Next Week, Feb 13 – 17

Midterm break

The Week After, Feb 21 – 23

Lab: e/m of the electron

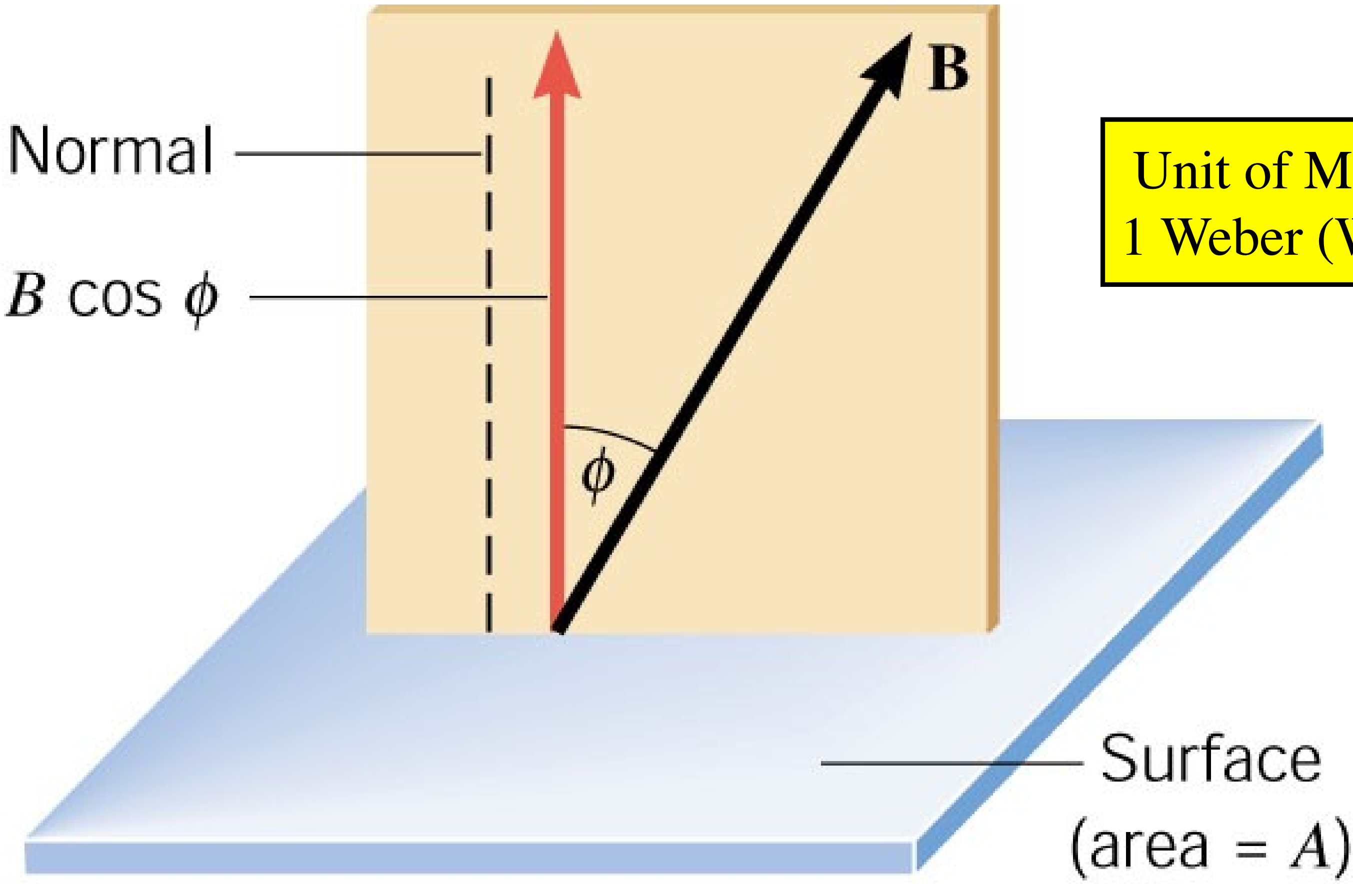
March 2, 7 – 9 pm

Term Test

Chapters 18 – 25

20 questions, formula sheet provided

Magnetic Flux



Unit of Magnetic Flux:
1 Weber (Wb) = 1 $T.m^2$)

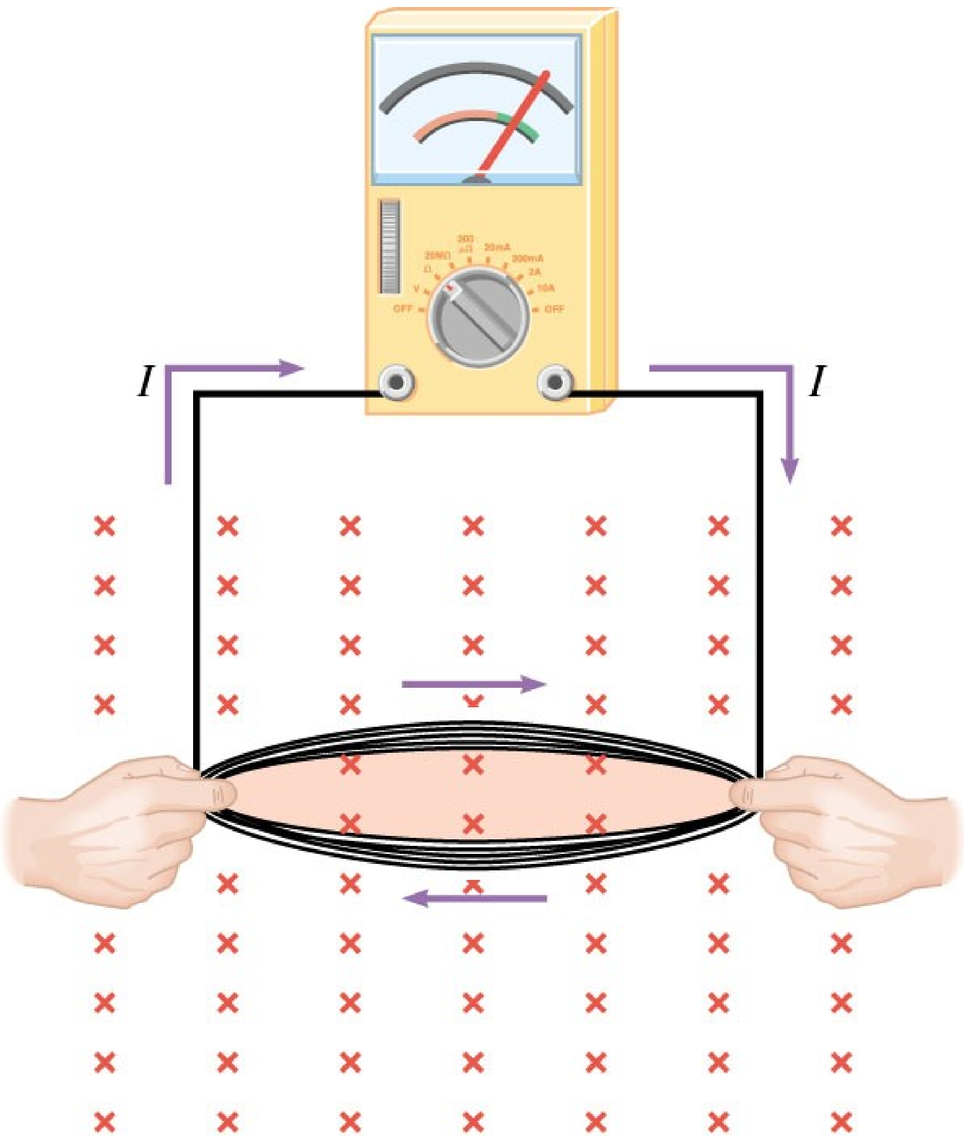
Magnetic flux, $\Phi = B\cos\phi \times A = BA\cos\phi$

Induced emf

Changing the magnetic field or the coil shape or angle to the field changes the magnetic flux passing through the coil.

The induced emf is equal to the rate of change magnetic flux. (Faraday's Law)

The magnetic field produced by the induced current opposes the original change of magnetic flux. (Lenz's Law)

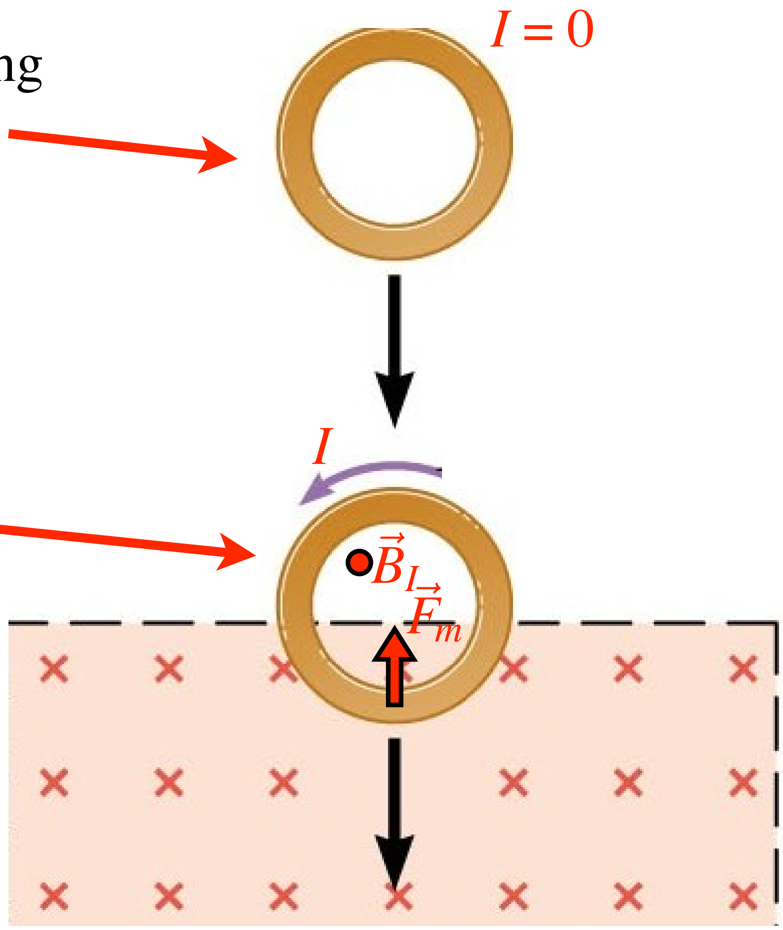


Conducting ring falling through a magnetic field

The magnetic flux passing through the ring is constant (zero), so there is no induced emf or current.

The magnetic flux passing through the ring is increasing and is directed into the page.

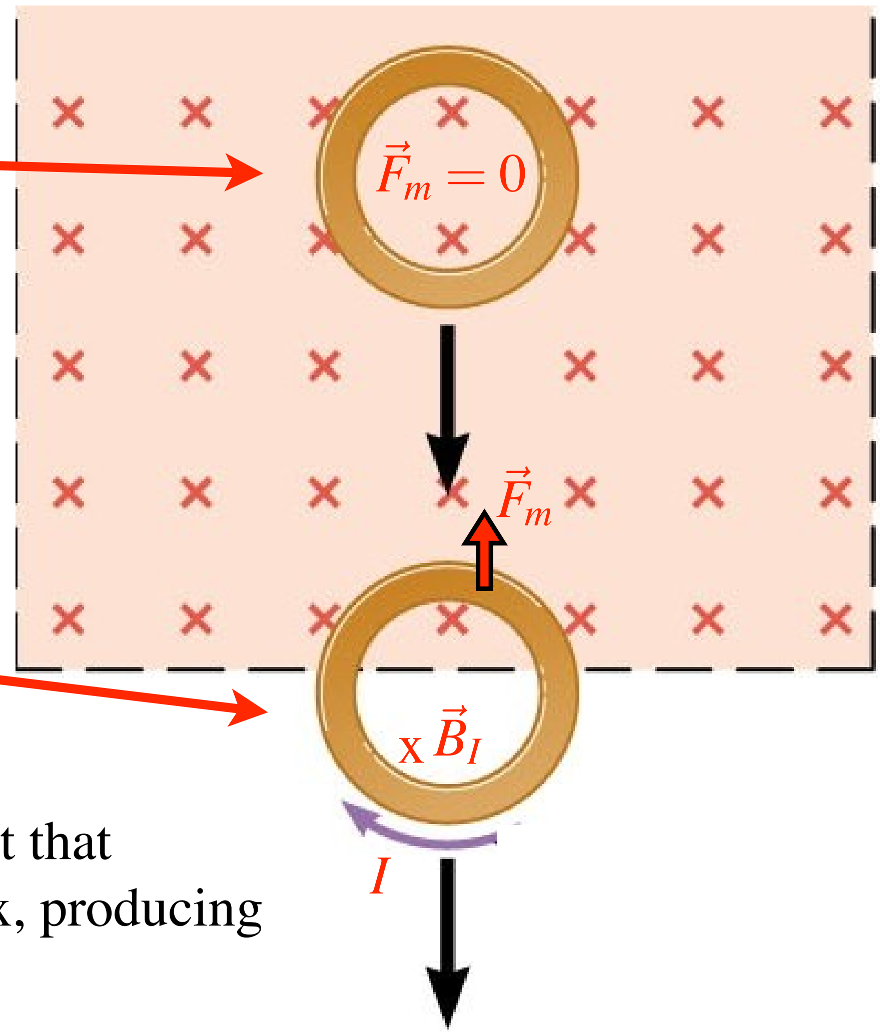
The induced current produces a magnetic field, B_I, that opposes the increase of flux.



A magnetic force is generated that opposes the motion of the ring.

The magnetic flux passing through the coil is constant, so there is no induced emf or current and no magnetic force.

The magnetic flux passing through the coil is decreasing and points into the page.



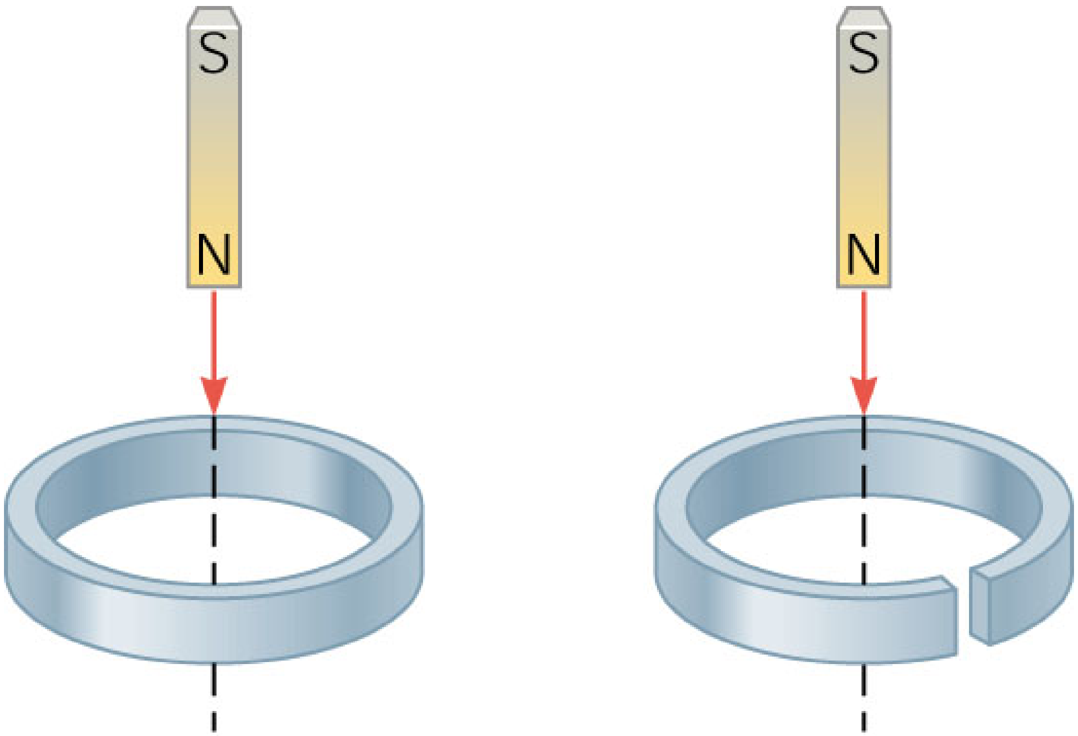
The induced emf generates a current that opposes the change in magnetic flux, producing a magnetic field, B_I, into the page.

A magnetic force opposes the motion of the coil.

22.70

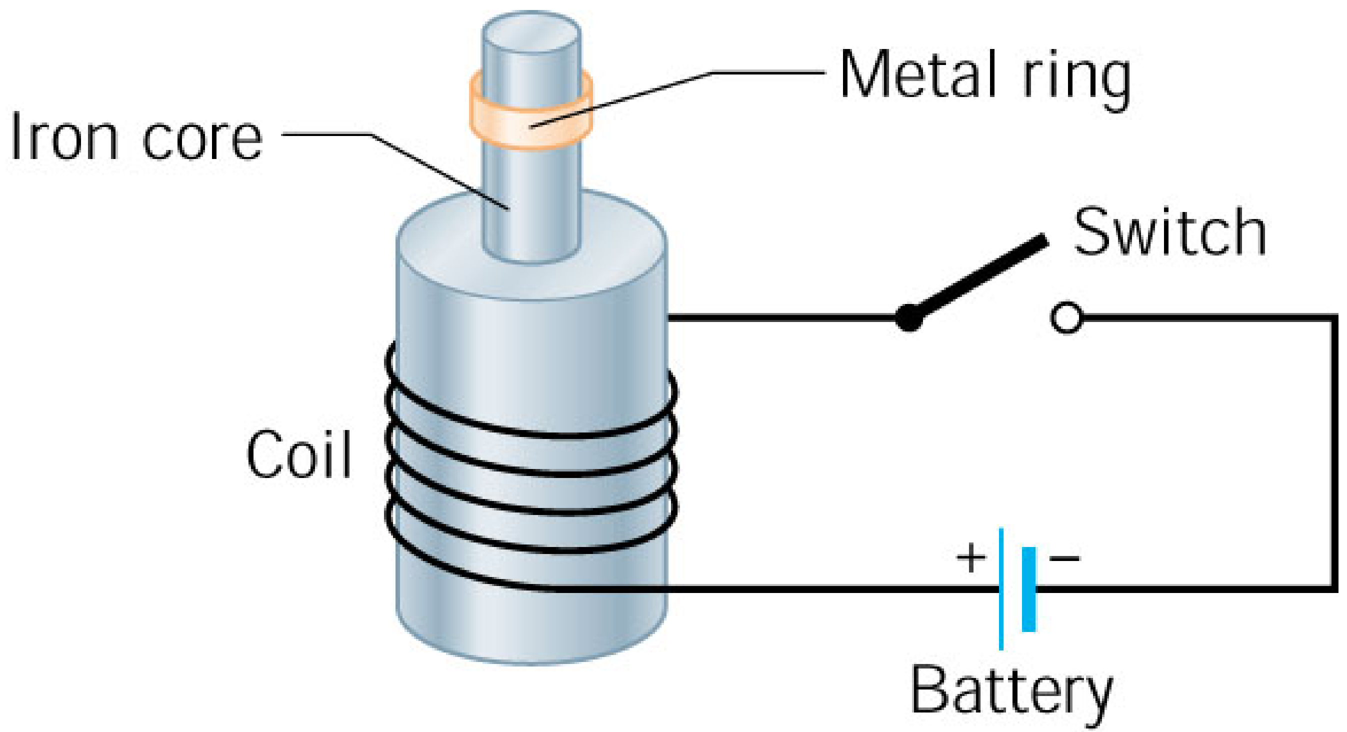
Prob. 22.70: A bar magnet is falling through a metal ring. In part *a* the ring is solid all the round around, but in part *b* it has been cut through.

Explain why the motion of the magnet in part *a* is retarded, whereas it is not in part *b*.



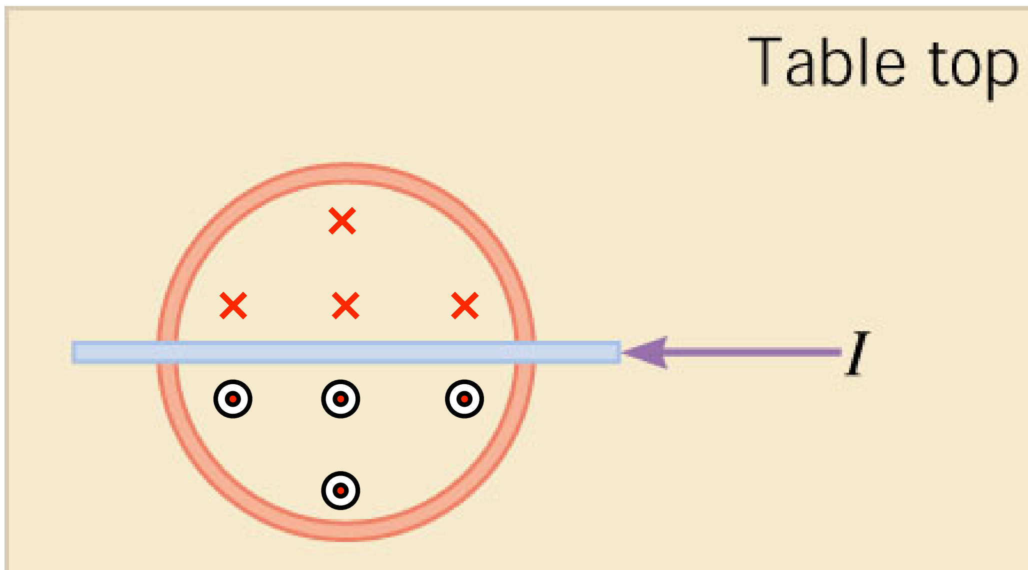
(*a*) (*b*)

Prob. 22.C12: When the switch is closed, a current is established in the coil and the metal ring jumps upward. Explain why.



Prob. 22.33: A circular loop of wire rests on a table. A long, straight wire lies on this loop over its centre.

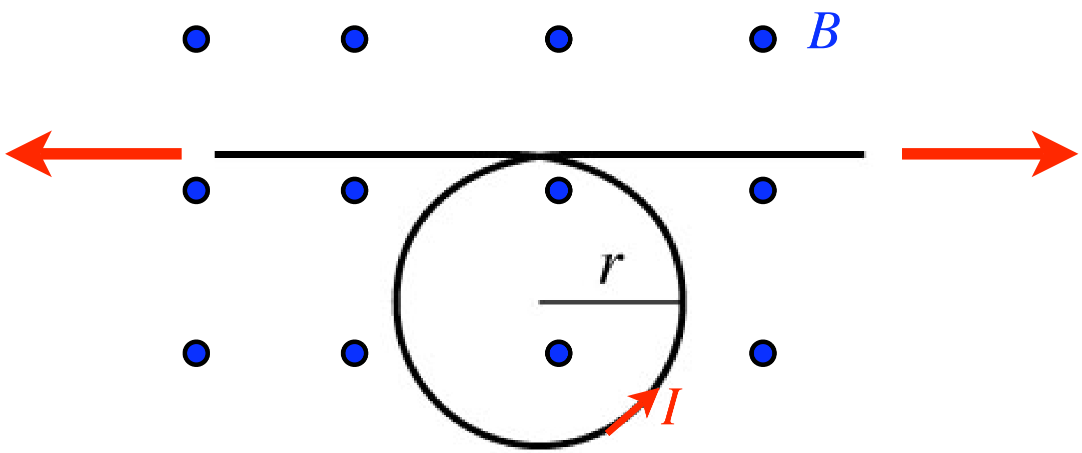
The current *I* in the straight wire is increasing. In what direction is the induced current, if any, in the loop?



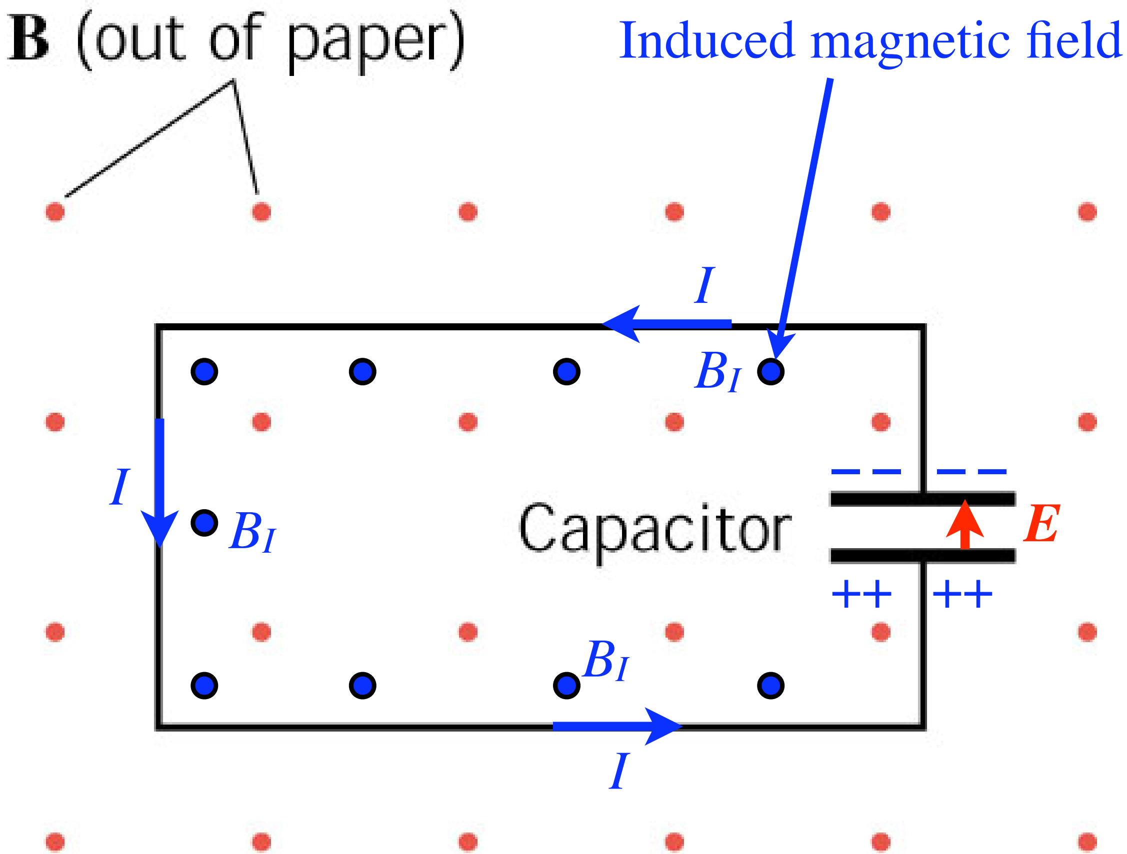
- What is the total magnetic flux through the loop?
- Does it change?

A wire is bent into a circular loop as shown. The radius of the circle is 2 cm. A constant magnetic field $B = 0.55$ T is directed perpendicular to the plane of the loop. Someone grabs the ends of the wire and pulls it taut, so the radius shrinks to zero in 0.25 s.

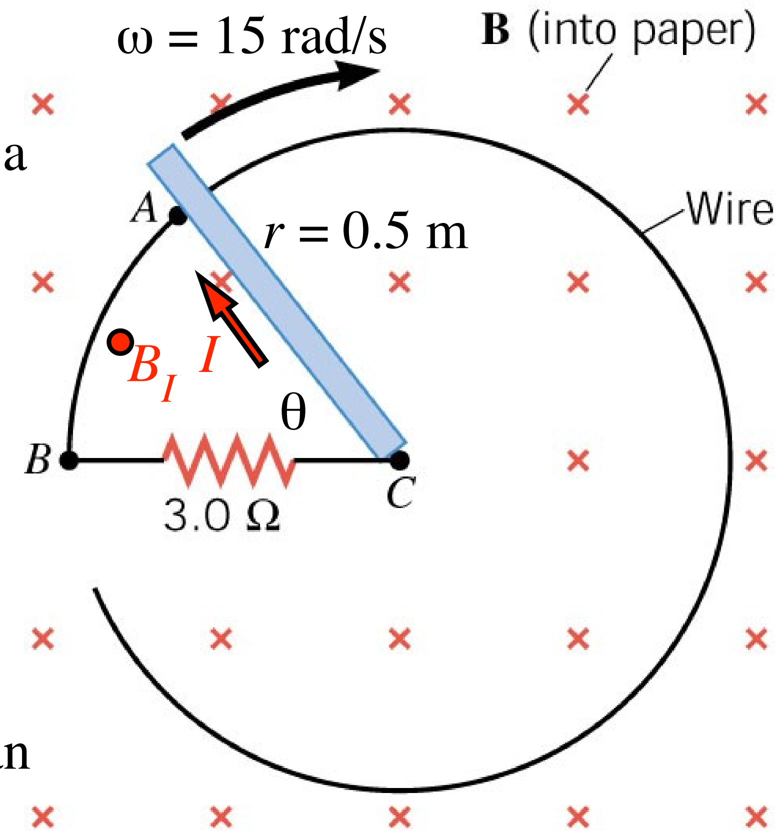
Find the magnitude of the average induced emf between the ends of the wire.



Prob. 22.32: Indicate the direction of the electric field between the plates of the capacitor if the magnetic field is **decreasing** in time.



Prob. 22.26



A 0.5 m copper bar, AC, sweeps around a conducting circular track at 15 rad/s. A uniform magnetic field points into the page, $B = 0.0038$ T.

Find the current in the loop ABC.

The loop forms a closed circuit of increasing area, so the magnetic flux passing through the loop increases and an emf is generated.

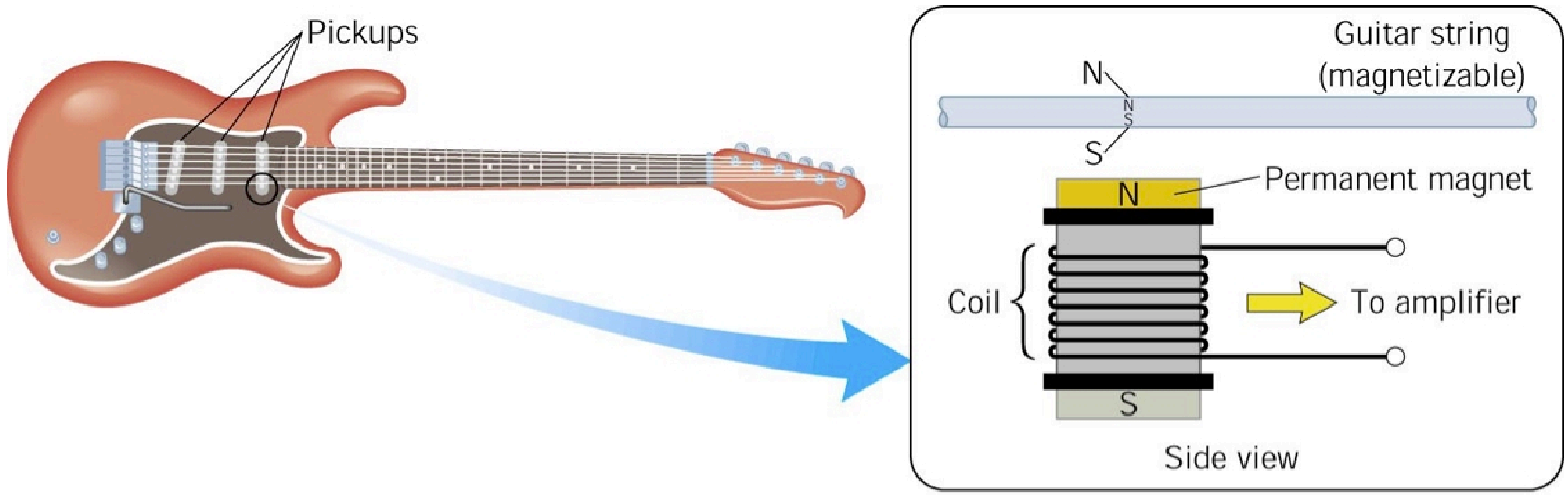
The flux passing through the loop is: $\Phi = BA = B\left(\dfrac{\theta}{2\pi}\right) \times \pi r^2 = Br^2\theta/2$

The induced emf is: $V = \dfrac{\Delta\Phi}{\Delta t} = \dfrac{Br^2}{2} \times \dfrac{\Delta\theta}{\Delta t} = \dfrac{Br^2\omega}{2}$

$$V = \frac{0.0038 \times 0.5^2 \times 15}{2} = 7.13 \times 10^{-3}\ \text{V}$$

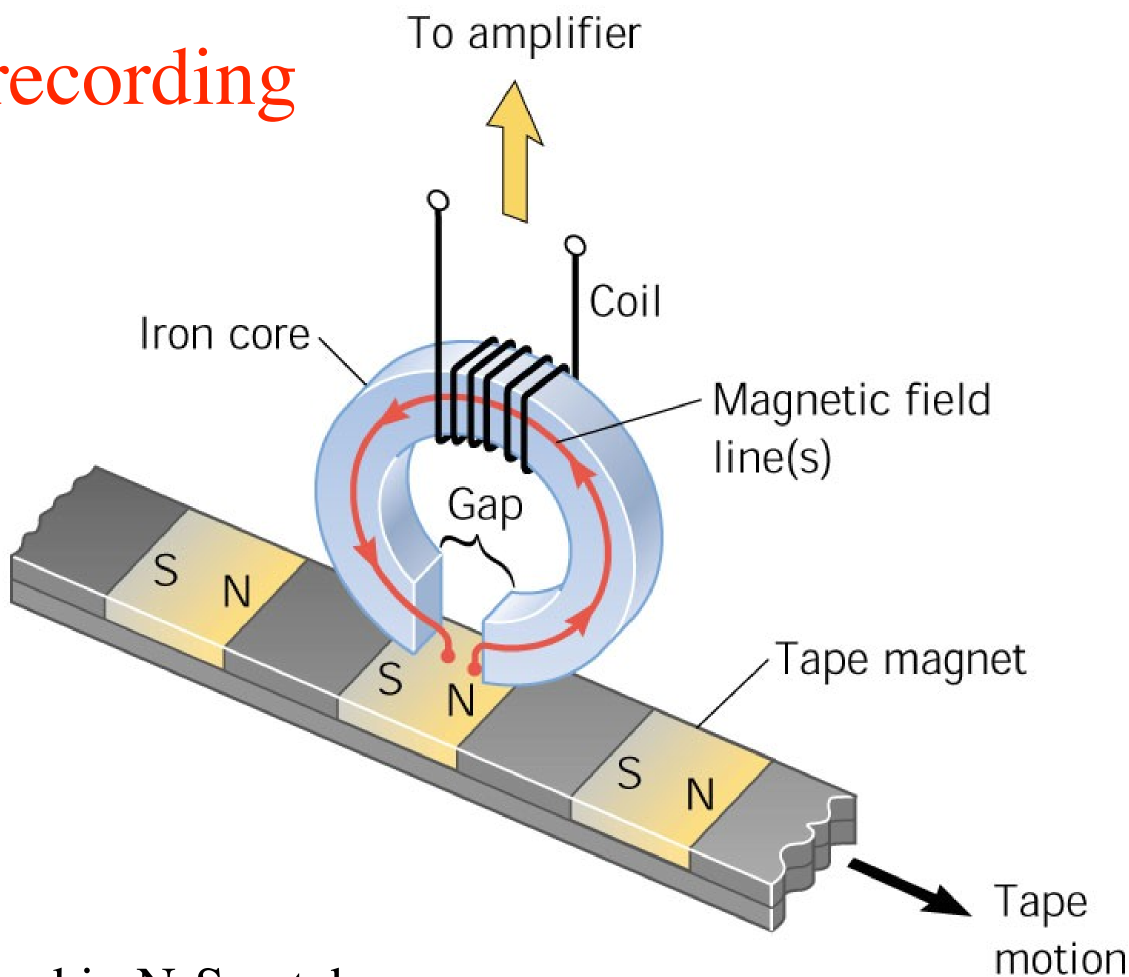
and $I = V/R = 0.00713/3$
$= 2.4$ mA

Guitar pickup



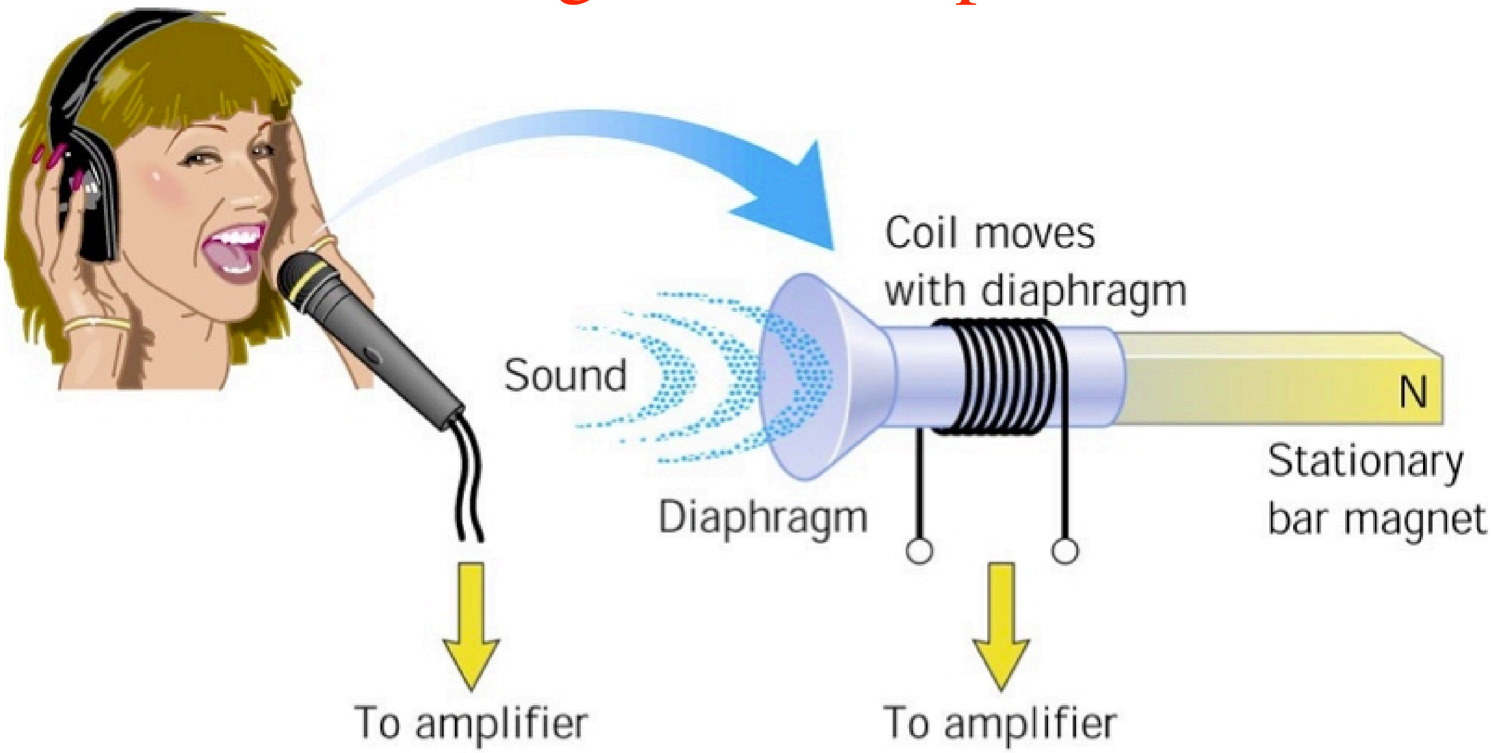
- The strings are magnetizable
- A permanent magnet magnetizes them
- The vibration of a string changes the magnetic flux through a coil close to it at the frequency of vibration of the string
- An emf is induced in the coil at that frequency

Playback of tape recording



- Recorded tape is magnetized in N-S patches
- The tape passes by the playback head which channels and concentrates the magnetic field through an iron core
- The changing magnetic flux induces an emf in the coil

Moving coil microphone

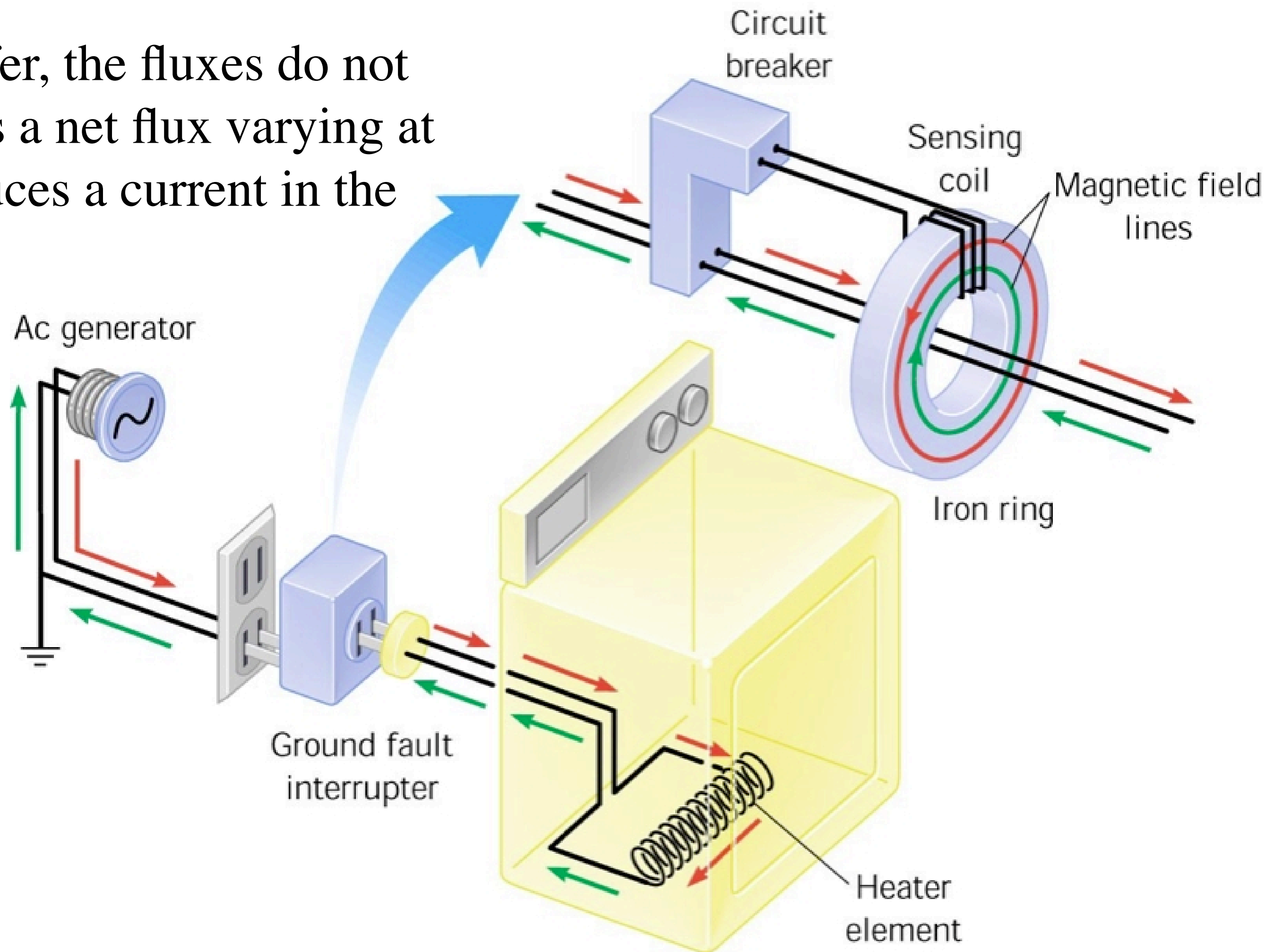


- Sound waves cause the diaphragm of the microphone to move in/out
- A coil moves with the diaphragm relative to a permanent magnet, causing the magnetic flux through the coil to change in step with the pressure variations of the sound wave
- An emf is set up in the coil at the frequency of the sound wave

Ground fault detector

If the return current (green) is equal to the supply current (red), the magnetic fluxes around the iron ring are equal and opposite and cancel.

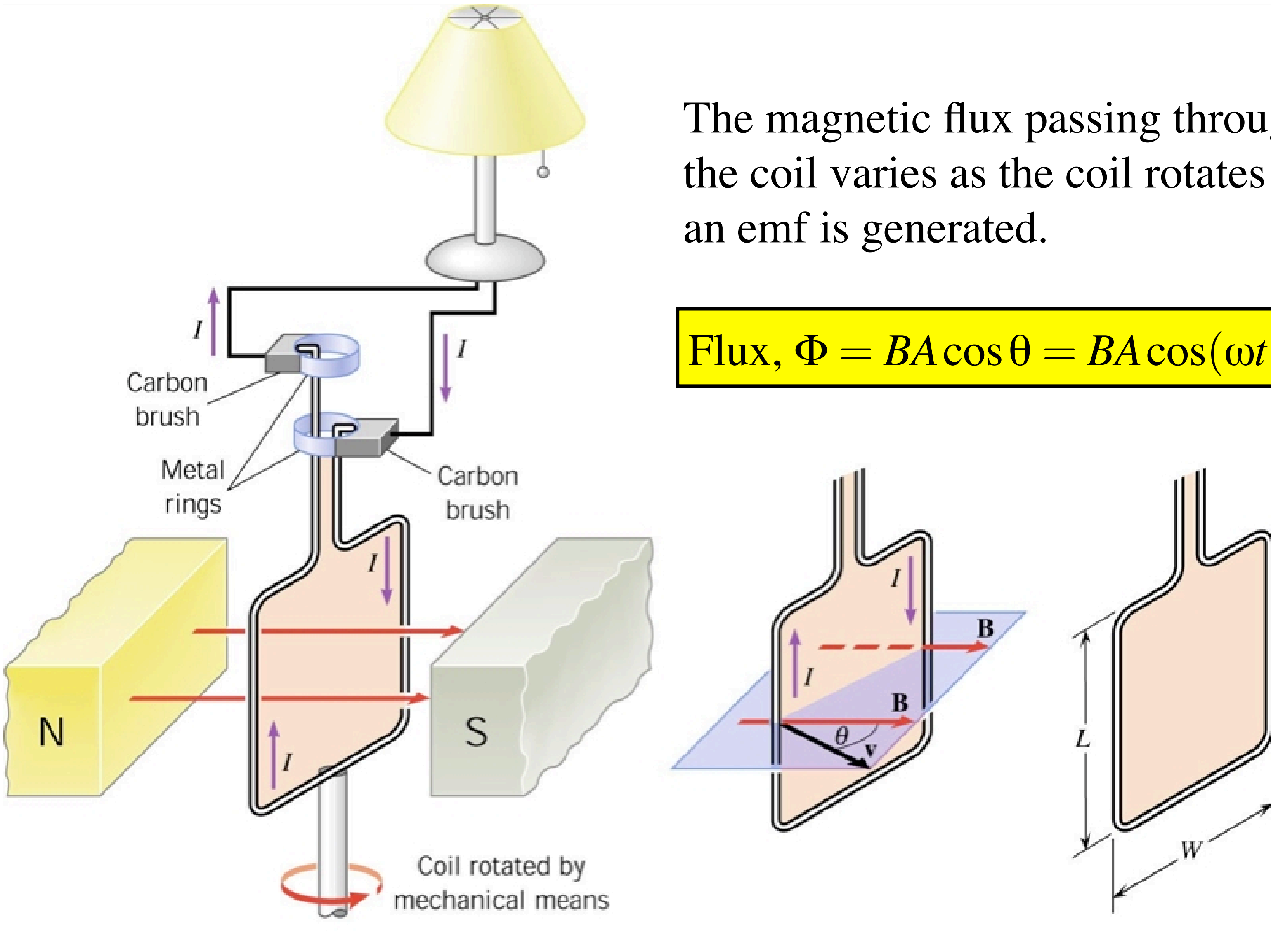
If the currents differ, the fluxes do not cancel and there is a net flux varying at 60 Hz, which induces a current in the sensing coil.



Electric Generator

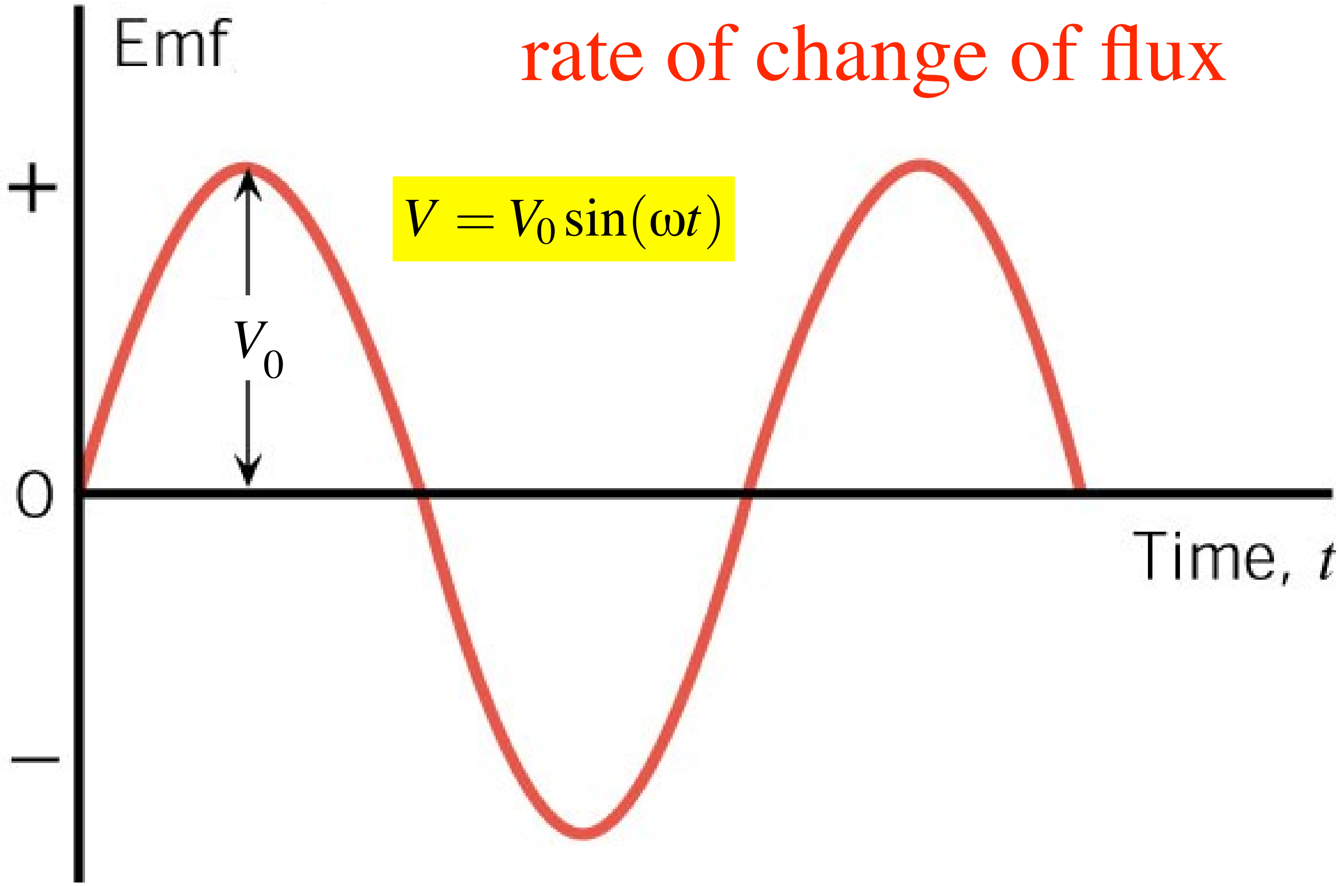
The magnetic flux passing through the coil varies as the coil rotates – an emf is generated.

$$\text{Flux, } \Phi = BA\cos\theta = BA\cos(\omega t)$$



(a) (b) (c)

EMF from electric generator, using rate of change of flux



$V = V_0 \sin(\omega t)$

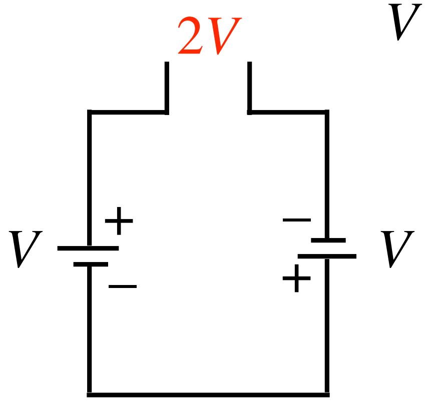
Flux, $\Phi = BA\cos\theta = BA\cos(\omega t)$

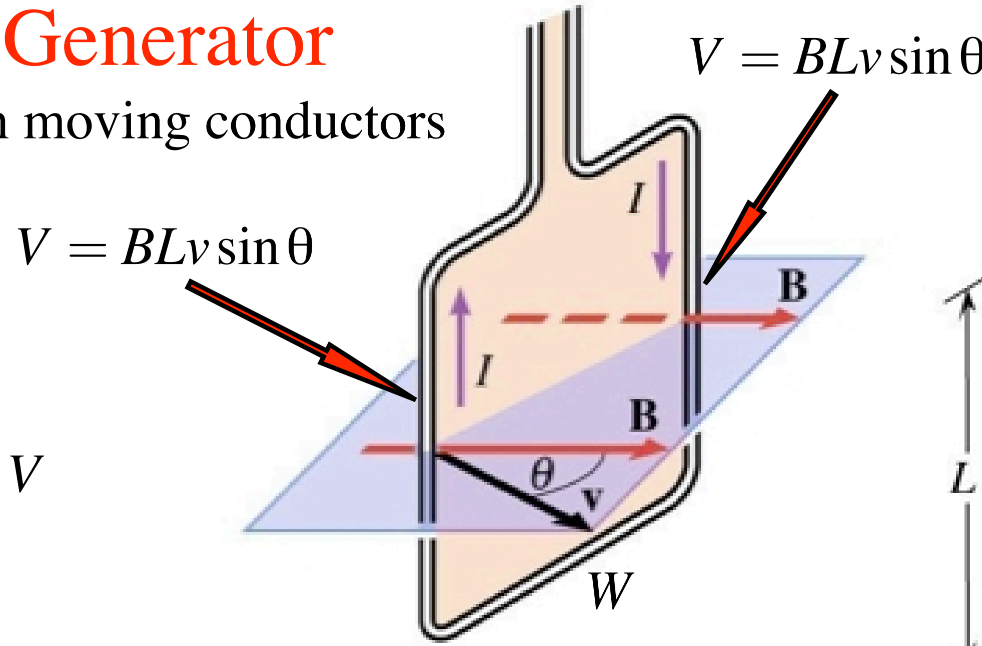
Then, the induced emf is $V = -\dfrac{\Delta\Phi}{\Delta t} = BA\omega\sin(\omega t)$ (diff. calculus)

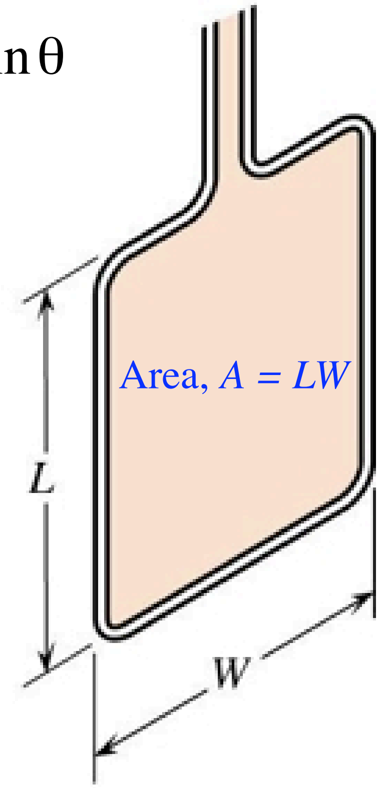
$V = V_0 \sin(\omega t),\ V_0 = BA\omega$

Electric Generator

EMF generated in moving conductors







Total emf generated: $V_{tot} = 2BLv\sin\theta$

$$v = r\omega = \left(\frac{W}{2}\right)\omega, \quad \omega = \text{ angular frequency of rotating coil}$$

Therefore, $V_{tot} = BLW\omega\sin\theta = BA\omega\sin\theta$

If the coil has N turns, then: $V_{tot} = NBA\omega\sin\theta = V_0\sin\theta$