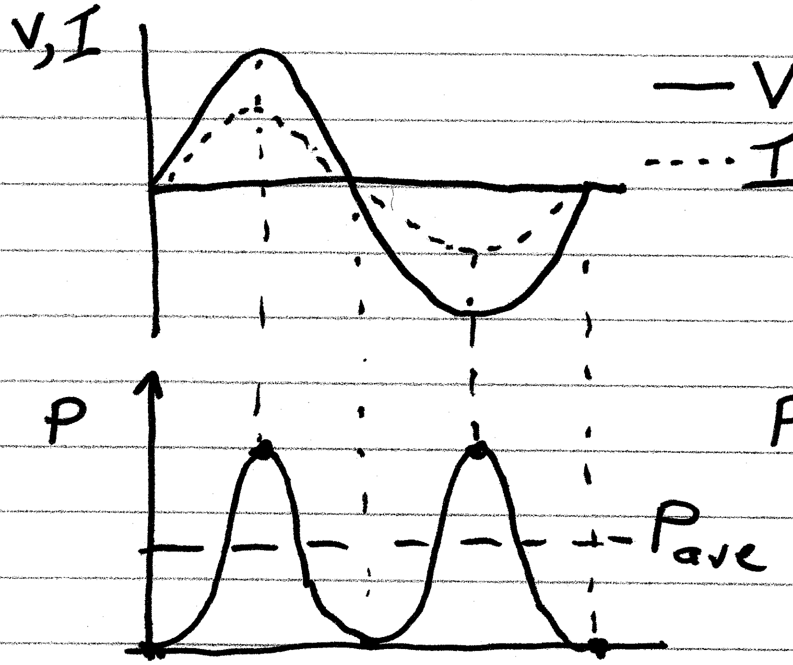
Phys 1402 2014-10-23

Power and Energy in AC

Resistor - Can only use power.
Does not store energy.

$$\text{Power} = \frac{\text{Energy}}{\text{Time}} = \frac{\text{Energy}}{\text{Charge}} \; \frac{\text{Charge}}{\text{Time}}$$

$$P = V I$$



P(t) is pulsed and always ⊕

$$P_{ave} = V_{RMS} I_{rms}$$ (For a resistor)

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

Only resistors use power in AC.

What about capacitors? $\frac{1}{2}CV^2$

Capacitors store energy.

- It takes power & time to build up the energy.
- But the energy is released as power for a time.
- The power is sometimes ⊕, sometimes ⊖.

(How? $V = V_0 \sin(\sim)$

$I = I_0 \cos(\sim)$

$P = V_0 I_0 \sin(\sim)\cos(\sim)$

$= V_0 I_0 \sin(2\sim)(\frac{1}{2})$)

For a capacitor $P_{ave} = 0$

What about inductors?

Inductors store energy. $\frac{1}{2}LI^2$

For an inductor $P_{ave} = 0$

Summary: To find power used by a circuit, Find the I of each R.

$P = IV = I^2 R$

Add for multiple R's.

③

$$V = (120\,V)\sin(50\pi t)$$

$$I = I_0 \sin(50\pi t)$$

$$I(t = 0.005\,s) = I_0 \sin(\underbrace{50\pi(0.005)}_{\text{in radians}})$$

Deg/Rad check : $\sin(45) = 0.707$ ← degrees.

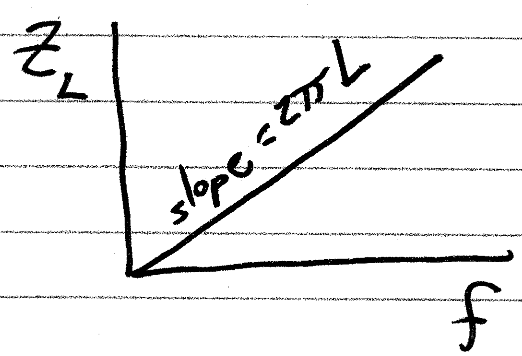
Inductor in AC

$V_{rms} = V_{max}/\sqrt{2}$

$Z_L = 2\pi f L$

$V_{rms} = I_{rms} Z$

Relationship between Z_L and f : $Z \propto f$ ← proportional



@ 60 Hz $\quad Z = 51.4\,\Omega$

@ 48 Hz $\quad Z = (51.4\,\Omega)(48/60) = 41.12\,\Omega$

④

Resonance

$$f_R = \frac{1}{2\pi\sqrt{LC}}$$

$$2\pi f_R = \frac{1}{\sqrt{LC}}$$

$$(2\pi f_R)^2 = \frac{1}{LC}$$

f_R and C have a inverse relationship.
(not inversely proportional)

Large $f_R \rightarrow$ small C
Small $f_R \rightarrow$ large C

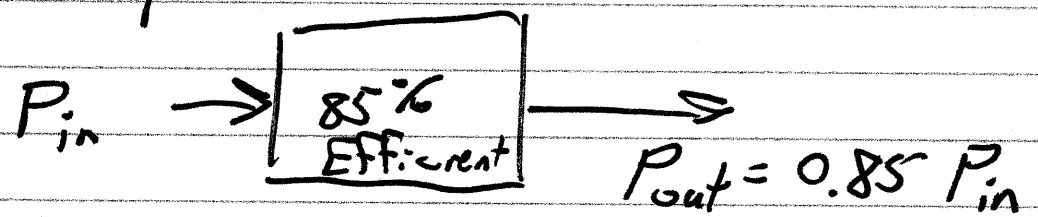
AM radio: 500 kHz — 1600 kHz

$L = 2\mu H$ $\quad C_{max} = \frac{1}{(2\pi f)^2 L} = \frac{1}{(2\pi(500\times10^3 Hz))(2\times10^{-6}}$

$= 5.066\times10^{-8}\,F$
$= 50.66\ nF$

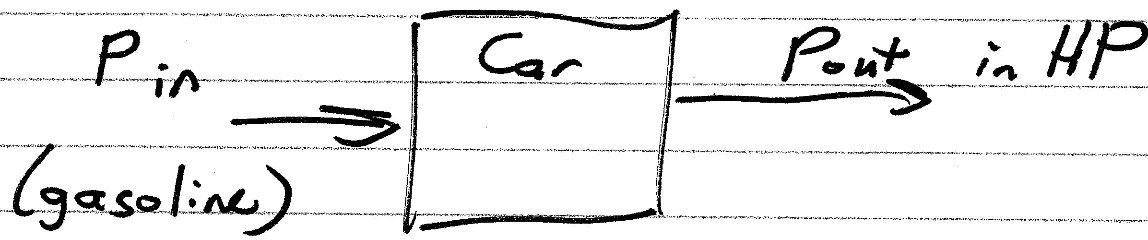
③

Efficiency



Let's say a car needs 20 BHP to drive up a hill, but the engine is only 25% efficient.

$1\ HP = 746\ W$



In one hour, energy $= P\Delta t$

$= (20\ HP)\left(\frac{746\ W}{HP}\right)(3600\ s)$

$= 3.43 \times 10^7\ J$

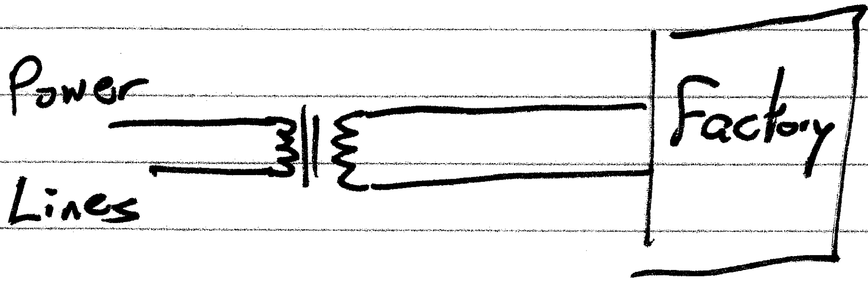
$= 34.3\ MJ$

$0.25\,(E_{in}) = (34.3\ MJ)$

$E_{in} = 137\ MJ$ in gasoline

$120\ MJ = 1$ gal gasoline equivalent

(6)



83%   2000 kW

P_{in} = more

$$P_{out} = \varepsilon P_{in}$$
$$(2000\ kw) = (0.83)\ P_{in}$$

ε always between 0 and 1.