Physics 122 – Class #29 (4/30/15) –

- Announcements

- Faraday's Law
- Flux
- Solenoids
- Generators

Exam 3 – Solutions posted. Can review in review session.

Practice Final is posted

http://kestrel.nmt.edu/~rsonnenf/phys122/homeworksolns/

Final Exam

Friday May 8, 1:30-4:30 pm Workman 109/113.

Possible Review Sessions (Clickers)

Sat 5/2 9 AM, Workman 113 [A]

Sat 5/2 1:30 P M, Workman 109 [B]

Tues 5/5 6:00 P M, Workman 113 [C]

Reading Assignments

Chapter 32, EXCEPT section 32.10

Chapter 33. Omit 33.6, 33.9, 33.10

You need to really understand Faraday's law and Lenz's law as well as generators and transformers. We will NOT study inductors specifically (though a coil of wire IS an inductor) so omit section 33.8 too.

Extra Credit Opportunity

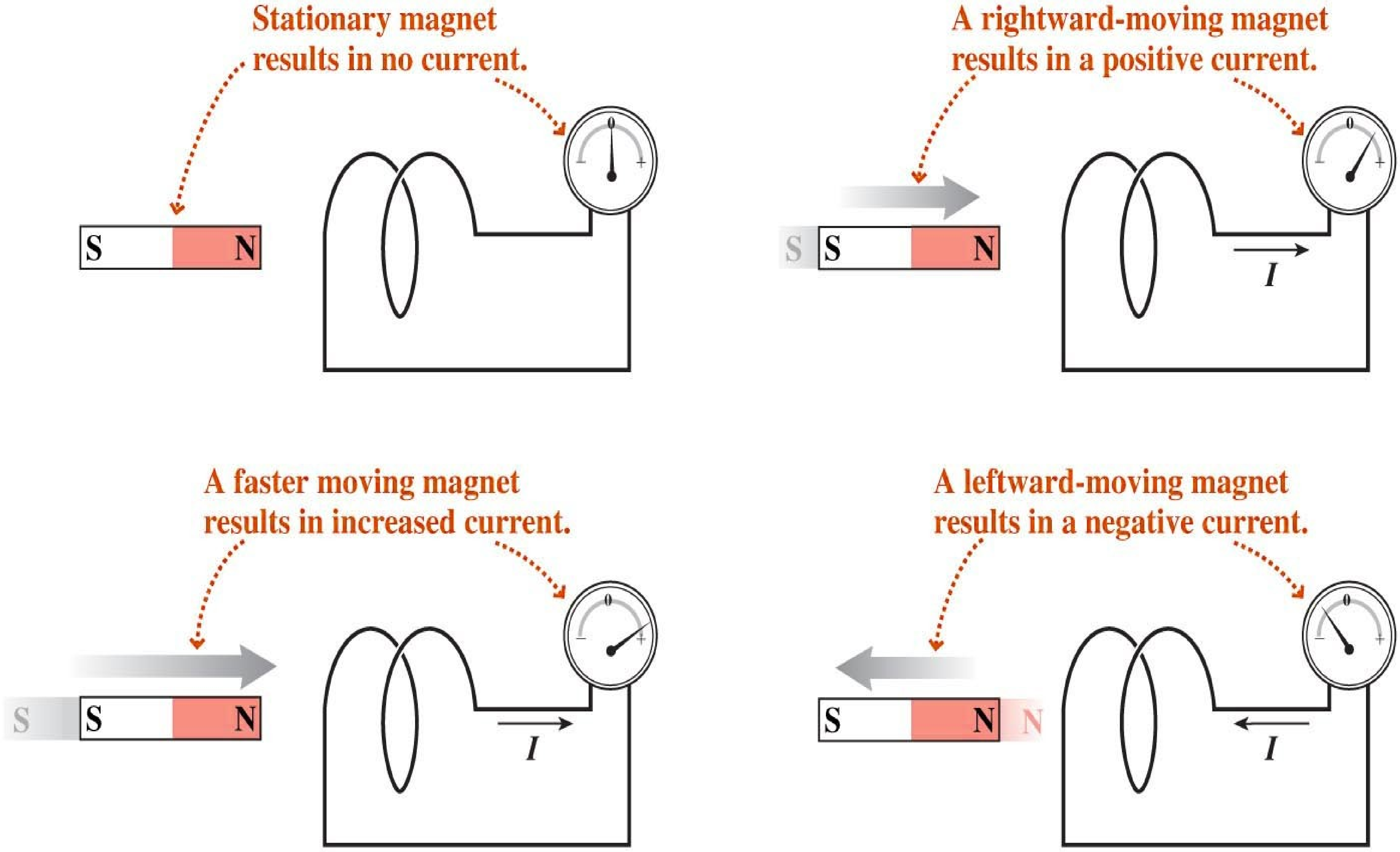
Show up in recitation this week and take the same electricity quiz you took at beginning of term.

Final Homework

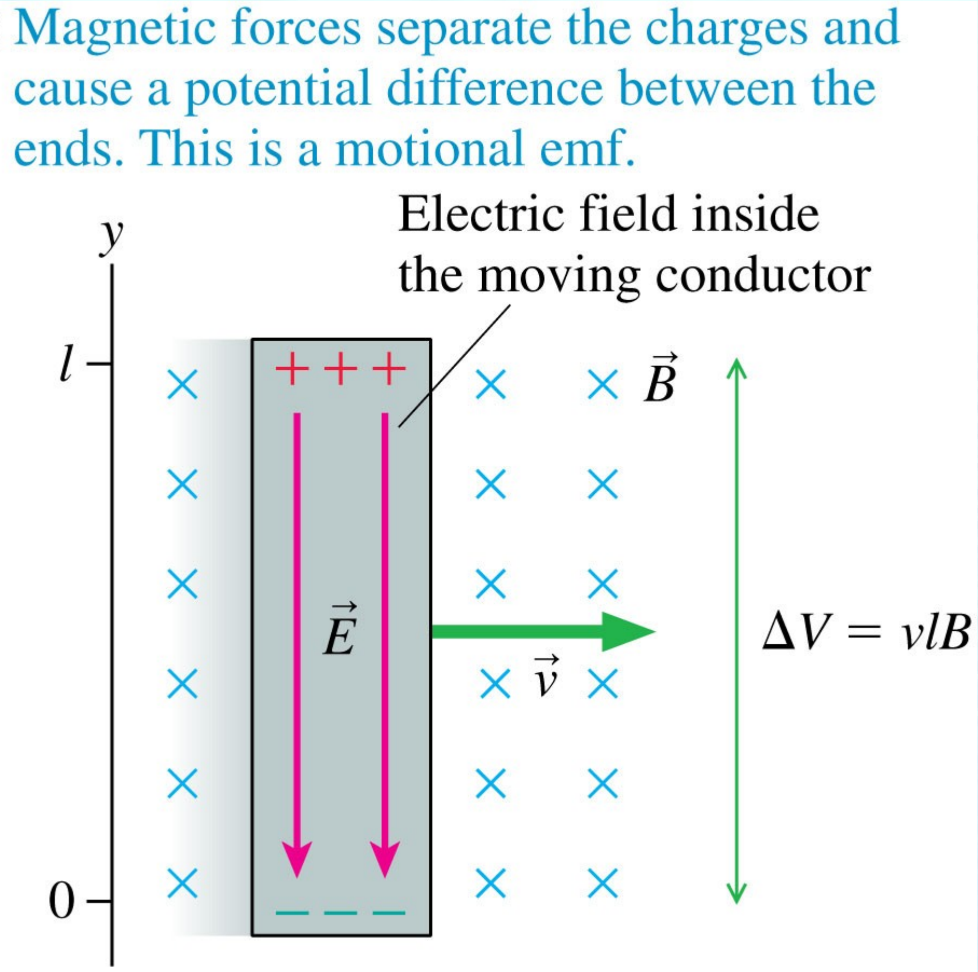
Written homework #10.
33.49, 33.54 … I will pick ONE of these and put it on the final exam.

MP Assignment #13 Due Sunday 5/3
33.1, 33.3, 4, 5, 6, 7, 9, 10, 11, 12, 13, 18, 19, 28, 29, 30, 31, 39, 41, 42, 50, 60

Any time you change the magnetic field In a loop, you cause a current



Motional emf

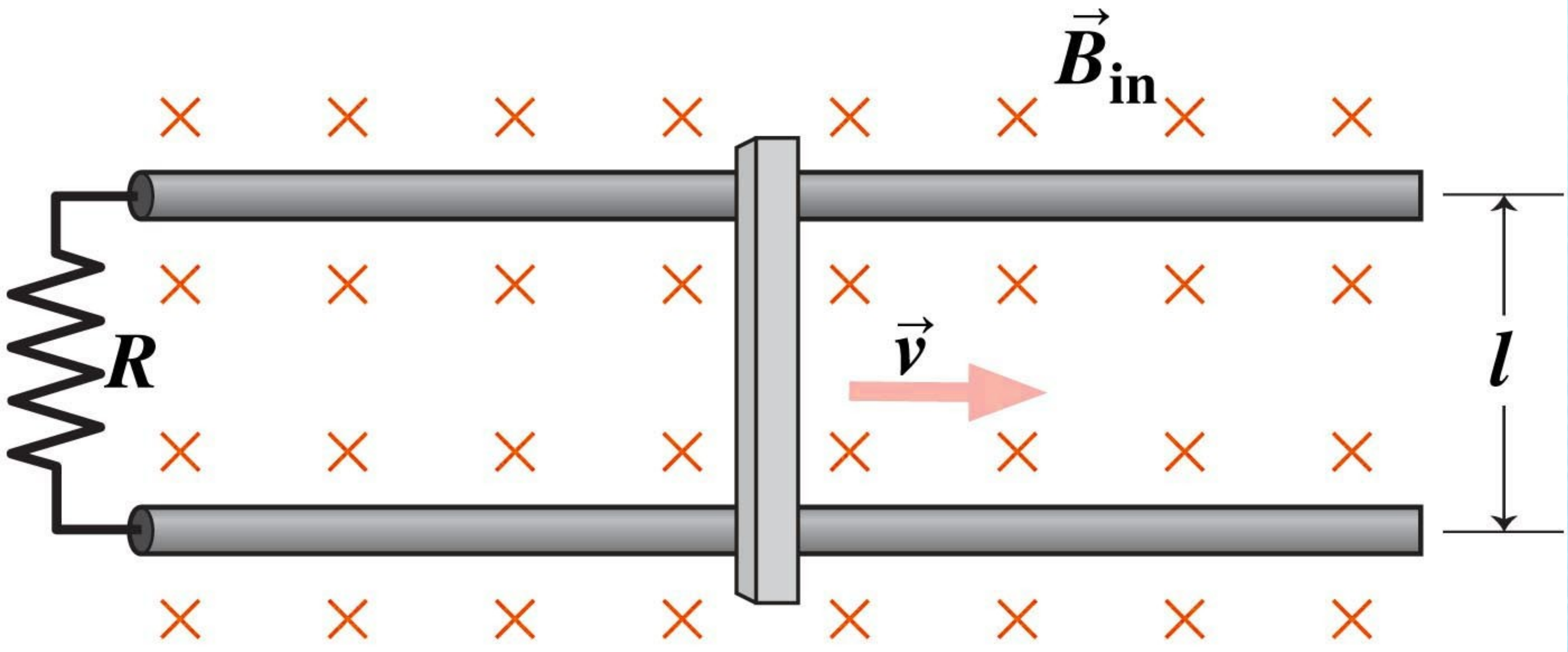


- The magnetic force on the charge carriers in a moving conductor creates an electric field of strength $E = vB$ inside the conductor.
- But Voltage is E L so ...
- For a conductor of length l, the motional emf perpendicular to the magnetic field is:

$$\mathcal{E} = vlB$$

$$\varepsilon = vlB = \frac{dA}{dt}B = \frac{d\Phi_B}{dt}$$

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



Faraday's Law

Changing magnetic fluxes produce electric fields and hence voltages (also called emfs).

$$\Phi_B = \vec{B} \cdot \vec{A} \leftarrow \text{ Flux for B const. ovr space}$$

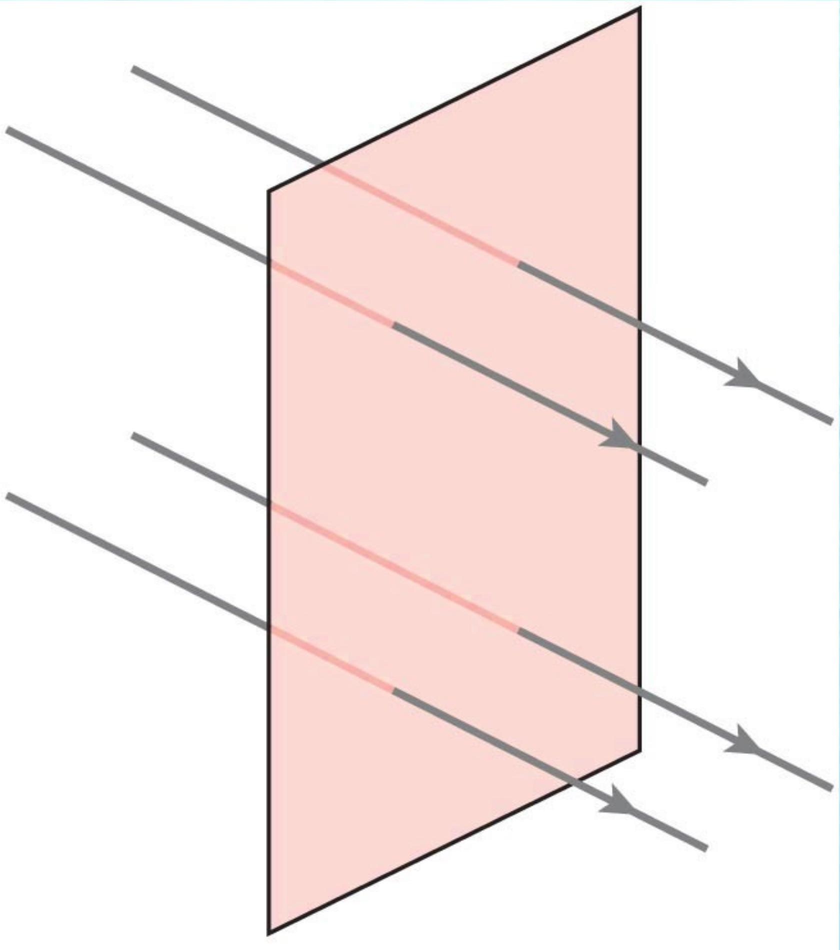
$$\varepsilon = \frac{-d\Phi_B}{dt} \leftarrow \text{Faraday 's Law (of induction)}$$

Energy from the air – a crystal radio

https://youtu.be/gcui0K7JZXA

What is magnetic flux?

Flux – flow – like water through a river,
or magnetic field lines through a surface.



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

For B uniform
over area A:

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

Flux in science and engineering

The word flux comes from Latin: fluxus means "flow",

Electric flux, Magnetic flux amount of E or B-field crossing a unit of area ← **Physics, EE**

Momentum flux, the rate of transfer of momentum across a unit area – Viscosity ← **Mech. E, Chem E.**

Heat flux – Rate of heat flow across a unit area --Heat conduction – (Fourier's law) ← **Mech. E.**

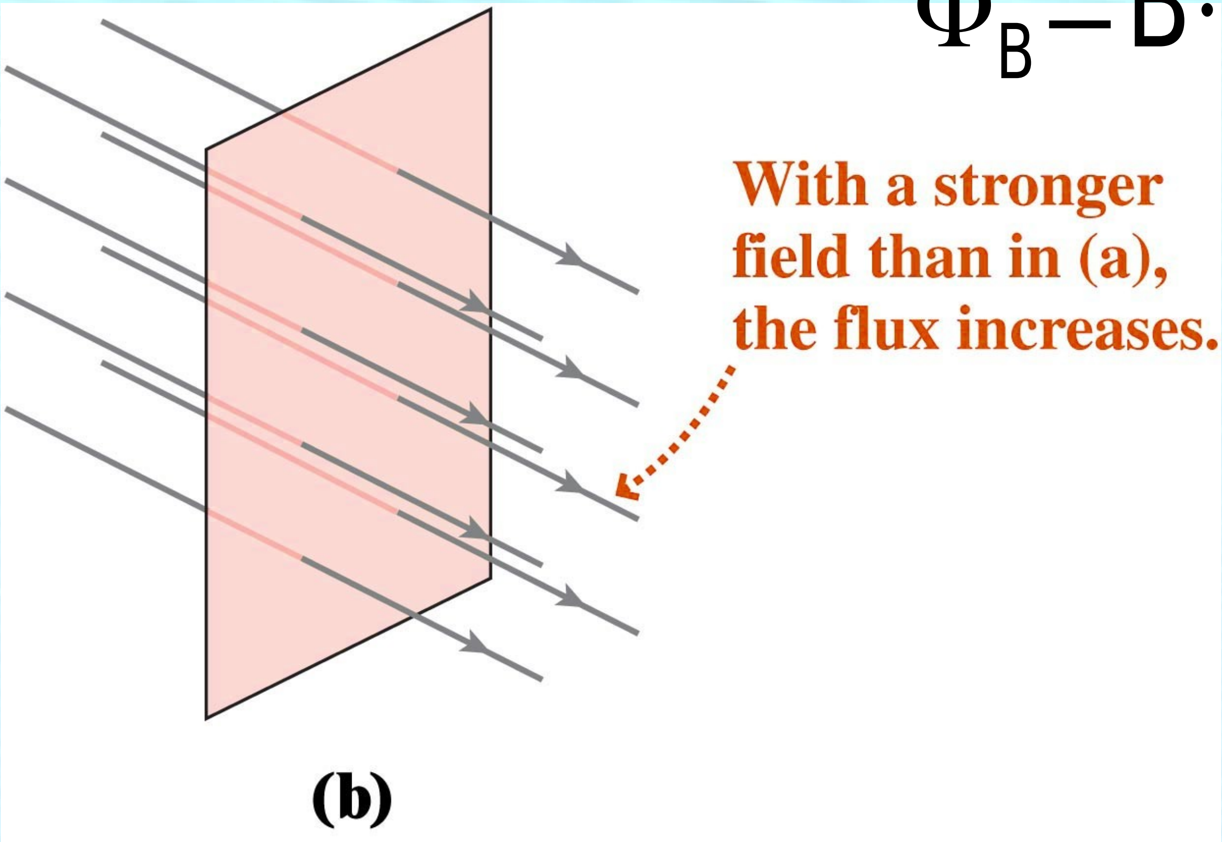
Diffusion flux, the # of molecules across a unit area per second – (Fick's law of diffusion) ← **Chem, Bio.**

Volumetric flux, the # of kilograms of water crossing a unit area per second (Darcy's law, groundwater flow) **Hydrology**

What is flux?

Flux – flow – like water through a river, or magnetic field lines through a surface.

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



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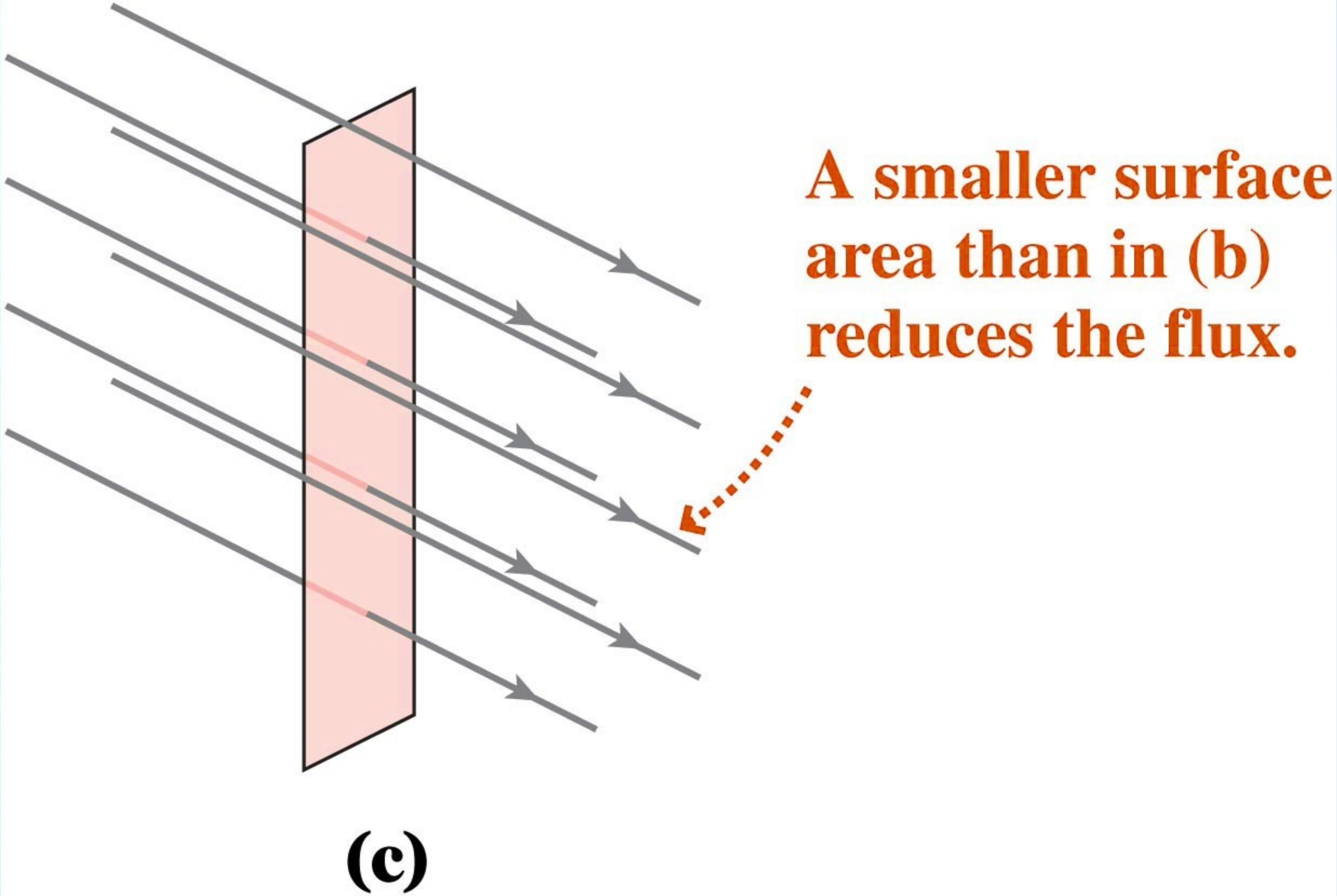
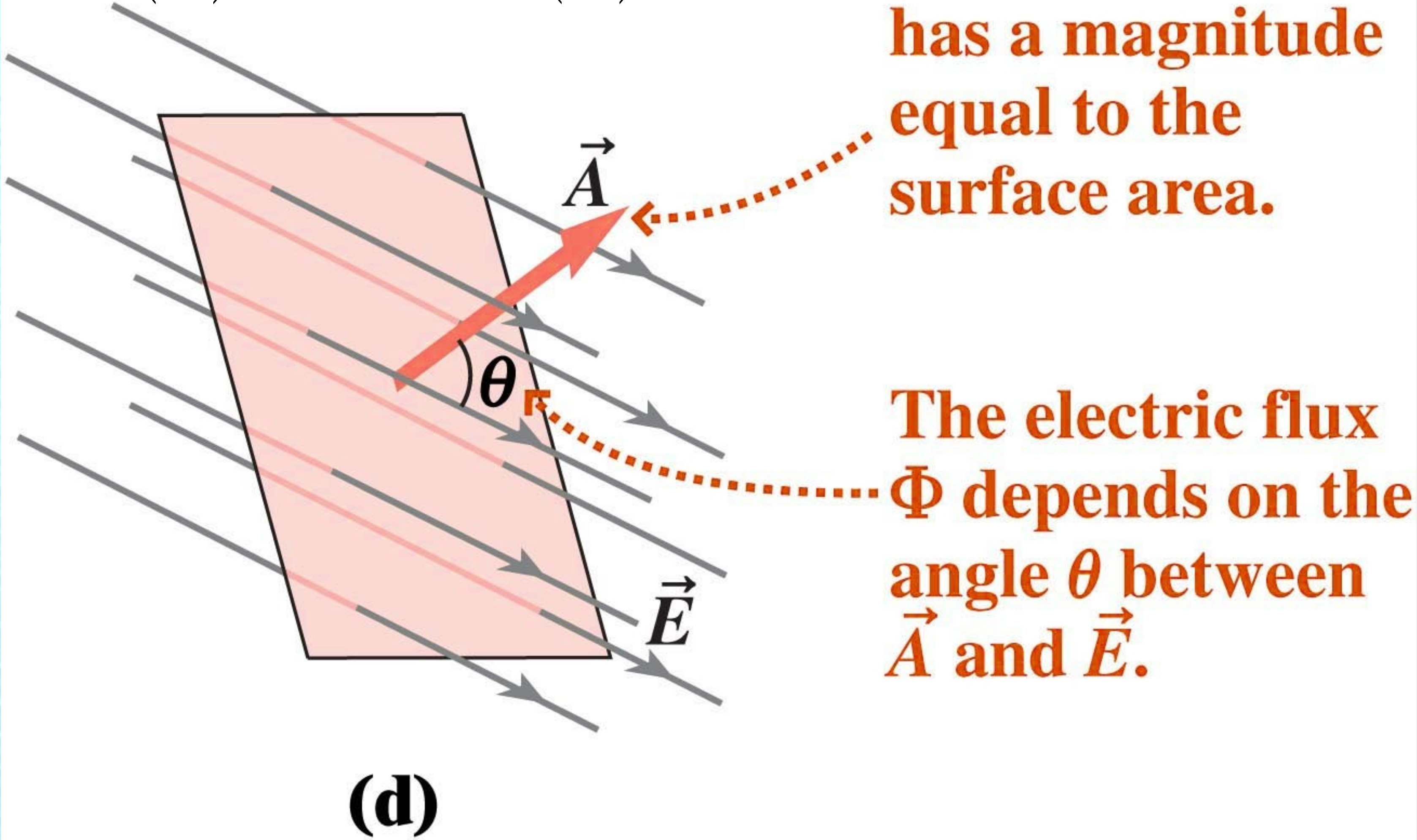


$$\Phi = \vec{B} \cdot \vec{A}$$

$$\Phi = |\vec{B}||\vec{A}|\cos(\theta) = B\,A\cos(\theta)$$



Flux videos

www.youtube.com/user/pelletierphysics

Electric Flux

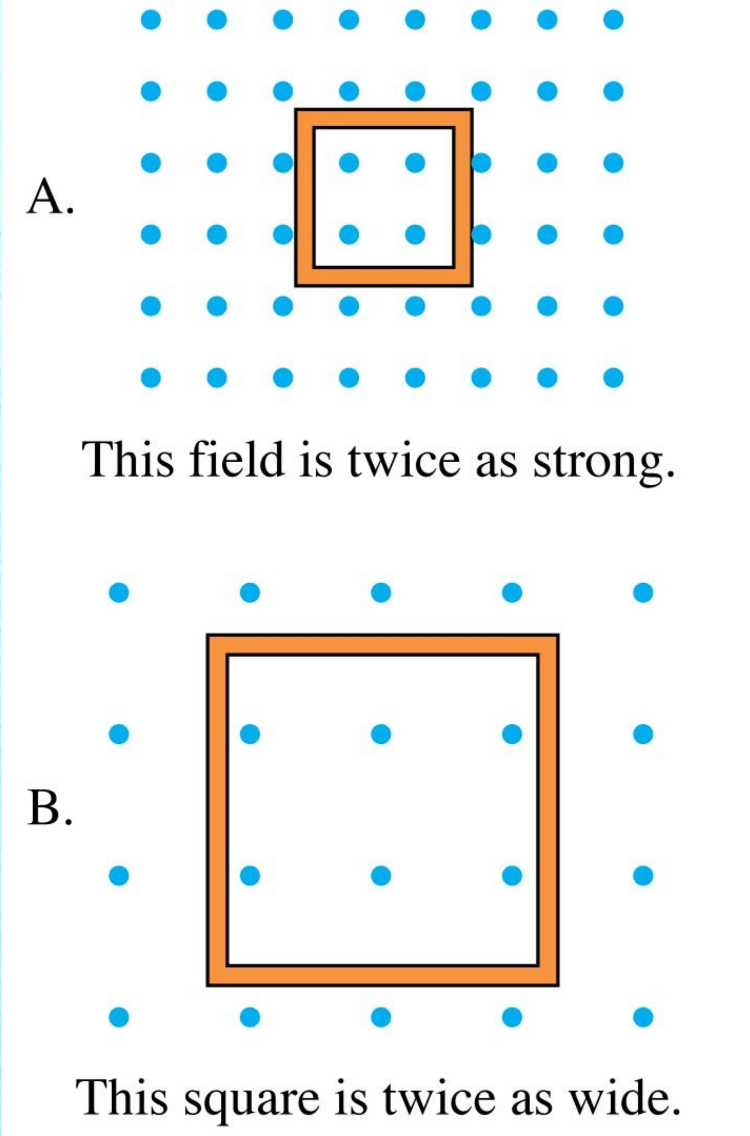
Which loop has the larger magnetic flux through it?

A. Loop A.

B. Loop B.

C. The fluxes are the same.

D. Not enough information to tell.



Clicker

Find the flux through a square loop 10 cm on a side with the loop normal at 60 degrees to a uniform 0.08 T magnetic field

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

$(A)\, 8 \times 10^{0}\, T \cdot m^2$

$(B)\, 8 \times 10^{-2}\, T \cdot m^2$

$(C)\, 8 \times 10^{-4}$ Webers

$(D)\, 6.9 \times 10^{-4}$ Webers

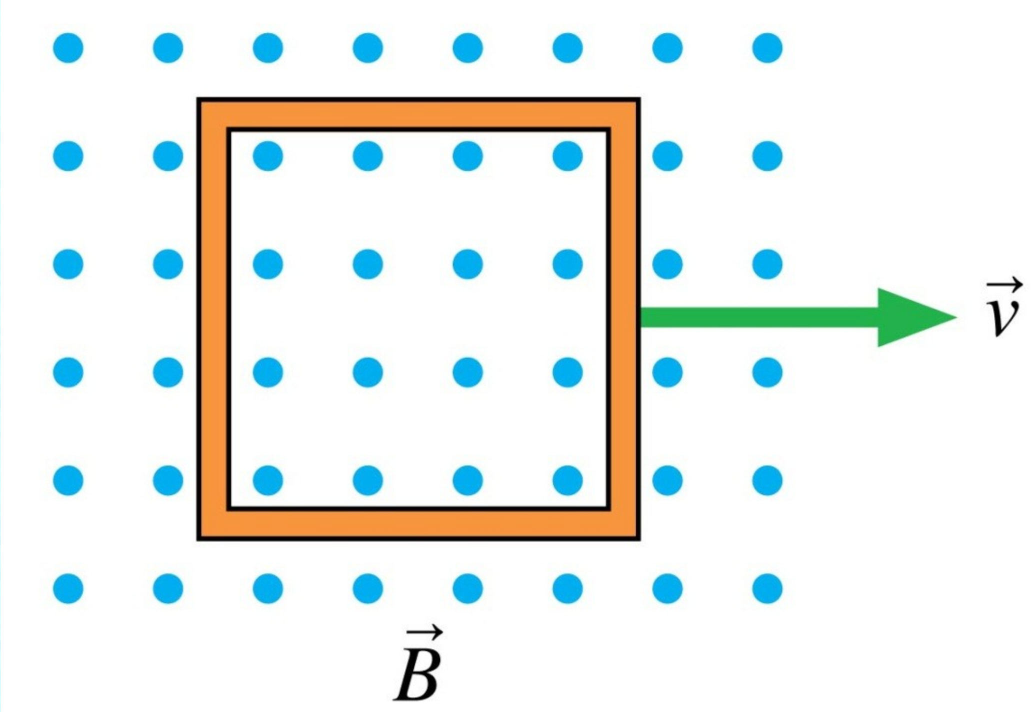
$(E)\, 4 \times 10^{-4}$ Webers

Clicker

The metal loop is being pulled through a uniform magnetic field. Is the magnetic flux through the loop changing?

A. Yes.

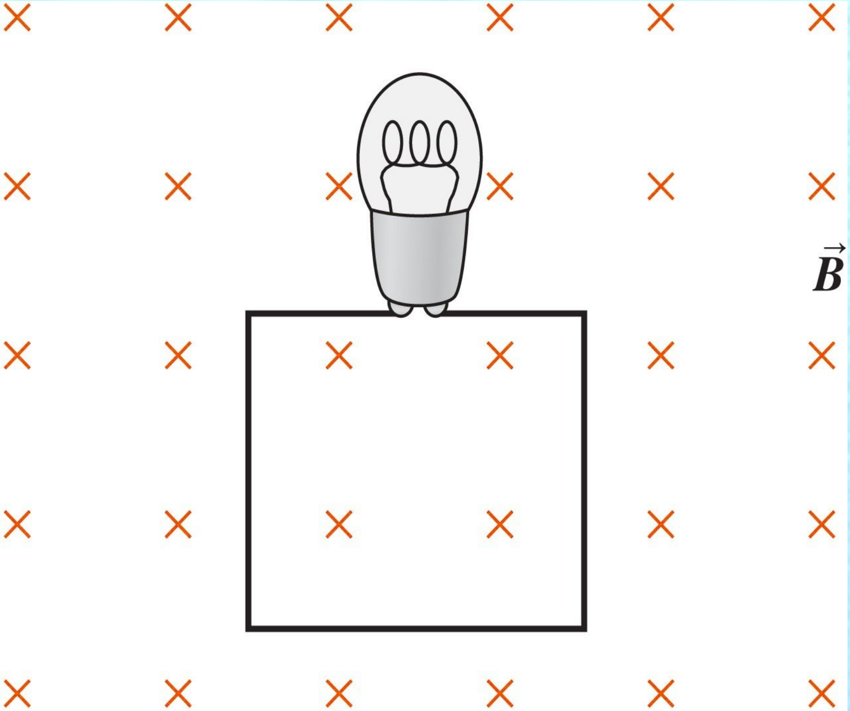
B. No.



Changing Flux by changing B-field

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

In the sketch below $B(t) = 2t^2 + 3$



The loop is square with side 3 m.
At 1 second,
What voltage is applied to the bulb?

[A] 5 V, [B] 9 V, [C] 18 V, [D] 36 V, [E] 45 V

Similar to homework 33.41

A 40-turn, 4.0 cm diameter coil with R= 2 Ohm surrounds a 2.0 cm diameter solenoid. The solenoid is 40 cm long and has 1000 turns. A 1000 Hz current runs through the solenoid. What is its amplitude if the maximum induced coil current is 0.3 Amps?

Similar to homework 33.41

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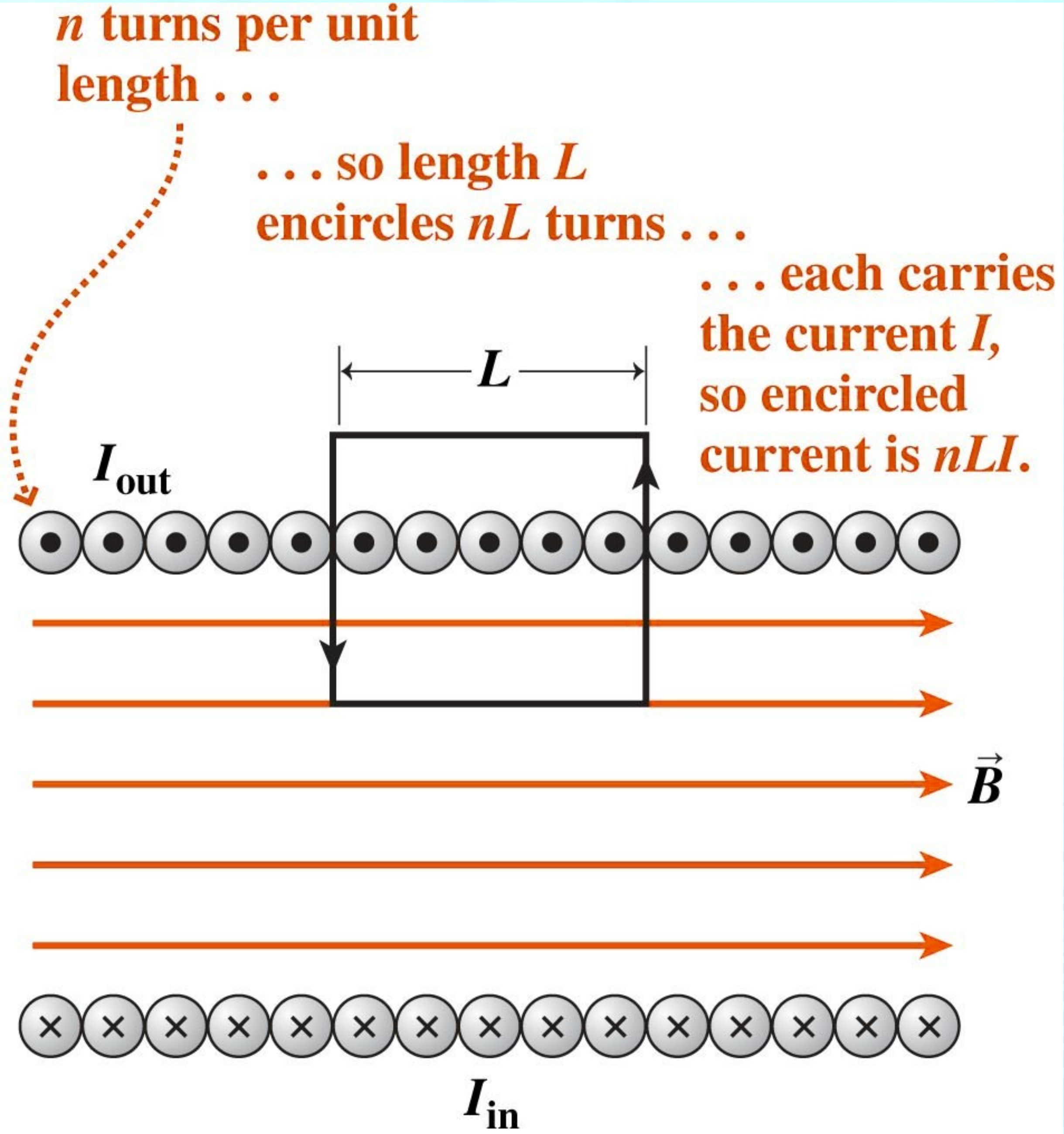
Solenoid

$$\int \vec{B} \cdot d\vec{s} = \mu_0 I_{encircled}$$

$$B \cdot L = \mu_0 I N$$

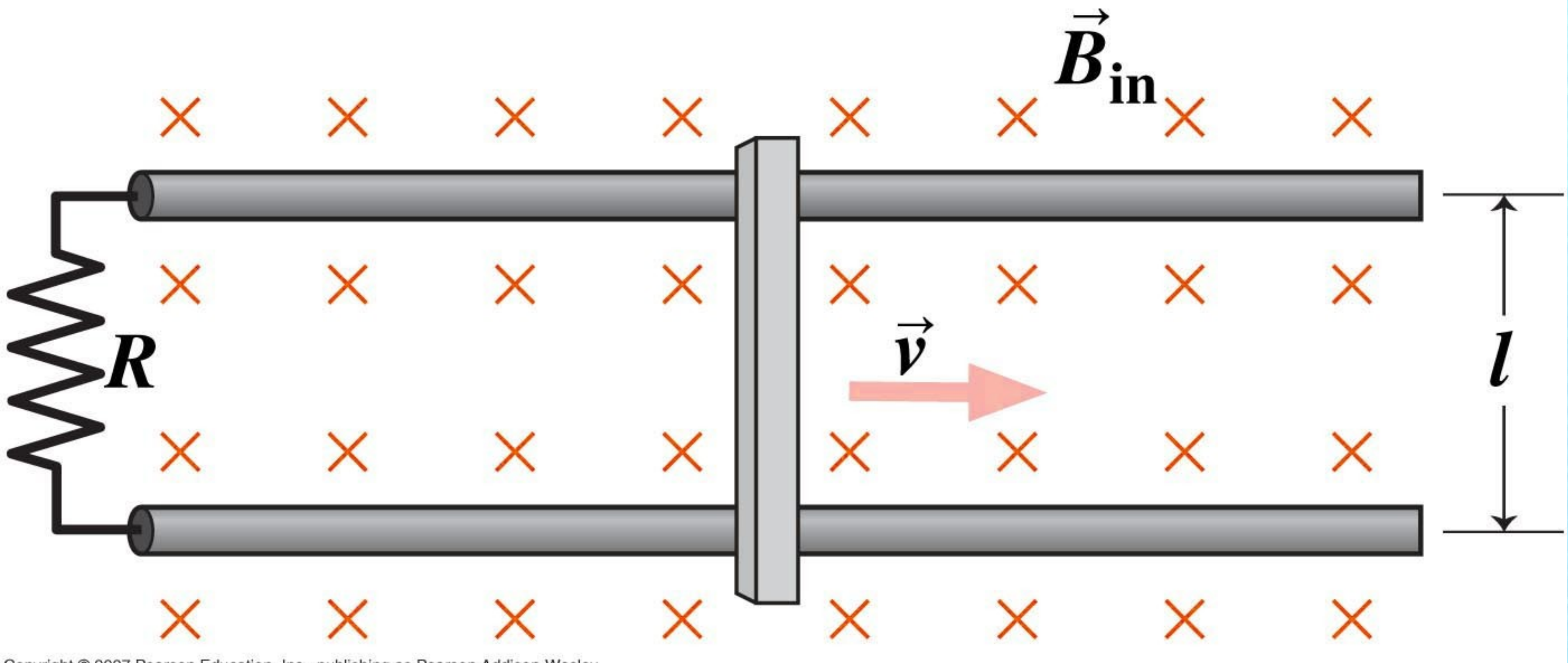
$$\rightarrow B = \mu_0 I \frac{N}{L}$$

$$\rightarrow B = \mu_0 I n$$



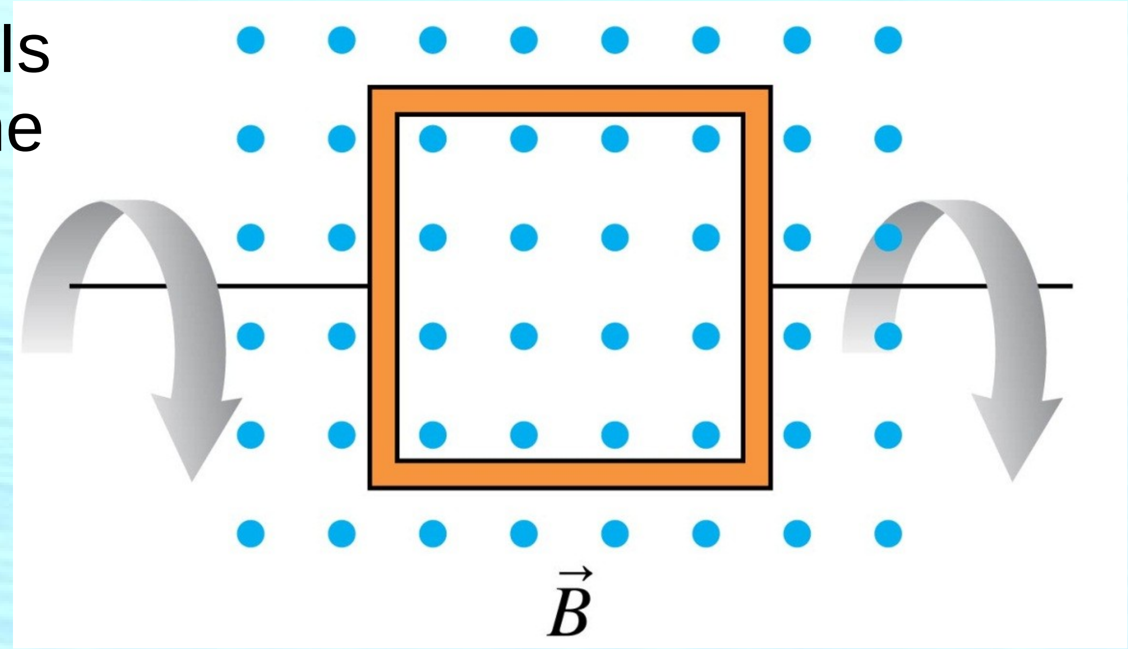
Changing Flux by Changing size Of Loop

$$\frac{d\Phi_B}{dt} = \frac{d\vec{B}}{dt}\cdot\vec{A} + \frac{d\vec{A}}{dt}\cdot\vec{B} \rightarrow \frac{d\Phi_B}{dt} = \frac{d\vec{A}}{dt}\cdot\vec{B}$$



Clicker

The metal loop is rotating in a uniform magnetic field. Is the magnetic flux through the loop changing?



A. Yes.

B. No.

Ways to change flux

Let $\vec{B}$ be uniform over the loop. Then

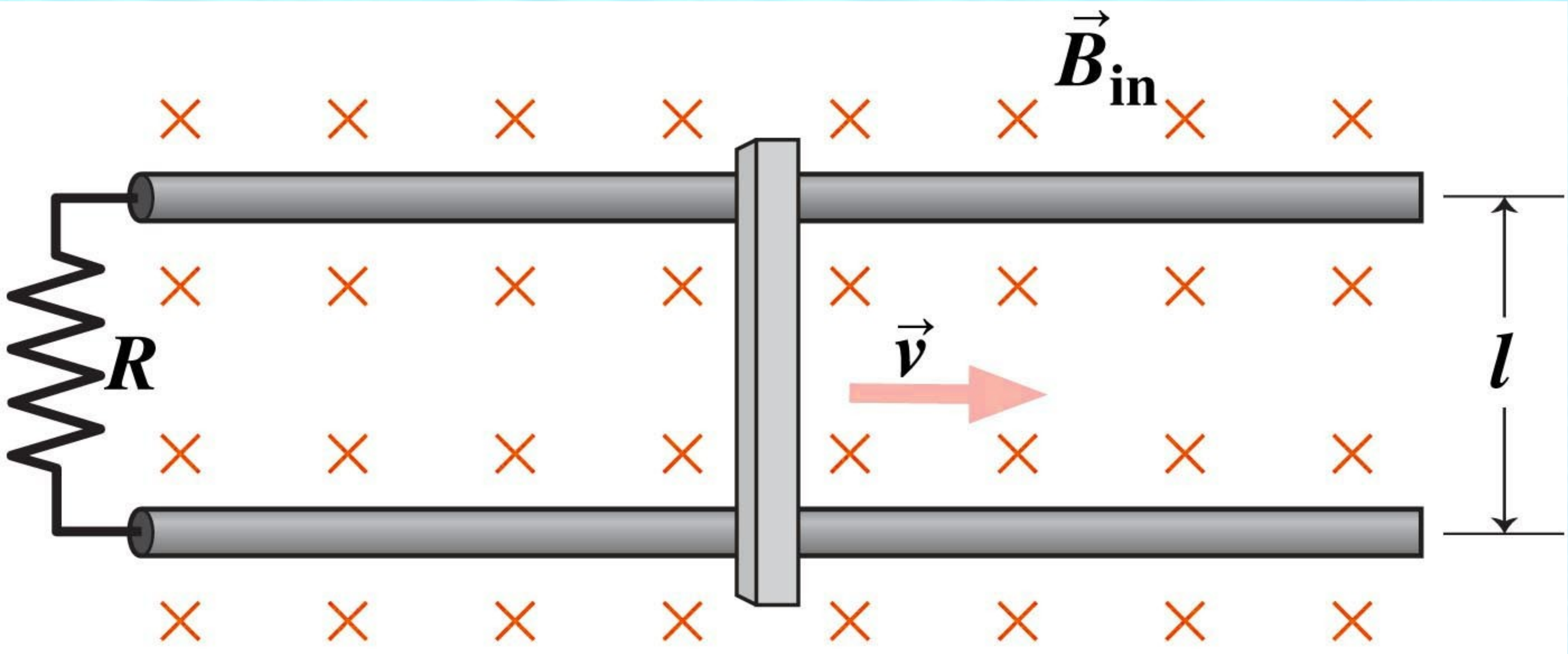
$$\Phi_B = \int \vec{B} \cdot d\vec{A} \rightarrow \vec{B} \cdot \vec{A}$$

$$\frac{d\Phi_B}{dt} = \frac{d\vec{B}}{dt} \cdot \vec{A} + \frac{d\vec{A}}{dt} \cdot \vec{B}$$

- Can move loop into stronger or weaker B.
- Can increase/decrease B.
- Can rotate B.
- Can increase/decrease size of loop.
- Can rotate loop.

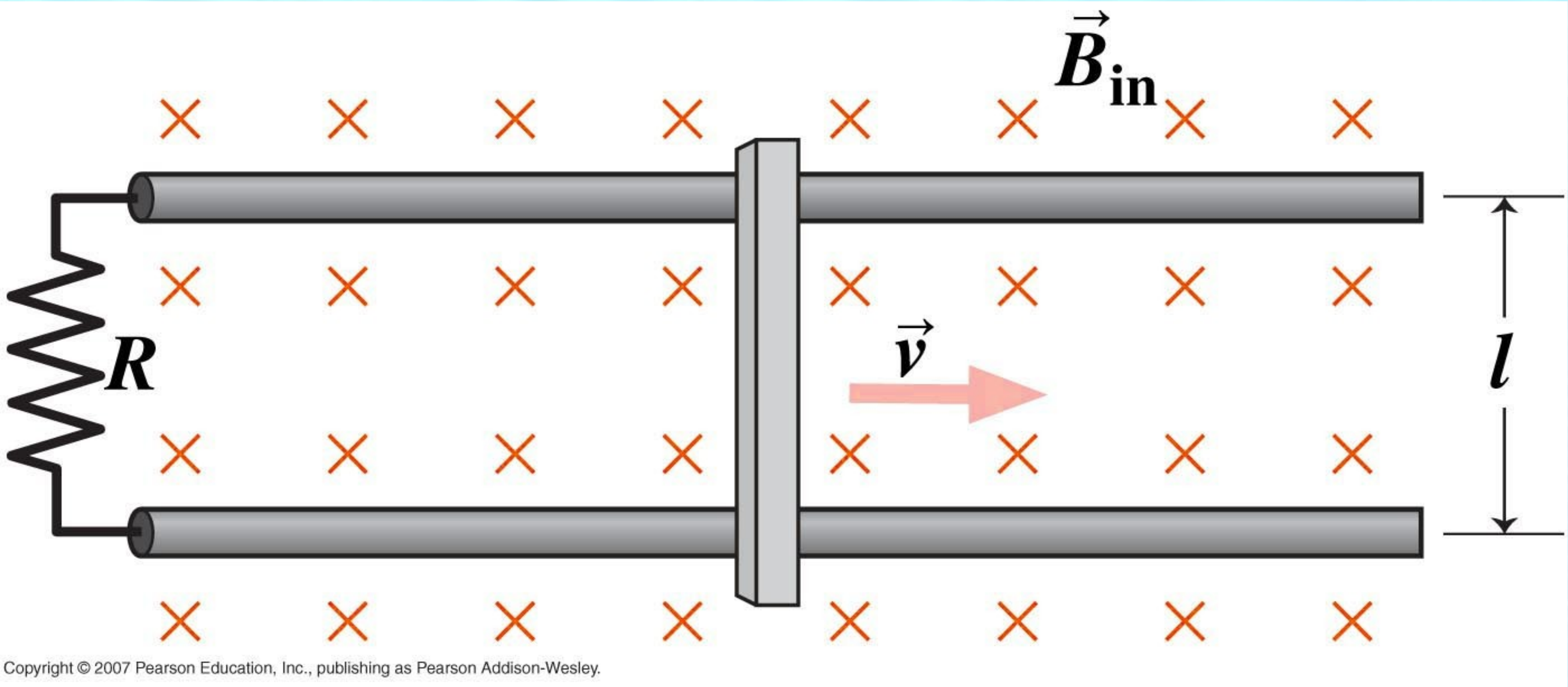
Changing Flux by Changing size Of Loop

$$\frac{d\Phi_B}{dt} = \frac{d\vec{B}}{dt}\cdot\vec{A} + \frac{d\vec{A}}{dt}\cdot\vec{B} \rightarrow \frac{d\Phi_B}{dt} = \frac{d\vec{A}}{dt}\cdot\vec{B}$$



Changing Flux by Changing size Of Loop

Given B=0.1 T, "l"=0.1 m, v=20 m/s, R=30 Ohms, What are V, I, and P?



Faraday's law, electromagnets, generators etc.

http://phet.colorado.edu/en/simulation/faraday

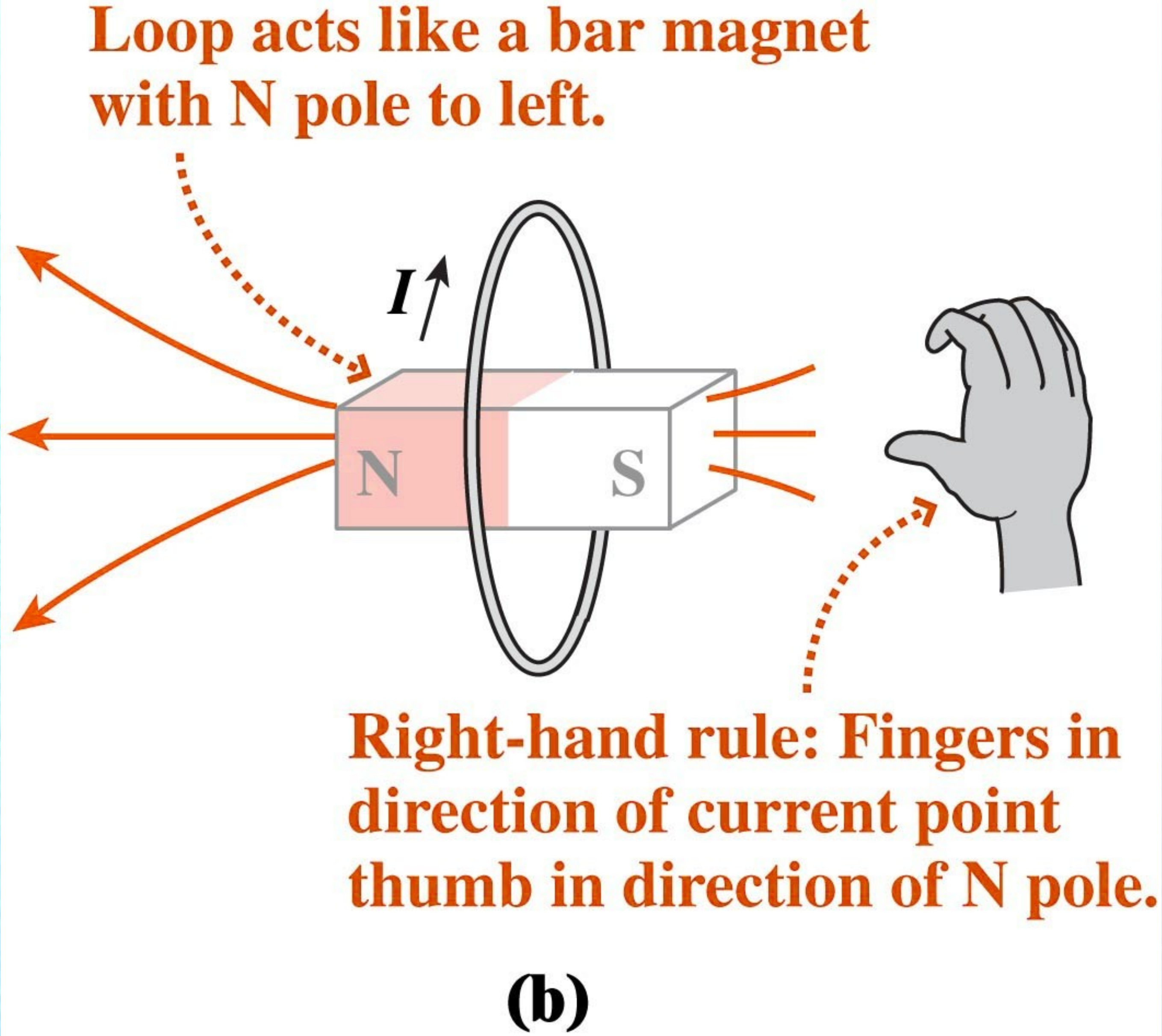
Lenz's Law
(the minus sign in Faraday's Law)

Lenz's law: Induced currents always OPPOSE changing magnetic fields

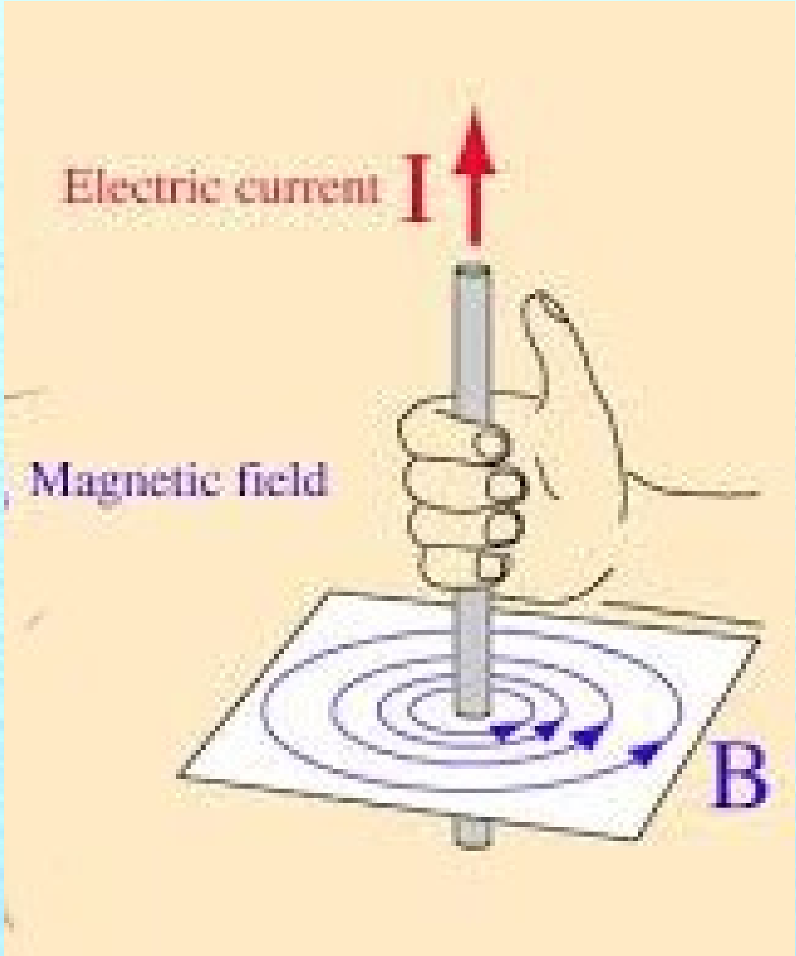
The copper tube demo

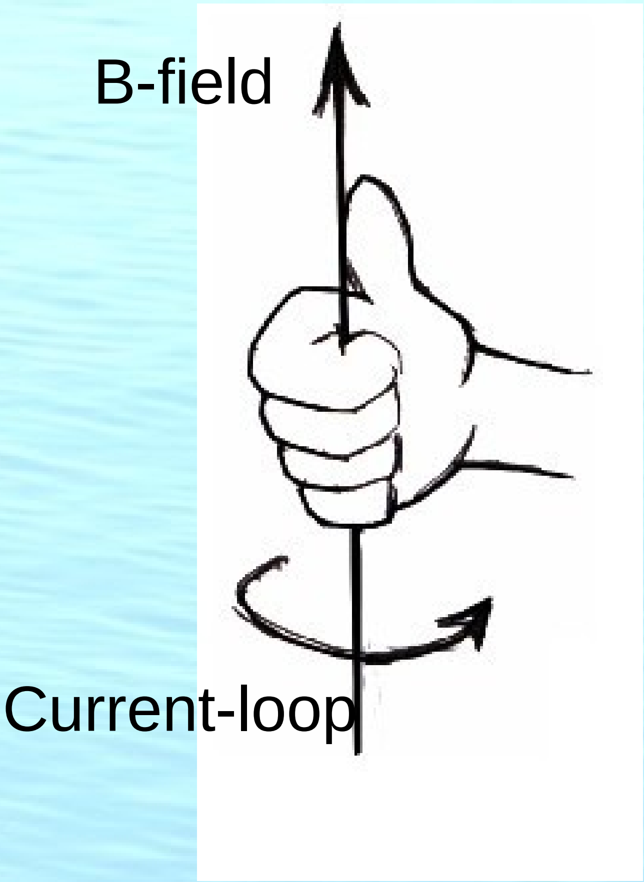
The damped pendulum

Jumping rings


Loop acts like a bar magnet
with N pole to left.
I
N
S
Right-hand rule: Fingers in
direction of current point
thumb in direction of N pole.
(b)

Two ways to use the hitch-hikers rule.





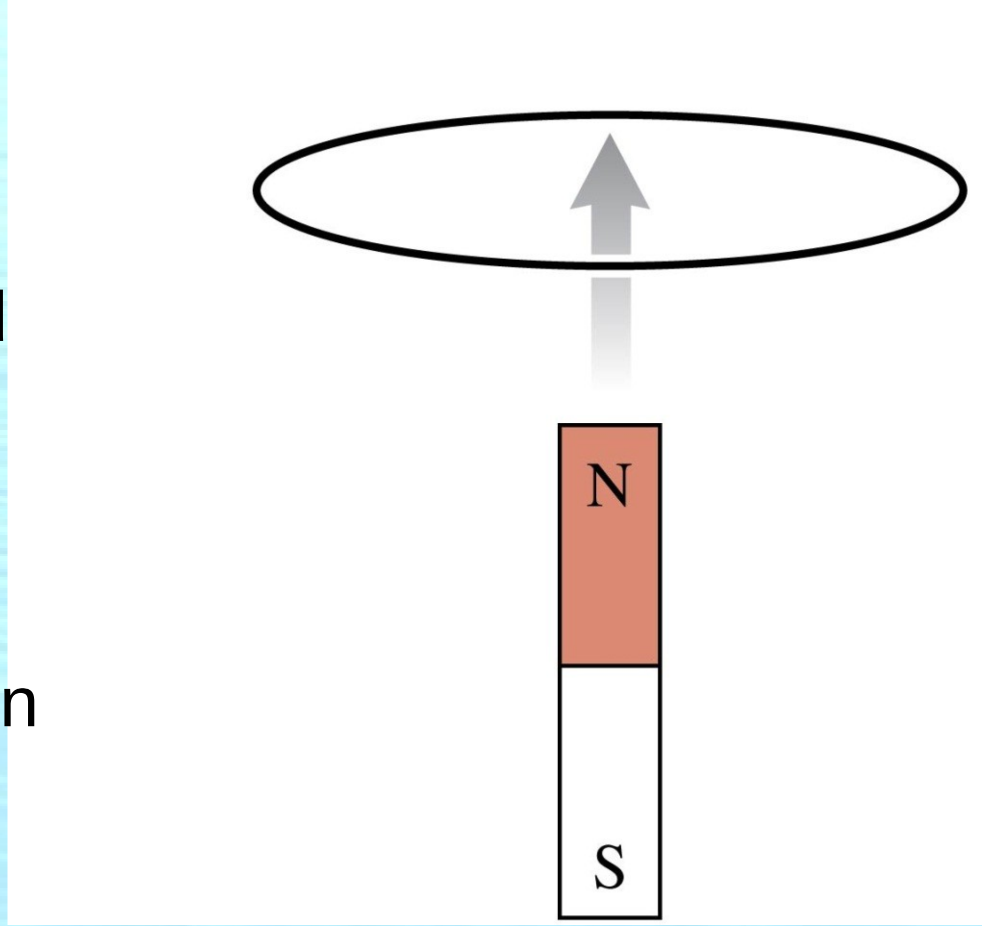
Figuring out direction of induced current

The bar magnet is pushed toward the center of a wire loop. Which is true?

A. There is a clockwise induced current in the loop.

B. There is a counterclockwise induced current in the loop.

C. There is no induced current in the loop.



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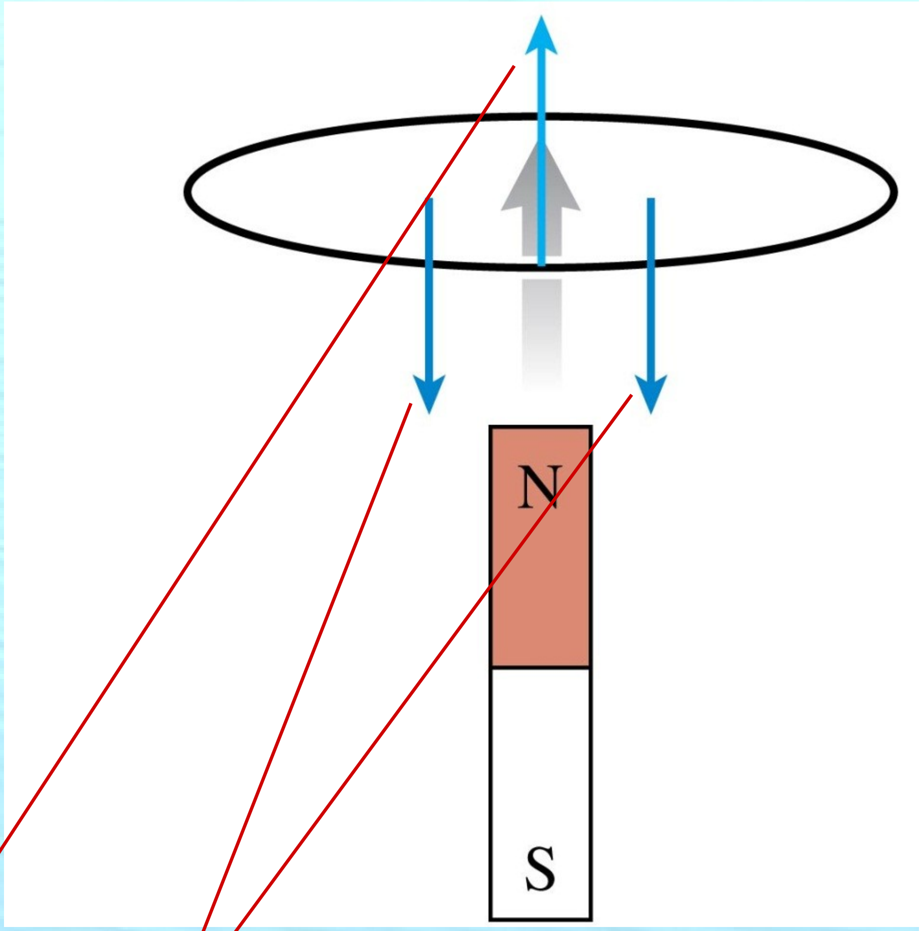


1. Upward flux from magnet is increasing.
2. To oppose the increase, the field of the induced current points down.
3. From the right-hand rule, a downward field needs a cw current.

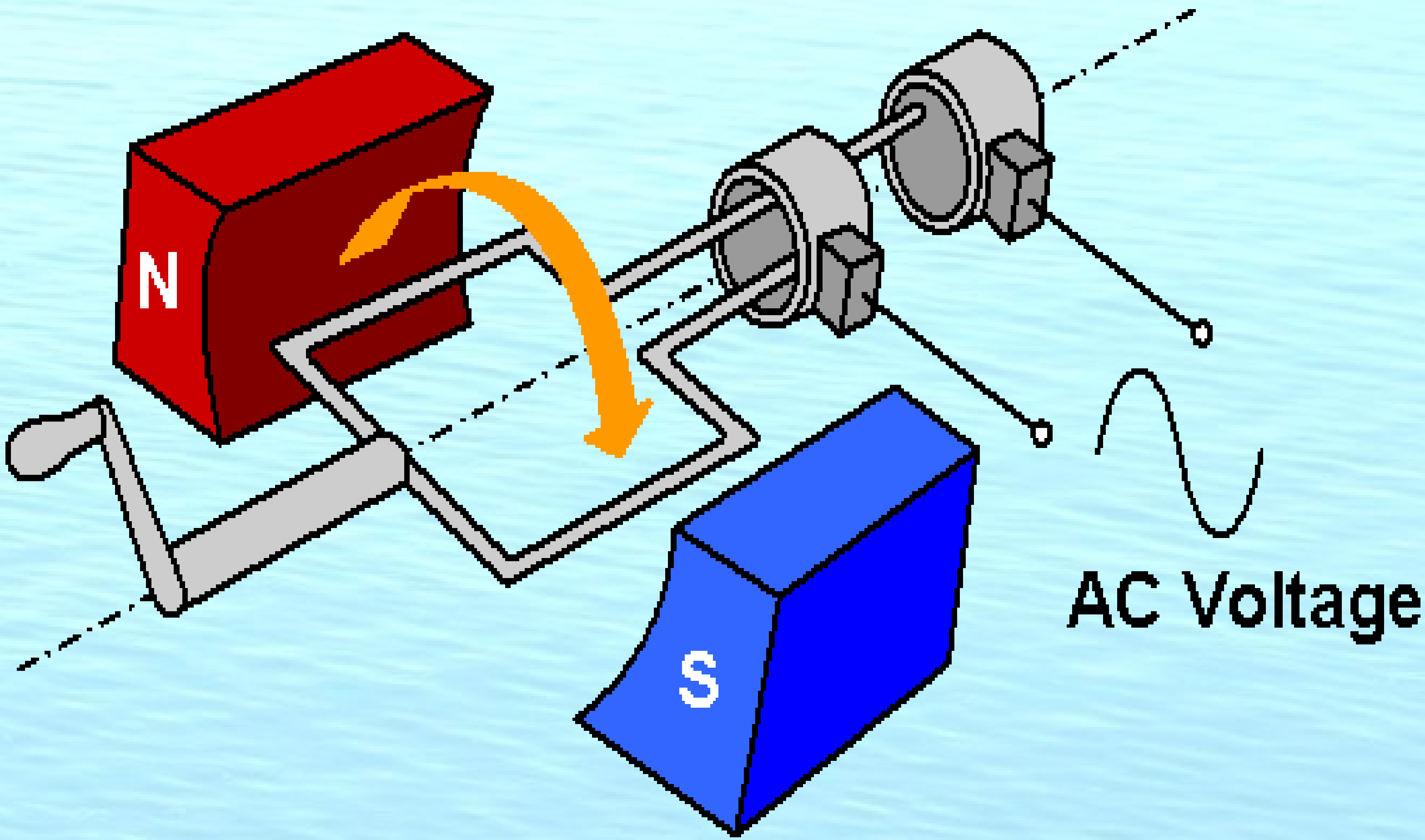
Why MUST there be a minus sign in Lenz's law?

Why MUST the induced current oppose a changing magnetic field?

Similar to homework 33.49

You spin a coil consisting of 20 turns of wire 25 cm in diameter at 60 Hz in a magnetic field of 0.2 Tesla. What is the equation of the EMF induced in the coil?

Changing flux by rotating loop



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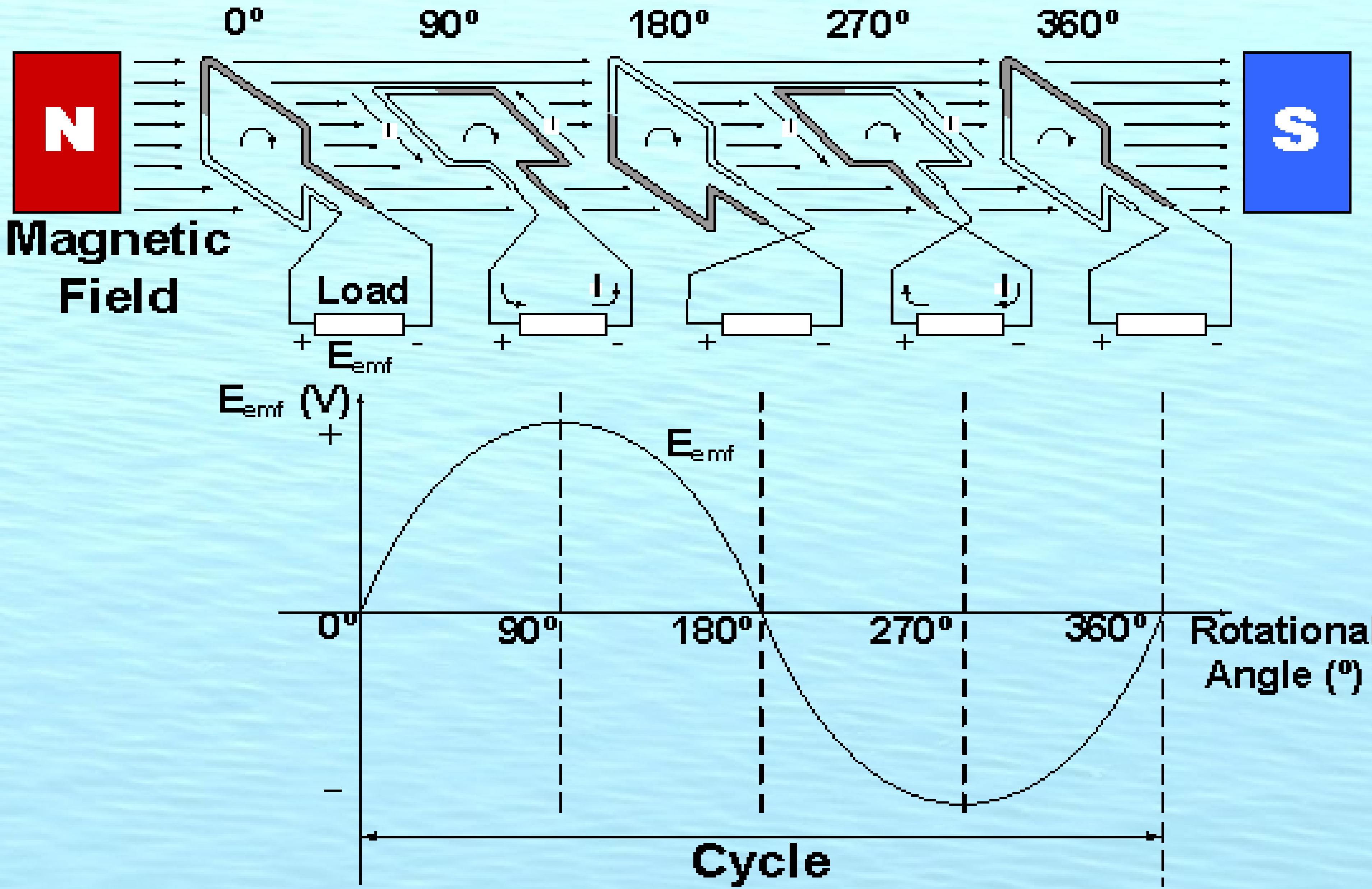

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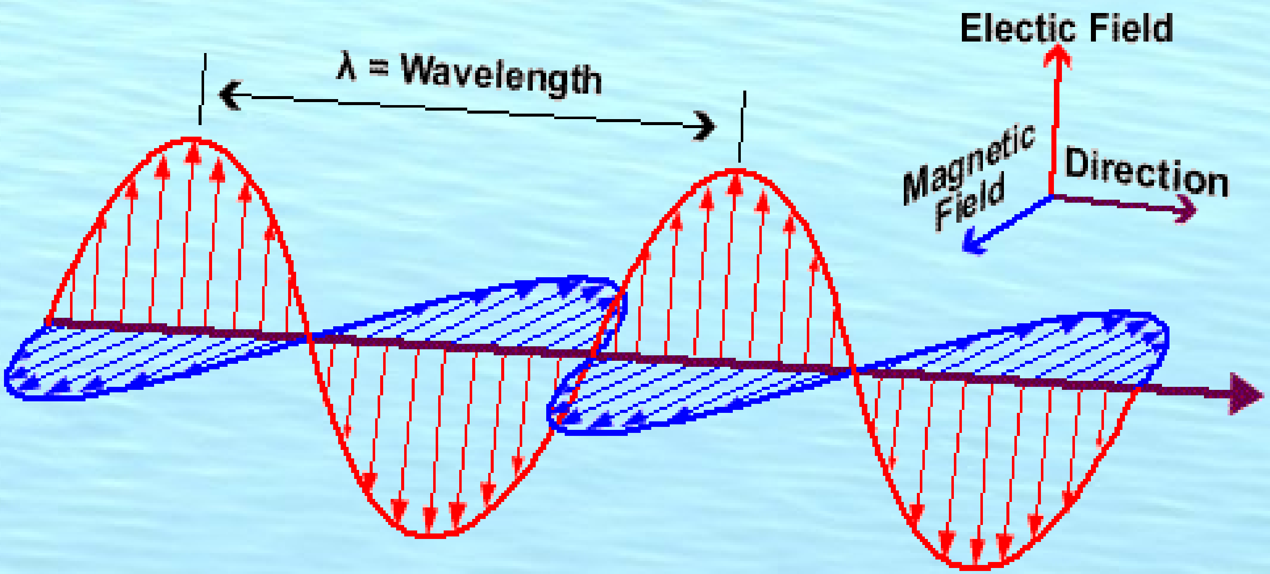
Changing magnetic fields cause electric fields. (Consequence of Faraday's Law)

Changing electric fields cause magnetic fields (The 4th Maxwell equation)



And God said

$$\oiint_{\partial V} \vec{E} \cdot d\vec{A} = \frac{Q}{\epsilon_0}$$

$$\oiint_{\partial V} \vec{B} \cdot d\vec{A} = 0$$

$$\oint_{\partial S} \vec{E} \cdot d\vec{l} = -\iint_{S} \frac{\partial \vec{B}}{\partial t} \cdot d\vec{A}$$

$$\oint \vec{B} \cdot d\vec{l} = \mu_0 I_S + \mu_0 \epsilon_0 \iint_{S} \frac{\partial \vec{E}}{\partial t} \cdot d\vec{A}$$

and *then* there was light.

squidyes

.

Eval Forms

Tuesday recitation	66714
Thursday afternoon	66808
Thursday evening	66956

Delivery person??