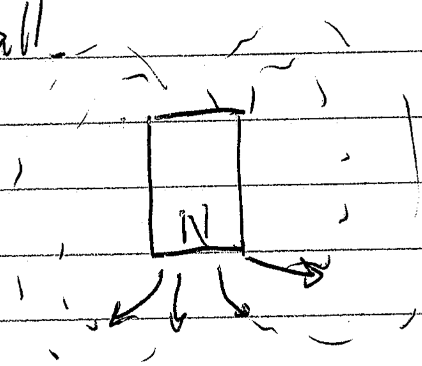
① Phys 2426 2017-10-17 Lec 13

EM Induction – Voltage generated by varying magnetic flux.

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

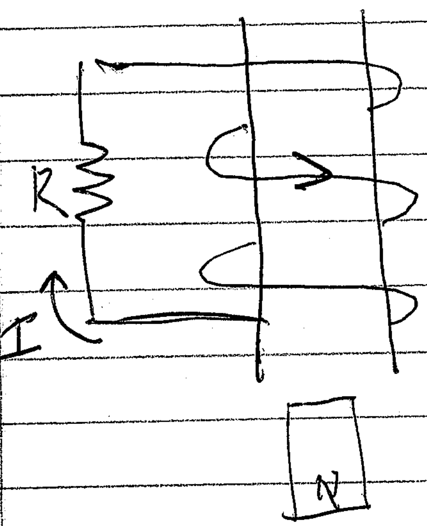
↑ Lenz's Law

The direction of the EMF is such that the induced current (if it exists) creates a magnetic field that opposes the change in flux that started it all.



As the magnet approaches:

- $\vec{B}$ points down
- $|\Phi_B|$ is increasing.
- Coil fights that by making $\vec{B}_{ind}$ = (up)
- Induced I is to right on front side.
- I is up thru R.



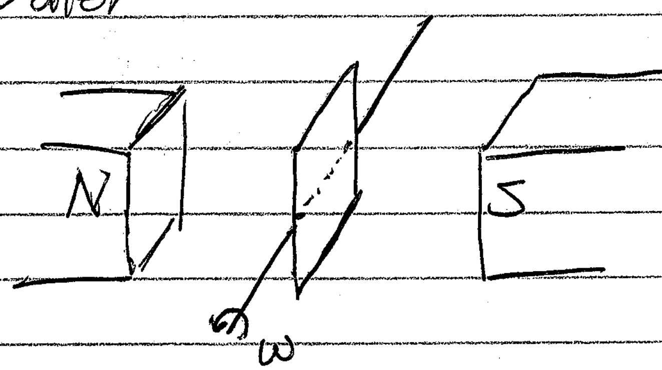
As the magnet leaves:

- $|\Phi_B|$ is decreasing
- B_{ind} = (Down)
- I = reverse of previous.

AC Electricity

- Varying Voltage → Varying I
- Varying I → Varying B
- Varying B → Induced $\mathcal{E}$

AC Generator



Magnetic Flux $\Phi_B = NBA\cos(\omega t)$

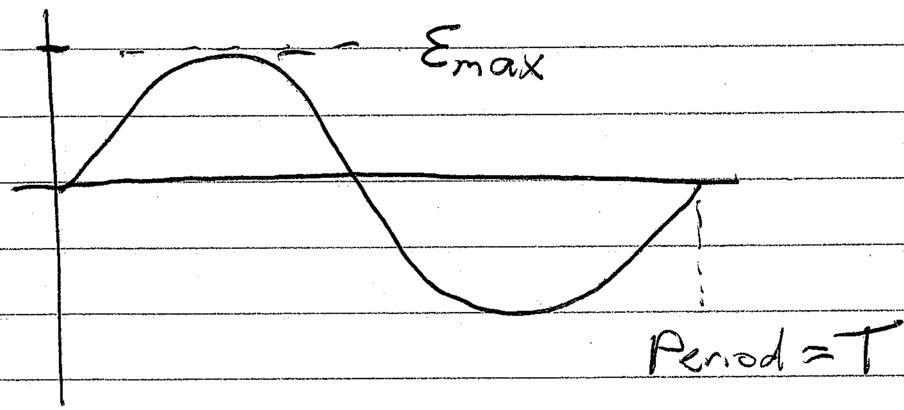
$$\mathcal{E} = NBA\omega \sin(\omega t)$$

- ω = angular speed in rad/s = s^{-1}
- f = frequency in rev/s = $\frac{cycles}{s}$ = Hz

$$\omega = 2\pi f$$

AC Wave Form $\mathcal{E} = \mathcal{E}_{max} \sin(2\pi f t)$

Amplitude ↗



$\sin(\theta)$ repeats when $\Delta\theta = 2\pi$

$\sin(2\pi f t)$ repeats when $\Delta(2\pi f t) = 2\pi$

$f\Delta t = 1$

$fT = 1$

$f = 1/T \qquad T = 1/f$

Resistors in AC

$V = IR$ Ohm's Law for instantaneous values

$V_{max}\sin(2\pi f t) = IR$

$\frac{V_{max}}{R}\sin(2\pi f t) = I = I_{max}\sin(2\pi f t)$

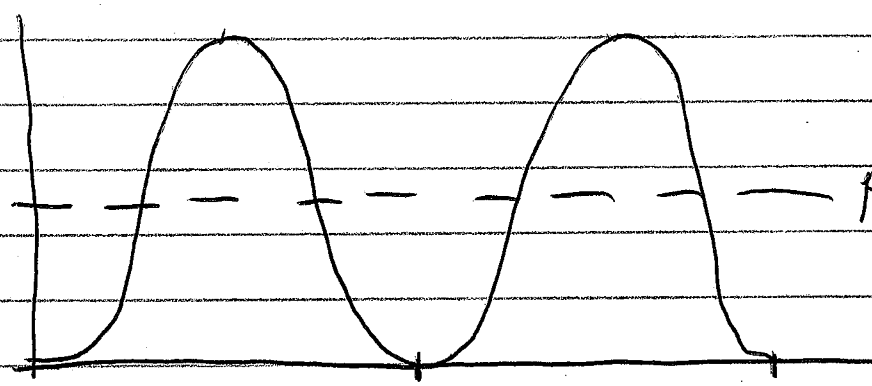
$V_{max} = I_{max}R$ Ohm's Law for Amplitudes

Resistor Power in AC

Used Power is $P = IV = I^2 R$

$$P = \left(I_{max} \sin(2\pi f t)\right)^2 R$$

$$= I_{max}^2 R \sin^2(2\pi f t)$$



$P_{avg} = \frac{1}{2} P_{max}$

$$\sin^2\theta = \frac{1}{2}\left(1 - \cos(2\theta)\right)$$

$P_{max} = I_{max}^2 R$ ← Looks like DC formula

$$V_{avg} = \frac{\Delta x}{\Delta t} \qquad P_{avg} = \frac{\Delta \text{Energy}}{\Delta t}$$

$$P_{avg} = \frac{1}{2} P_{max} = \frac{1}{2} I_{max}^2 R = I^2 R$$

$$\frac{1}{\sqrt{2}} I_{max} = I_{RMS}$$

$$V_{RMS} = I_{RMS} R$$

(5)

In the US: $V_{RMS} = 120\ V$
$f = 60\ Hz$

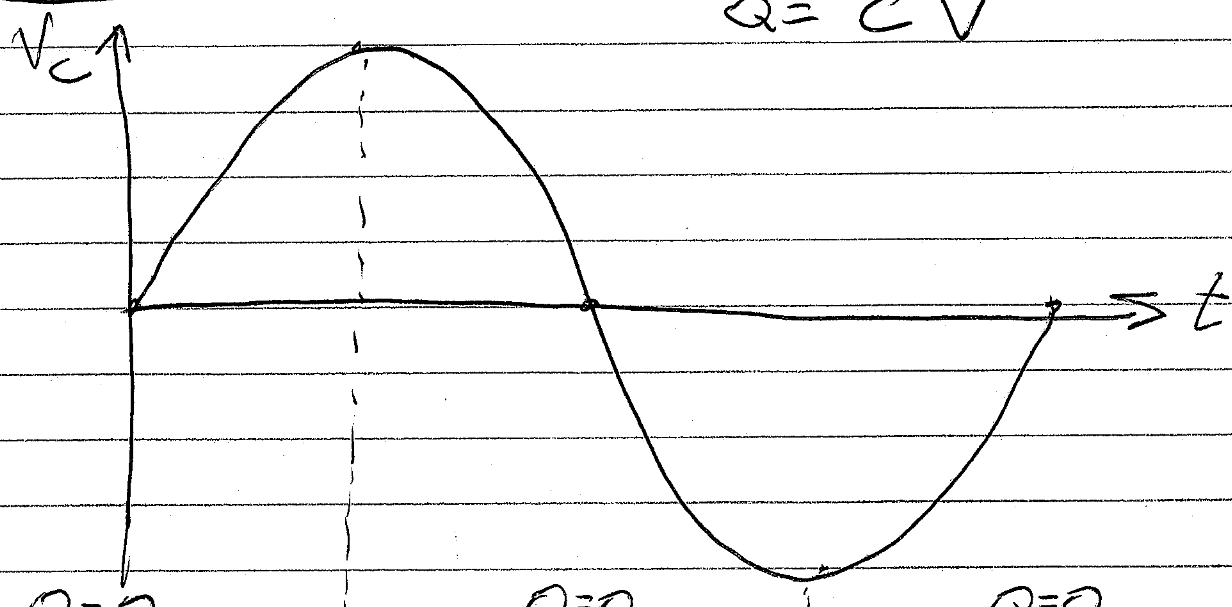
Ex: 6W Bulb

$$P_{avg} = V_{RMS}\, I_{rms}$$
$$6W = (120\ V)\, I_{rms}$$
$$0.05A = I_{rms}$$

$$V_{rms} = I_{rms}\, R$$
$$120\ V = (0.05A)\, R$$
$$2400\,\Omega = R$$

Capacitors in AC

$Q = CV$



$Q=0$ $Q=0$ $Q=0$

$Q=+Q_{max}$ $Q=-Q_{max}$

Q increasing Q decreasing

$I=+I_{max}$ $I=0$ $I=-I_{max}$ $I=0$