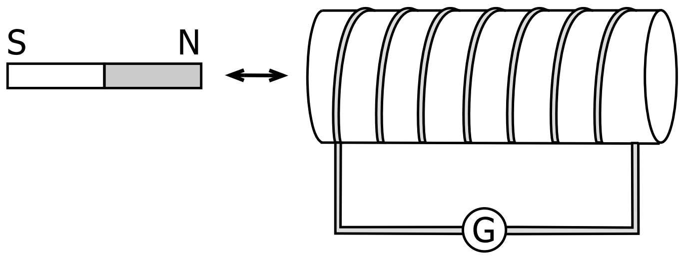
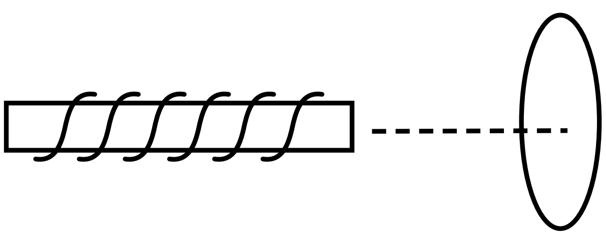
Lecture 31

Demo: Levitation of a cubic magnet
Jumping Ring
Falling magnet in a metal tube
Single faraday's law demo

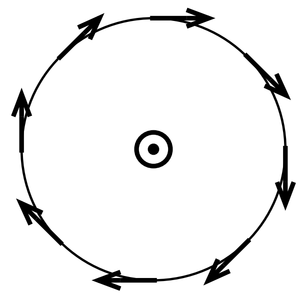


Flux ϕ_B through 1 loop: $\phi = BA$

Change of magnetic flux defined by the solenoid $\Rightarrow$ induced emf.



side view:



$\phi_B \odot, \uparrow$

Inducing magnetic flux: $\odot \Rightarrow$ CW E_{ind}

$$\text{Faraday's Law:} \quad \oint E \cdot dl = -\frac{d\phi_B}{dt}$$

$$\text{Direction: } \langle E_{ind} \rangle : \ \text{CW}$$

$$RHS: \left\langle -\frac{d\phi}{dt} \right\rangle = \langle \Delta\phi \rangle = \text{"Opposite the change"}$$

Lenz Law: Current loop has magnetic inertia.
It has the tendency to maintain its flux state.

Initial: 10 lines out
Next: 12 lines out (2 lines in to maintain original 10 lines out status

$$\therefore I_{ind} \otimes \quad E_{ind} \ \text{CW}$$

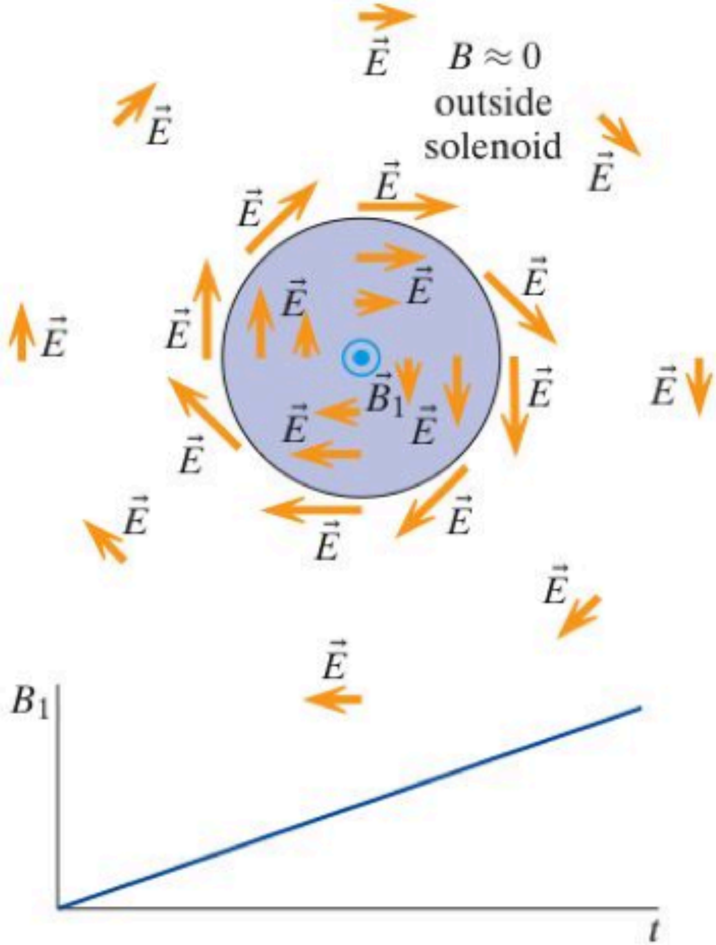


Figure 23.3 There is a curly electric field in the presence of a time-varying magnetic field (top). In this case B_1 is increasing with time (bottom).

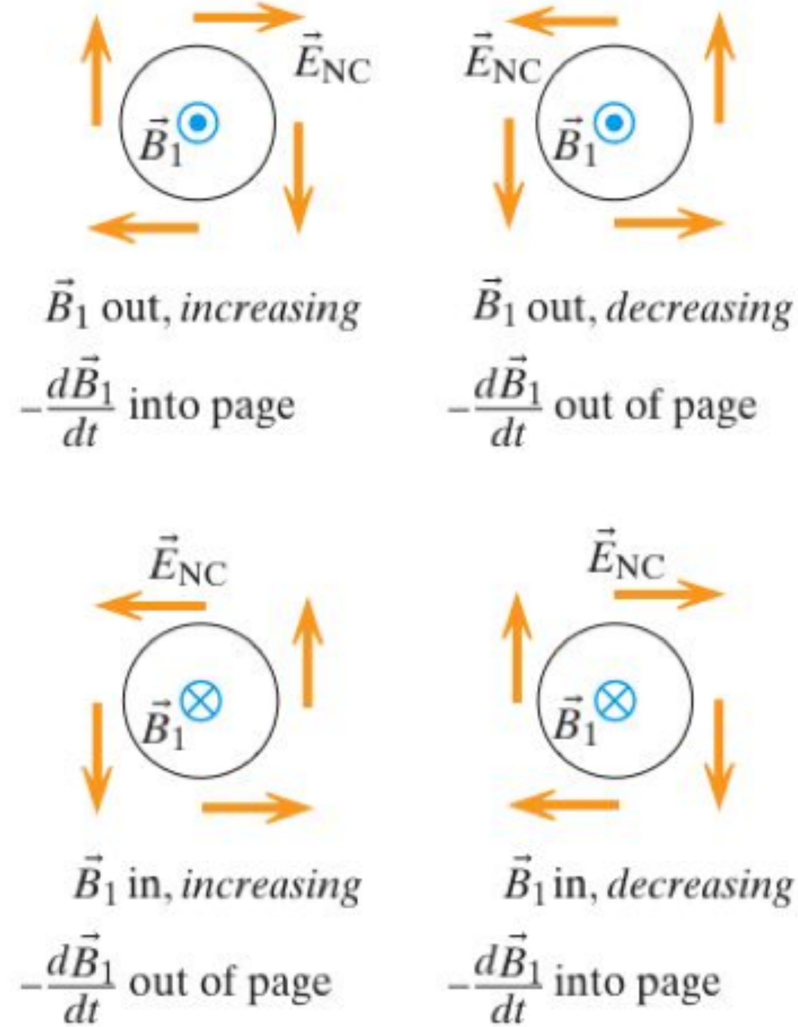
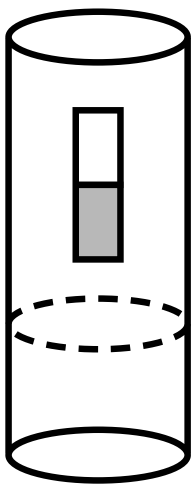


Figure 23.4 Four cases: magnetic field out or in, increasing or decreasing.

Application: Falling magnet in a metal tube

Demo: The falling magnet moves slowly



Do the <u>current</u> below the magnet

You will do the case where the loop is above the magnet.

The loop has magnetic inertia:

Now: 3 lines ⬇

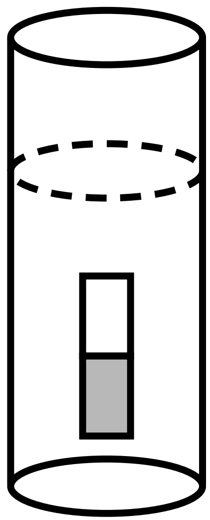
Next: 5 lines ⬇

Loop generates B_{in}, 2 lines up to maintain original 3 lines.

$\therefore B_{in} \uparrow$ opposing the fall.

I_{ind} CCW. Or E_{ind} CCW pattern.

Now for the current loop above the magnet



Now: 3 lines ⬇

Next: 1 line ⬇

$$\text{Loop generates } B_{in} : \ \downarrow 2 \text{ lines}$$

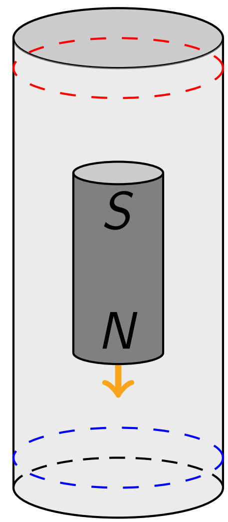
$$\therefore B_{in} \ \downarrow$$

It affects the falling magnet:

$\therefore$ Loop below opposes its fall (by repulsion)

Loop above opposes it's fall (by attraction)

$\therefore$ It takes the loop a longer time to fall.



Q22.2g

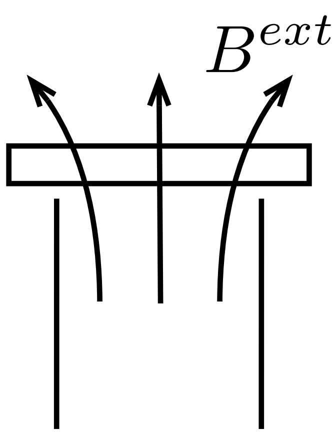
Choice	Direction of I_{ind} in the loop above the falling magnet, as viewed from above	Direction of the magnetic dipole moment in the loop below the falling magnet, as viewed from above
1	CW	Down
2	CW	Up
3	CCW	Down
4	CCW	Up

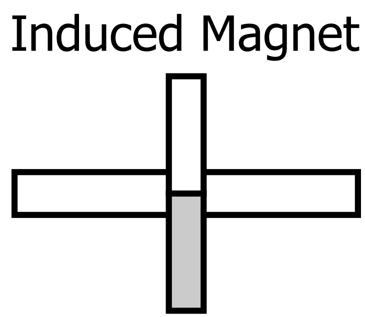
Jumping Ring Demo:

Show current loop as magnetic initial. $\text{Initial flux} = 0$

After we turn on B of the solenoid, the ring jumps away to maintain net flux state.

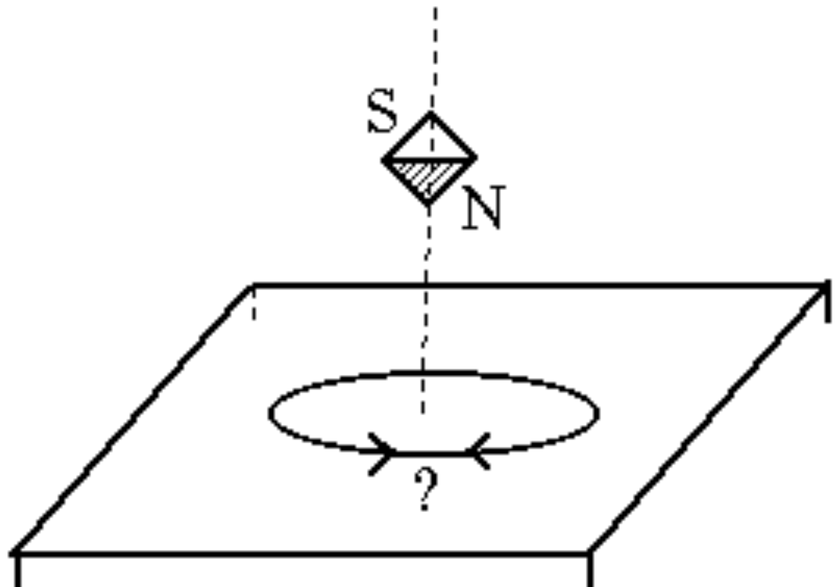
Understanding the force affecting the ring:





= stronger lifting force

31.3.1 Levitation of a magnet



Consider levitation of magnet by a superconducting surface. The north pole is pointing downward. The direction of induced current as viewed from above is:

1	2	3
clockwise	0	counterclockwise

Hint: The loop of induced current should correspond to an equivalent induced dipole which repels the magnet.

Extra: If the polarity of susupending magnet is reversed, what is the direction of induced current? Will the magnet fall?

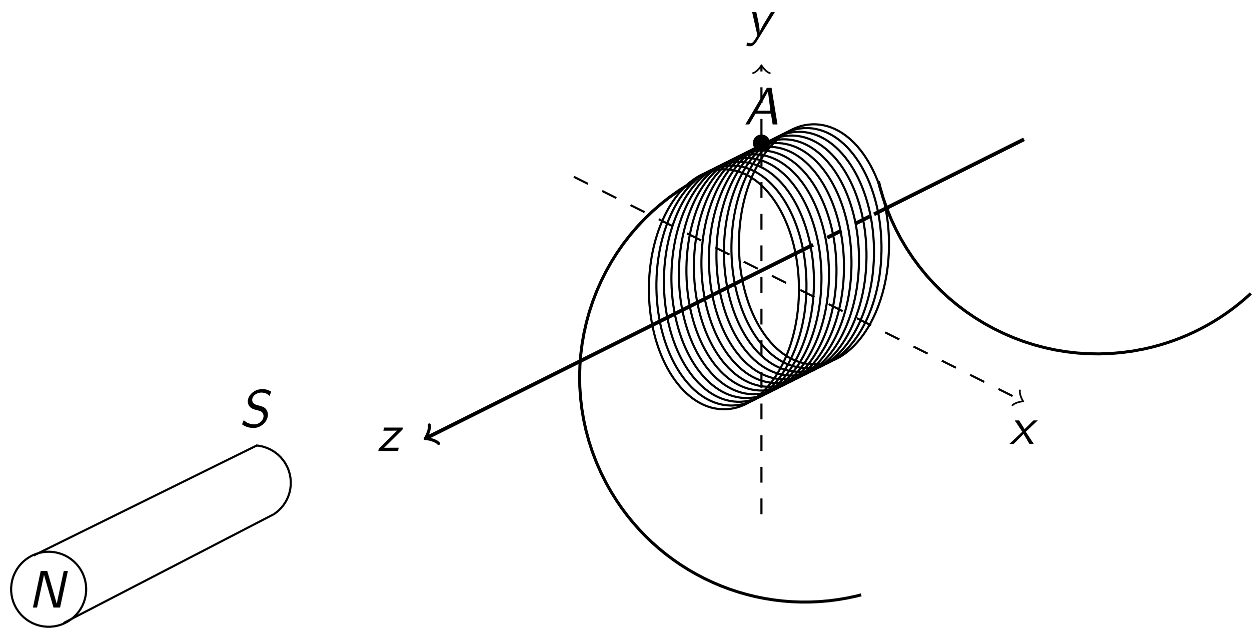


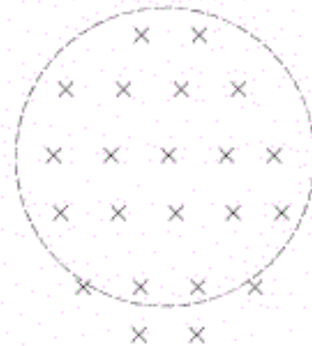
fig30.1

As the magnet is moved in the z direction, what is the. . .

Choice	direction of $-d\mathbf{B}/dt$ at the origin?	direction of induced current at A from Faraday's Law?
1	$\hat{z}$	$-\hat{x}$
2	$-\hat{z}$	$-\hat{x}$
3	$\hat{z}$	$\hat{x}$
4	$-\hat{z}$	$\hat{x}$

31.4.1 Varying flux & Induced emf

B_1 at t_1



B_2 at t_2

Given: r=1m. At t_1= 0 sec, B_1=1T. At t_2= 2 sec, B_2=2T.

Find: Induced emf ε_{ind}, in volts.

	1	2	3	4
ε_{ind} (in volts)	π	$\pi/2$	π	$\pi/2$
dir of ε_{ind}	clock-wise	clock-wise	counter-clockwise	counter-clockwise

Hint: $\varepsilon_{ind} = \left|\frac{d\phi}{dt}\right| = \left|\frac{B_2 A - B_1 A}{t_2 - t_1}\right|$. Use Lenz law