ECE 2210 / 00 Lecture 8 Notes Basic AC

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1/27/03,
9/9/20

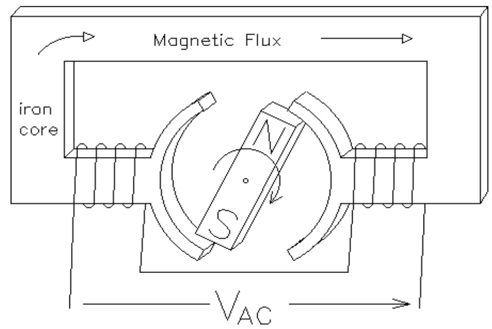
AC stands for **A**lternating **C**urrent as opposed to DC, **D**irect **C**urrent. AC refers to voltages and currents that change with time, usually the voltage is + sometimes and - at other times. This results in currents with go one direction when the voltage is + and the reverse direction when the voltage is -.

AC is important for two reasons.
Power is created and distributed as AC. Signals are AC.

AC Power

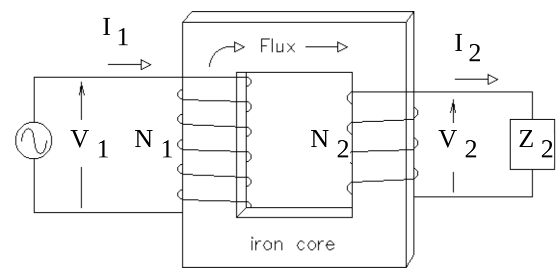
Power is generated by rotating magnetic fields.
This naturally produces sinusoidal AC waveforms.

It is easier to make AC motors than DC motors.



AC Power allows use of transformers to reduce line losses

pIron-core transfsecondary



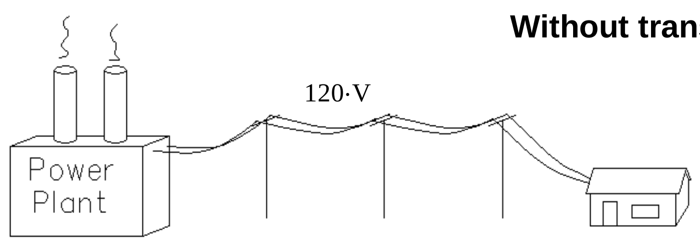
Transformers work with AC, but not DC. Transformers can be used to raise or lower AC voltages (with an opposite change of current). This can be very useful in power distribution systems. Power is voltage times current. You can distribute the same amount of power with high voltage and low current as you can with low voltage and high current. However, the lower the current, the lower the I^2R loses in the wires (all real wires have some resistance). So you'd like to distribute power at the highest possible voltage. Transformers allow you to do this with AC, but won't work with DC.

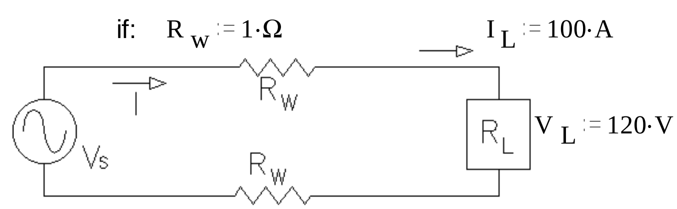
Ideal: power in = power out

Ideal transformation of voltage and current: $\frac{N_1}{N_2} = \frac{\mathbf{V_1}}{\mathbf{V_2}} = \frac{\mathbf{I_2}}{\mathbf{I_1}}$

Example:

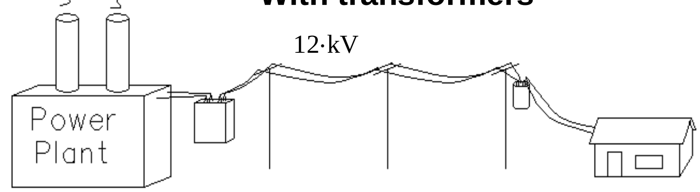
Without transformers

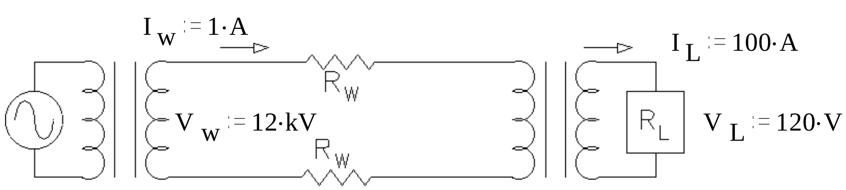




Wire loss: $P_W = I_L^2\cdot 2\cdot R_w = 20\cdot kW$

With transformers





Wire loss: $P_W = I_w^2\cdot 2\cdot R_w = 2\cdot W$

In this example, the power lost in the transmission lines is only 1/10,000th what it is without transformers.

That's why they raise the voltage in transmission lines to the point where they crackle and buzz. That crackle is the sound of the losses into the surrounding air and can become significant if the voltage is *too* high.

Signals

A time-varying voltage or current that carriers information. If it varies in time, then it has an AC component.

| | |
| Audio, video, position, temperature, digital data, etc...

In some unpredictable fashion

DC is not a signal, Neither is a pure sine wave. If you can predict it, what information can it provide?
Neither DC nor pure sine wave have any "bandwidth". In fact, no periodic waveform is a signal & no periodic waveform has bandwidth. You need bandwidth to transmit information.

Signal sources

Microphone	Audio
Camera	Video
Thermistor or other thermal sensor	Temperature
Potentiometer	Position
LVDT (Linear Variable Differential Transformer)	Position
Light sensor	
Computer	
switch	
etc...	

A transducer is a device which transforms one form of energy to another. Some sensors are transducers, many are not

Most often a signal comes from some other system.

Periodic waveforms: Waveshape repeats

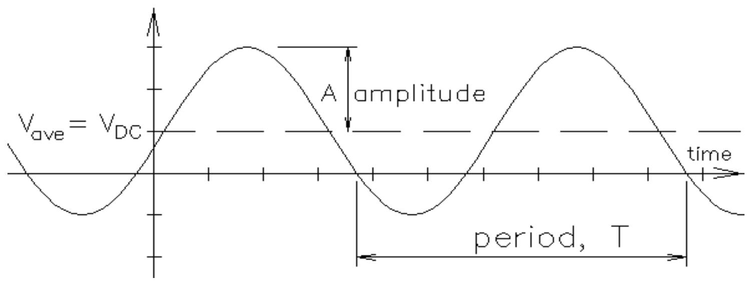
T = Period = repeat time

f = frequency, cycles / second $\quad f = \frac{1}{T} = \frac{\omega}{2\cdot\pi}$

ω = radian frequency, radians/sec $\quad \omega = 2\cdot\pi\cdot f$

A = amplitude

DC = average



Sinusoidal AC

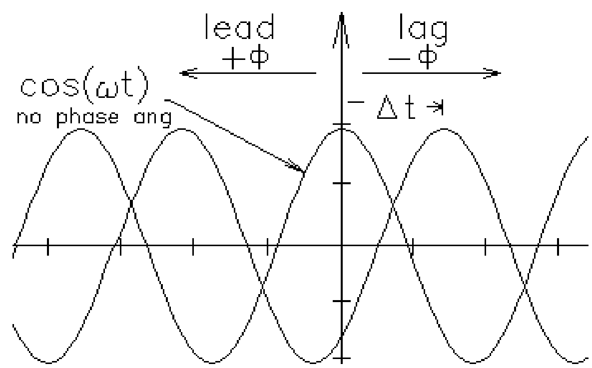
$y(t) = A\cdot\cos(\omega\cdot t + \phi)$

voltage: $v(t) = V_p\cdot\cos(\omega\cdot t + \phi)$

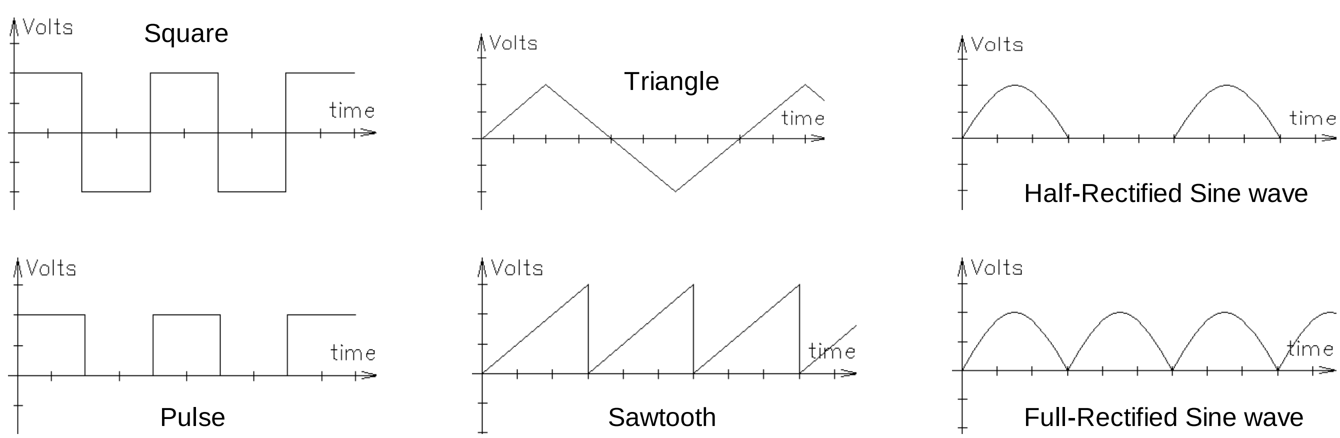
current: $i(t) = I_p\cdot\cos(\omega\cdot t + \phi)$

Phase: $\phi = -\frac{\Delta t}{T}\cdot 360\cdot deg$ or: $\phi = -\frac{\Delta t}{T}\cdot 2\cdot\pi\cdot rad$

Phase:



Other common periodic waveforms



All but the square and triangle waves have a DC component as well as AC.

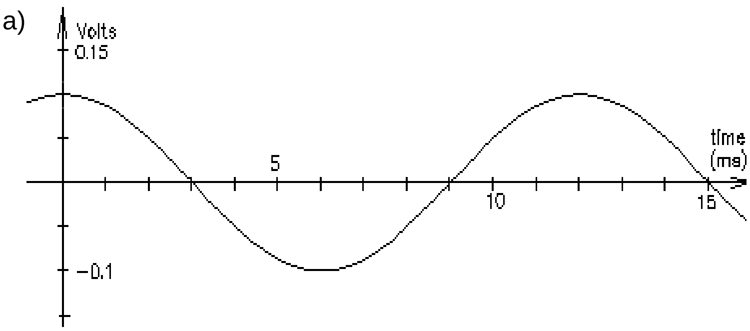
ECE 2210 / 00 homework # 7 Due: Fri, 9/18/20

1st exam on Fri. 9/22/20 <u>will</u> include this material

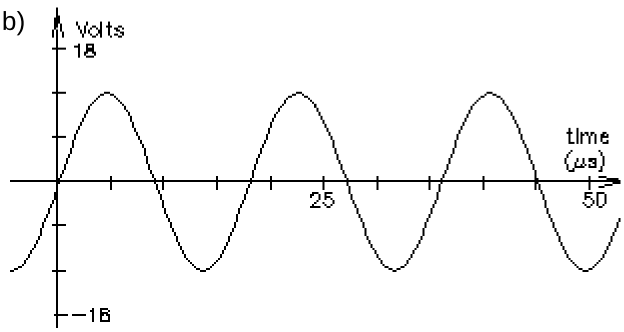
Answer the following problems on your own paper.

1. For each of the following sinusoidal waves, find:
   1) peak-to-peak voltage or current, V_{pp} or I_{pp}
   2) amplitude, A, V_p, or I_p
   3) period, T
   4) frequency f in cycles/sec or Hz
   5) an expression for $v(t)$ or $i(t)$ in terms of $A\cos(\omega t + \phi)$
      the frequency ω is in radians/sec
      the phase angle ϕ is in rad/sec or degrees

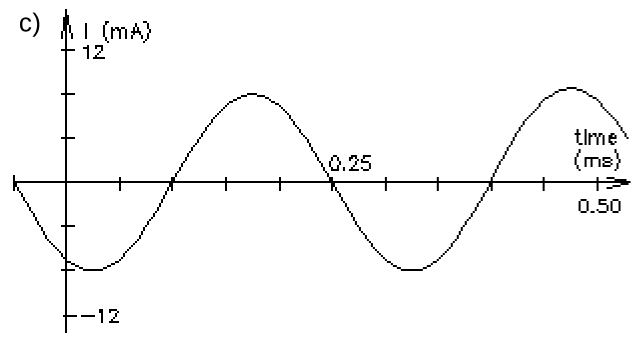
a)



b)

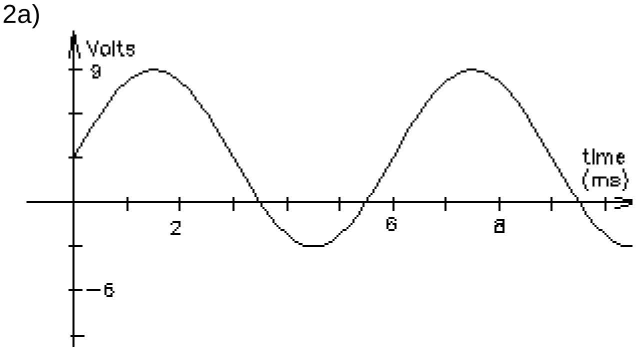


c)

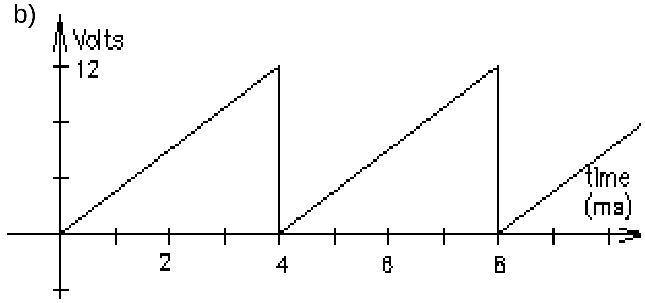


2. For each of the following waveforms, find:
   1) Peak-to-peak voltage or current, V_{pp} or I_{pp}
   2) Average, (V_{DC}, I_{DC}, V_{ave}, or I_{ave})
   3) Period, T
   4) Frequency f in cycles/sec or Hz

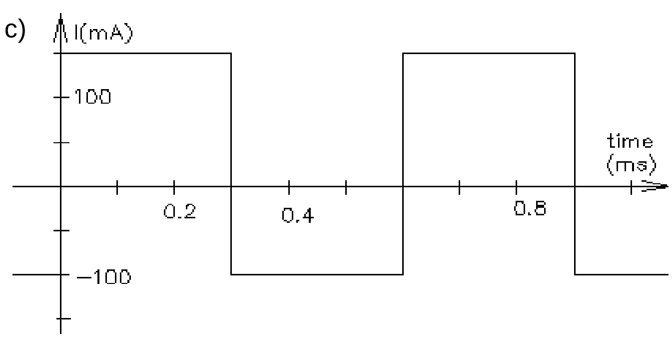
2a)



b)



c)



3. For problem 2a above, write a full expression for $v(t)$ in terms of $v(t) = A\cos(\omega t + \phi) + V_{DC}$

<u>Answers</u>

1. a) $0.2\cdot V$ $0.1\cdot V$ $12\cdot ms$ $83.3\cdot Hz$ $0.1\cdot V\cdot\cos(523.6\cdot t)$

   b) $24\cdot V$ $12\cdot V$ $0.018\cdot ms$ $55.6\cdot kHz$
   $v(t) := 12\cdot V\cdot\cos(349100\cdot t - 90\cdot deg)$

   c) $16\cdot mA$ $8\cdot mA$ $0.3\cdot ms$ $3333\cdot Hz$
   $8\cdot mA\cdot\cos(20940\cdot t + 150\cdot deg)$

2. a) $12\cdot V$ $3\cdot V$ $6\cdot ms$ $167\cdot Hz$

   b) $12\cdot V$ $6\cdot V$ $4\cdot ms$ $250\cdot Hz$

   c) $250\cdot mA$ $25\cdot mA$ $0.6\cdot ms$ $1.667\cdot kHz$

3. $v(t) := 6\cdot V\cdot\cos(1047\cdot t - 90\cdot deg) + 3\cdot V$