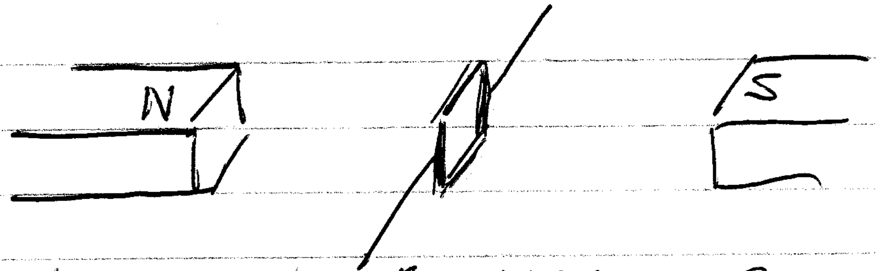
Electric Generator (Alternator)



Without movement, $\Phi_B = NBA\cos\theta$ = const.

$$\mathcal{E} = -d\vec{\Phi}/dt = 0$$

Spin the loop on the axis: $\theta = \omega t$ ← angular speed

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

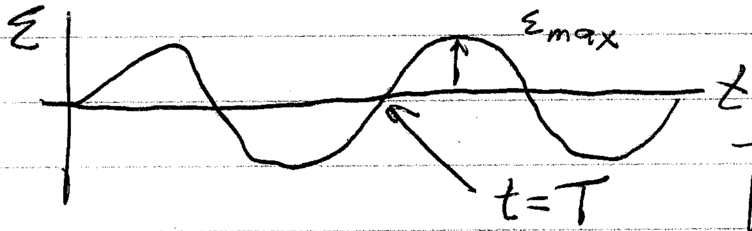
$$\mathcal{E} = \frac{-d\Phi}{dt} = -NBA(-\sin(\omega t))\,\omega$$

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

$\theta = 2\pi$

$\omega t = 2\pi$

$t = \frac{2\pi}{\omega}$



$$\boxed{f = \frac{1}{T}} = \frac{\omega}{2\pi}$$

$$\boxed{\omega = 2\pi f}$$

$$\mathcal{E}_{max} = NBA\omega$$

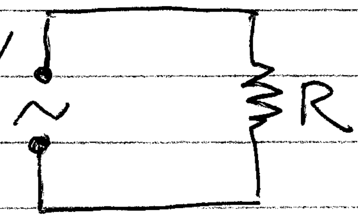
$f = \frac{\omega}{2\pi}$ ← angular freq.

US Household: $\mathcal{E}_{max} = 170\,V$ $f = 60\,Hz$

What happens when AC voltage is applied to a load?

$\mathcal{E}_{max} = 170\ V$

$f = 60\ Hz$



Voltage	Brightness
0	Off
170 V	Bright
0	Off
−170 V	Bright

Average 0 Medium

meaningless → 0

The avg brightness is the same as if the bulb was hooked to $V_{DC} = 120\ V$.

If we take an RMS average of the AC signal, it is 120 V.

$$\sqrt{\overline{(V(t))^2}}$$

$$V_{RMS} = \frac{1}{\sqrt{2}} V_{max} = 0.707\ V_{max}$$

AC Ohm's Law

$$V_{RMS} = I_{RMS} R \qquad P_{avg} = V_{RMS} I_{RMS}$$

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

③

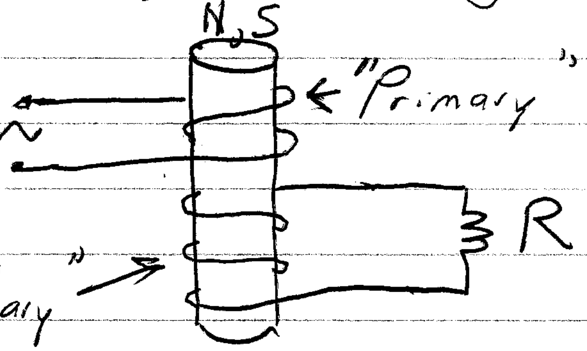
Ex: Cell Phone Charger

$V_{rms} = 120\,V$ $\qquad (10\,W) = (120\,V)(I_{rms})$

$I_{rms} = 0.083\,A$

$\left.\begin{array}{l} V_{out} = 5.0\,V \\ I_{out} = 2.0\,A \end{array}\right\} P_{out} = VI = 10\,W$

Transformers - Interlocking Coils



Current in primary causes B in core.
Since I oscillates, so does B.
Each coil feels flux $\Phi_B = NBA \cancel{\cos\theta}$
They have the same B, A.
Primary: $\Phi_1 \propto N_1 \rightarrow \mathcal{E}_1 \propto N_1$

This $\mathcal{E}_1$ limits the current I_1.

Secondary: $\Phi_2 \propto N_2 \rightarrow \mathcal{E}_2 \propto N_2$
This $\mathcal{E}_2$ pushes I_2 thru R.

(4)

Transformer equations:

$$\frac{N_2}{N_1} = \frac{V_2}{V_1} = \text{"turns ratio"}$$

$$V_1 I_1 = V_2 I_2 = \text{power transmitted}$$

With efficiency ϵ

$$P_{out} = \epsilon P_{in}$$

$$P_{in} = P_{out} + P_{waste}$$

Cell Charger Transformer

$V_1 = 120\ V$ $\quad N_1 = 2400$

$V_2 = 5\ V$ $\quad N_2 = ? = 100$

Electrical Devices

Resistor: R $V = IR$ $P = IV$

Input: Voltage that pushes current
Output: Heat, Light, other

Battery: $\mathcal{E}$

Input: Chemical Energy
Output: Specific voltage $= \mathcal{E}$, any current

Motor: $\tau = NBAI \sin\theta$

Input: Voltage that pushes current.
Output: Torque that spins a shaft.
Side-effect: $\mathcal{E}$ limits $I \Rightarrow$ more I when slow.

Generator: $\mathcal{E} = NBA\omega \sin\theta$

Input: Spinning shaft
Output: Voltage that pushes current.
Side-effect: Torque increases with I.
Harder to spin when lights are on.