① Phys 1402 2014-10-16

Mass Spec

$$F = ma$$
$$qvB = mv^2/R$$
$$R = \frac{mv}{qB}$$

Conversion by substitution

$$5\times10^{-5}\,T = 50\times10^{-6}\,T$$
$$= 50\,\mu T$$

Induced Voltages

Faraday's Law $\mathcal{E} = -\frac{\Delta\Phi_B}{\Delta t}$

Magnetic Flux $\Phi_B = NBA\cos\theta$

Inductor: any coil

$$I \rightarrow B \rightarrow \Phi_B \xrightarrow[\text{change}]{} \mathcal{E} = \text{Voltage}$$

Net result:

$$V = -L\frac{\Delta I}{\Delta t}$$

L = inductance in henries (H)

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Ex: Solenoid coil

magnetic field $B = \mu_0 I N/\ell$

flux $\Phi_B = NBA = \mu_0 I N^2 A/\ell$

Change in flux $\Delta\Phi_B = \underbrace{(\mu_0 N^2 A/\ell)}_{L} \Delta I$

Once the inductor is built, L = const.

The inductor opposes any change in current.

- First plug it in - takes time to get going.
- Try to disconnect - jolt of voltage tries to keep current flowing.

Most motors have a "condenser capacitor" to absorb this jolt.

- Once current is flowing, the inductor is happy and doesn't oppose it.

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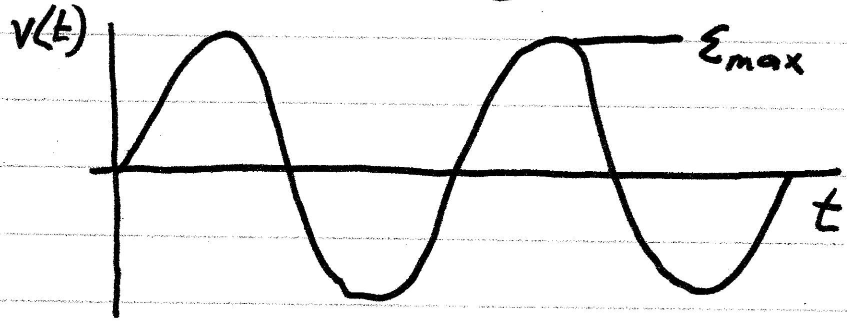
Generators produce a varying voltage.

$\mathcal{E}_{max} = NBA\omega$ — ω: rotation in rad/s



If you hook $\mathcal{E}_{max} = 12\text{ V}$ to a light bulb,
Sometimes $V(t) = \pm 12\text{ V} \Rightarrow$ Bright
other times $V(t) \approx 0\text{ V} \Rightarrow$ Dim

Average brigtness corresponds to a smaller battery.

$$V_{RMS} = \frac{V_{max}}{\sqrt{2}} = 0.707\, V_{max}$$

Ex: Want 14 V max voltage. What RMS?

$$V_{rms} = \frac{(14\text{ V})}{\sqrt{2}} = 9.9\text{ V}$$

In one analysis, stick to either RMS or max.

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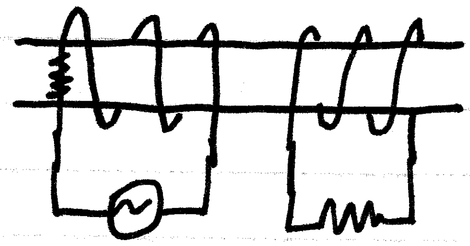
Transformers



First coil: Primary

$$\frac{\Delta I}{\Delta t} \rightarrow \frac{\Delta B}{\Delta t} \rightarrow \frac{\Delta \Phi_1}{\Delta t} \rightarrow V_1$$

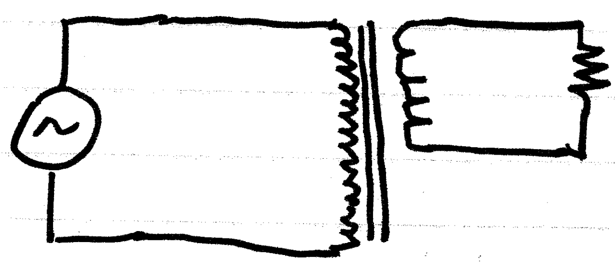
Second Coil: Secondary

$$\frac{\Delta B}{\Delta t} \rightarrow \frac{\Delta \Phi_2}{\Delta t} \rightarrow V_2$$

The only difference between the coils is N_1 vs. N_2. This scales the voltages.

Ex:

120 V



$N_1 = 240$

$N_2 = 20$

$$\frac{N_2}{N_1} = \frac{V_2}{V_1}$$

Turns ratio (pri : sec) = 12:1

Voltage ratio is also 12:1

$$V_2 = \frac{N_2}{N_1} V_1 = \frac{1}{12}(120V) = 10 V$$

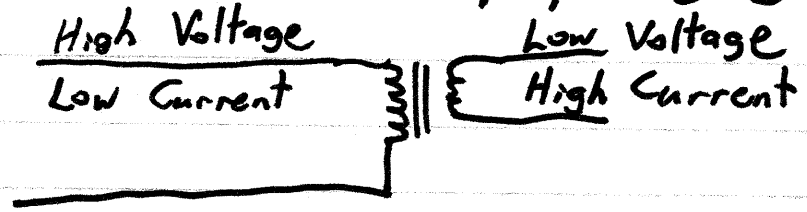
Transformers don't create energy

For resistor-type loads $P_{ave} = V_{RMS} I_{RMS}$

For a transformer

$$P_{in} = P_{out}$$

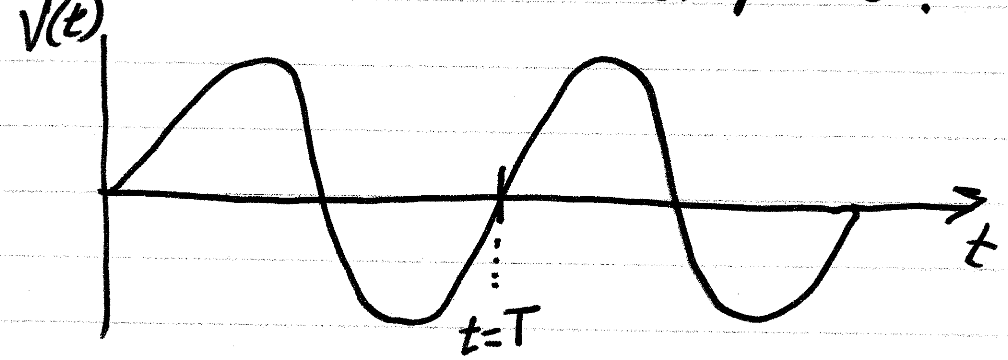
$$V_1 I_1 = V_2 I_2$$



The power lines are resistors.

$$P_{lost} = V_R I_R = I^2 R$$

← lower I means less lost power.



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

f = Frequency in hertz (Hz)
= # cycles per second.

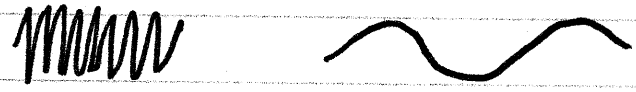
T = period in seconds. $T = \frac{1}{f}$
= time of one cycle

In US Power systems, $f = 60$ Hz.

How do the basic components deal w/ AC?

Resistor: Same as DC. $V_R = IR$

Inductor: Opposes changing I.



rapid change	slow change
High-f	Low-F
More V_L	Less V_L

$$V_L = I\,2\pi f L = I Z_L$$

Z = impedance (or X = reactance) in ohms.

Inductor blocks High-f
allows Low-f (and DC)

Capacitor: opposite of inductor

$$V_C = I\left(\frac{1}{2\pi f C}\right) = I Z_C$$