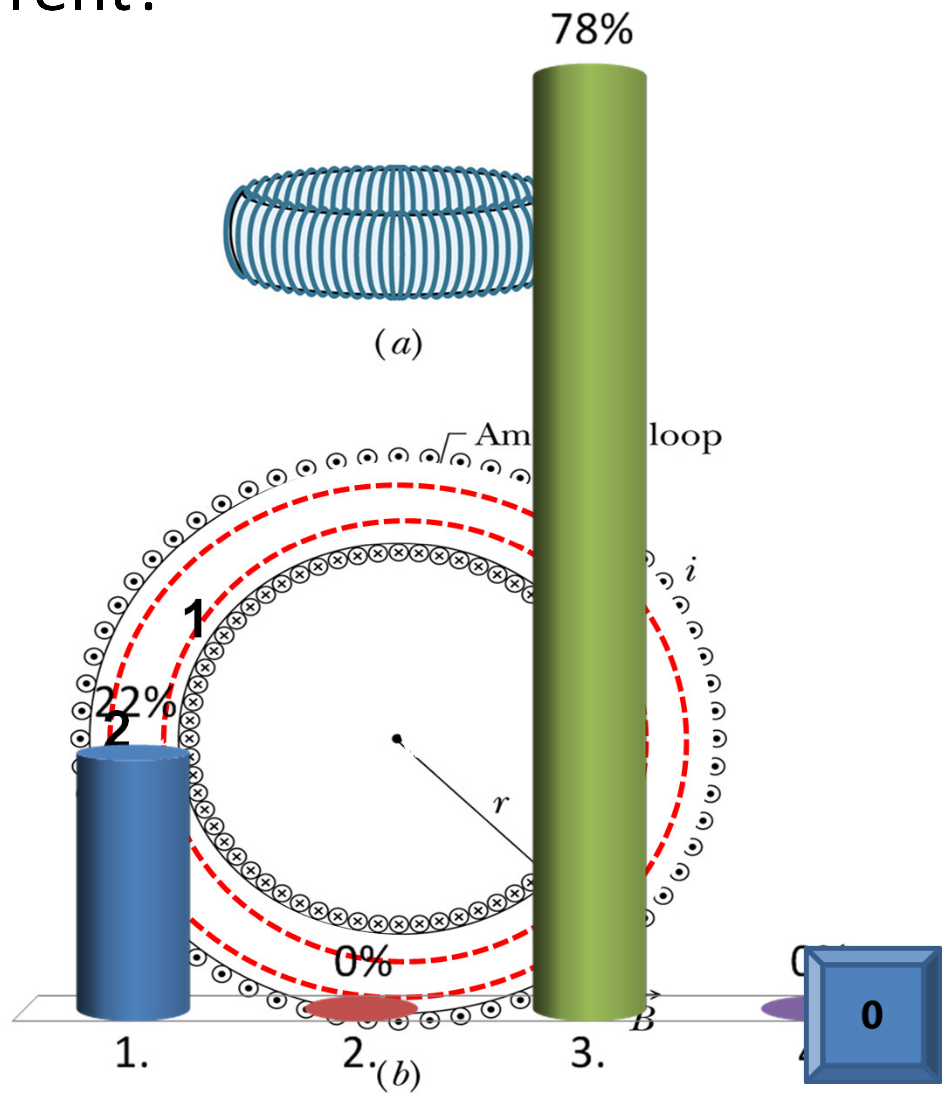
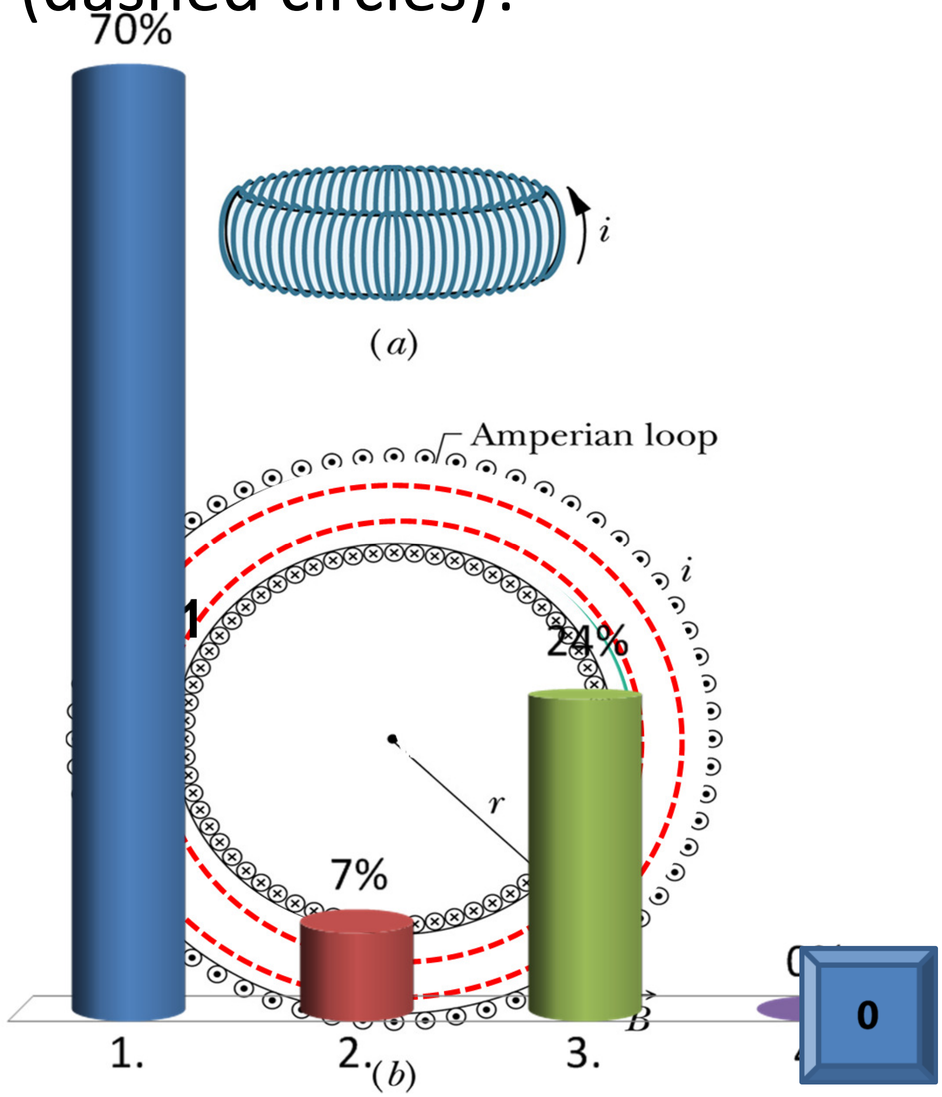


The magnetic field is greater for points on which amperian loop (dashed circles)?

1. Loop 1
2. Loop 2
3. Both B's are the same
4. Need more data



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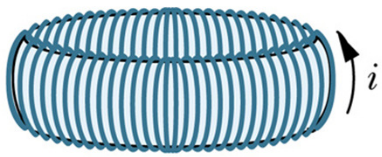
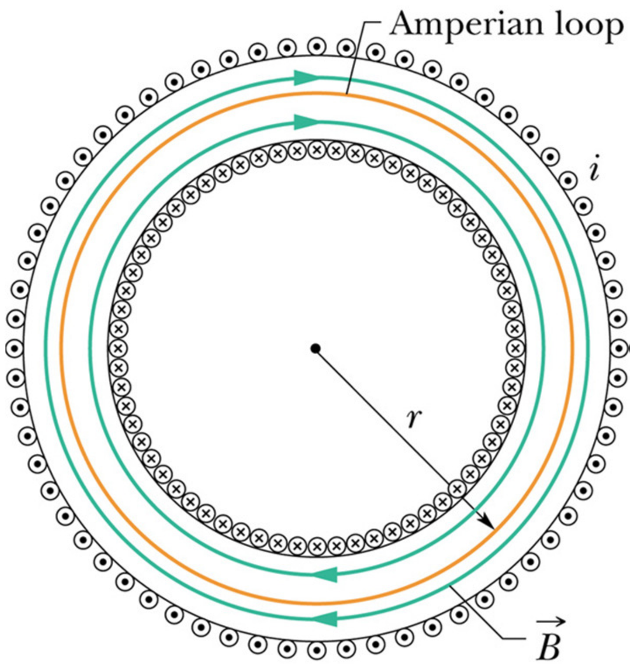
This is #3 on worksheet, “toroid”

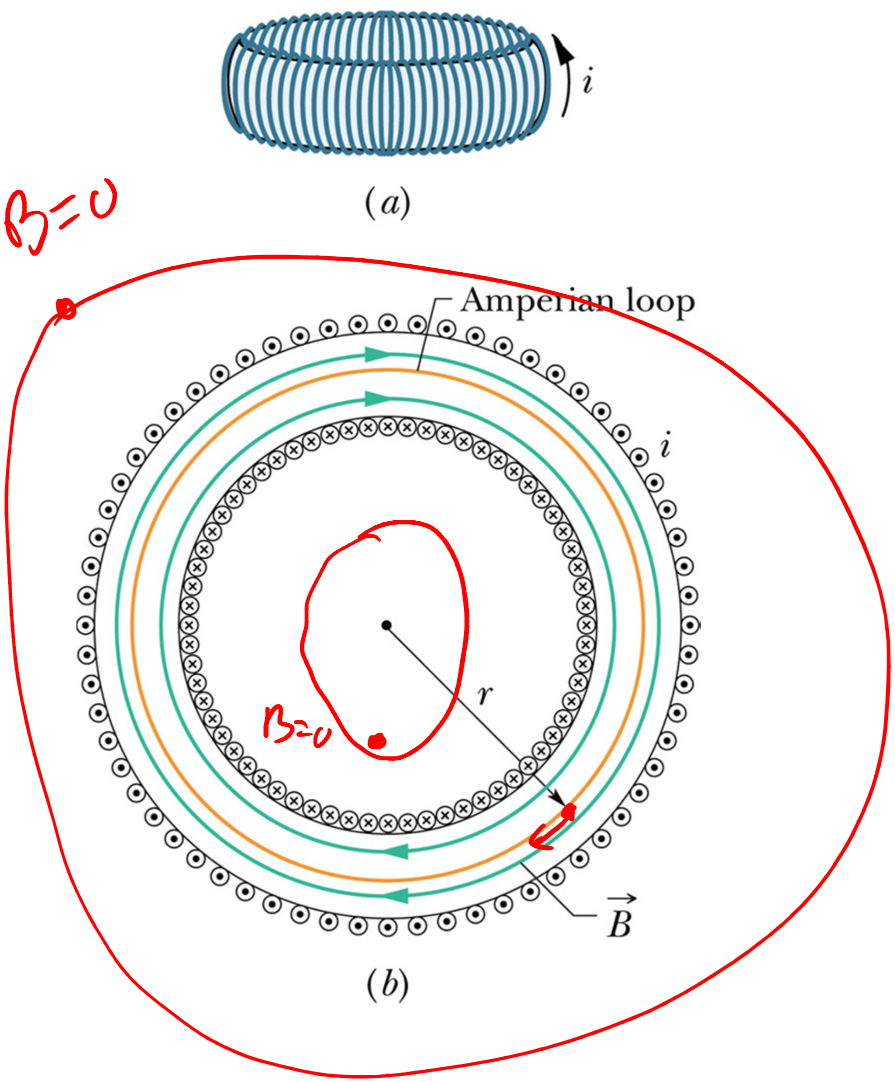


(a)



(b)

This is #3 on worksheet, “toroid”



$$\oint \vec{B}\cdot d\vec{l} = \mu_0 I_{enc}$$

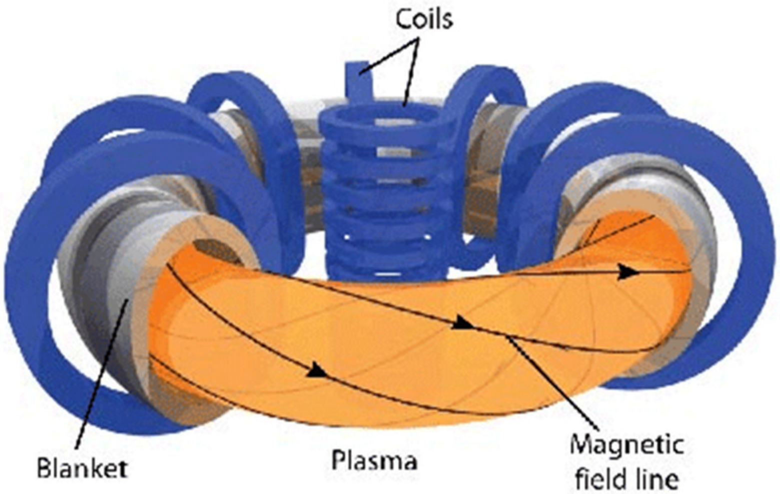
B, dl are ||

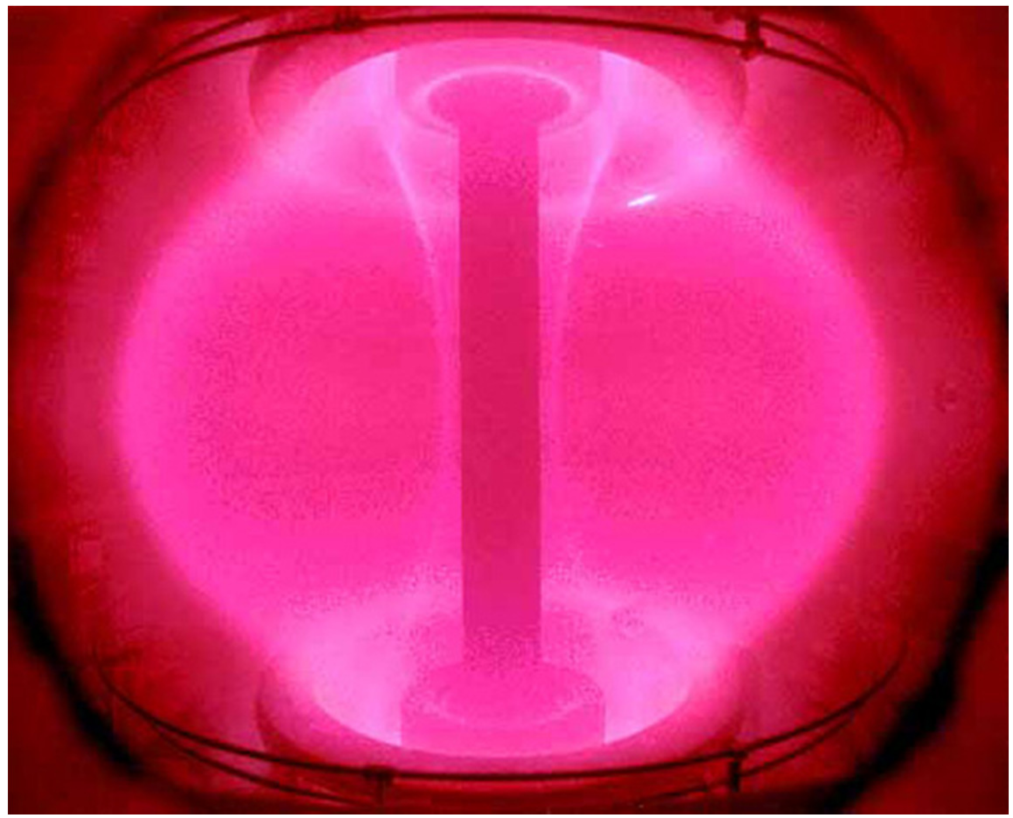
$$\oint |B||dl|\cos 0 = \mu_0 I_{enc}$$

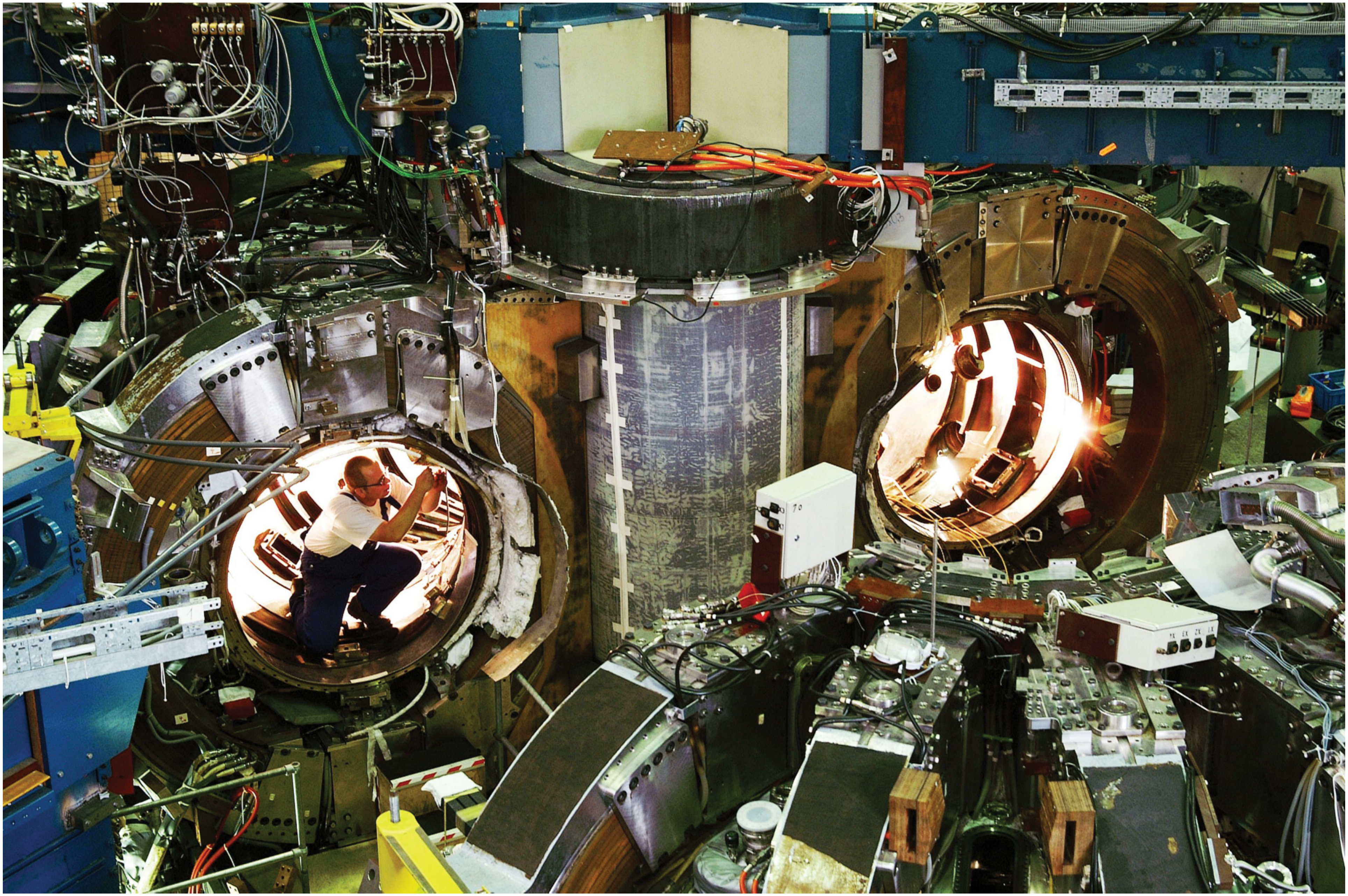
$$B\oint dl = B(2\pi r) = \mu_0 I_{enc}$$

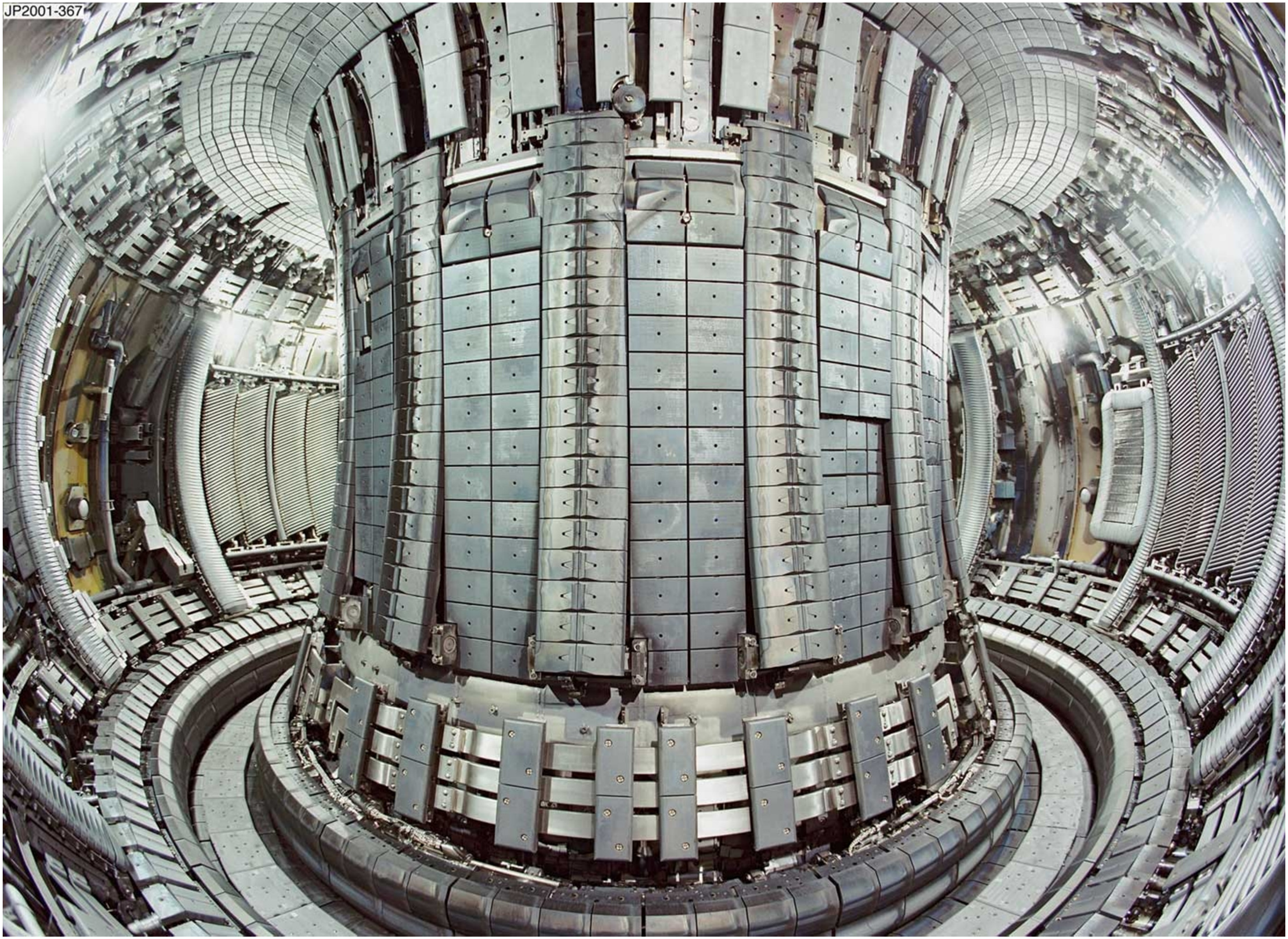
$$= \mu_0 N I$$

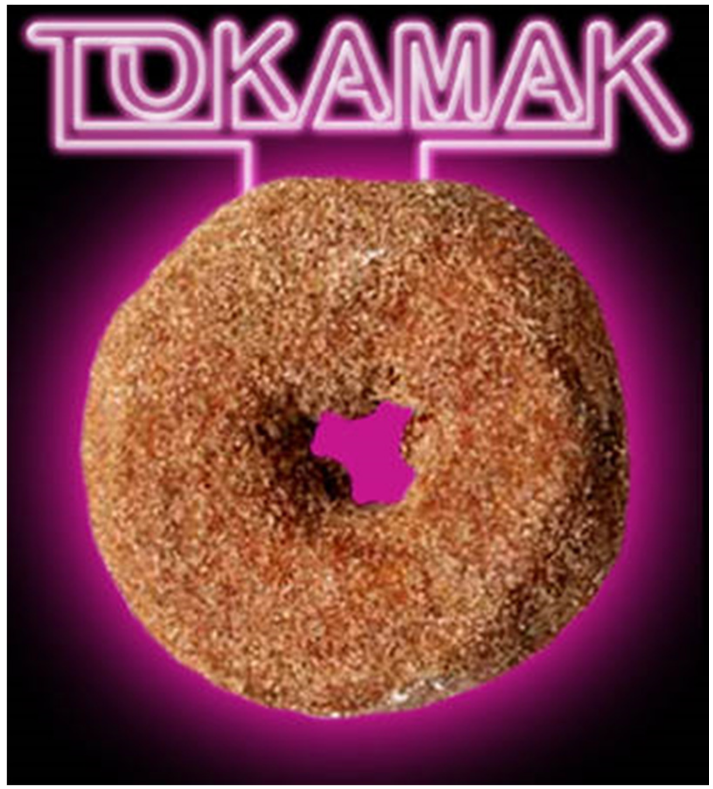
so $B = \dfrac{\mu_0 I N}{2\pi r}$


Coils
Blanket
Plasma
Magnetic
field line

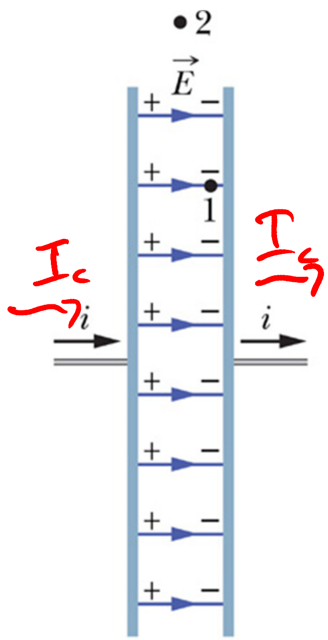




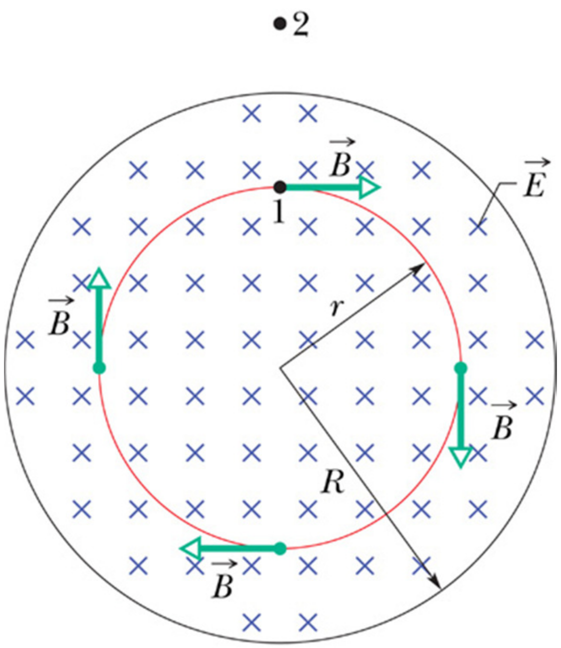

JP2001-367



Mmmm….. Plasma



(a)



(b)

I_c builds up Q

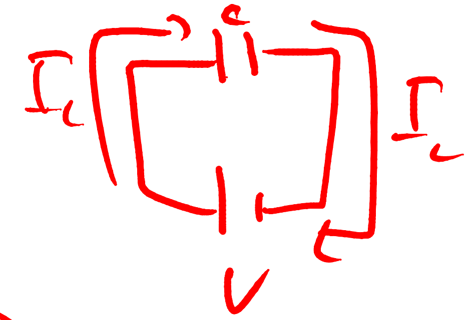
more Q, more V

more V comes from more $\vec{E}$

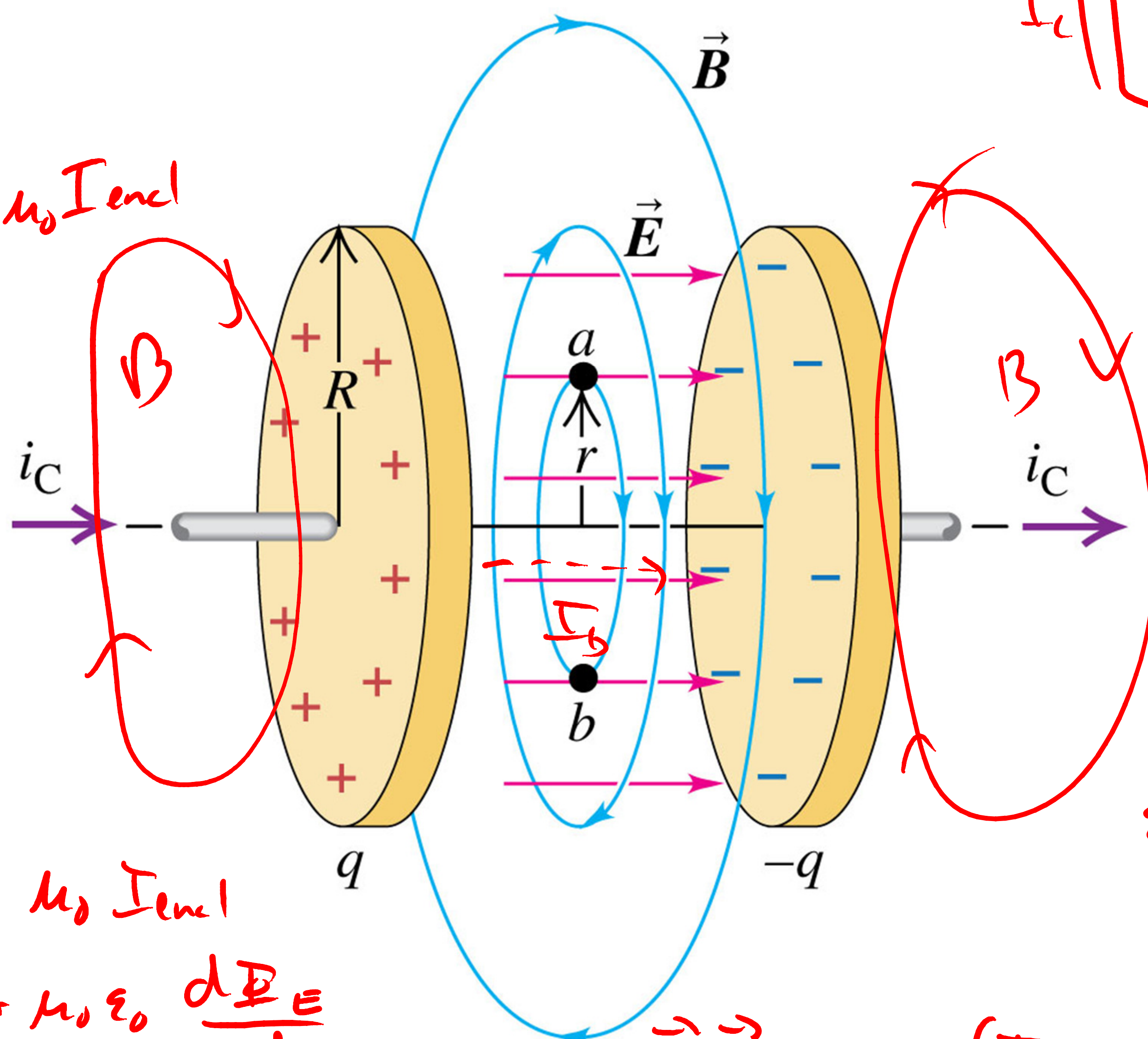
Φ_E

more Q from I_c: $\Phi_E \uparrow$

have $\dfrac{d\Phi_E}{dt}$



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

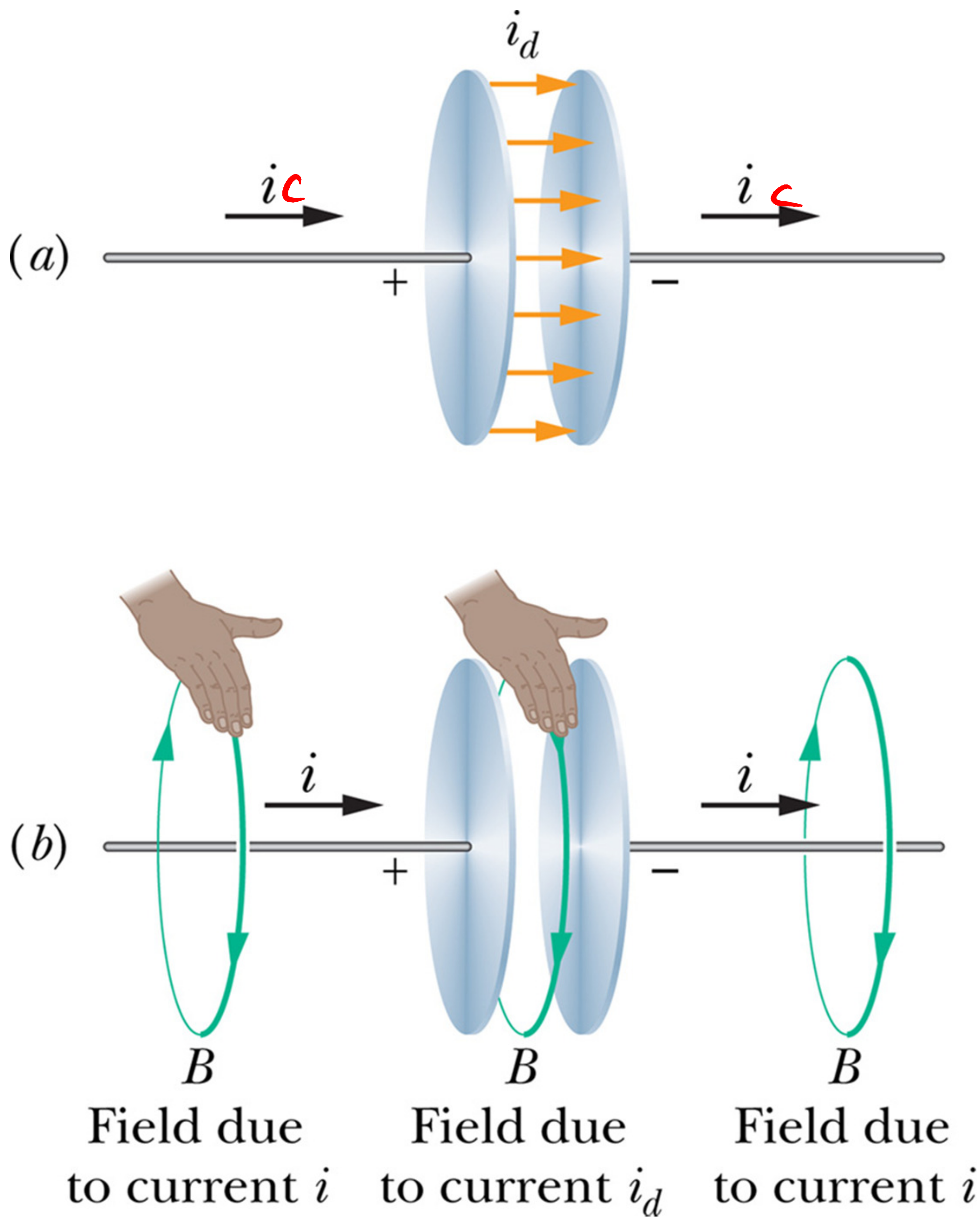


Maxwell:

$$\oint \vec{B}\cdot dl = \mu_0 I_{encl} + \mu_0 \varepsilon_0 \frac{d\Phi_E}{dt}$$

$$= \oint \vec{B}\cdot d\vec{l} = \mu_0 (I_c + I_D)_{encl}$$

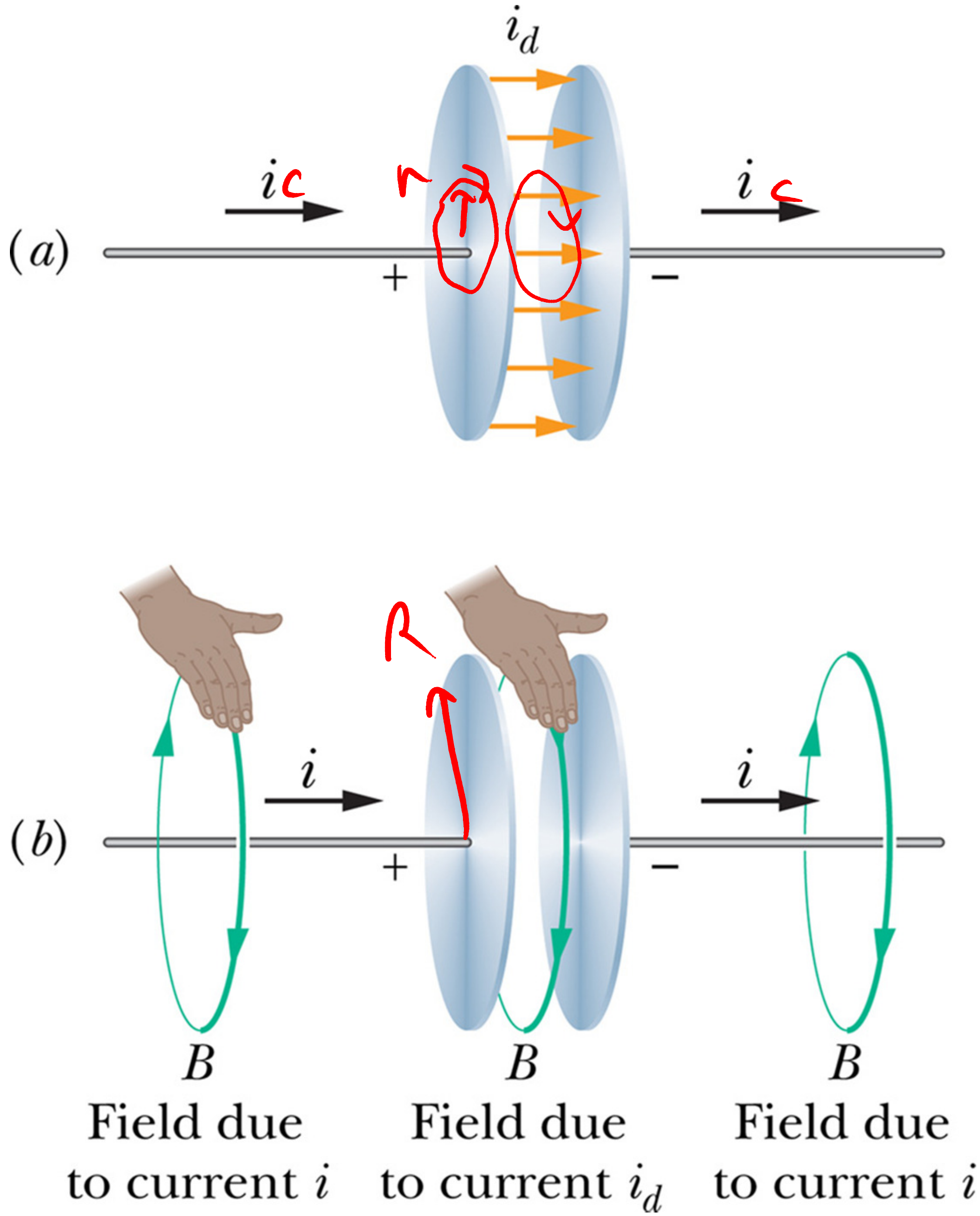
$$\varepsilon_0 \frac{d\Phi_E}{dt}$$



I_d = displacement current

$$\oint \vec{B} \cdot \vec{dl} = \mu_0 \varepsilon_0 \frac{d\Phi_E}{dt} + \mu_0 I_{encl}$$

$$\oint \vec{B} \cdot \vec{dl} = \mu_0 \left(\underbrace{\varepsilon_0 \frac{d\Phi_E}{dt}}_{I_d} + I_{encl} \right)$$



What, B induced?

$$\oint \vec{B}\cdot d\vec{l} = \mu_0 \varepsilon_0 \frac{d\Phi_E}{dt} + \mu_0 I_{enc}$$

$$\oint \vec{B}\cdot d\vec{l} = \mu_0 (I_c + I_d)$$

inside cap. $I_c = 0$

$$B = \left(\frac{\mu_0 I_d}{2\pi R^2}\right) r$$

(just like when we did $\vec{B}$ in a wire)

When a parallel-plate capacitor is charging, there is both an electric field and an induced magnetic field between the plates. After some time, the charging stops. At that point, what is true concerning the fields within the capacitor?

1. The magnetic field is zero, but the electric field is constant
2. The magnetic field is zero; and the electric field slowly decreases to zero over time
3. Both the electric and magnetic fields are equal to zero
4. The electric field is zero; and the magnetic field slowly decreases to zero over time
5. The electric field is zero, but the magnetic field is constant

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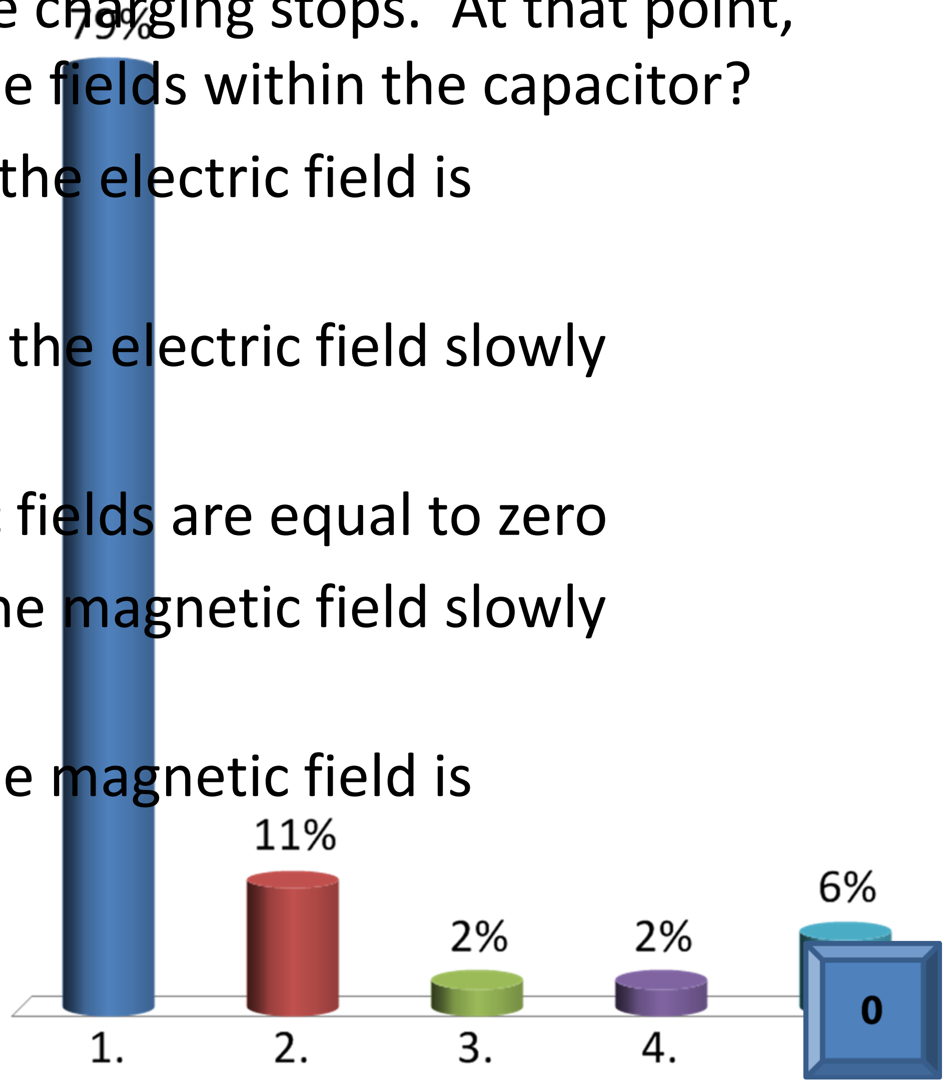
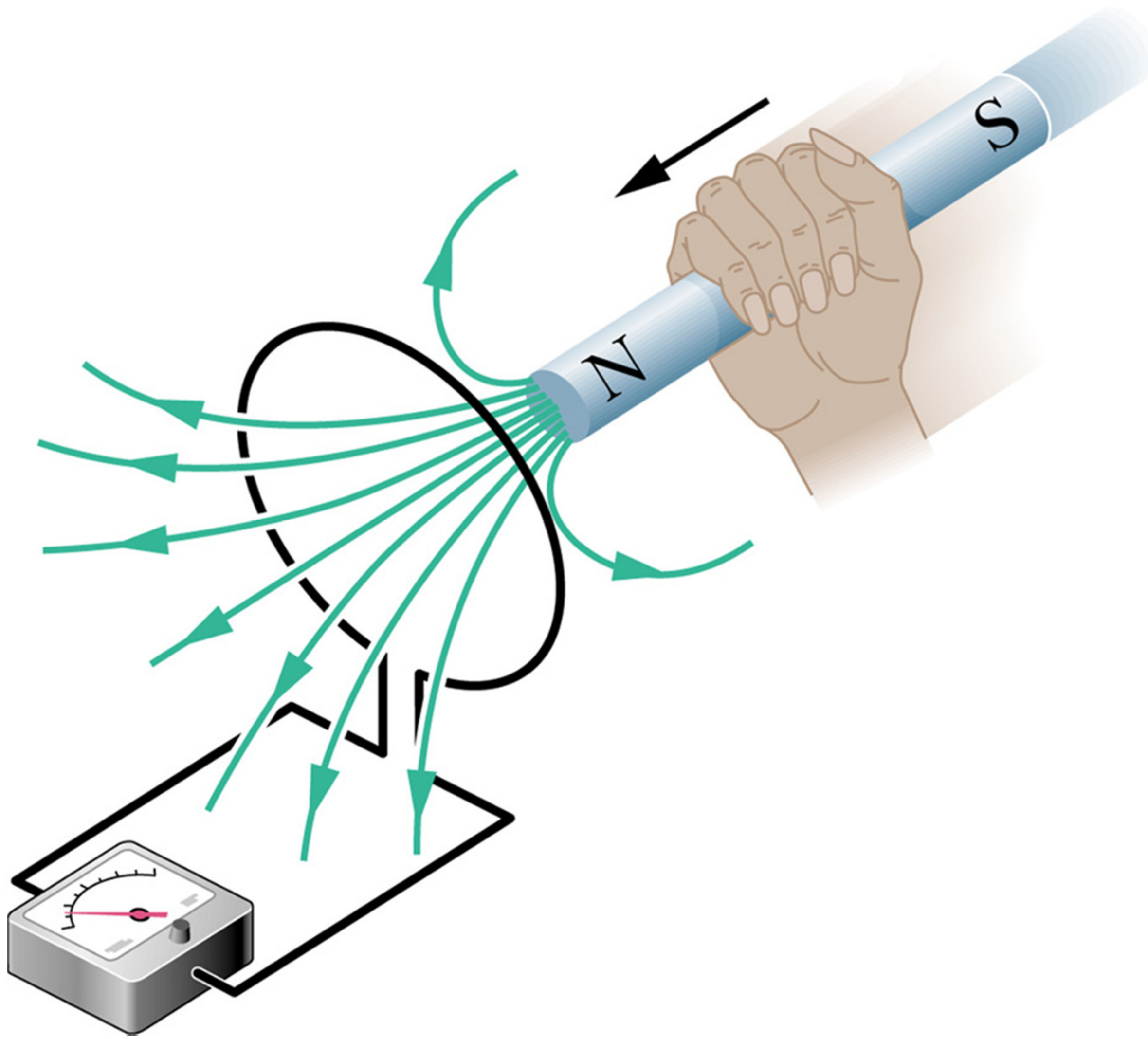
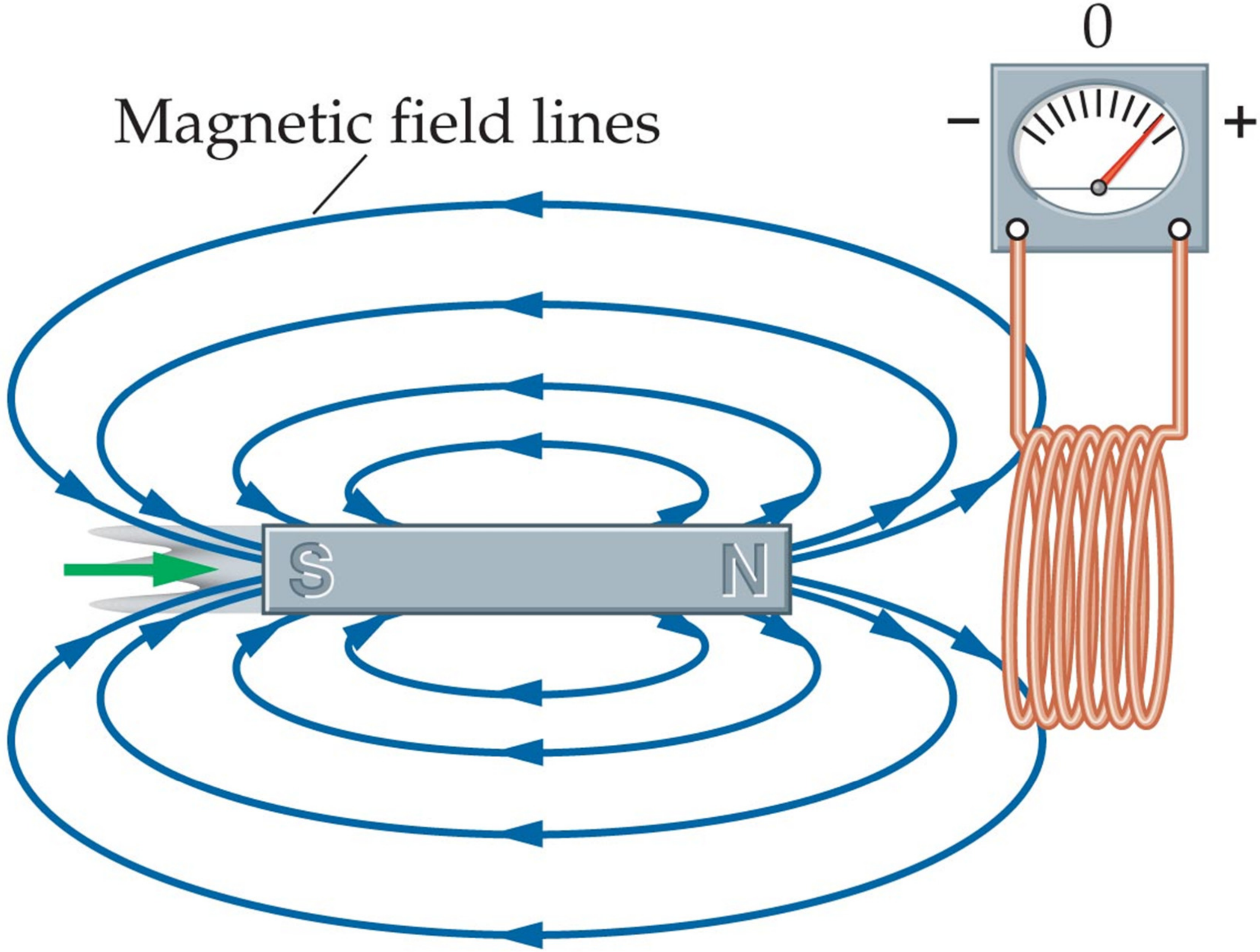
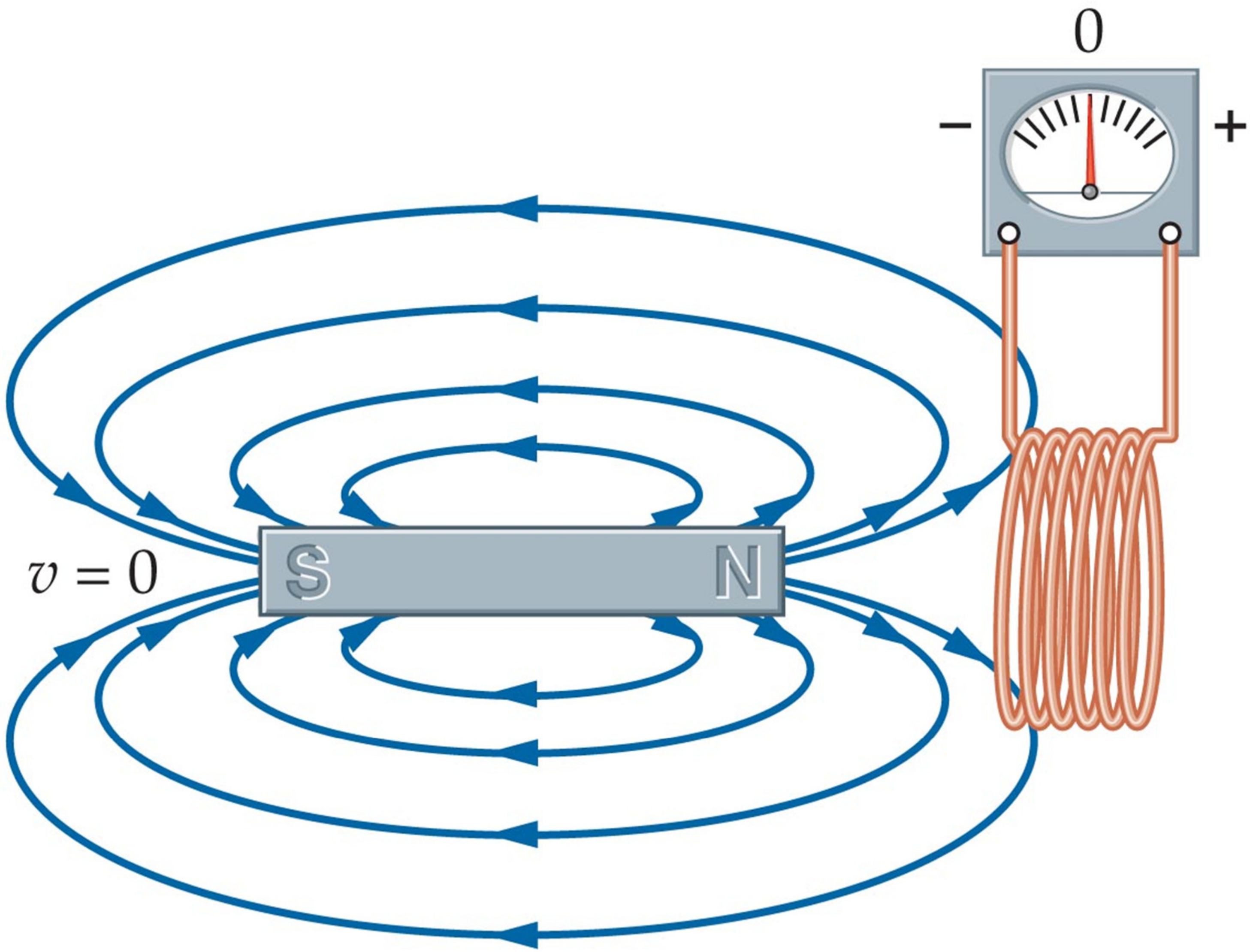


Ch.32, Faraday’s Law of Induction

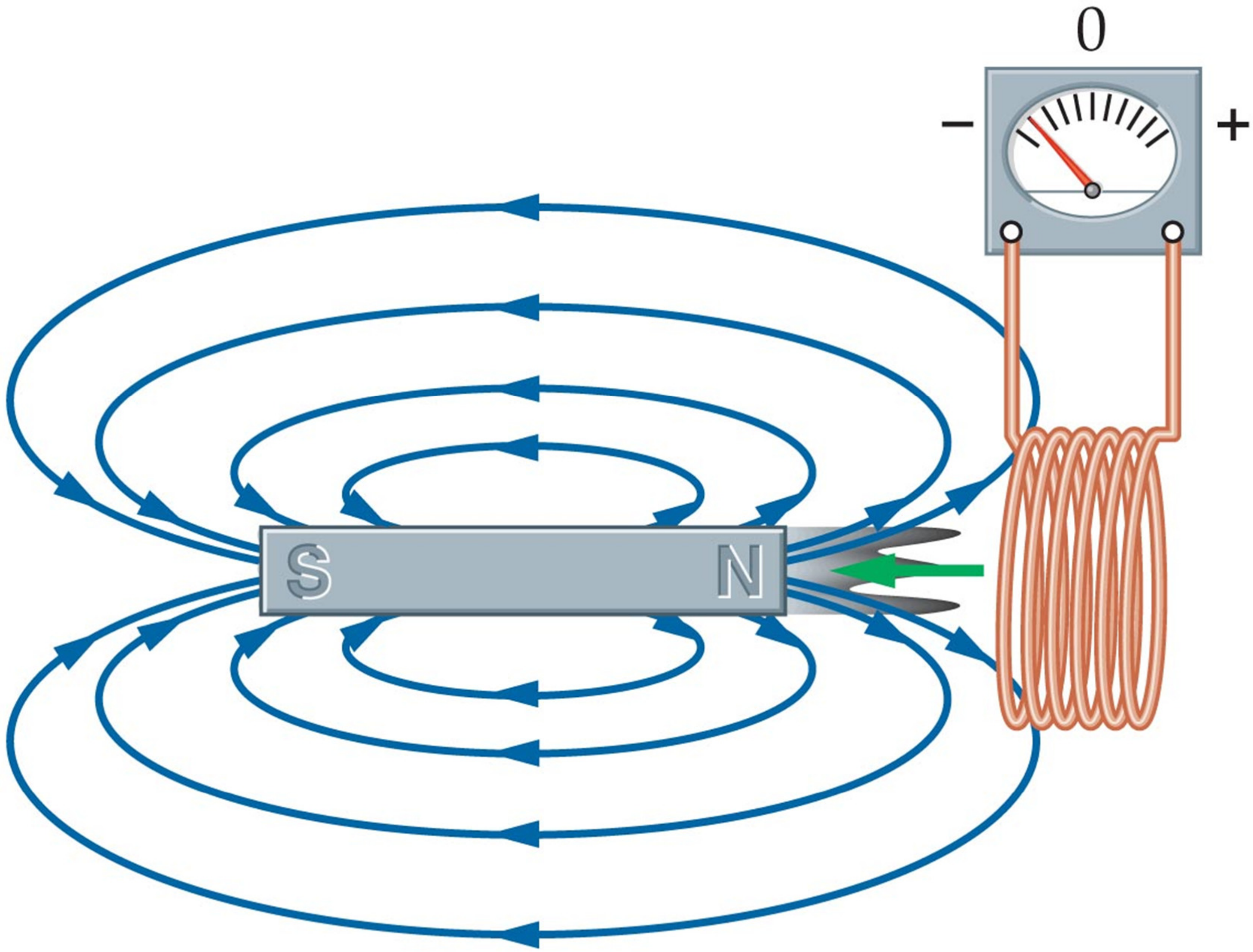

N
S



(a) Moving magnet toward coil induces current in one direction



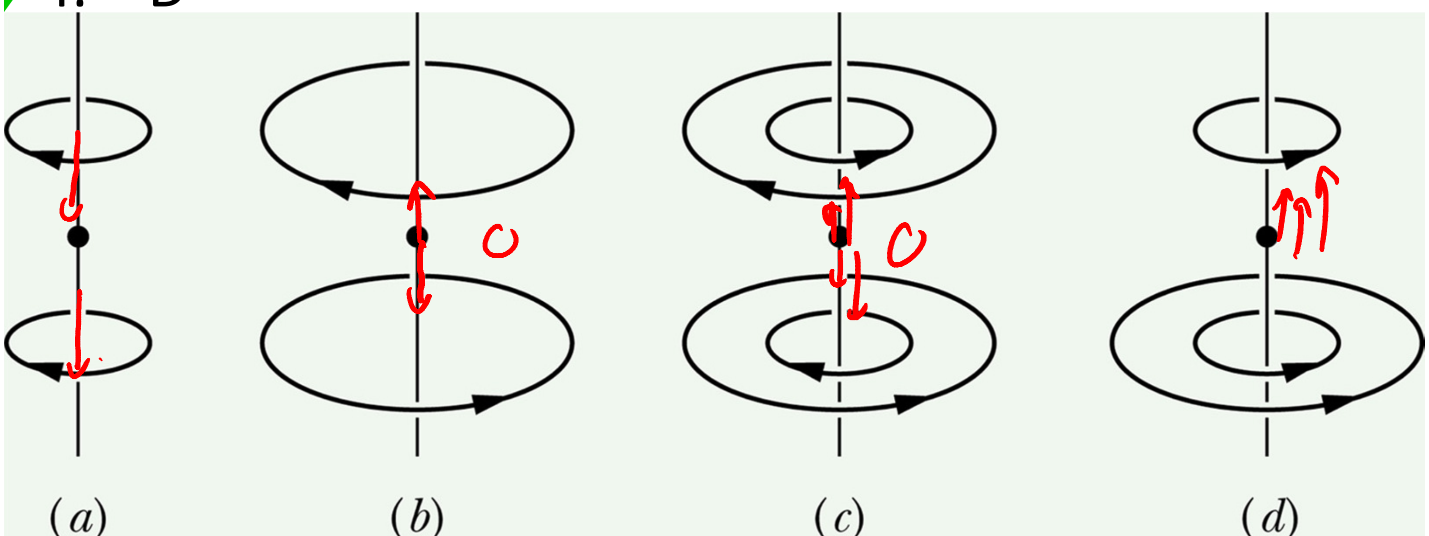
(b) No motion, no induced current

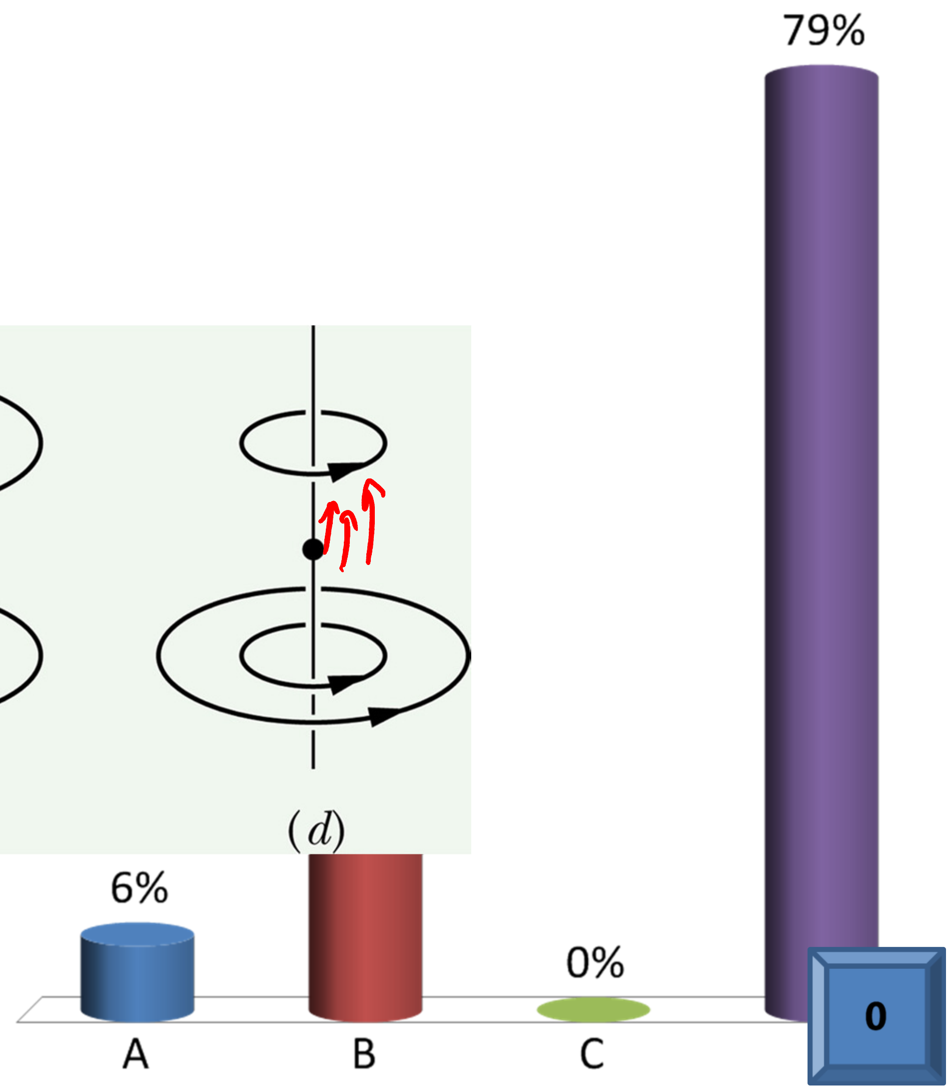


(c) Moving magnet away from coil induces current in opposite direction

4 loops, radius r or 2r, same currents in the directions shown. Which has the largest B-field at the dot?

1. A
2. B
3. C
4. D





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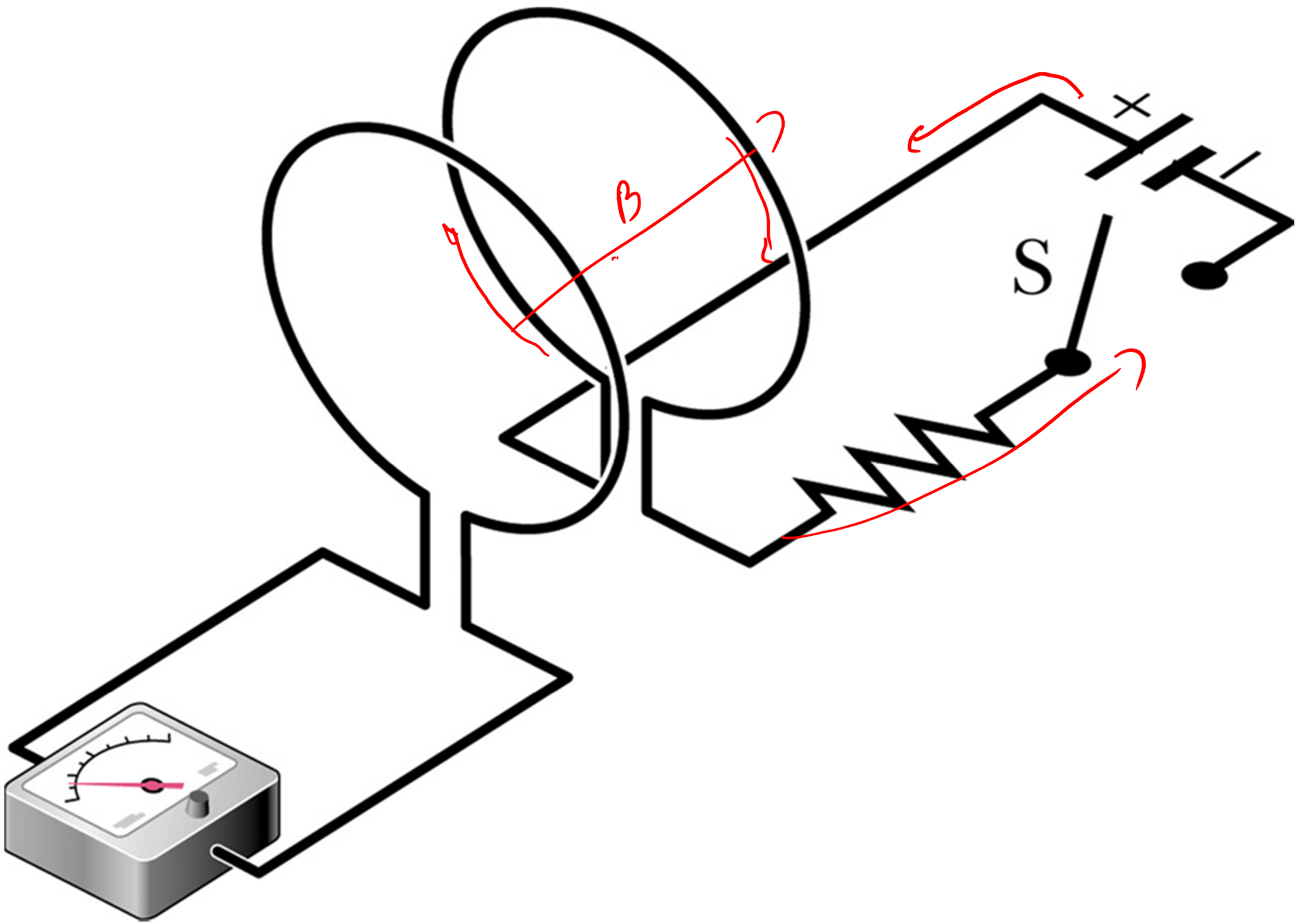
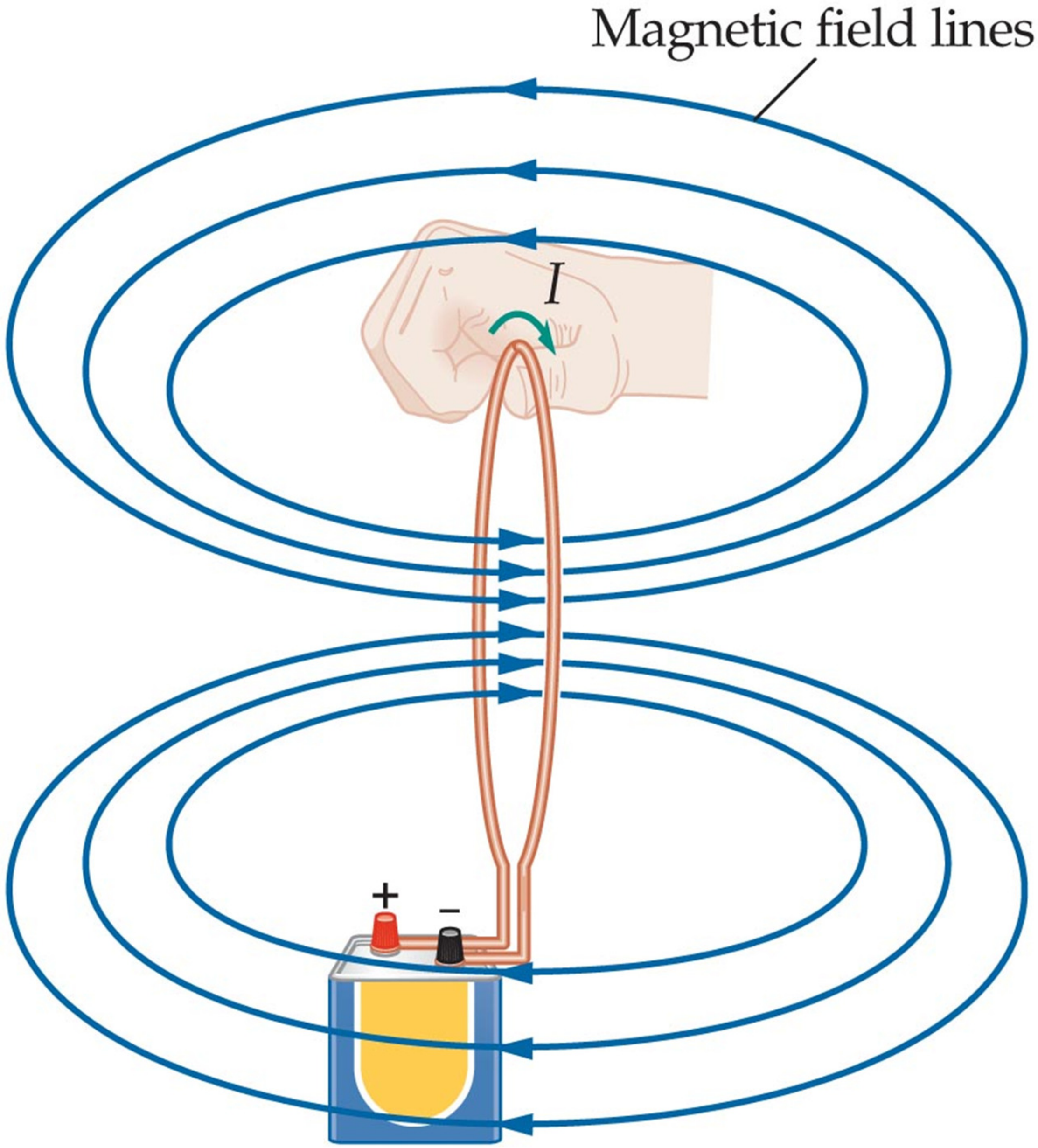
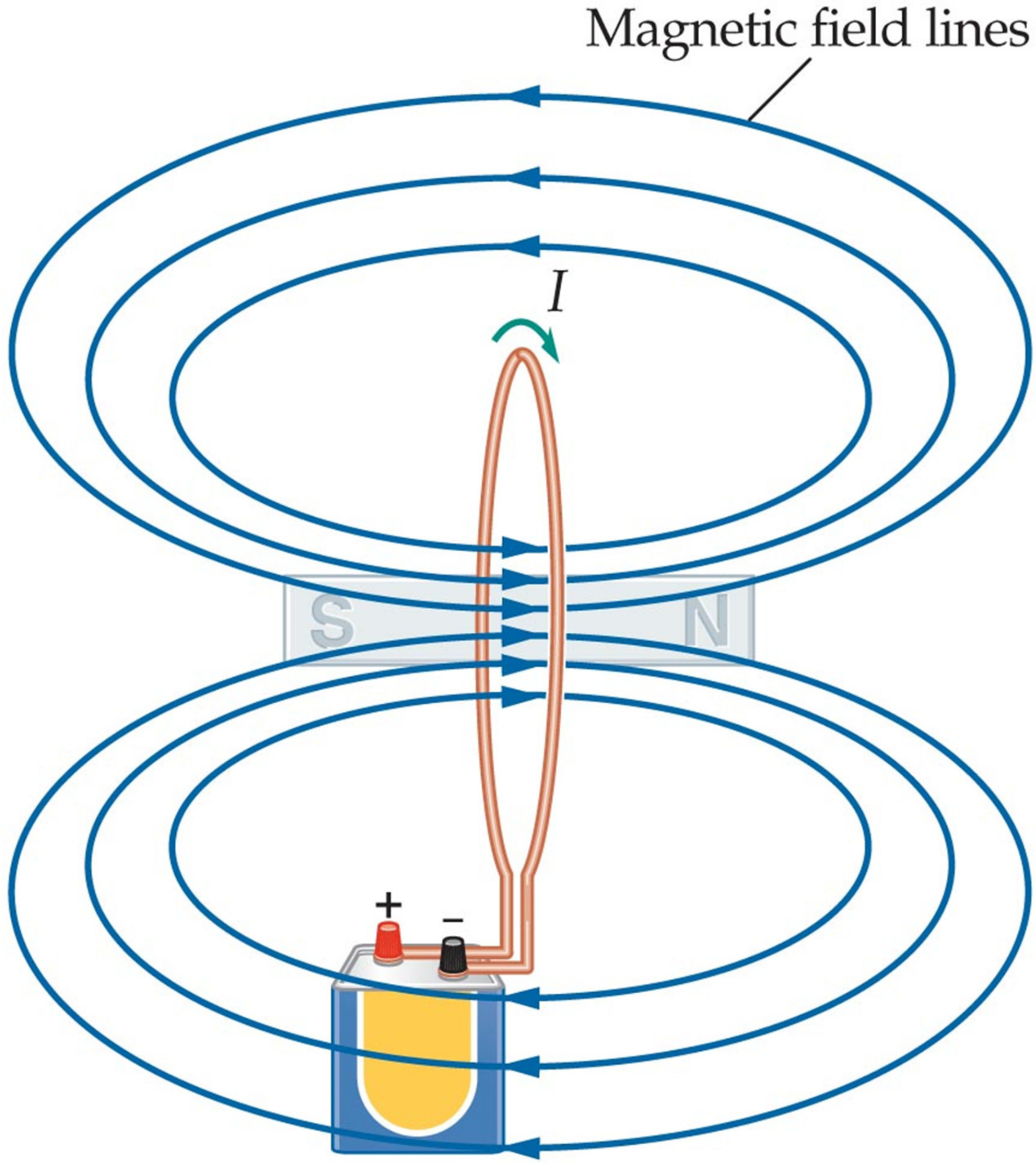
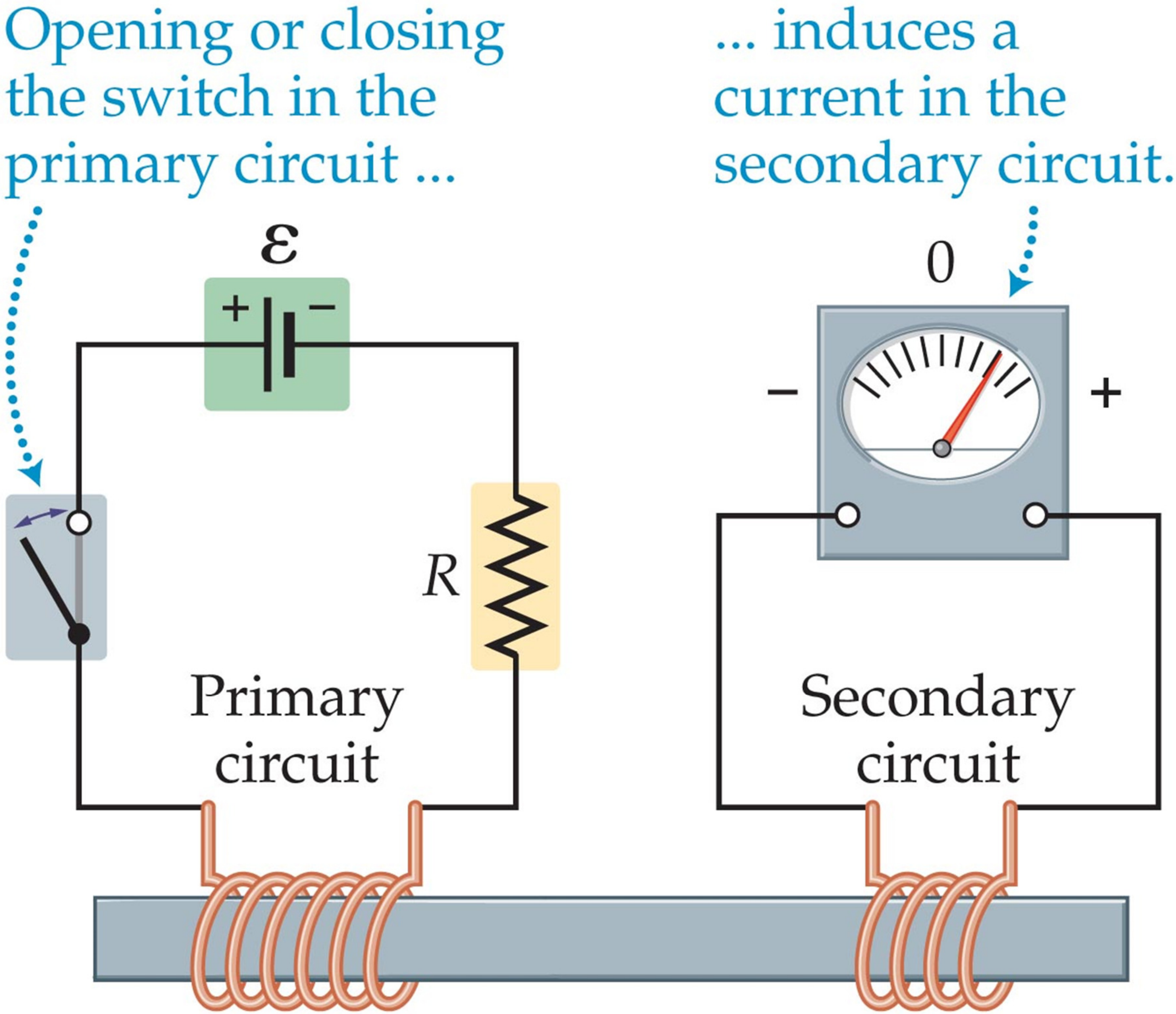

+
−
S
B

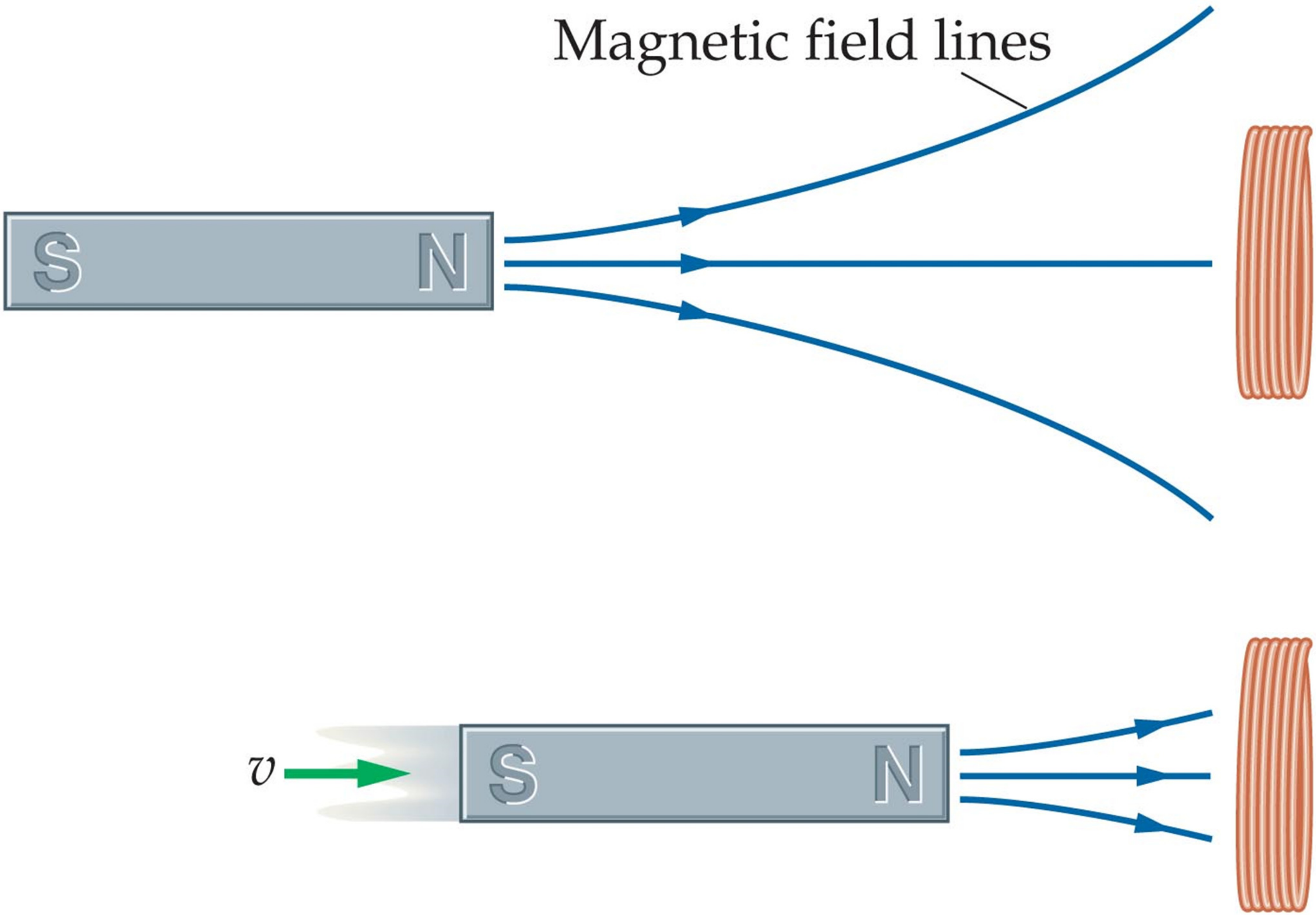


(a) Magnetic field of a current loop



(b) Magnetic field of bar magnet is similar

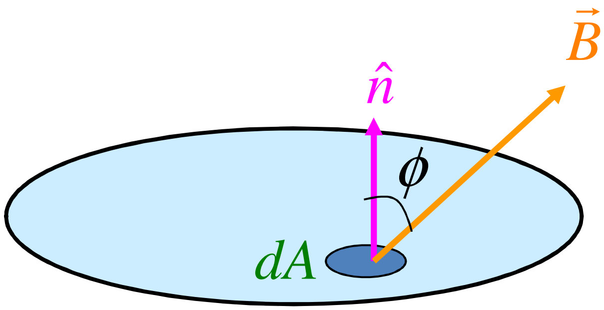

Opening or closing the switch in the primary circuit ...
... induces a current in the secondary circuit.
ε
+
−
R
Primary circuit
0
−
+
Secondary circuit


Magnetic field lines
S
N
v
S
N

Faraday's Law

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

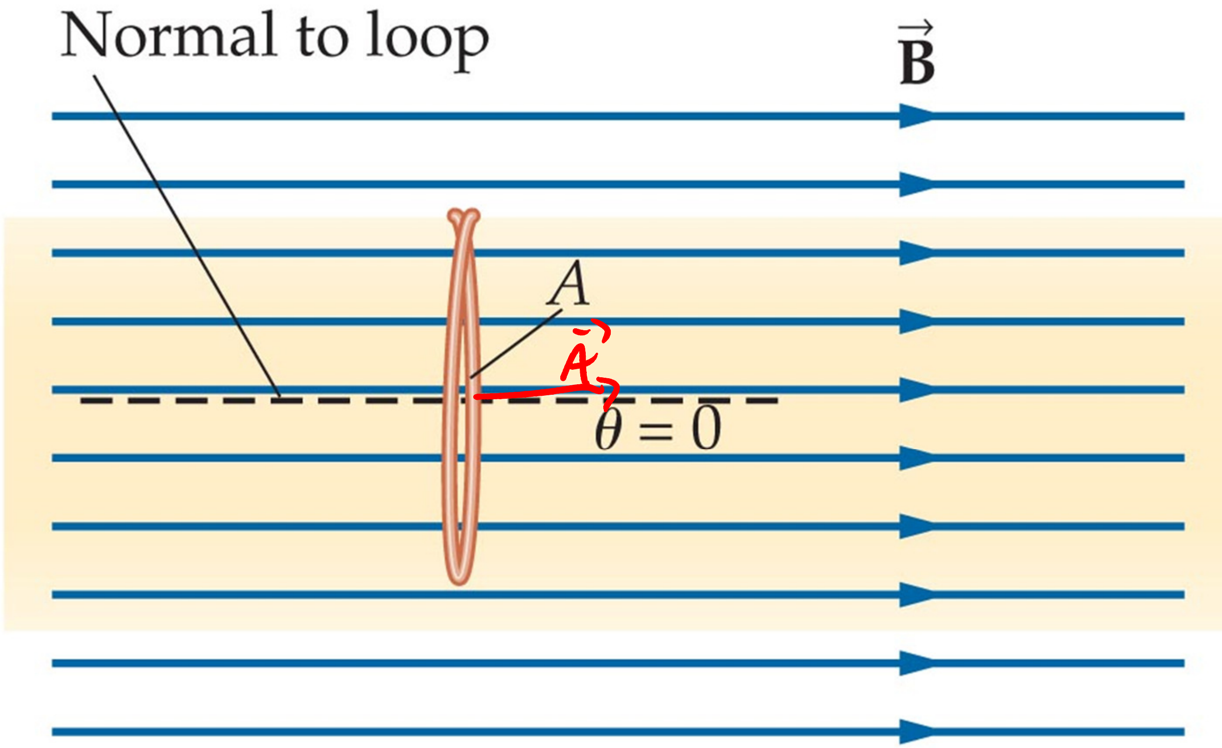
$$\mathcal{E} = -\frac{d\Phi_B}{dt}$$



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

$$|B||dA| \cos\theta$$

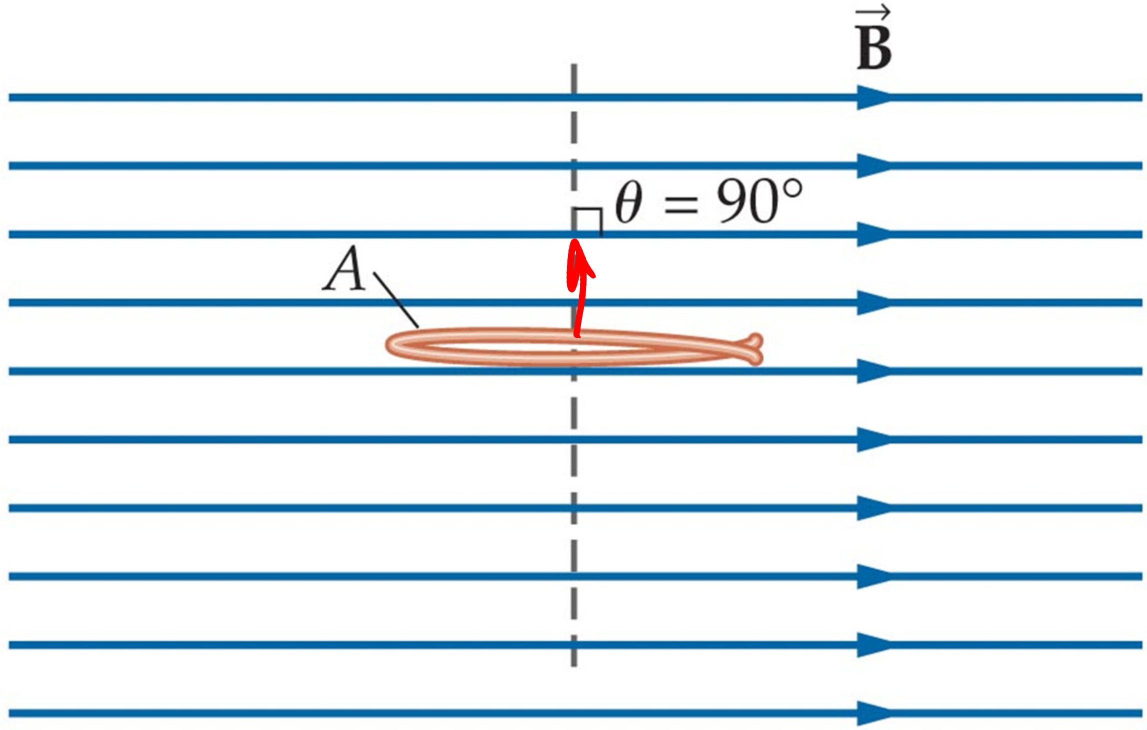
$\oint \vec{B} \cdot d\vec{A}$



(a)

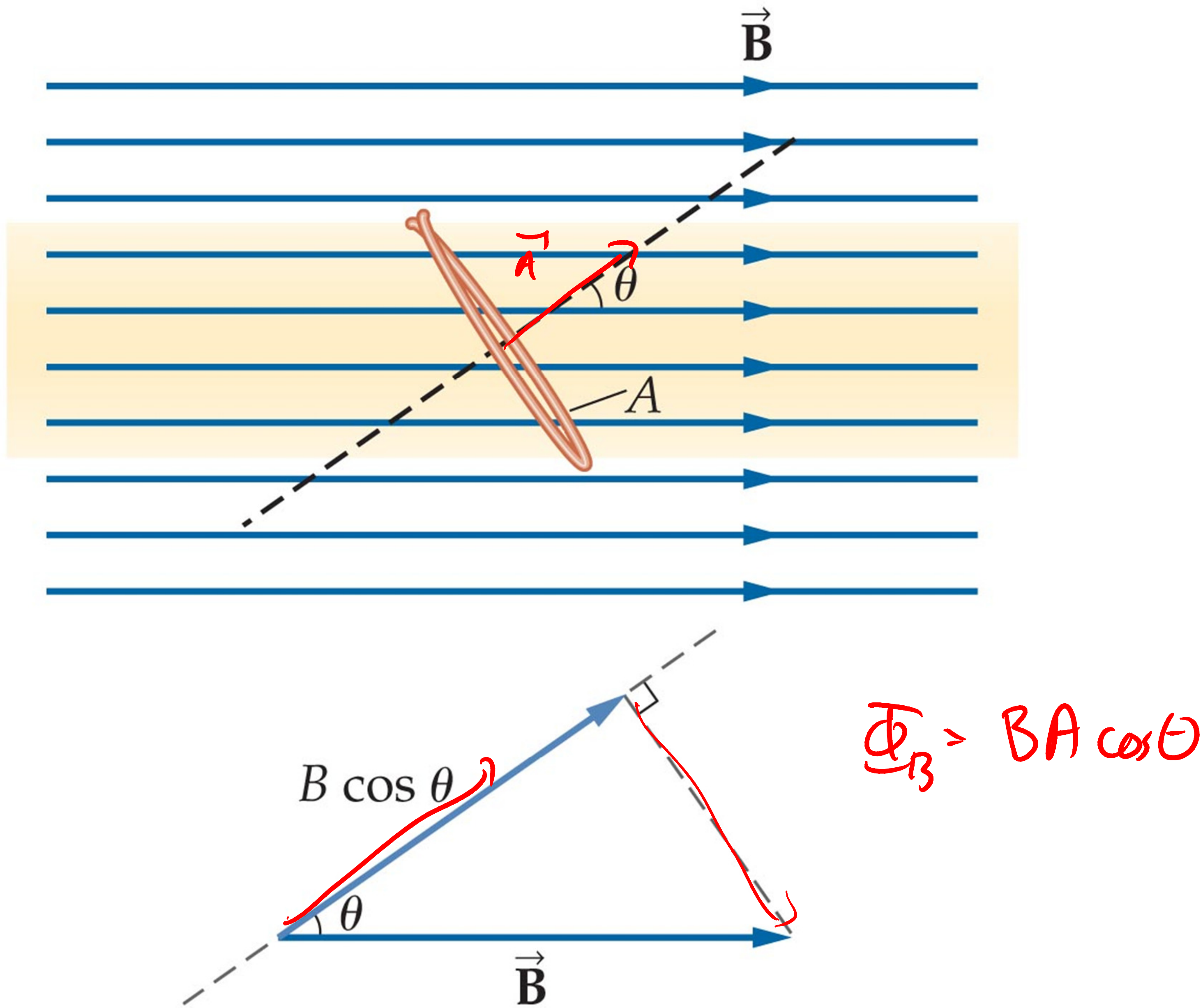
$\Phi_B = BA$

$\oint \vec{B} \cdot d\vec{A}$ $\quad \cos 90 = 0$

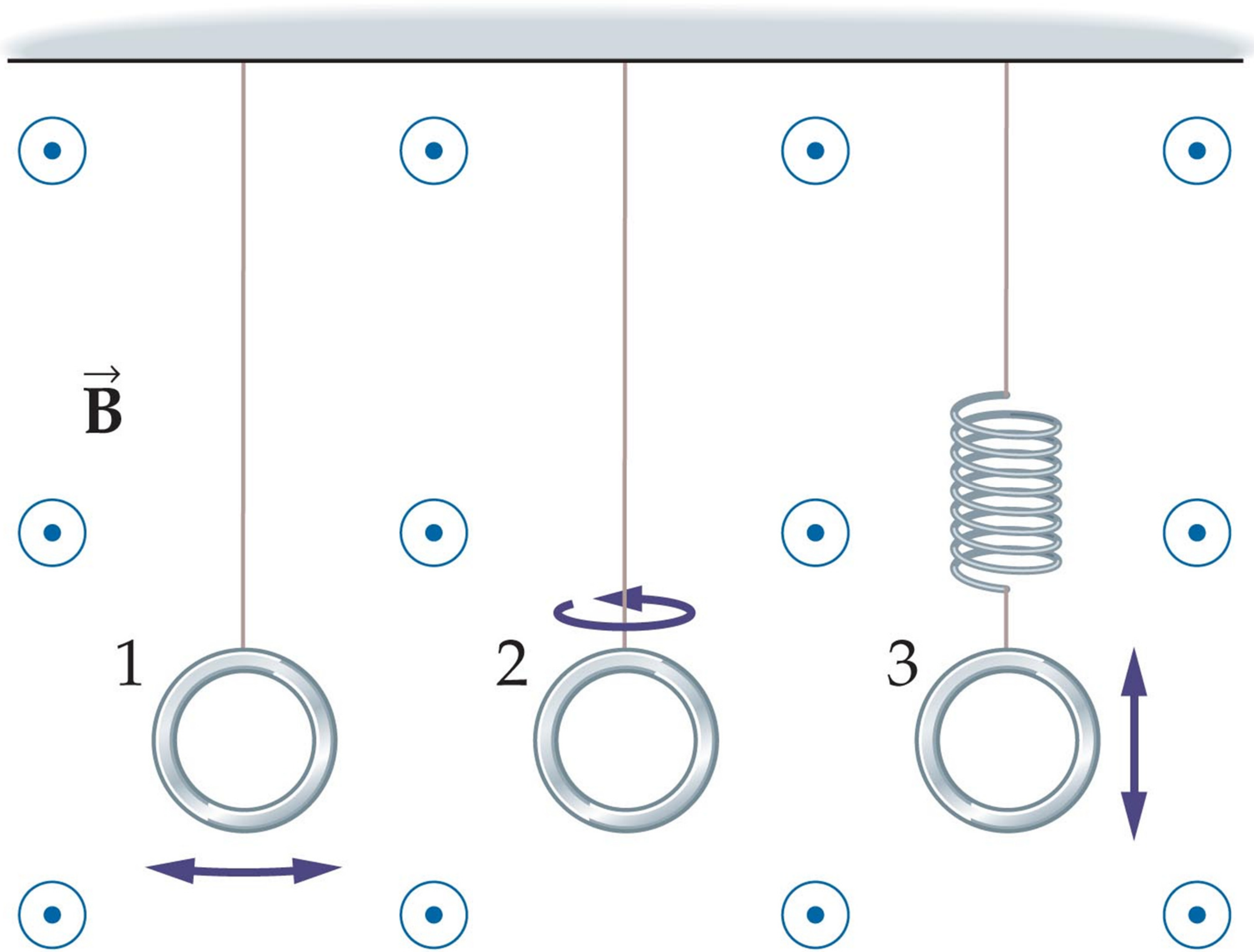


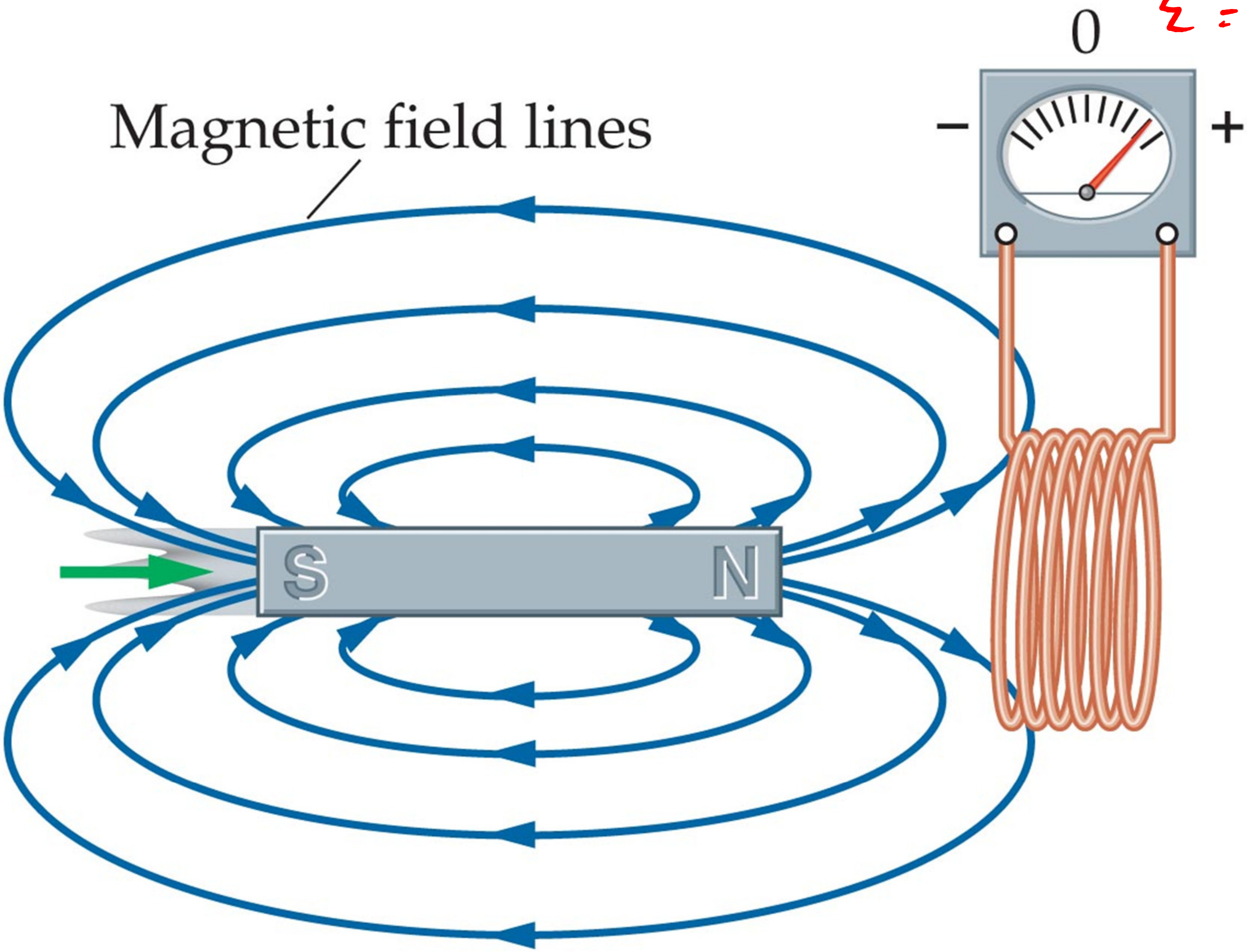
(b)

$\Phi_B = 0$



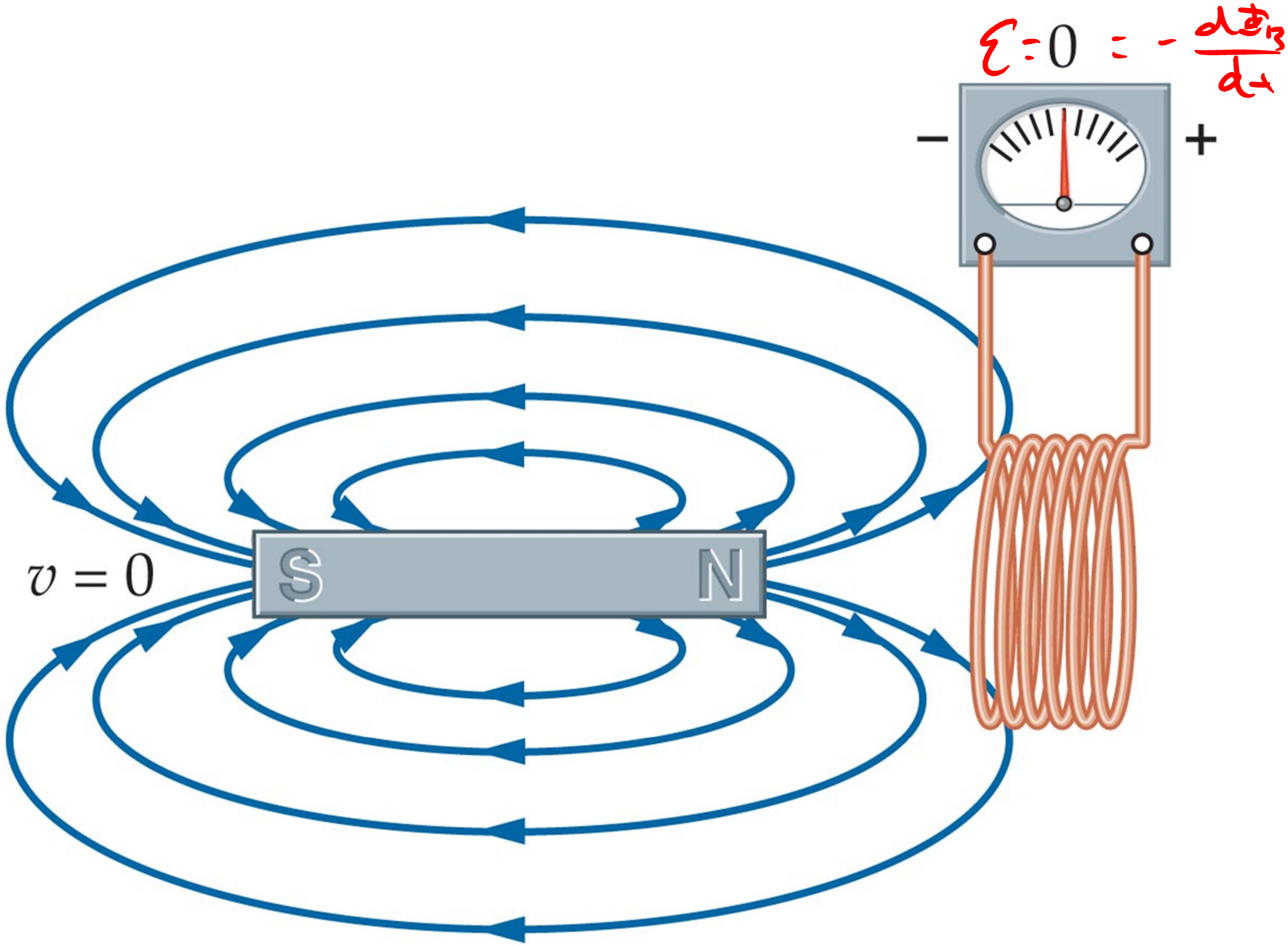
(c)


B
1
2
3

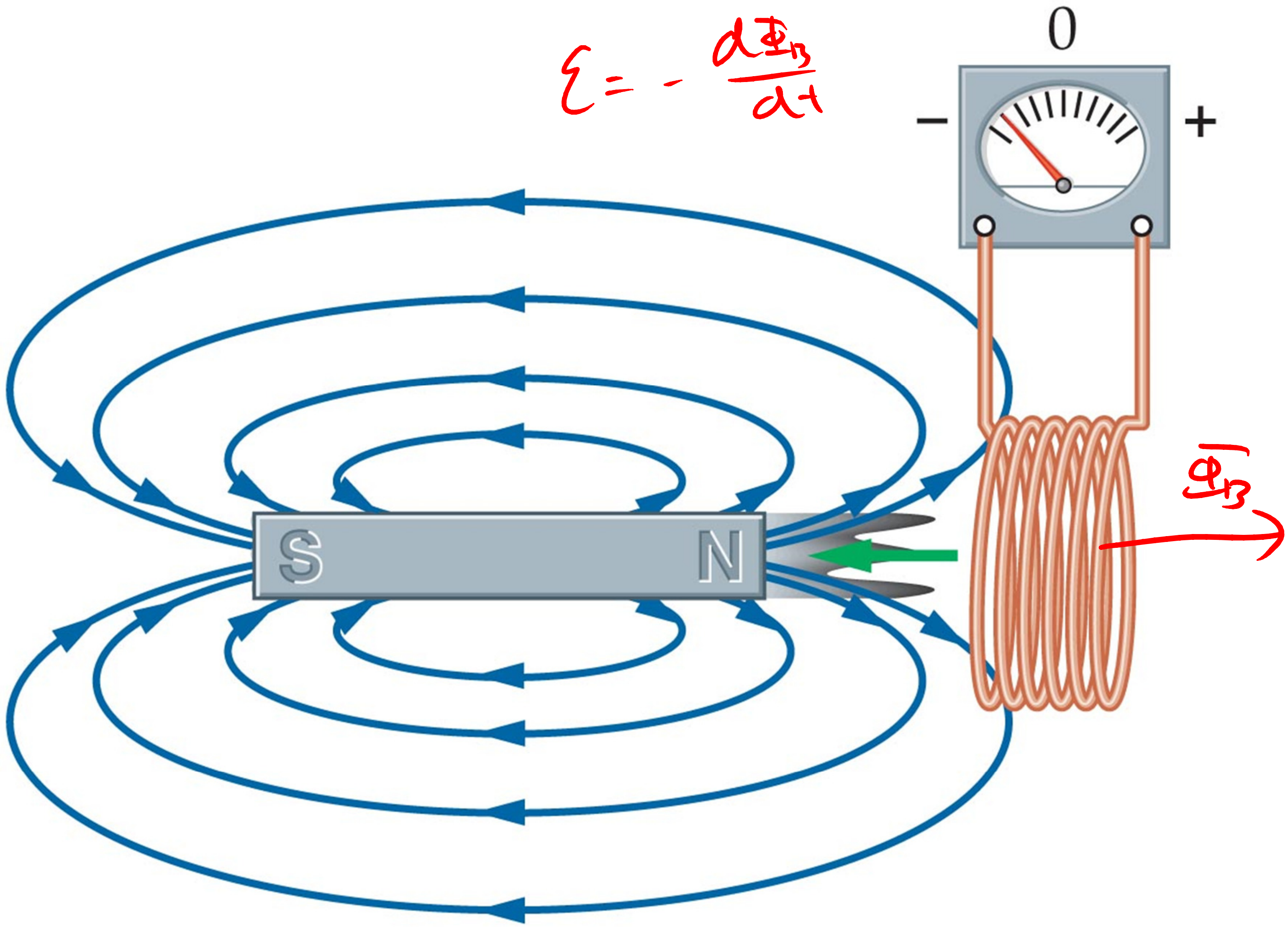


$\mathcal{E} = -\frac{d\Phi_B}{dt}$

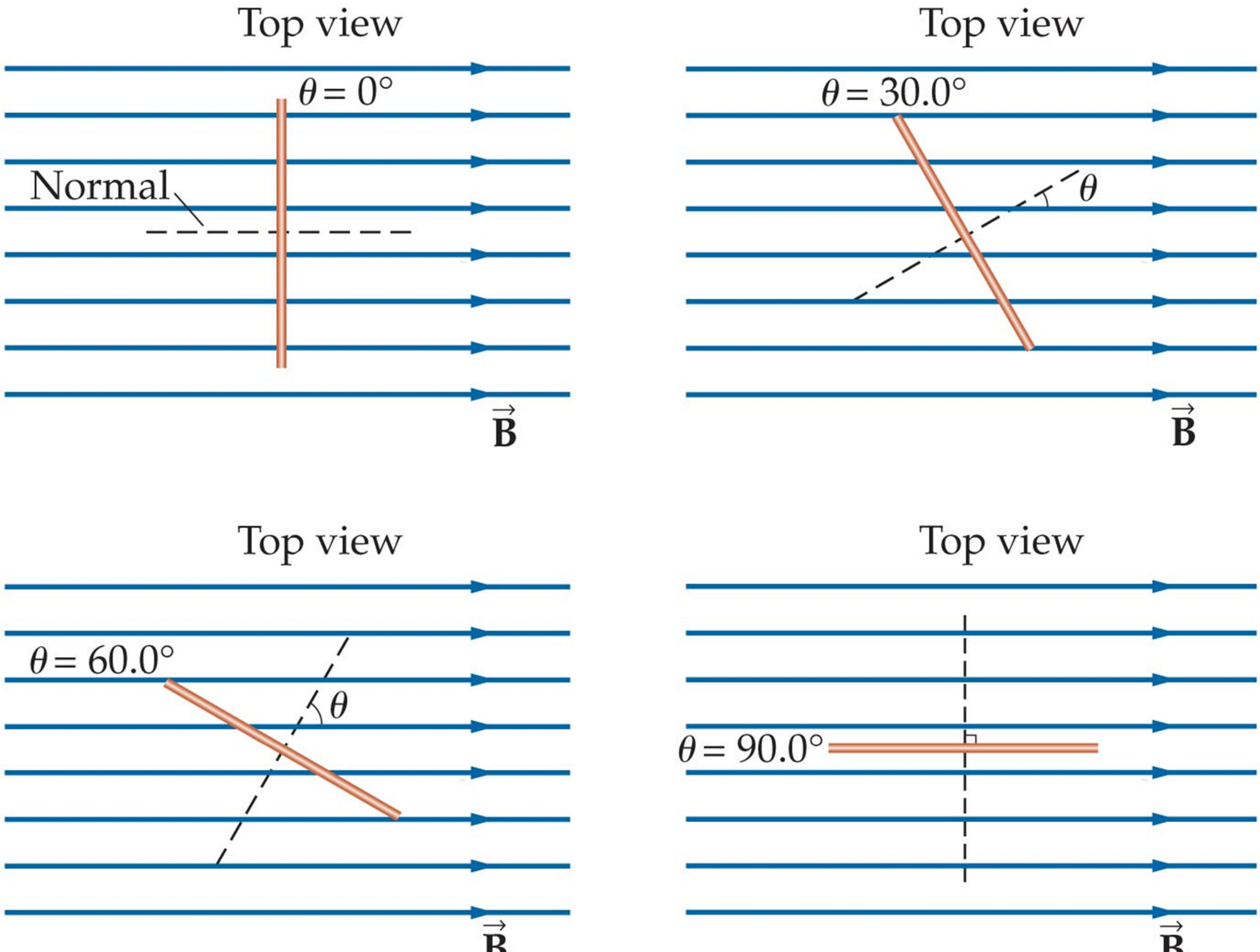
(a) Moving magnet toward coil induces current in one direction

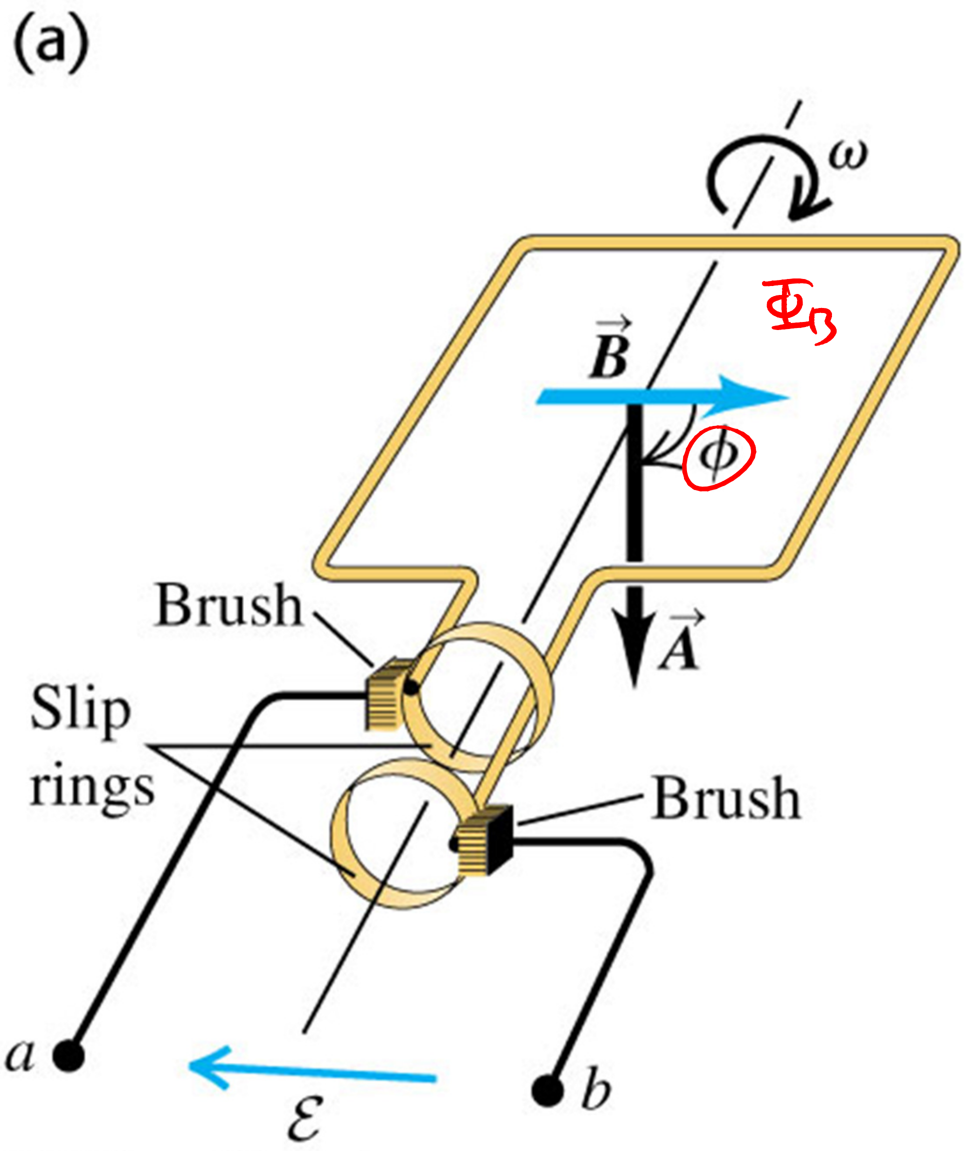


(b) No motion, no induced current



(c) Moving magnet away from coil induces current in opposite direction


Top view
θ = 0°
Normal
B
Top view
θ = 30.0°
θ
B
Top view
θ = 60.0°
θ
B
Top view
θ = 90.0°
B

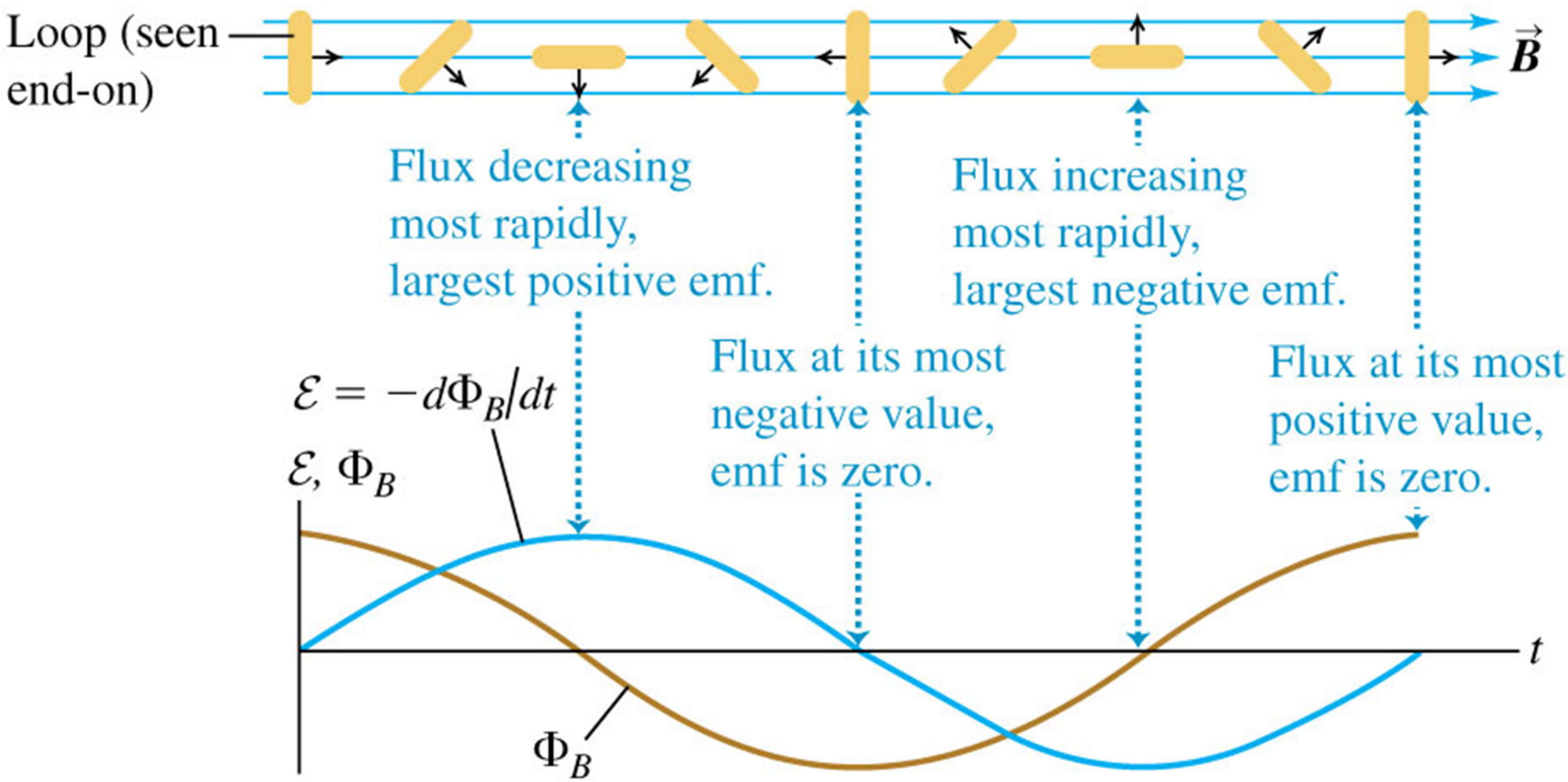


$$\Phi_B = BA\cos\theta$$
$$= BA\cos(\omega t)$$

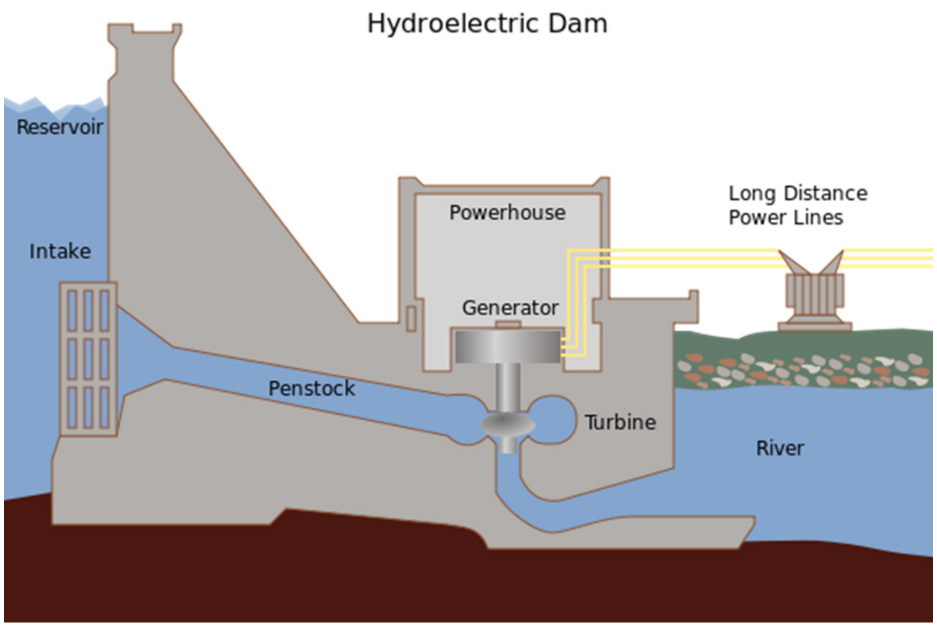
$$\mathcal{E} = -\frac{d}{dt}\left(BA\cos\omega t\right)$$

$$\mathcal{E}(t) = BA\,\omega\sin\omega t$$

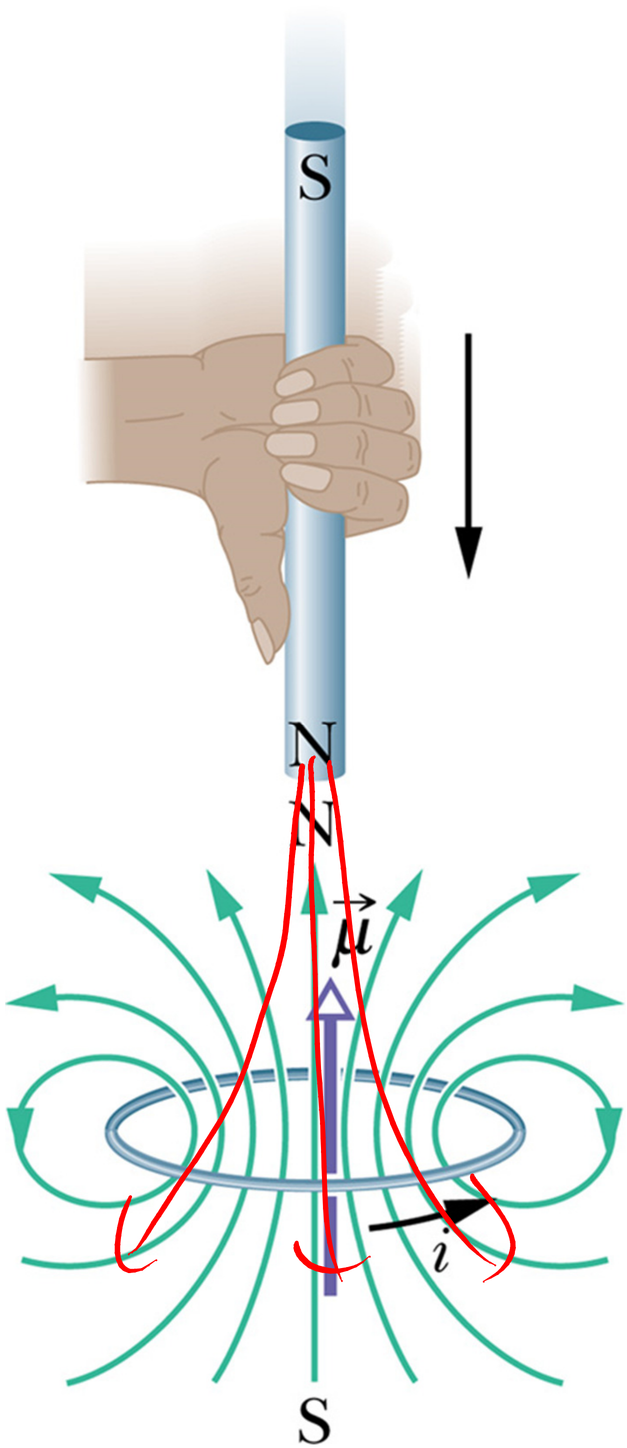
(b)



Loop (seen end-on)
$\vec{B}$
Flux decreasing most rapidly, largest positive emf.
Flux increasing most rapidly, largest negative emf.
Flux at its most negative value, emf is zero.
Flux at its most positive value, emf is zero.
$\mathcal{E} = -d\Phi_B/dt$
$\mathcal{E}$, Φ_B
t
Φ_B



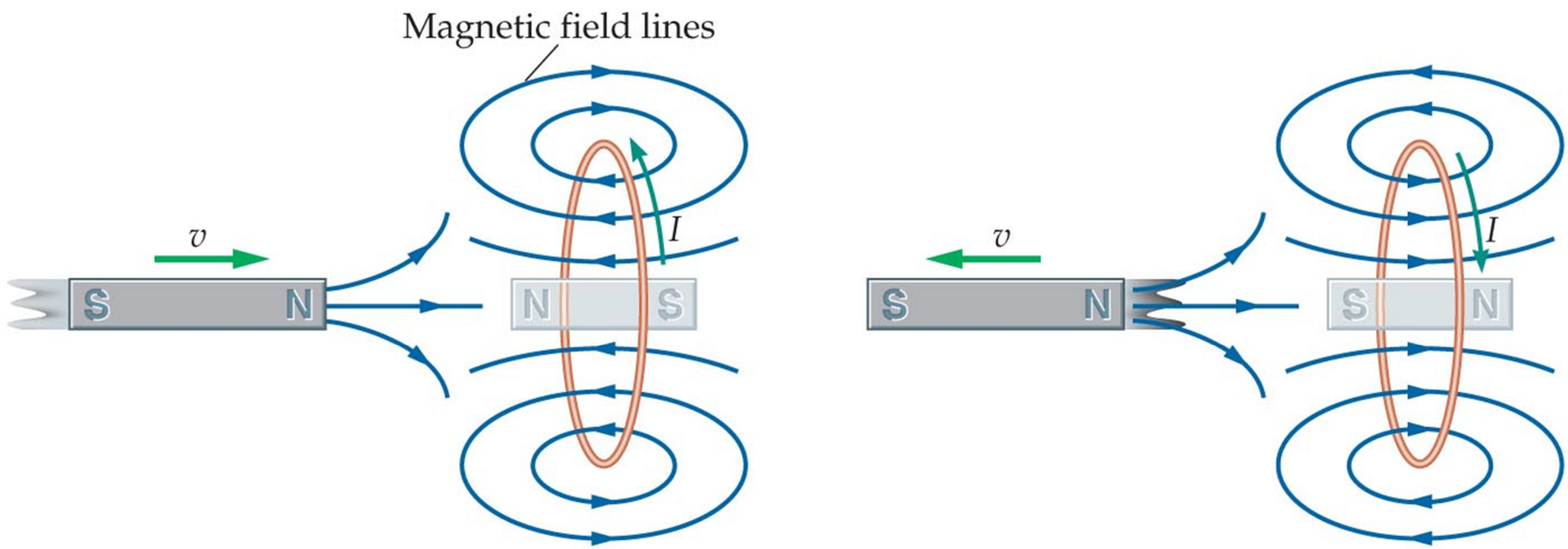
These pictures swiped from Wikipedia



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

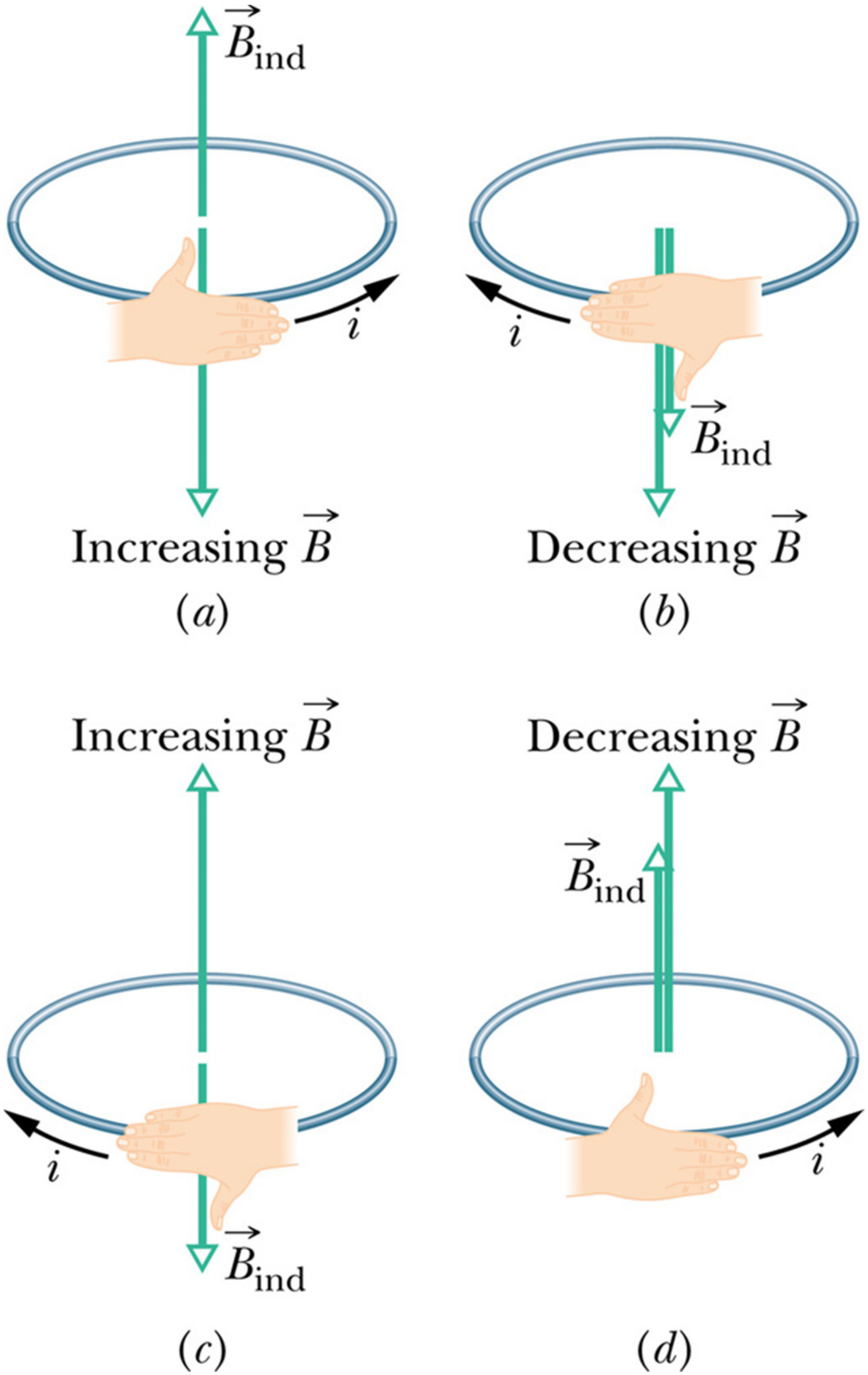
Lenz's Law:

current goes in the direction that opposes the change in Φ_B

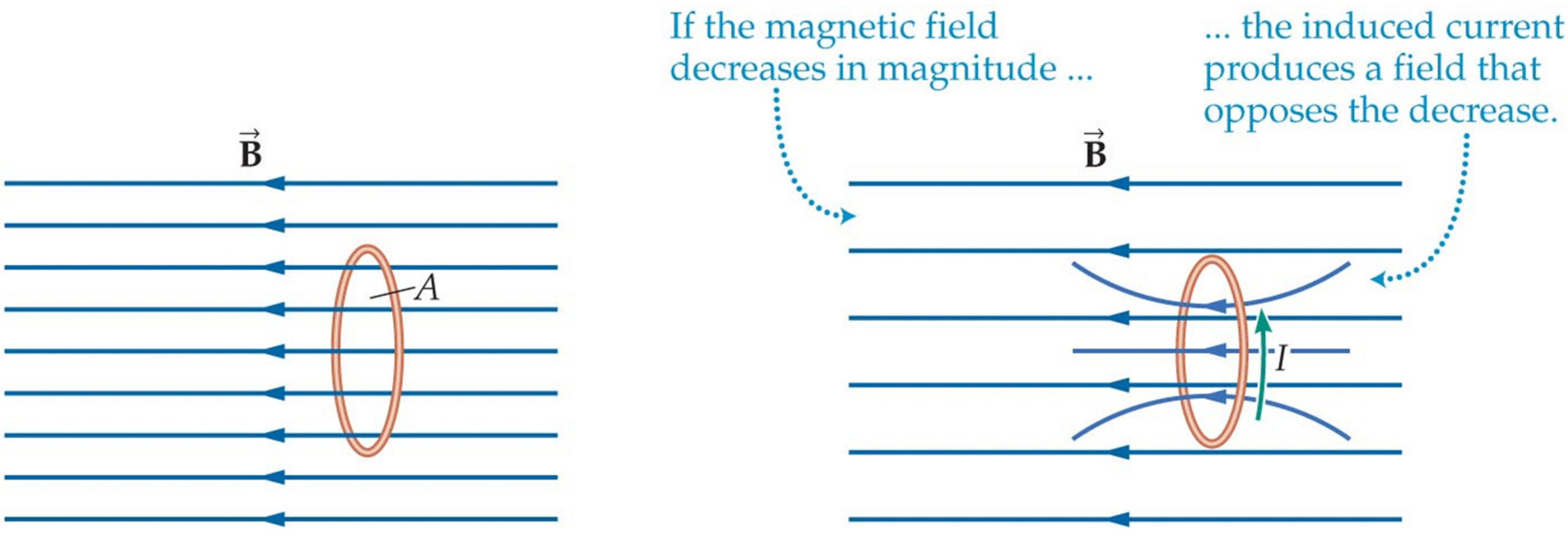


(a) Moving magnet toward coil induces a field that repels the magnet

(b) Moving magnet away from coil induces a field that attracts the magnet

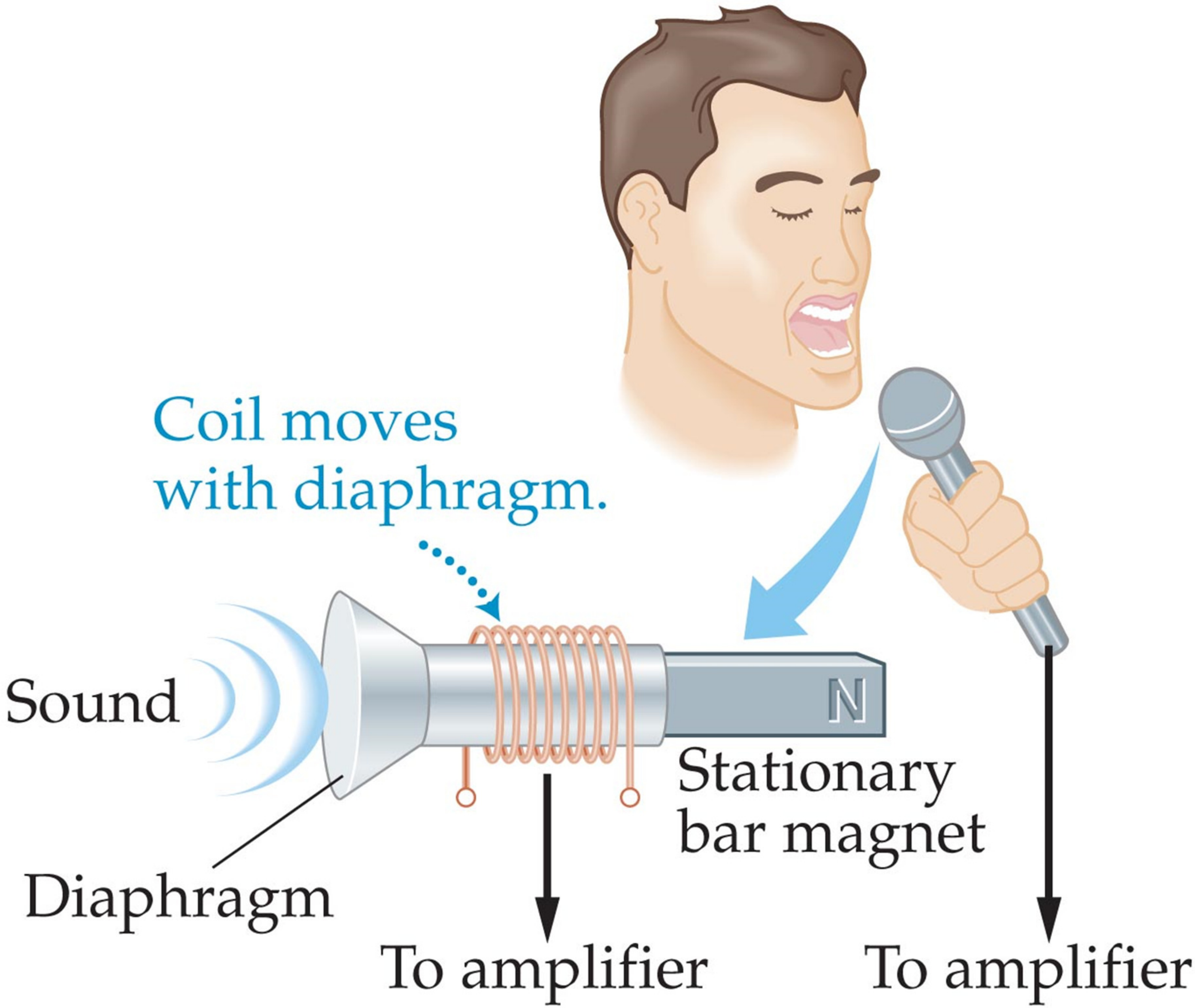


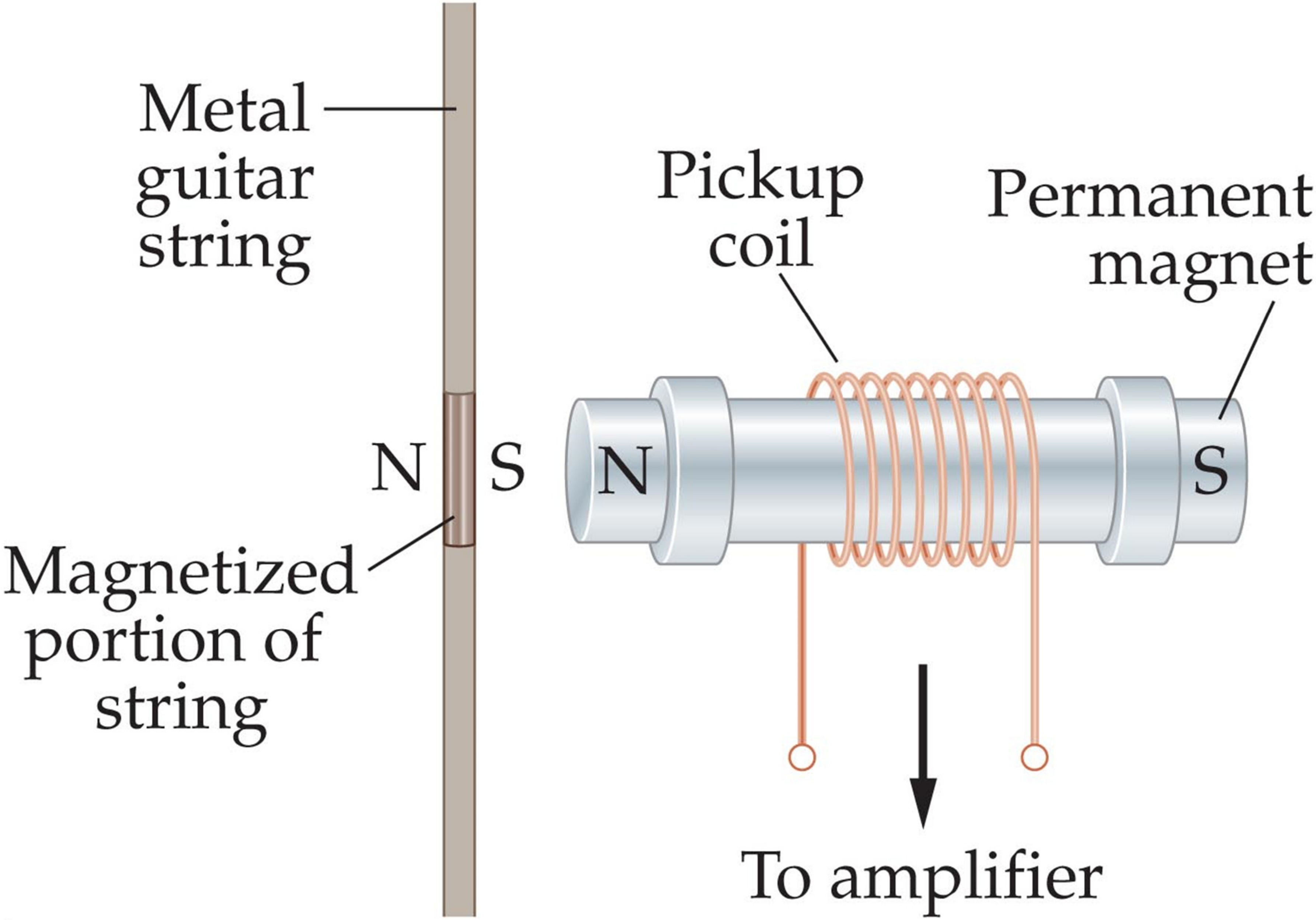
$\vec{B}_{ind}$
i
Increasing $\vec{B}$
(a)
i
$\vec{B}_{ind}$
Decreasing $\vec{B}$
(b)
Increasing $\vec{B}$
i
$\vec{B}_{ind}$
(c)
Decreasing $\vec{B}$
$\vec{B}_{ind}$
i
(d)



(a) A conducting loop in a constant magnetic field

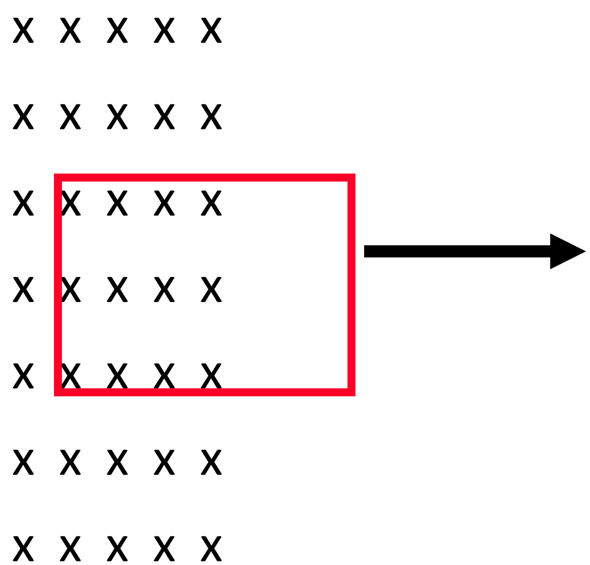
(b) A change in the field induces a current

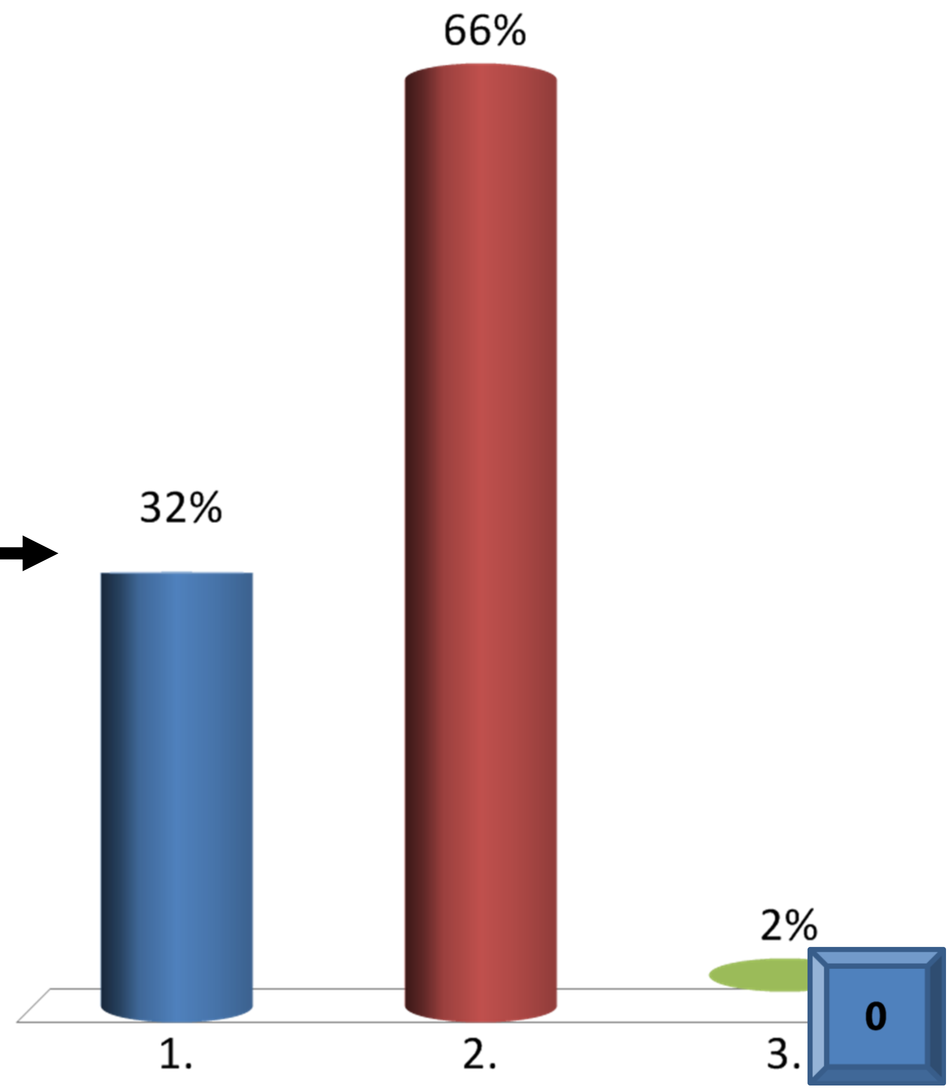

Coil moves
with diaphragm.
Sound
N
Stationary
bar magnet
Diaphragm
To amplifier
To amplifier


Metal guitar string
Pickup coil
Permanent magnet
N
S
N
S
Magnetized portion of string
To amplifier

A wire loop is being pulled through a uniform magnetic field that suddenly ends. What is the direction of the induced current?

✓ 1. Clockwise
2. Counter-clockwise
3. There is no induced current





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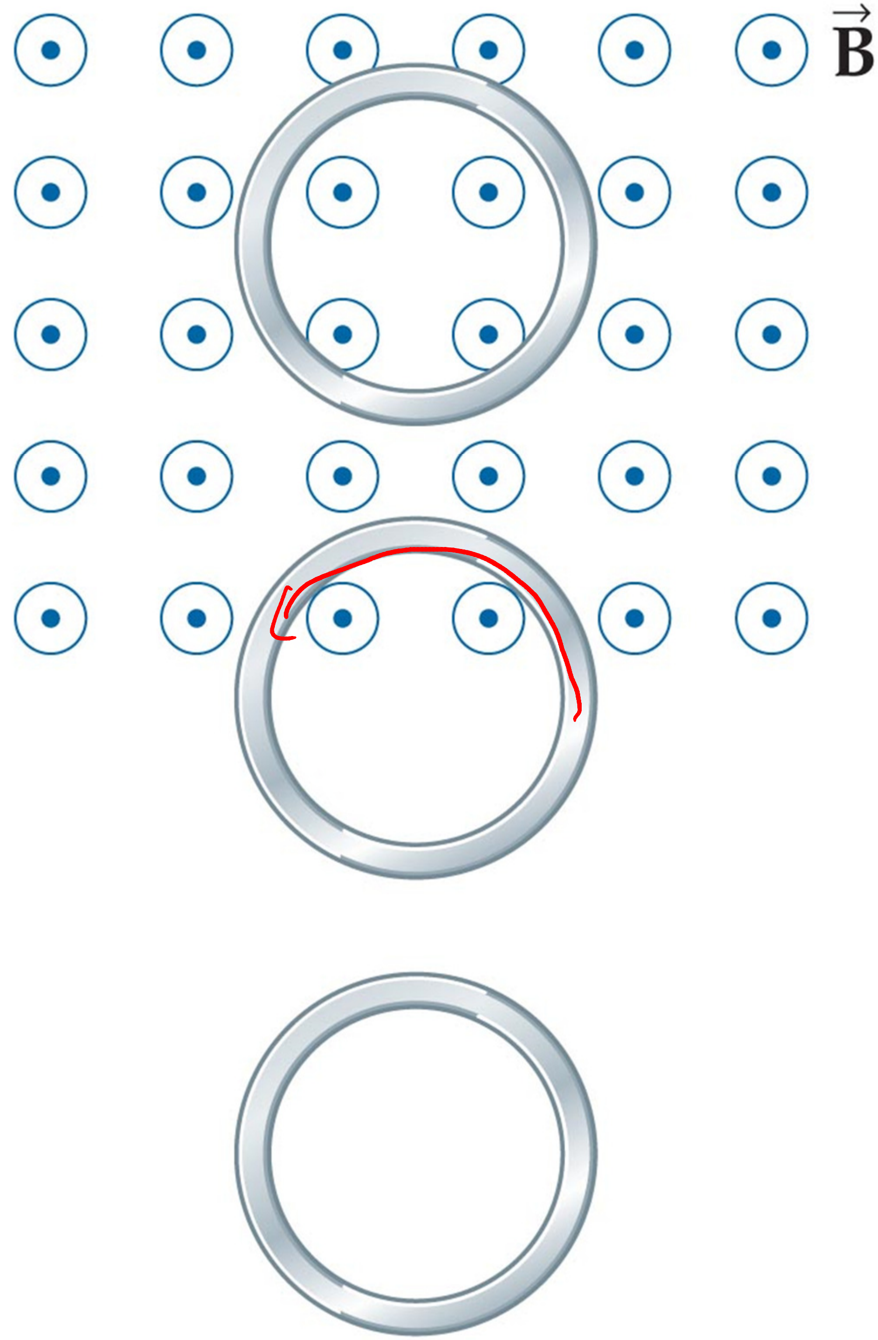
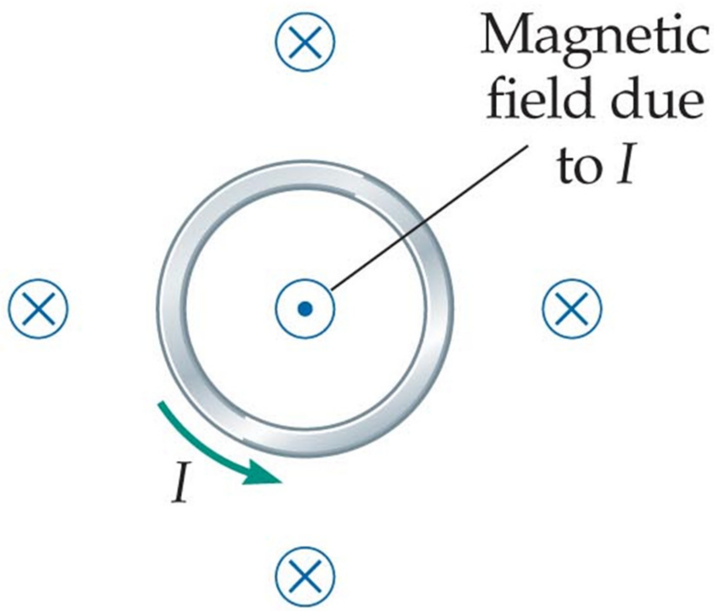
Lenz’ Law Worksheet

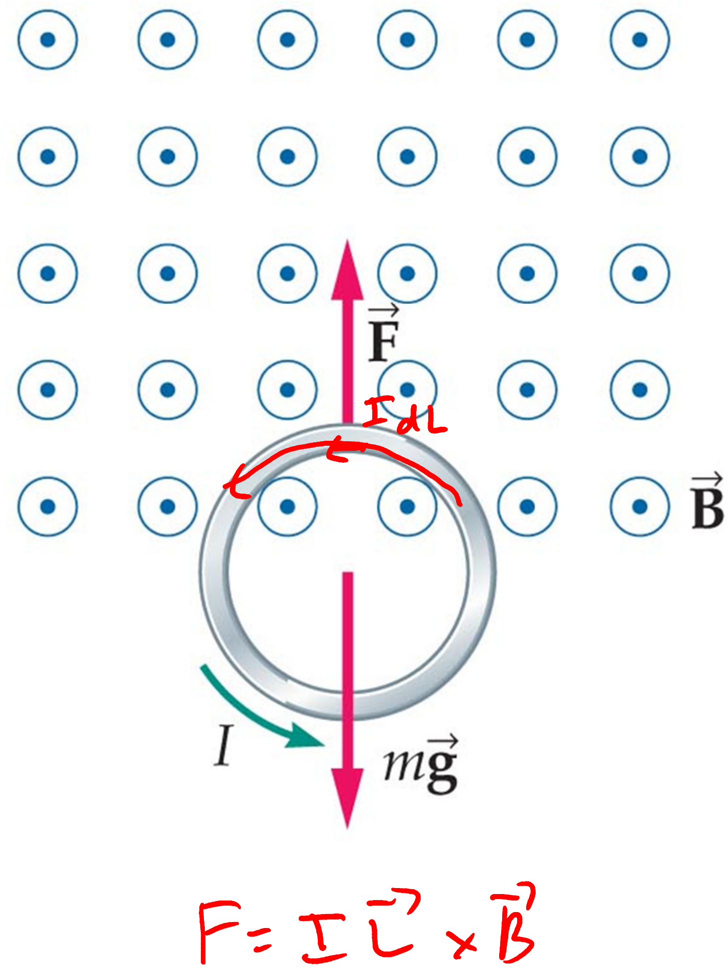
No current

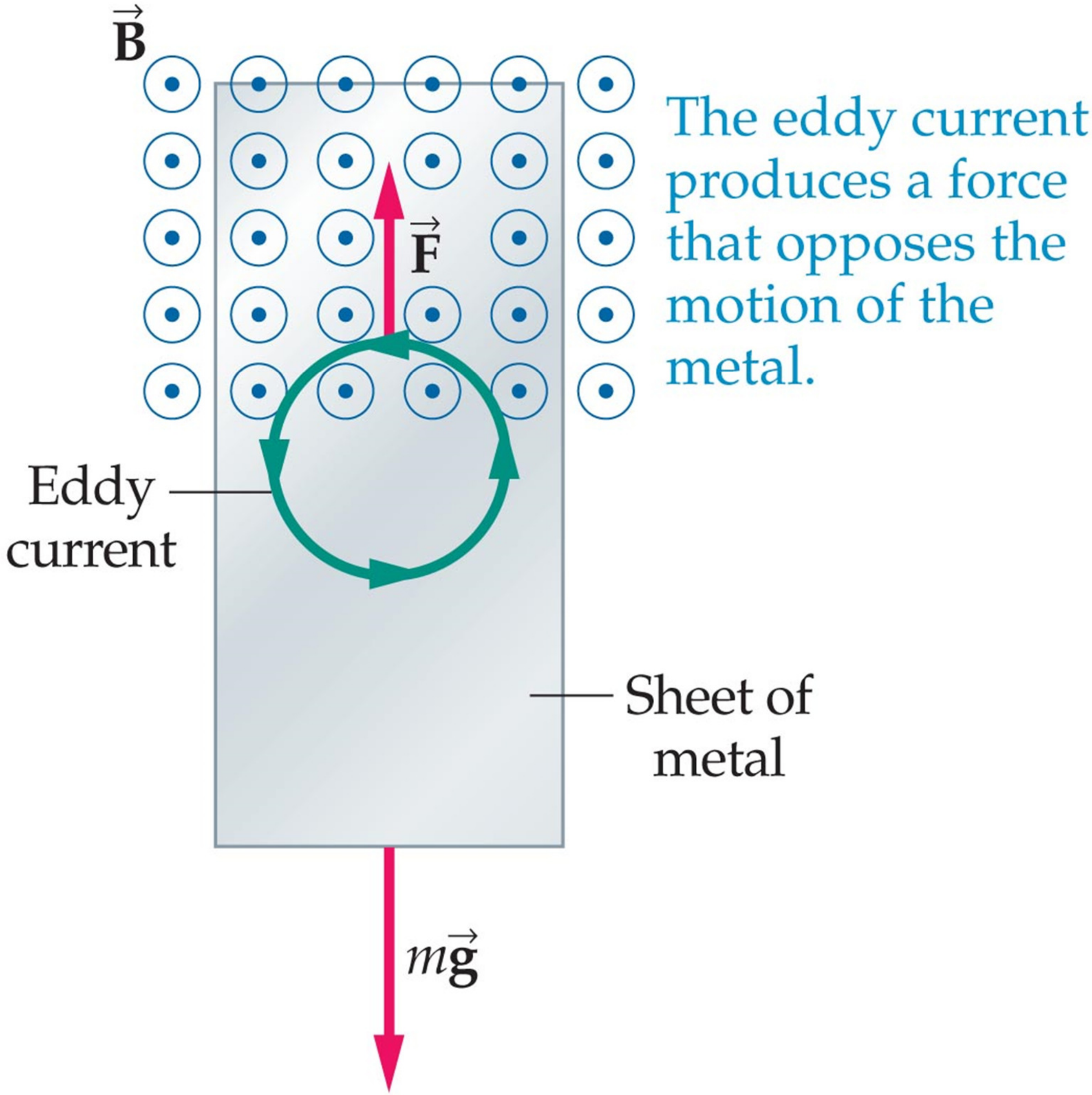
Induced current

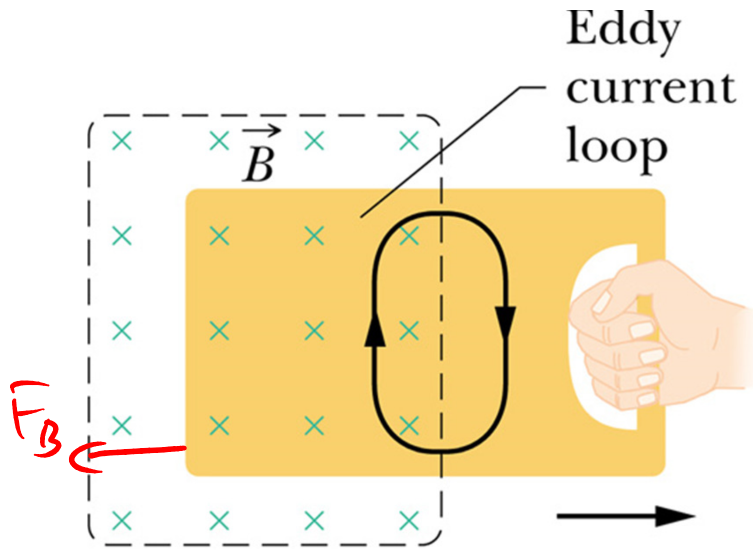
No current



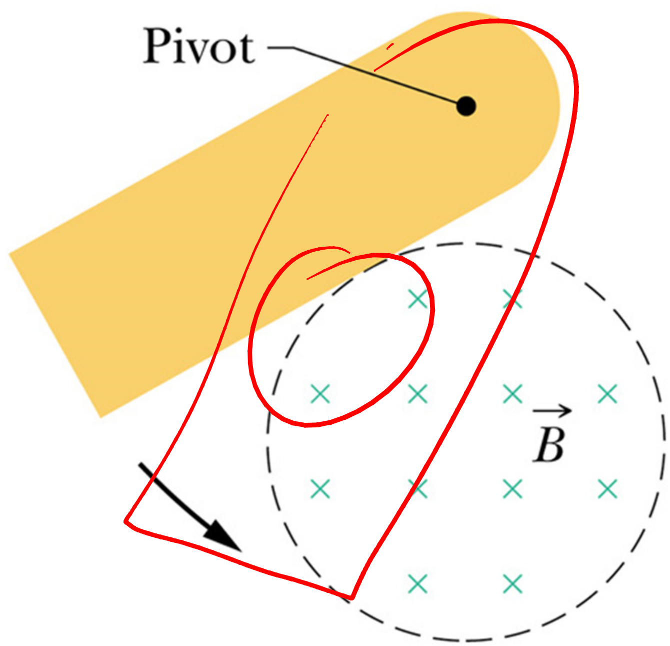

Magnetic
field due
to I
I


$\vec{F}$
$I\,dL$
$\vec{B}$
I
$m\vec{g}$
$F = I\vec{L} \times \vec{B}$

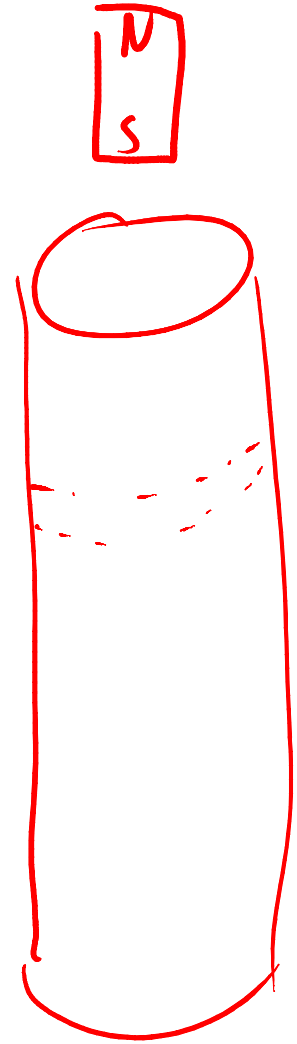

$\vec{B}$
$\vec{F}$
The eddy current produces a force that opposes the motion of the metal.
Eddy current
Sheet of metal
$m\vec{g}$



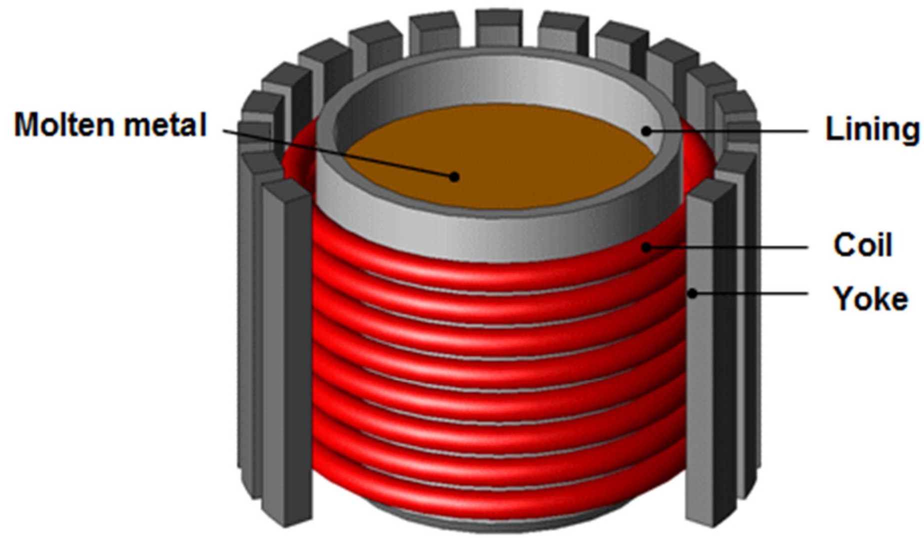
(*a*)

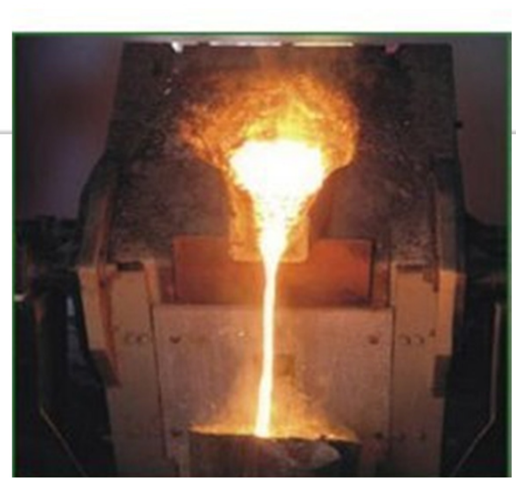


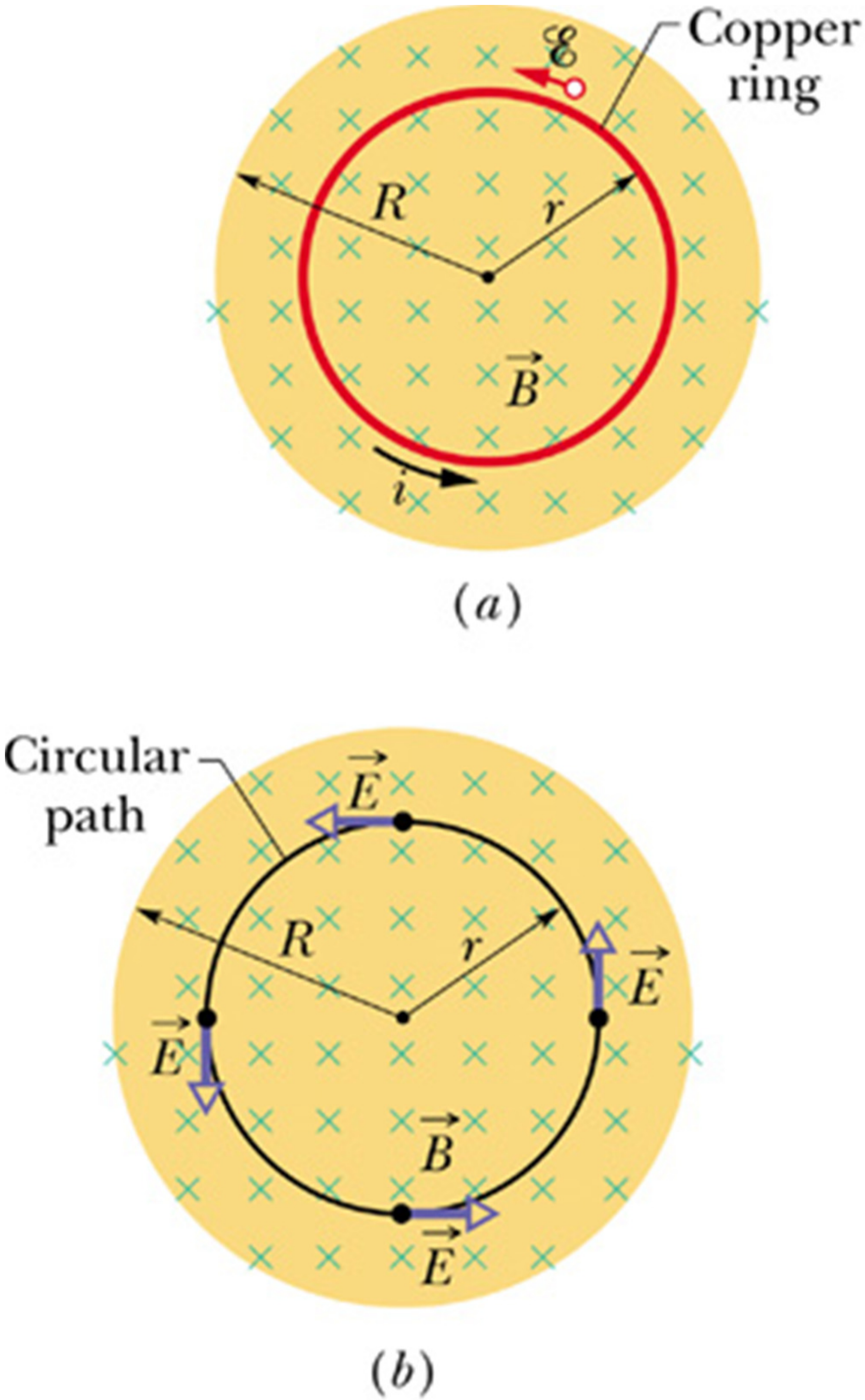
(*b*)




Induction


Molten metal
Lining
Coil
Yoke



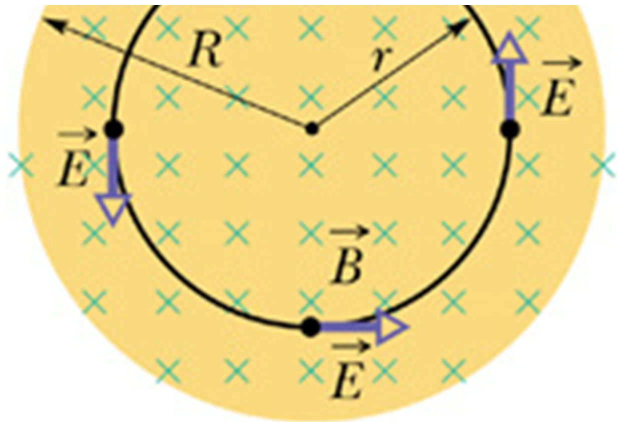


$$\oint \vec{E} \cdot \vec{dl} = -\frac{d\Phi_B}{dt}$$

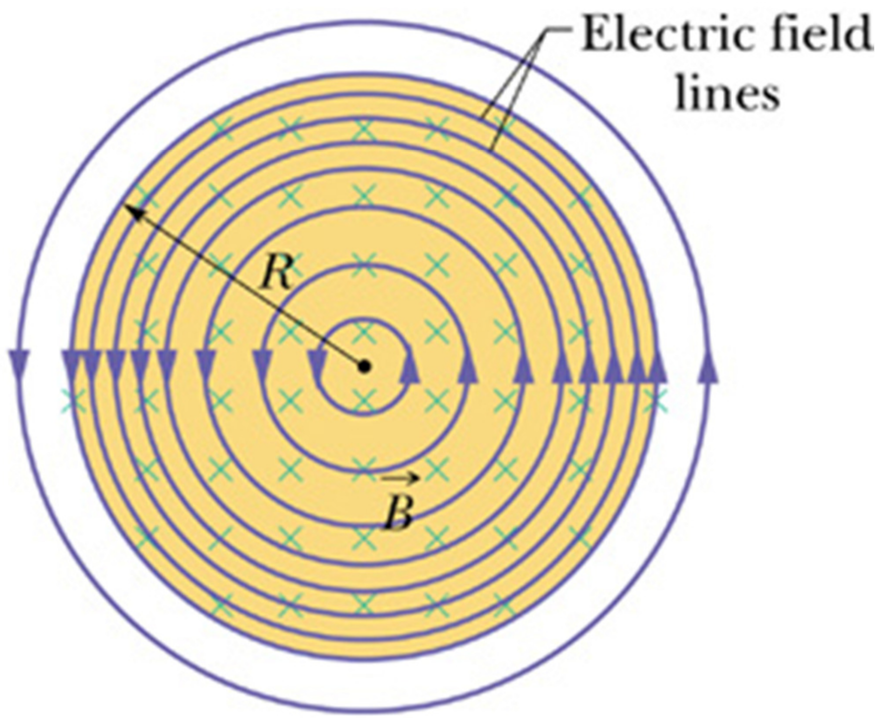
$$E \oint dl = \frac{-d\Phi_B}{dt}$$

$$E\,2\pi r = -\frac{d\Phi_B}{dt}$$

$$E = -\frac{d\Phi_B/dt}{2\pi r}$$



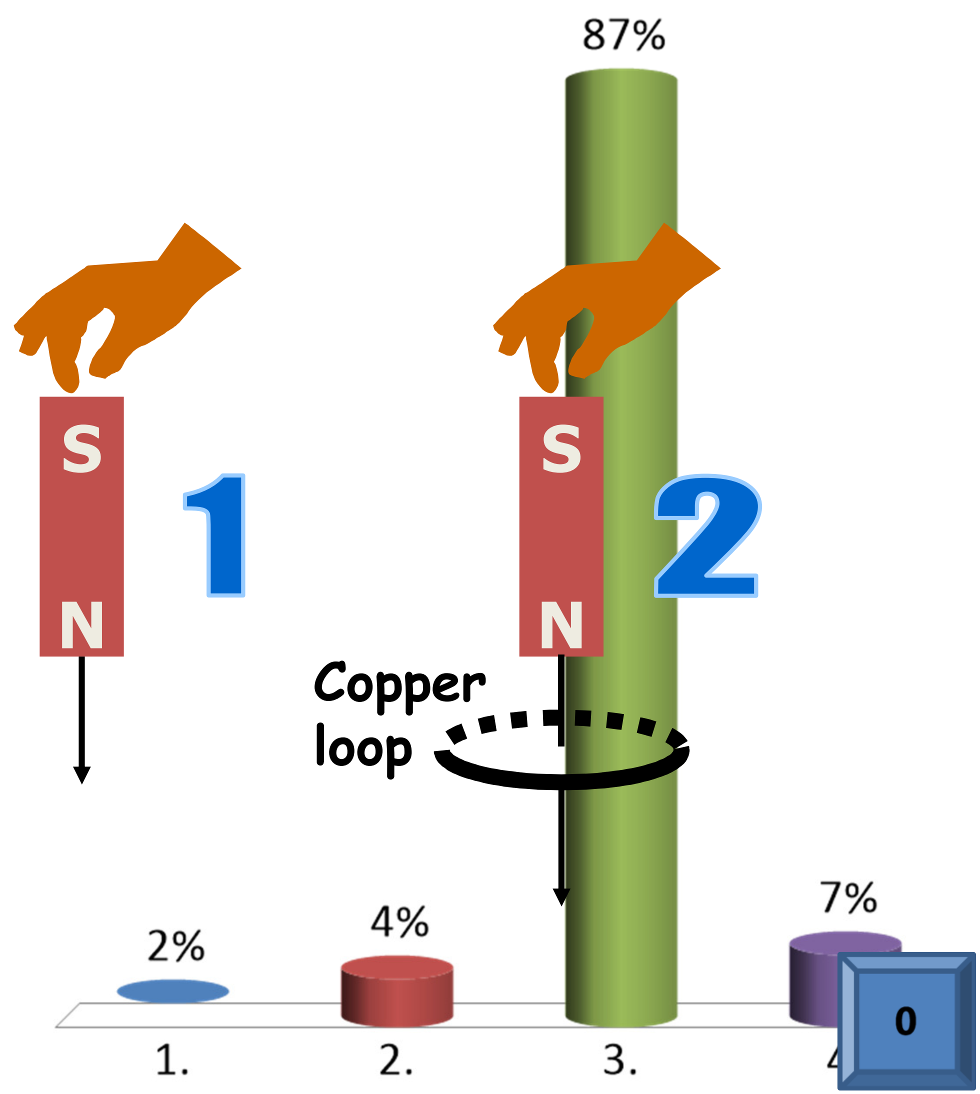
(*b*)



(*c*)

If there is induced current, doesn't that cost energy? Where would that energy come from in case 2?

1. Induced current doesn't need any energy
2. Energy conservation is violated in this case
3. ✓ There is less kinetic energy in case 2
4. There is more potential energy in case 1



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