Alternating Current & Sine Waves

Session 2a of Basic Electricity
A Fairfield University E-Course
Powered by LearnLinc

Basic Electricity

Two Sections

- Electron Flow and Resistance
  - 5 on-line sessions
  - Lab
- Inductance and Capacitance
  - 5 on-line sessions
  - Lab

Mastery Test, Part 1

Basic Electricity (Continued)

- Text: "Electricity One-Seven," Harry Mileaf, Prentice-Hall, 1996, ISBN 0-13-889585-6 (Covers several Modules and more)
- References:
  - "Digital Mini Test: Principles of Electricity Lessons One and Two," SNET Home Study Coordinator, (203) 771-5400
  - Electronics Tutorial (Thanks to Alex Pounds at alex_tb@hotmail.com)
  - Electronics Tutorial (Thanks to Mark Sokos at sokos@desupernet.net)

Section 2:
Electron Flow and Resistance

- 0BJECTIVES: This section introduces AC voltage / current and additional circuit components (inductors, transformers and capacitors).

Section 1

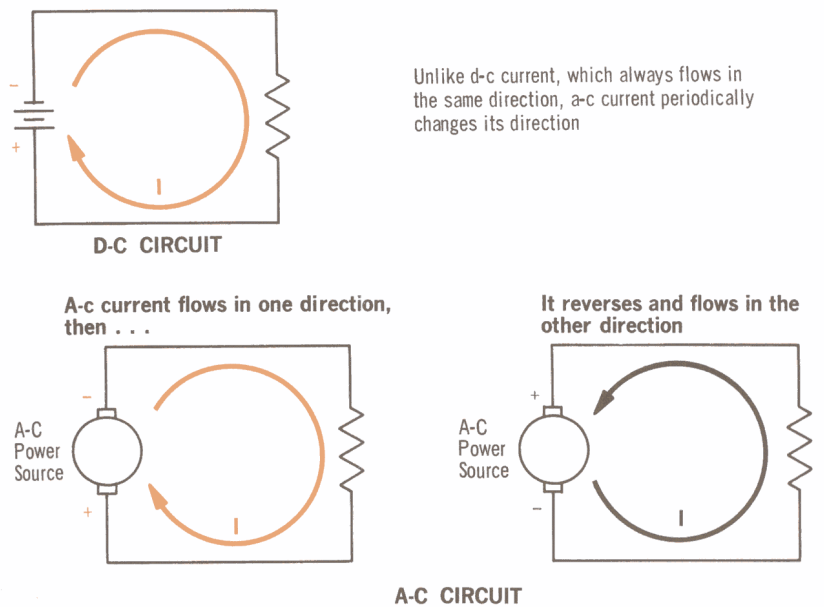
Session a – 03/04 *03/06 & 03/08 were Math Tutorials*	Atoms, Charge and Current	Text 1.1 – 1.39
	Conductivity (G), Electric Fields and Electromotive Force (EMF)	Text 1.40 – 1.68
Session b – 03/11	Resistance (R), Conductance (G), Ohms Law (Ω) & Power (Watts)	Text 2.1 – 2.52
Session c – 03/13 (lab - 03/16, sat.)	Resistors in Series and Parallel and Working with Equations	Text 2.53 – 2.98
Session d – 03/18	Series / Parallel Simplification Voltage and Current Dividers	2.99 – 2.115
Session e – 03/20	Kirchoff, Thevenin & Norton	2.116 – 2.133
Session f – 03/25	Review (Discuss Quiz_1)	1.42, 1.63, 2.5, 2.129 Sokos

Section 2 Schedule:

Session 2a – 03/27	**Alternating Current & Sine Waves**	**Text 3.1 – 3.41**
Vector Math – 04/01	Sine Waves, Magnitude, Phase and Vectors	Text 4.1 – 4.24
Session 2b – 04/03	Inductors and Circuits	Text 3.42 – 3.75
Session 2c – 04/08	Transformers	Text 3.76 – 3.100
Session 2d – 04/10 (lab - 04/13, Sat.)	Capacitors	Text 3.101 – 3.135
Session 2e – 04/15	More Capacitors	Text 3.135 – 3.148
Session 2f – 04/22	Review (Discuss Quiz_2)	

AC Current

- DC current
  - Always flows in one direction
- AC current
  - Changes direction at regular intervals

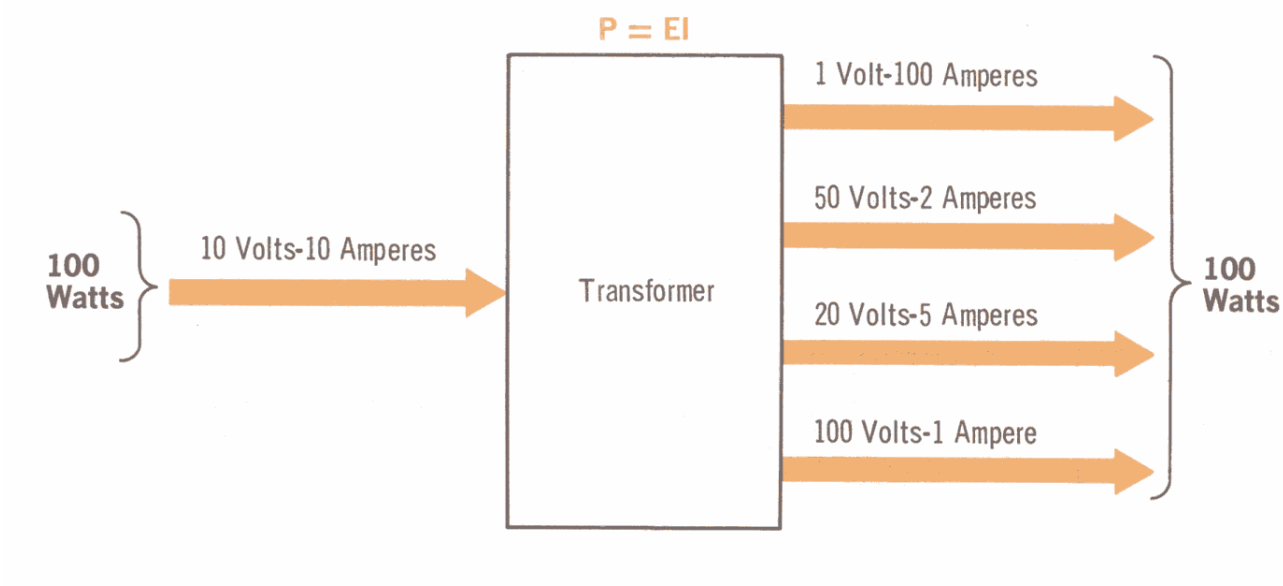


AC vs. DC

- Thomas Alva Edison
  - Began the electrical power industry by inventing:
    - The incandescent electric light
    - The first practical electric power station
  - These inventions and his project to “light” a NYC neighborhood started:
    - Commonwealth Edison Company (and its siblings)
    - General Electric
  - Edison was a strong proponent of using DC power
    - He didn’t recognize the value of transformers

AC and Transformers

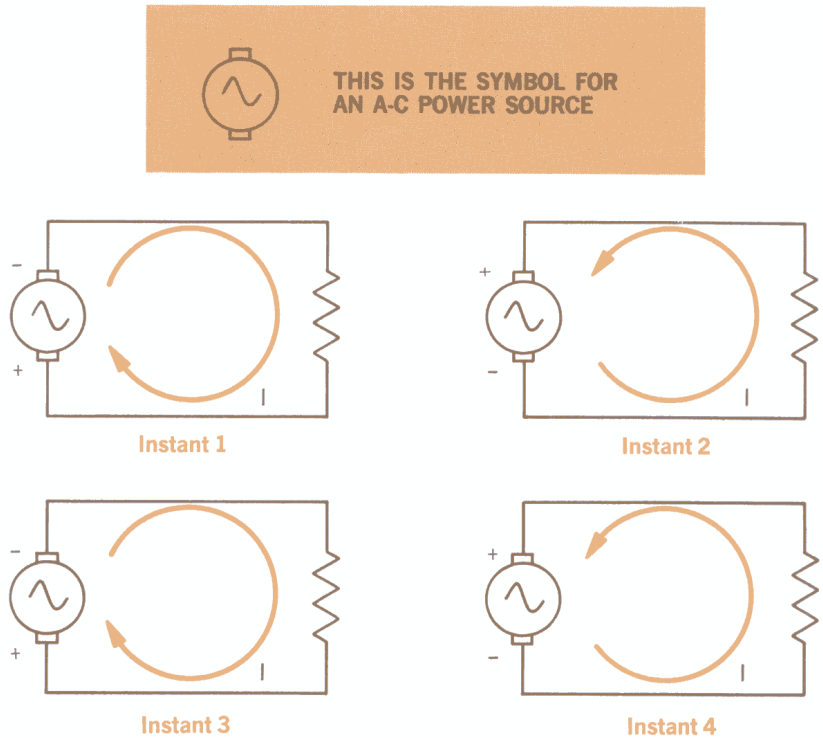
- Power is conserved from input to output
- P = V*I, the transformer changes the ratio
- Only works for AC, Transformers can't deal with DC.



Either one at a time or the total output power equals the total input power

AC in Circuits

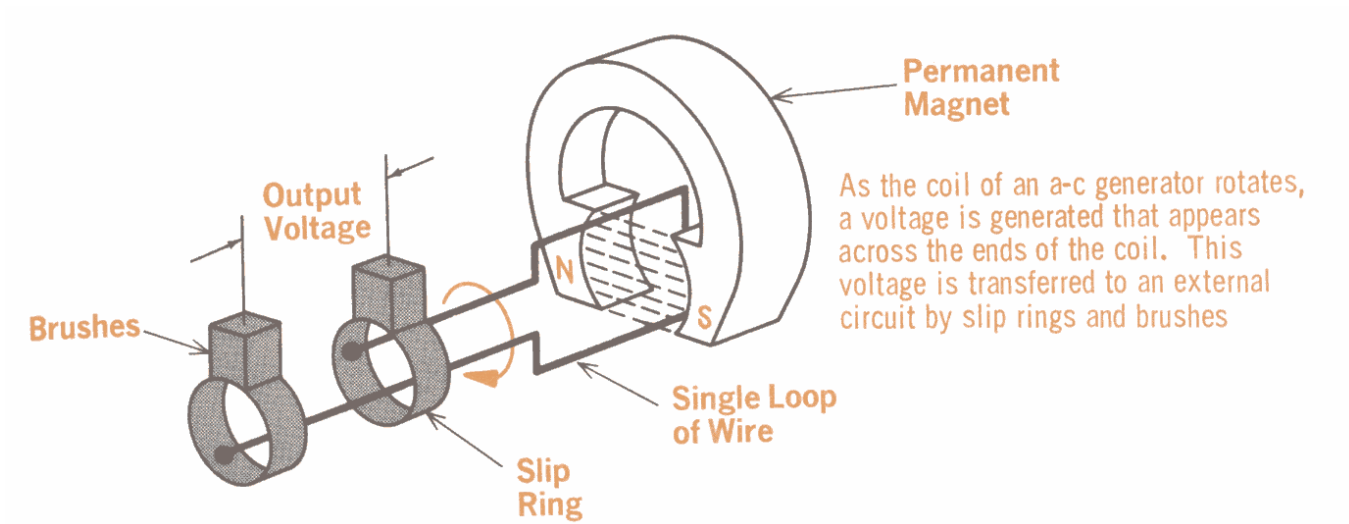
- An AC voltage "pushes" (pulls) an AC Current in a resistor circuit.
- Ohm's Law still applies (V = I*R)



The polarity of a-c power sources changes continuously. Each time the polarity reverses, the circuit current also changes direction

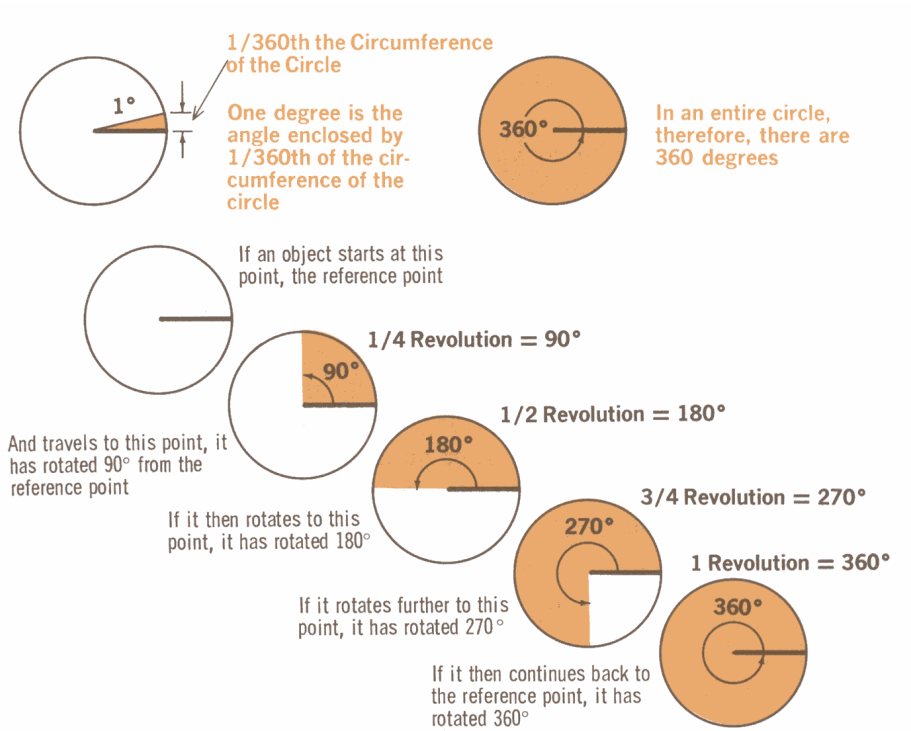
An AC Generator

- A coil of wire rotating in a Magnetic field will generate an AC voltage / current



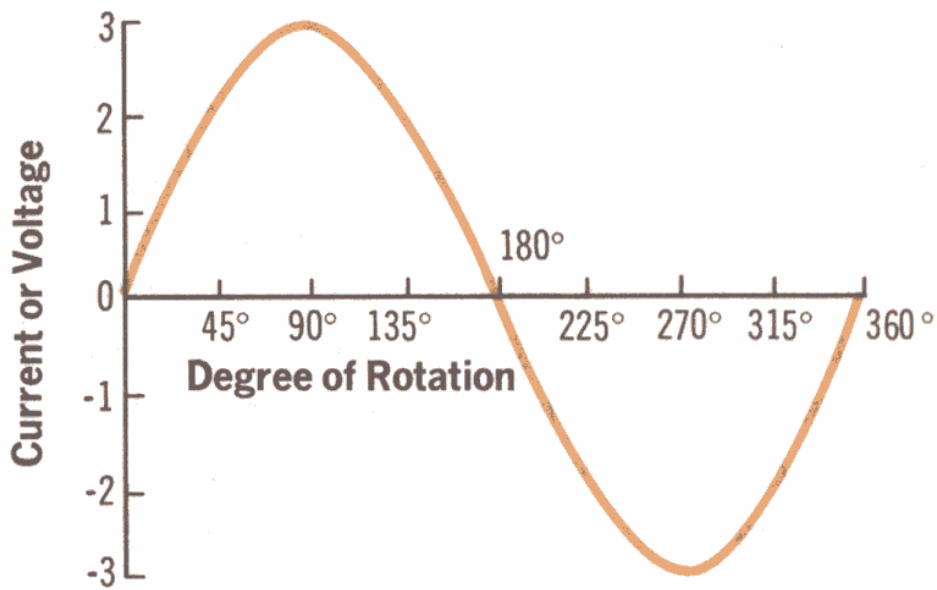
Angle: Degrees and Radians

- Degrees, minutes and seconds
  - 360° gets you around a circle
    - Invented by map makers in the middle ages
    - Reused for Time measurements
- Radians (in calculators)
  - 2 * π (2 * 3.14159) gets you around a circle
    - The real angle measure
    - The distance traveled around the perimeter of a "unit" circle (r = 1)



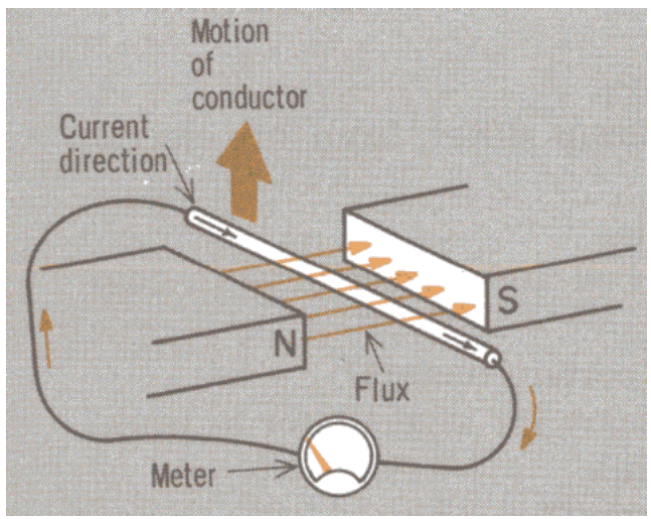
Sine Waves and Angle

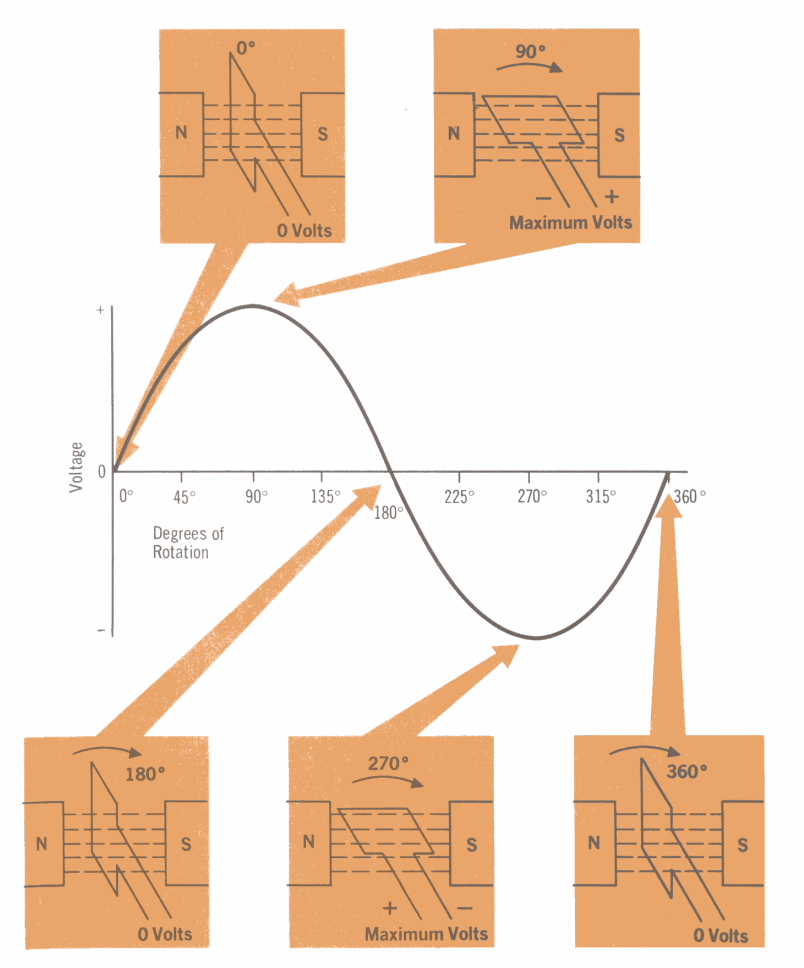
- V = 3*sine (angle)
  - Sine often shortened to sin [V = 3*sin(angle)]
  - 3 is the "Amplitude"
  - Starts at zero
  - Peak (3) at 90°(π/2)
  - Zero again at 180°(π)
  - Negative Peak (-3) at 270°(3*π/2)
  - Zero to Finish the "Cycle" at 360°(2*π)



AC Generator and Sine Waves

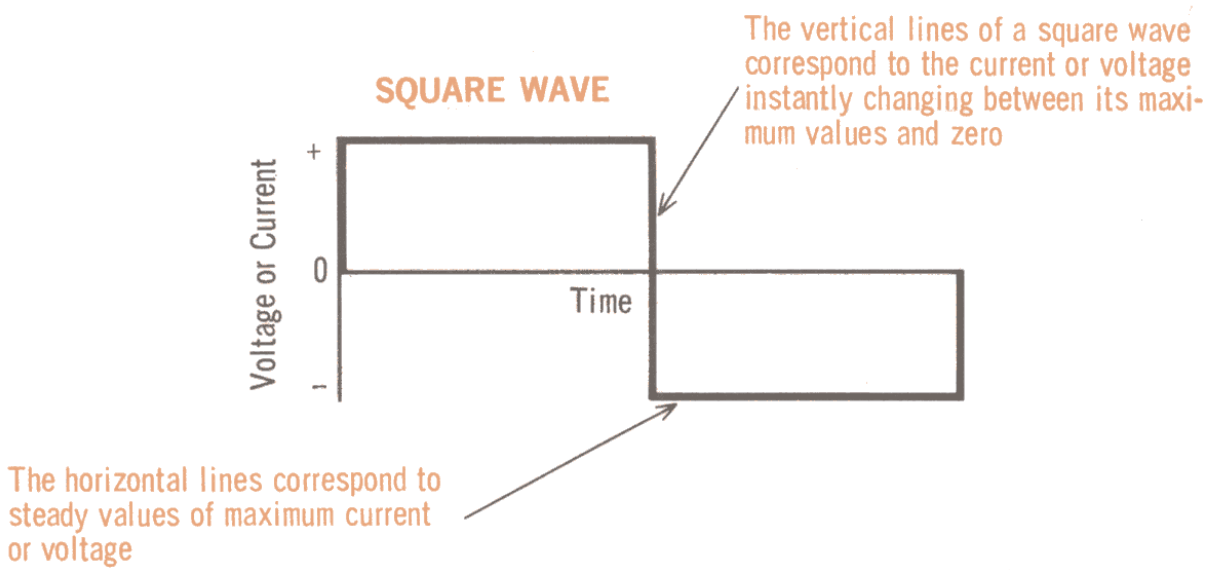
- The AC generator's output is a sine wave
- Vertical speed of the left & right parts of the coil determines the value at any time





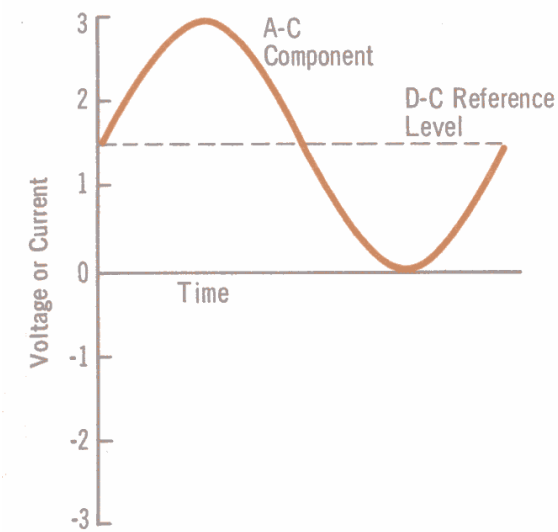
Square Waves

- There are other wave shapes ("Fluctuating DC")
- Square waves are the basis for computer logic – later in this course



AC and DC Together

- Superposition again
  - Deal with each frequency term independently
  - DC is the zero frequency component of the waveform, it is also the "average" value over a full cycle of the waveform.

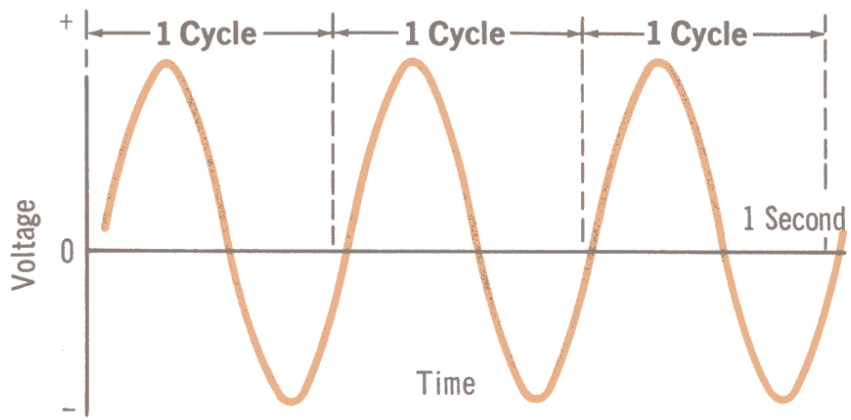


When a d-c voltage or current varies in an a-c way, it does not change direction. However, it fluctuates around the d-c reference level in exactly the same way that ac fluctuates around the zero level

Frequency and "Cycles"

- Cycles per second is the frequency in Hertz (Hz)

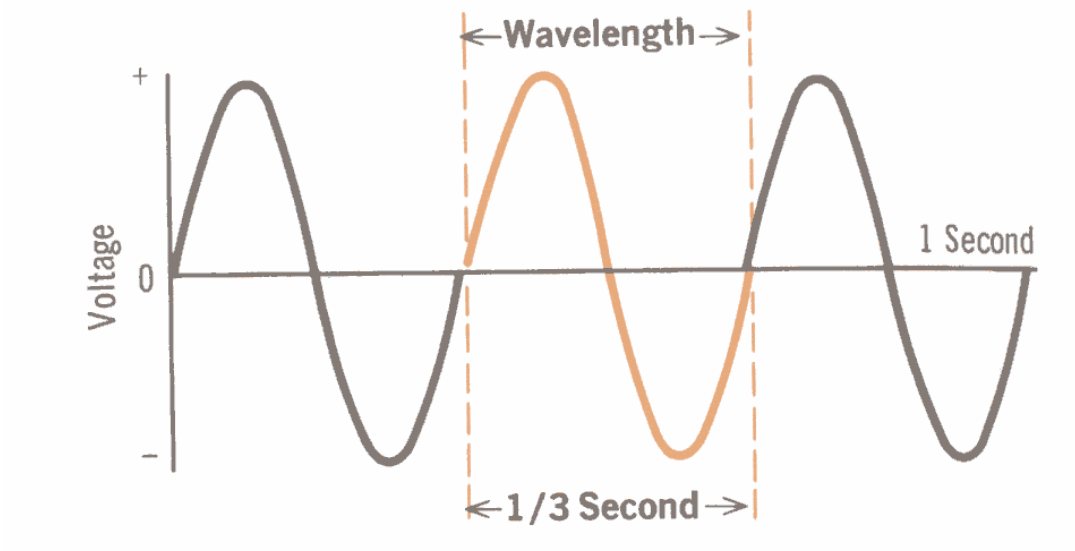
Unit	Hertz (Hz)	Kilohertz (KHz)	Megahertz (MHz)	GigaHertz (GHz)
Value	1	1000	1,000,000	1,000,000,000



The frequency of a voltage or current is the number of cycles generated each second. The frequency of this voltage is, therefore, 3 Hz

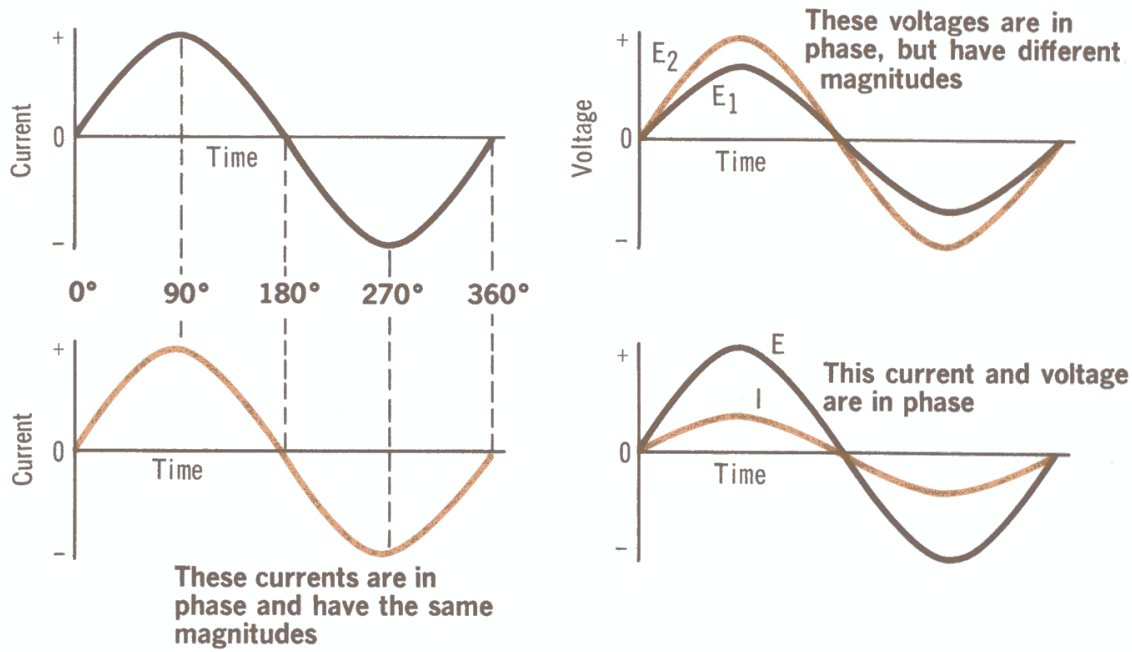
Period and Wavelength

- The period is “How long does a cycle take” (T in seconds)
- The Wavelength is “How far does the signal travel in one cycle” (λ in meters)



In-Phase Voltages/Currents

- In a resistive circuit, the current is “in-phase” with the voltage. (They move together)



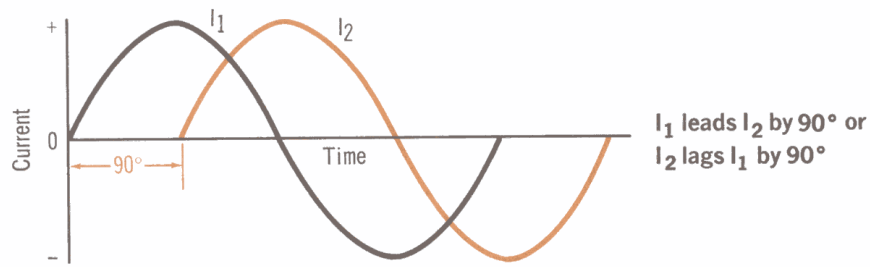
Phase Difference

- Waveforms can be “out of phase”
- Note:

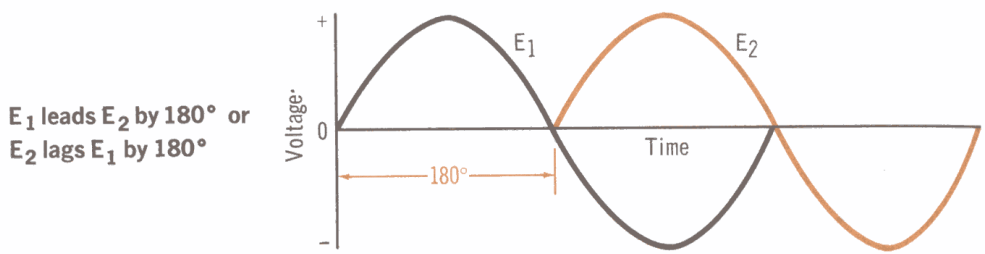
$\sin(2\pi ft - \pi/2) = \cos(2\pi ft)$

Cosine is the full name

  - Starts at 1 at t = 0
  - Looks just like sine but at a different phase

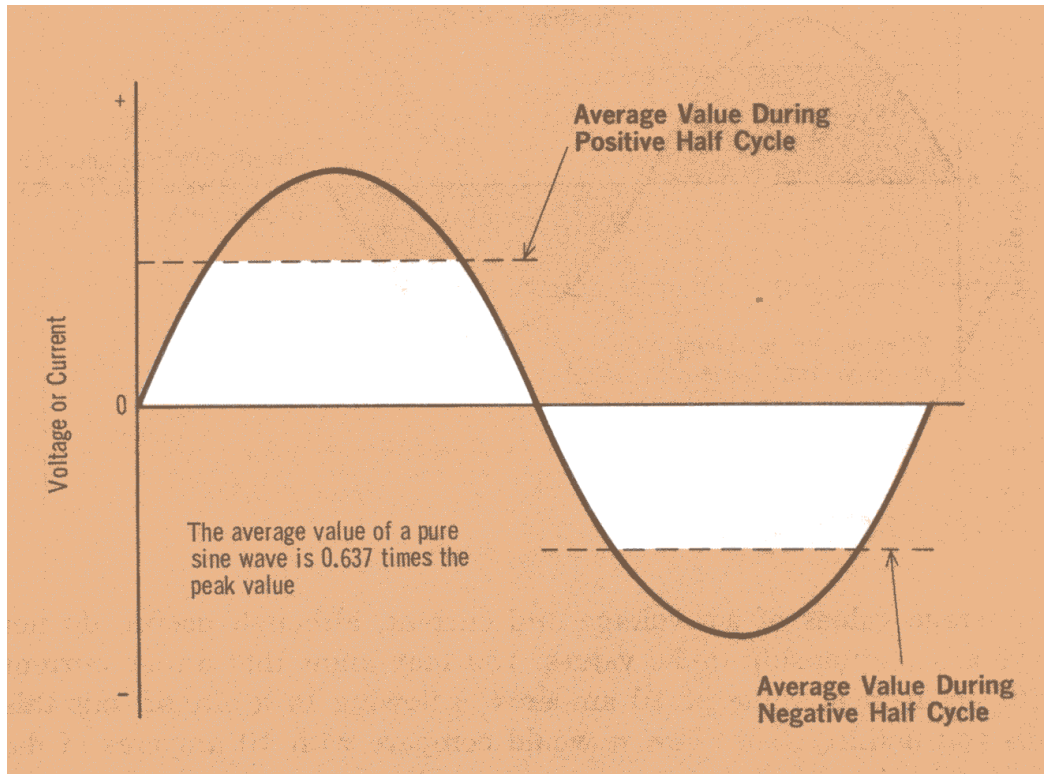


When maximum and minimum points of one voltage or current occur before the corresponding points of another voltage or current, the two are out of phase. When such a phase difference exists, one of the voltages or currents leads, and the other lags



Waveform Average

- "Average"
  - Book: over a half cycle
  - Normal: over a full cycle (DC)
- "Half-Cycle" average is important later in AC to DC conversion (rectification)



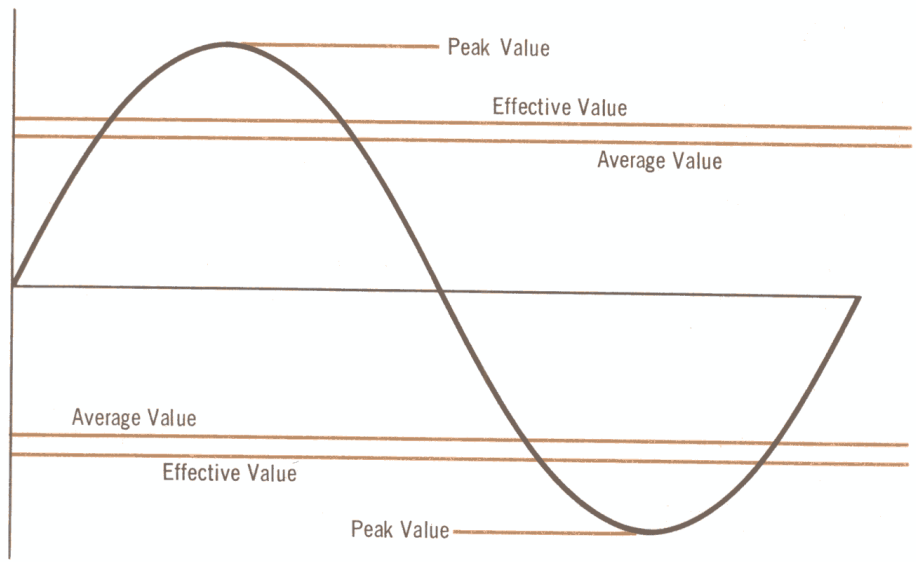
RMS vs Peak value

- The Peak value is the Amplitude
- The "Effective" or RMS value is used in the Power Equation ($P = I_{eff} * V_{eff}$)
- "Root Mean Square"

  Square the values of the waveform.

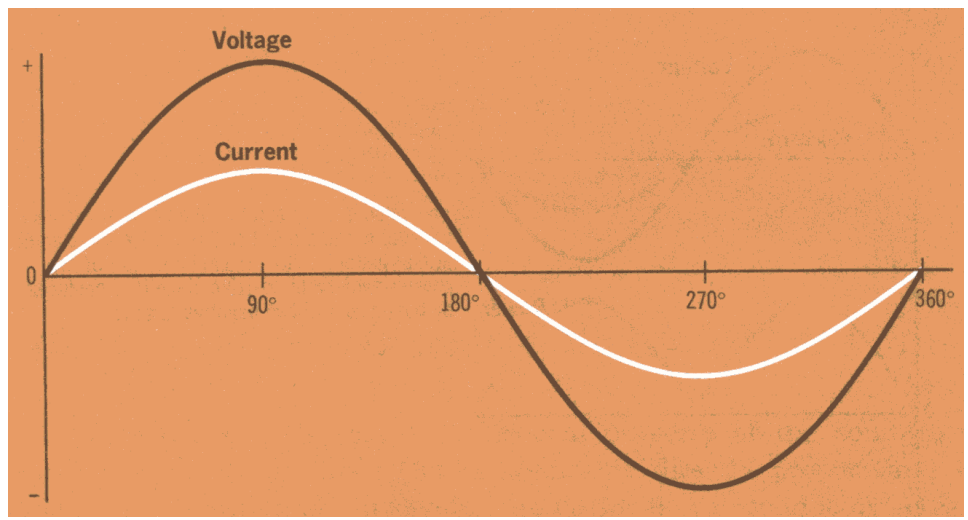
  Now take the average over a cycle

  Take the square root.



AC Current with a Resistor Load

- Ohm's Law
- $I = V / R$
- $I = 10*\sin(2\pi ft)/10$
- $I = 1*\sin(2\pi ft)$
- $I = \sin(2\pi ft)$



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