Basics of Electrical Technology

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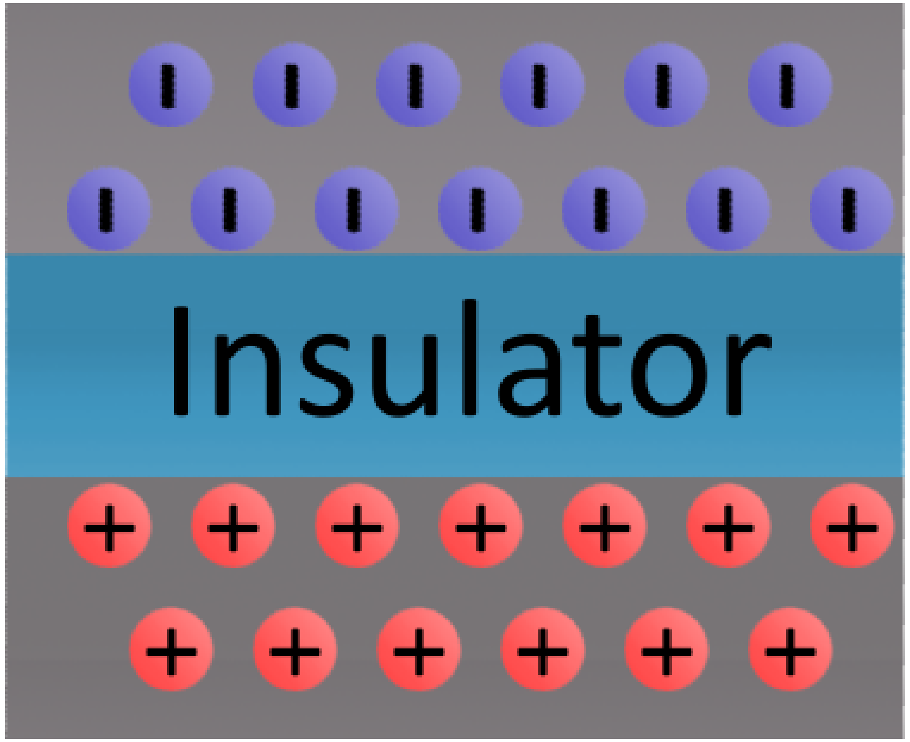
Electricity is all around us--powering technology like our cell phones, computers, lights, soldering irons, and air conditioners. It's tough to escape it in our modern world. Even when you try to escape electricity, it's still at work throughout nature, from the lightning in a thunderstorm to the synapses inside our body. But what exactly *is* electricity? This is a very complicated question, and as you dig deeper and ask more questions, there really is not a definitive answer, only abstract representations of how electricity interacts with our surroundings.

Electricity

- Static Electricity
- Current Electricity

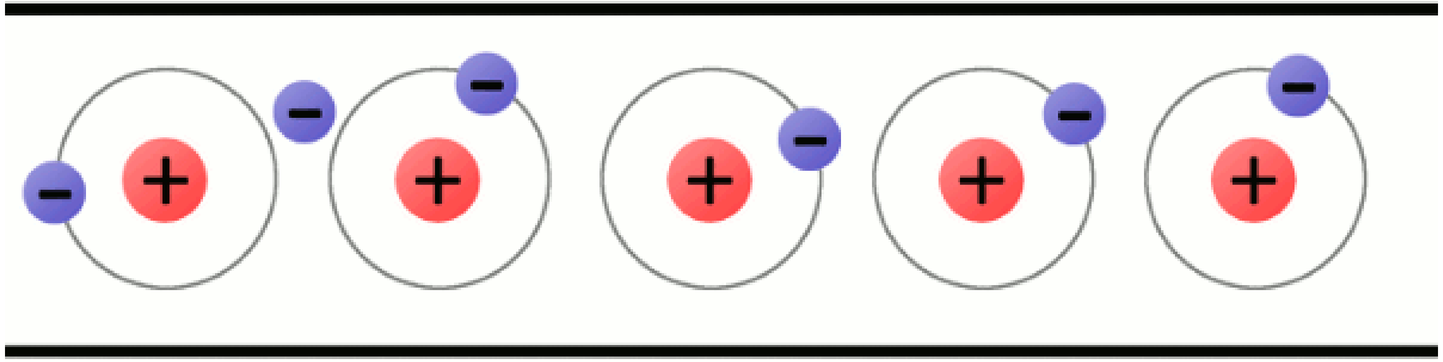
Static Electricity

Static electricity exists when there is a build-up of opposite charges on objects separated by an insulator. Static (as in "at rest") electricity exists until the two groups of opposite charges can find a path between each other to balance the system out.



When the charges do find a means of equalizing, a **static discharge** occurs. The attraction of the charges becomes so great that they can flow through even the best of insulators (air, glass, plastic, rubber, etc.). Static discharges can be harmful depending on what medium the charges travel through and to what surfaces the charges are transferring.

Current Electricity



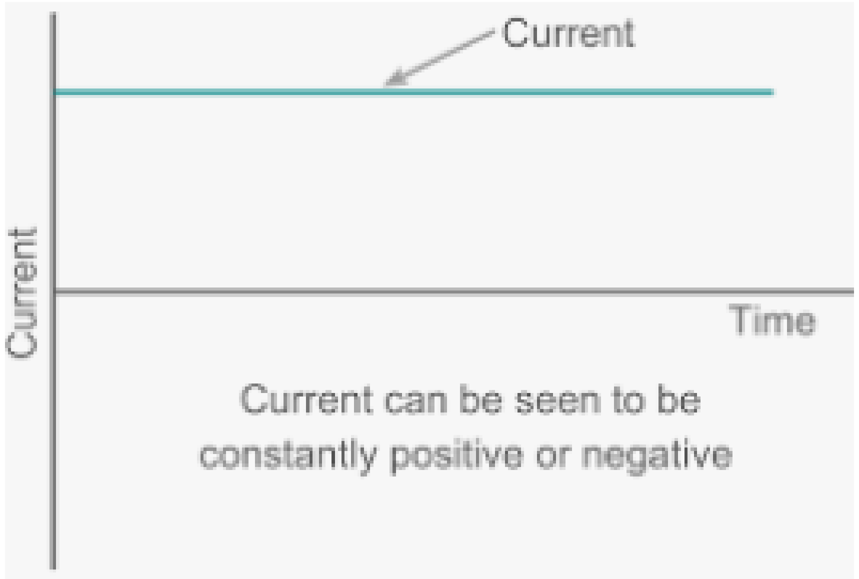
A very simplified model of charges flowing through atoms to make current.

What is Current Electricity? Current or dynamic electricity is defined as an electrical charge in motion. It consists of a flow of negatively charged electrons from atom to atom through a conductor in an electrical circuit. The external force that causes the electron current flow of electric charge is called the electromotive force (emf) or voltage.

Current Electricity

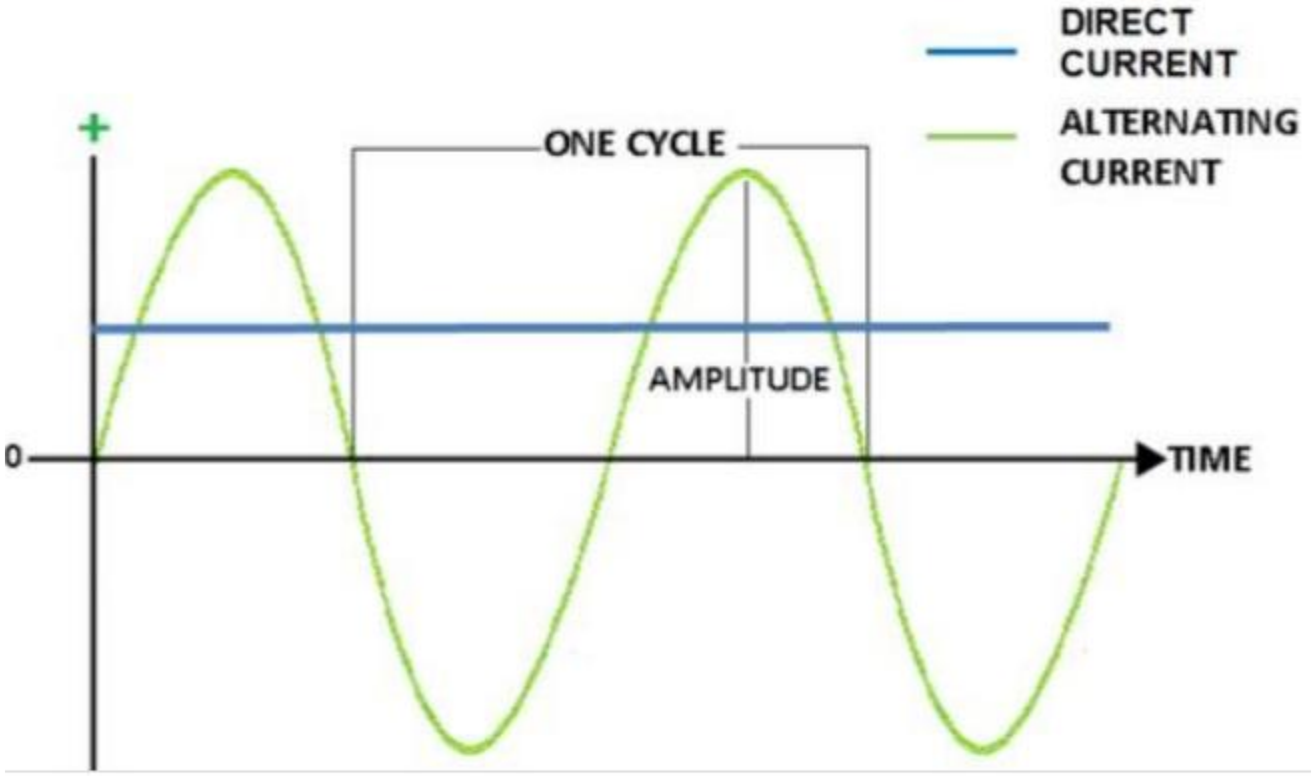
- Direct Current (DC)
- Alternative Current (AC)

Direct Current



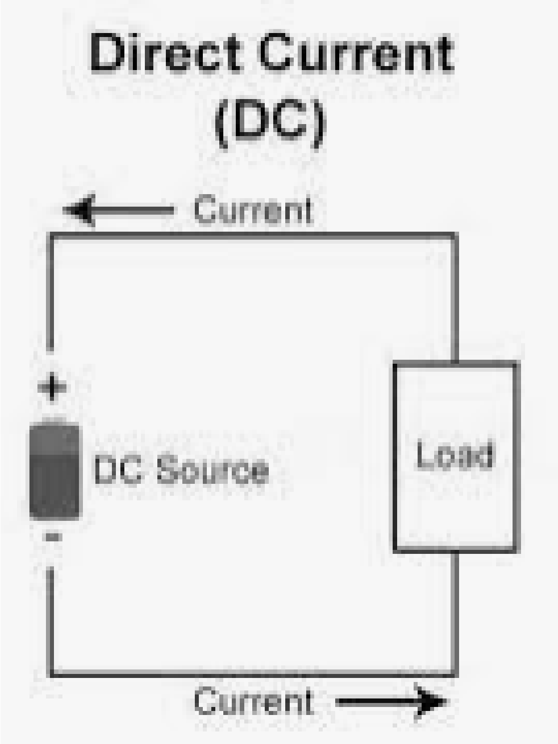
Direct **current** (**DC**) is the one directional flow of electric charge. An electrochemical cell is a prime example of **DC power**. Direct **current** may flow through a conductor such as a wire, but can also flow through semiconductors, insulators, or even through a vacuum as in electron or ion beams.

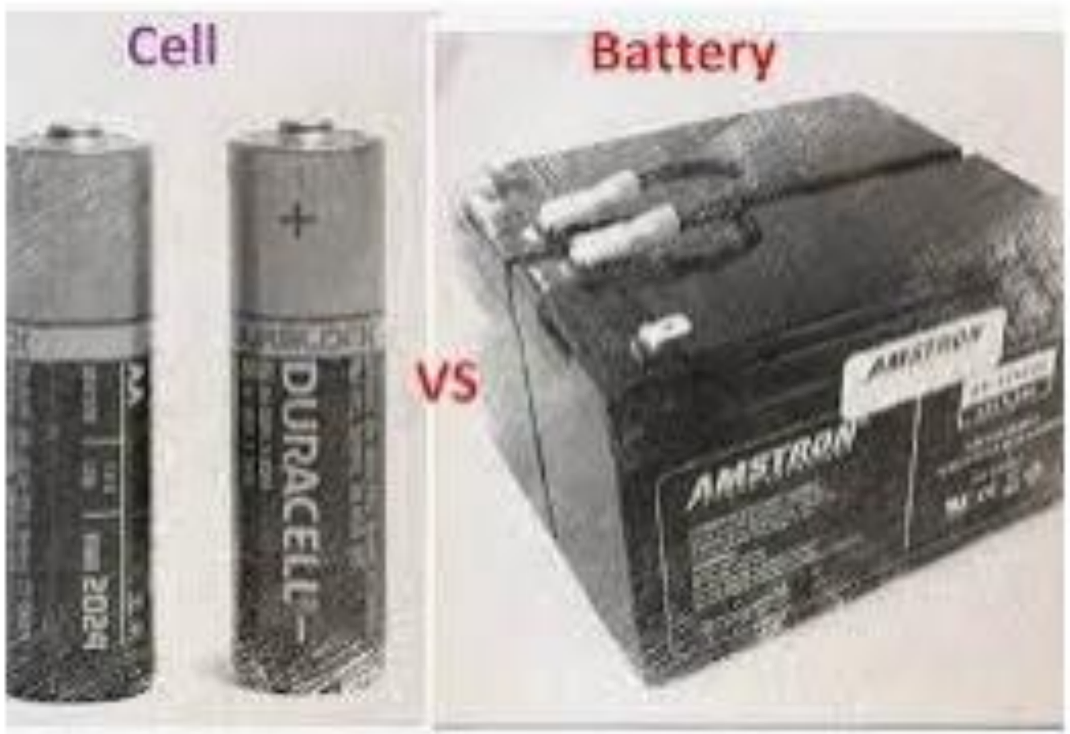
Alternating Current



Alternating current (**AC**) is an electric **current** which periodically reverses direction and changes its magnitude continuously with time in contrast to direct **current** (DC) which flows only in one direction.

DC Sources


Direct Current
(DC)
Current
+
DC Source
Load
-
Current

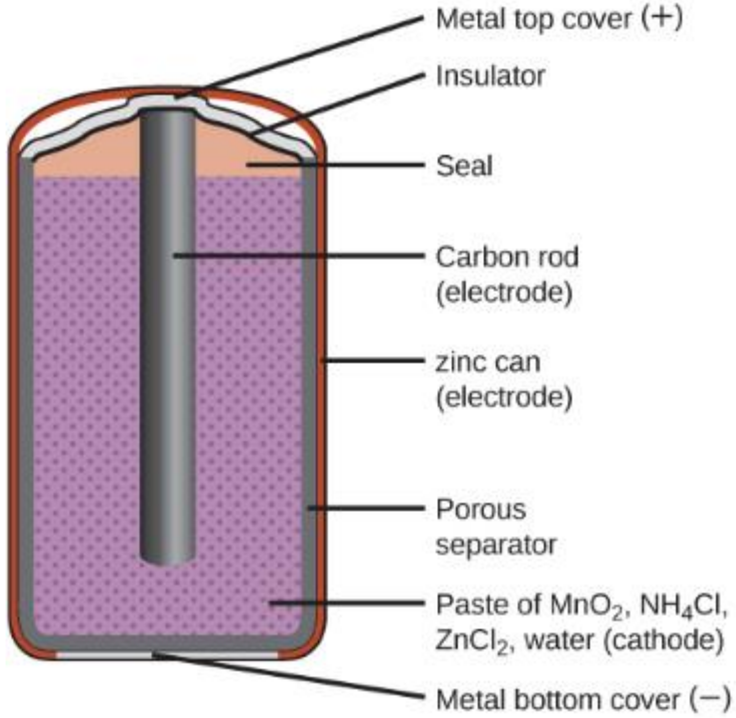

Cell
VS
Battery
DURACELL
AMSTRON

Difference between cell and battery:

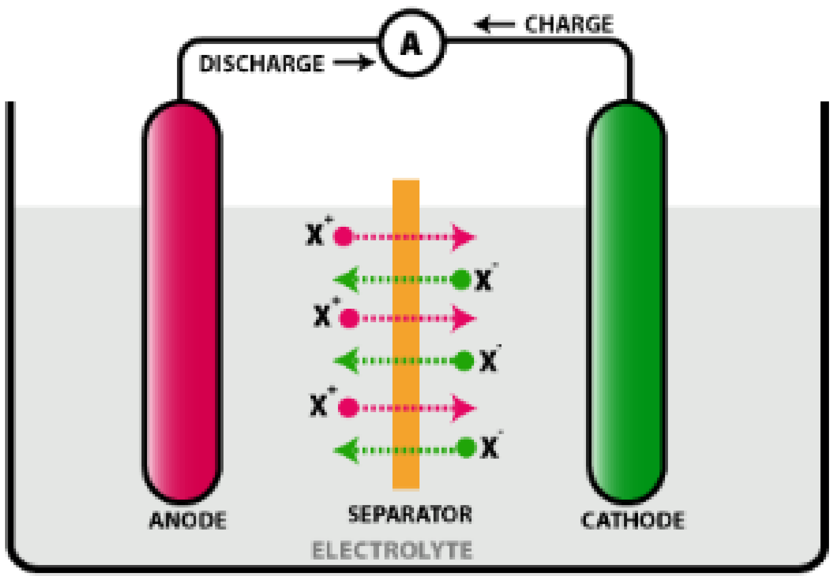
Battery or Cell, both are used to store the electrical energy in the form of chemical energy or converting electrical energy into chemical energy and Chemical energy to electrical energy. One of the solid difference between cell and battery is cell is consisting of single unit and battery consists of multiple units.

Primary Cell

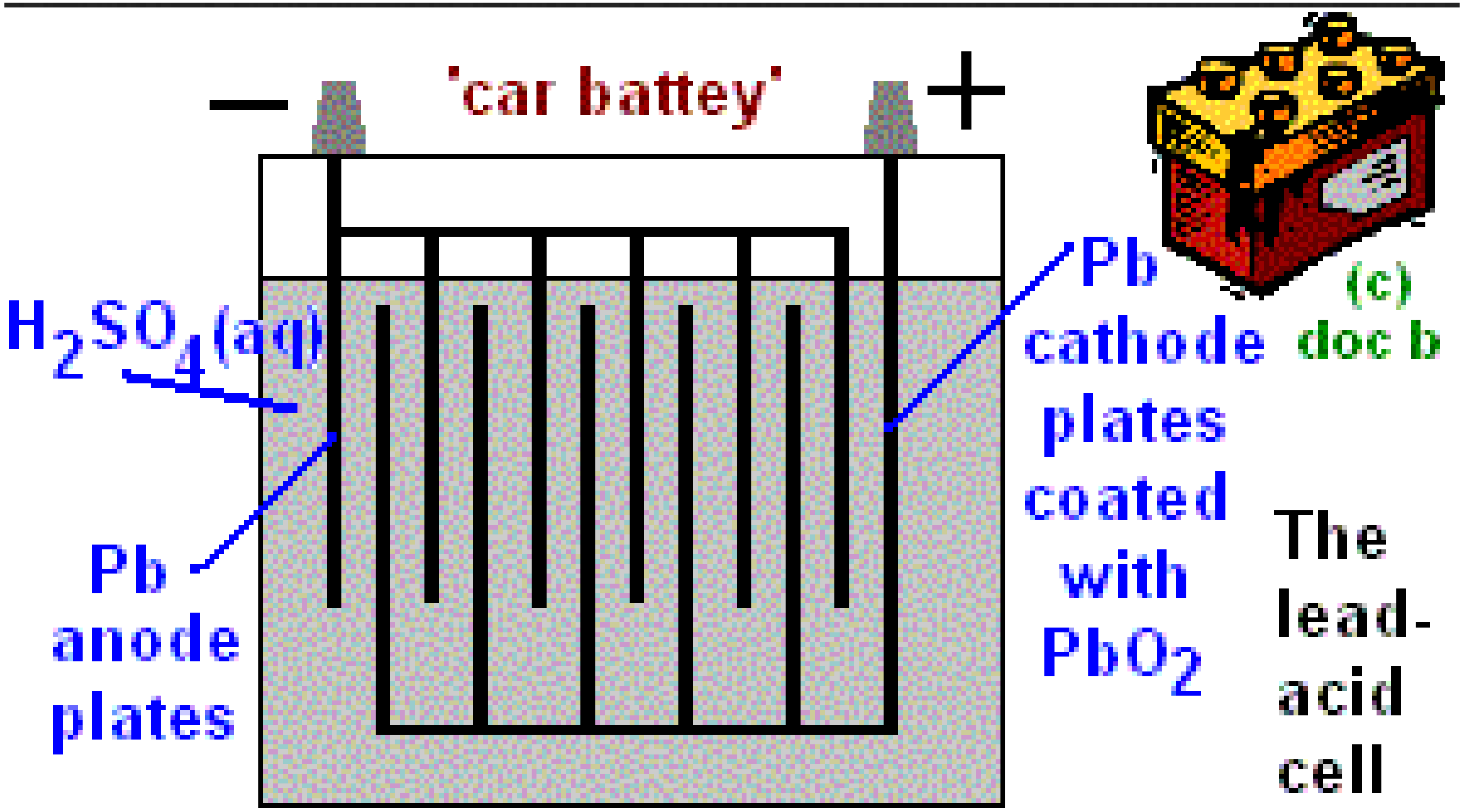
A **primary cell** is a **battery** (a galvanic **cell**) that is designed to be used once and discarded, and not recharged with electricity and reused like a secondary **cell** (rechargeable **battery**). In general, the electrochemical reaction occurring in the **cell** is not reversible, rendering the **cell** unrechargeable.

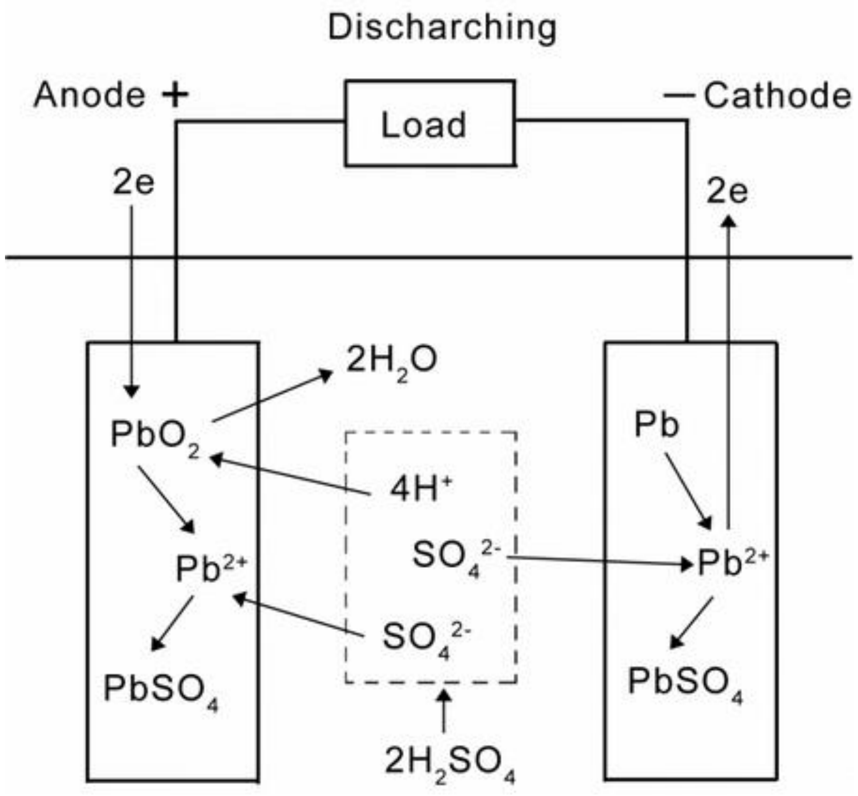


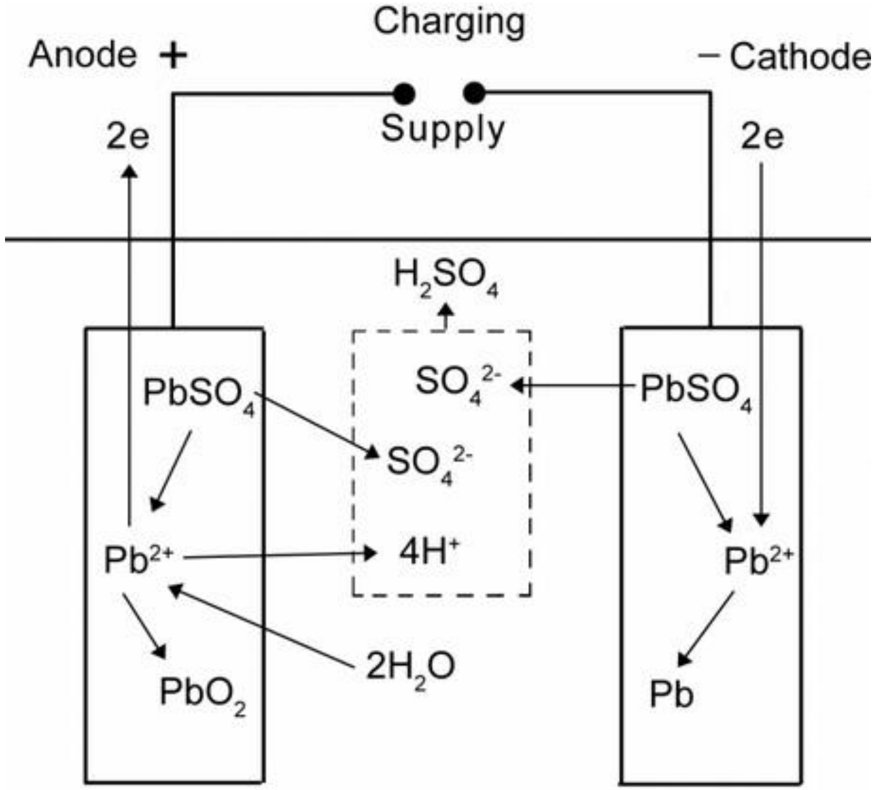
Secondary Cell



A **secondary cell** or **battery** is one that can be electrically recharged after use to their original pre-discharge condition, by passing current through the circuit in the opposite direction to the current during discharge.


'car battey'
−
+
$H_2SO_4(aq)$
Pb anode plates
Pb cathode plates coated with PbO_2
(c) doc b
The lead-acid cell


Discharching
Anode +
Load
− Cathode
2e
2e
$2H_2O$
PbO_2
$4H^+$
Pb^{2+}
SO_4^{2-}
SO_4^{2-}
Pb
Pb^{2+}
$PbSO_4$
$PbSO_4$
$2H_2SO_4$


Charging
Anode +
− Cathode
Supply
2e
2e
H_2SO_4
$PbSO_4$
SO_4^{2-}
$PbSO_4$
SO_4^{2-}
$4H^+$
Pb^{2+}
Pb^{2+}
$2H_2O$
PbO_2
Pb

Equation 1
Electrolyte

$$H_2SO_4 \rightleftharpoons H^+ + HSO_4^-$$

Equation 2
Negative Electrode

$$Pb_{(metal)} + HSO_4^- \underset{\text{Charge}}{\overset{\text{Discharge}}{\rightleftharpoons}} PbSO_4 + H^+ + 2e^-$$

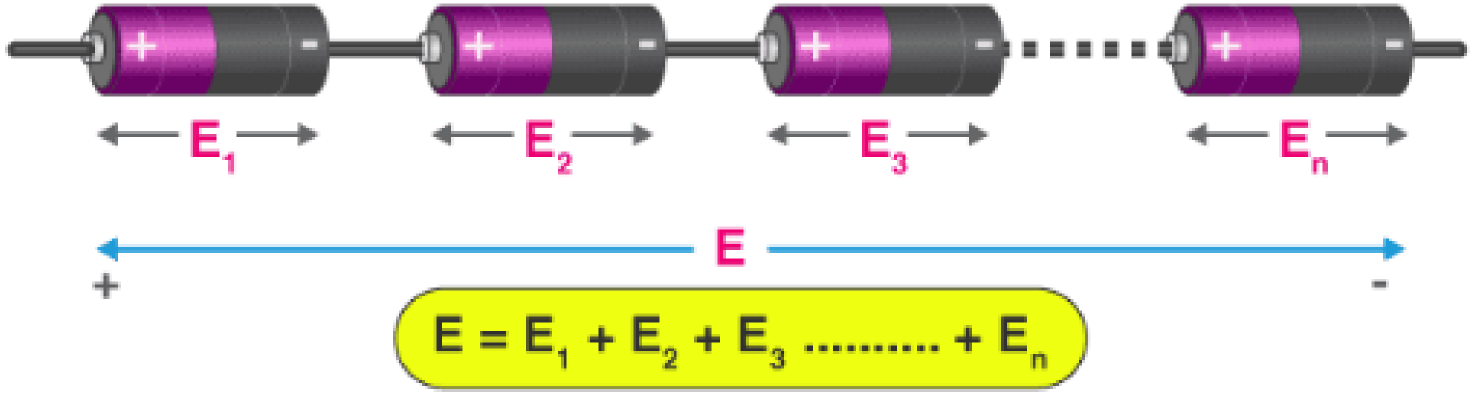
Equation 3
Positive Electrode

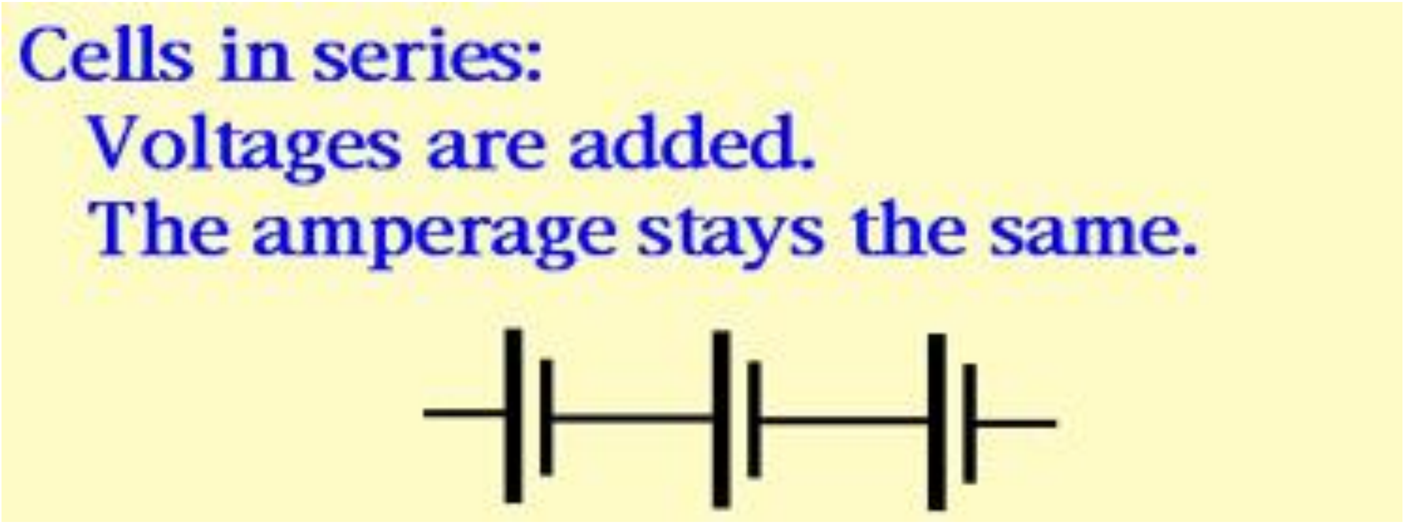
$$PbO_2 + 3H^+ + HSO_4^- + 2e^- \underset{\text{Charge}}{\overset{\text{Discharge}}{\rightleftharpoons}} PbSO_4 + 2H_2O$$

Equation 4
Total Reaction

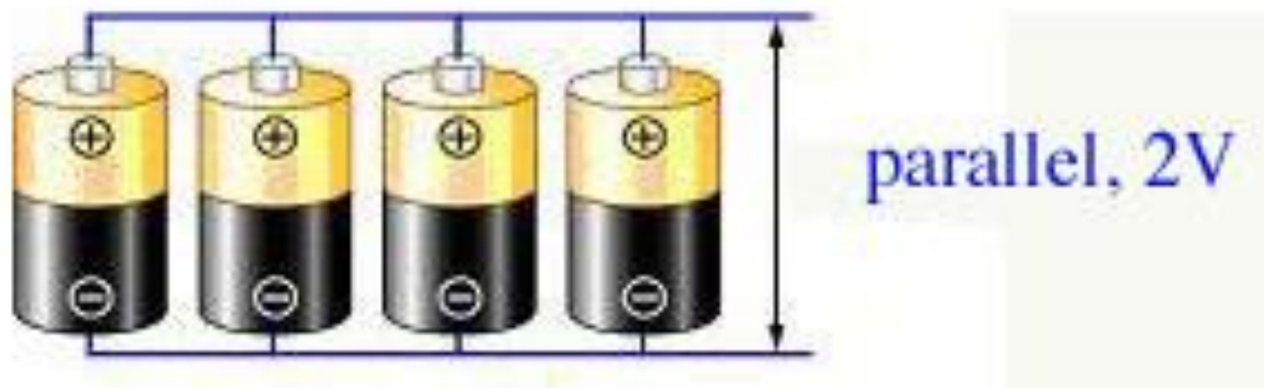
$$Pb_{(metal)} + PbO_2 + 2H_2SO_4 \underset{\text{Charge}}{\overset{\text{Discharge}}{\rightleftharpoons}} 2PbSO_4 + 2H_2O$$

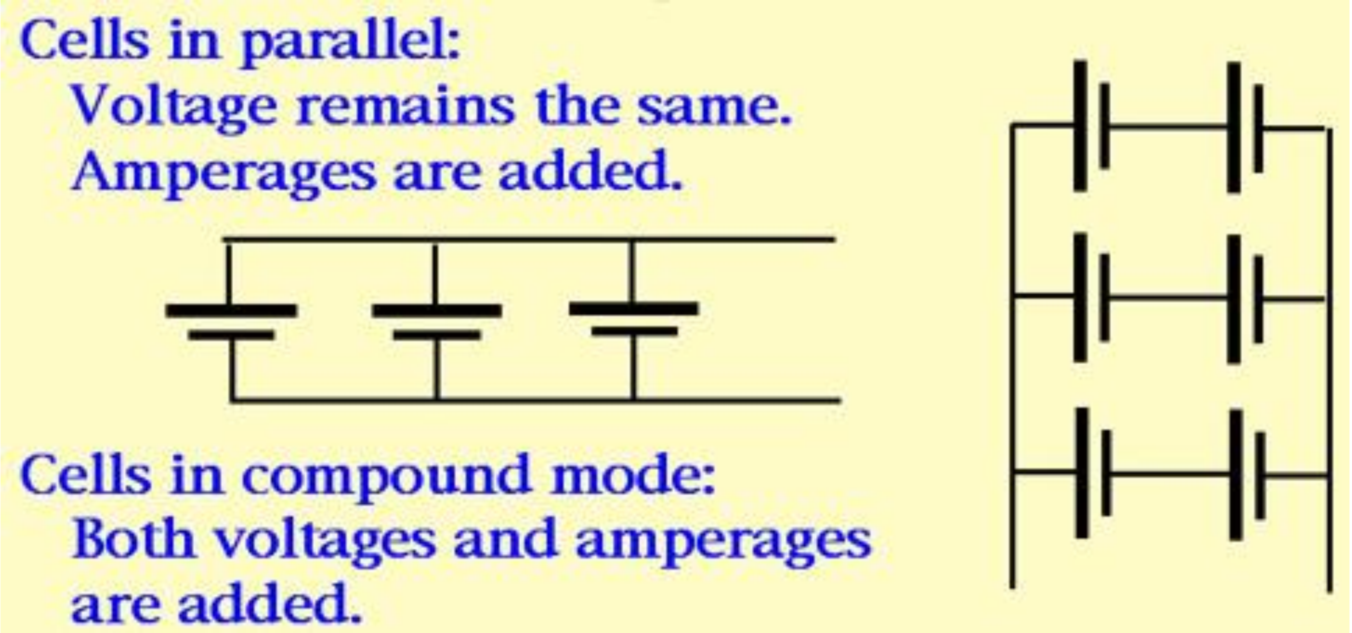
Cells in Series Connection





Cells in Parallel Connection



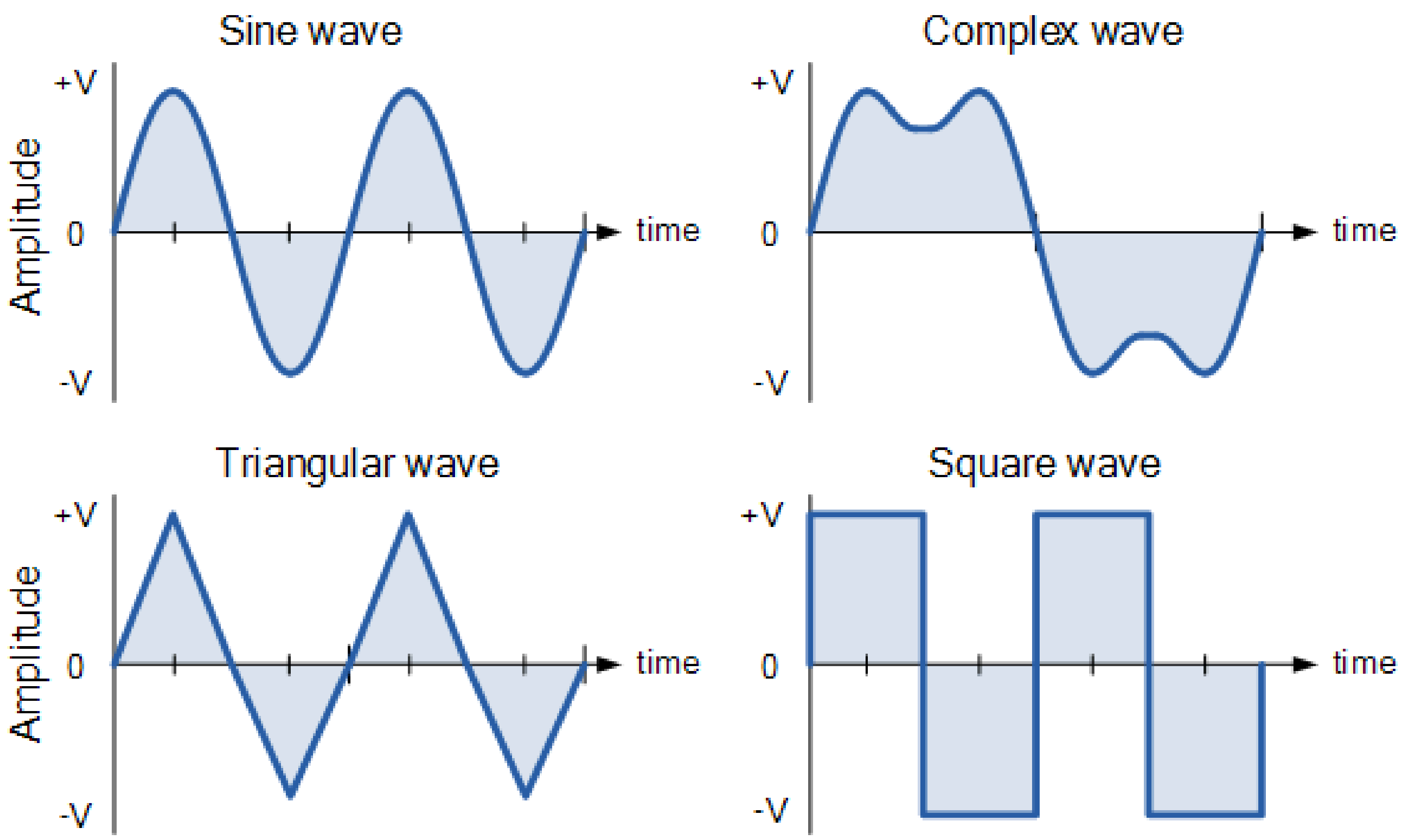


Questions ….

AC Voltage Sources

- Mega scale power stations
- AC Generators
- Wind power stations

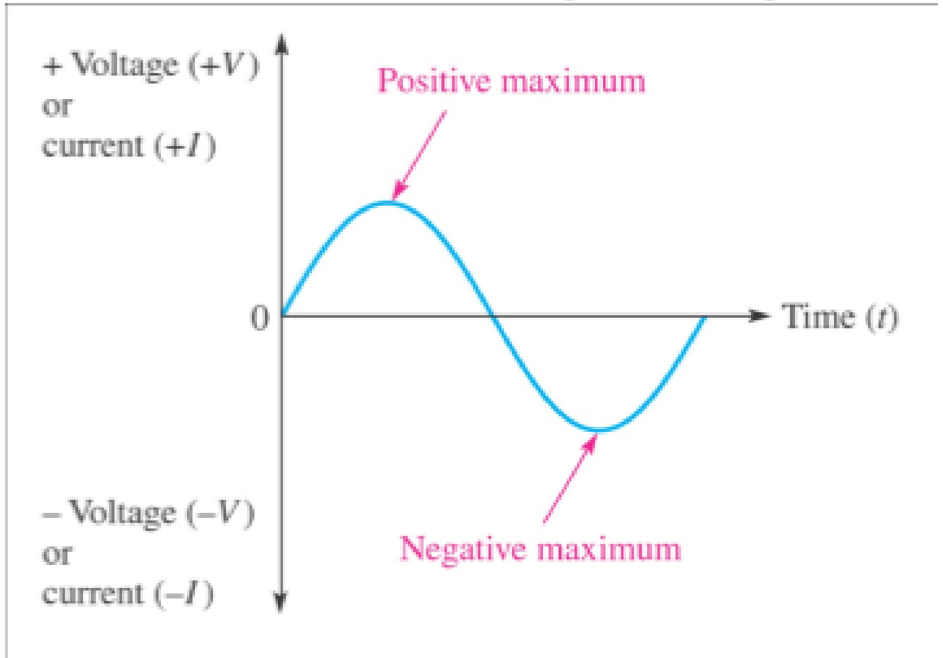
AC Wave form



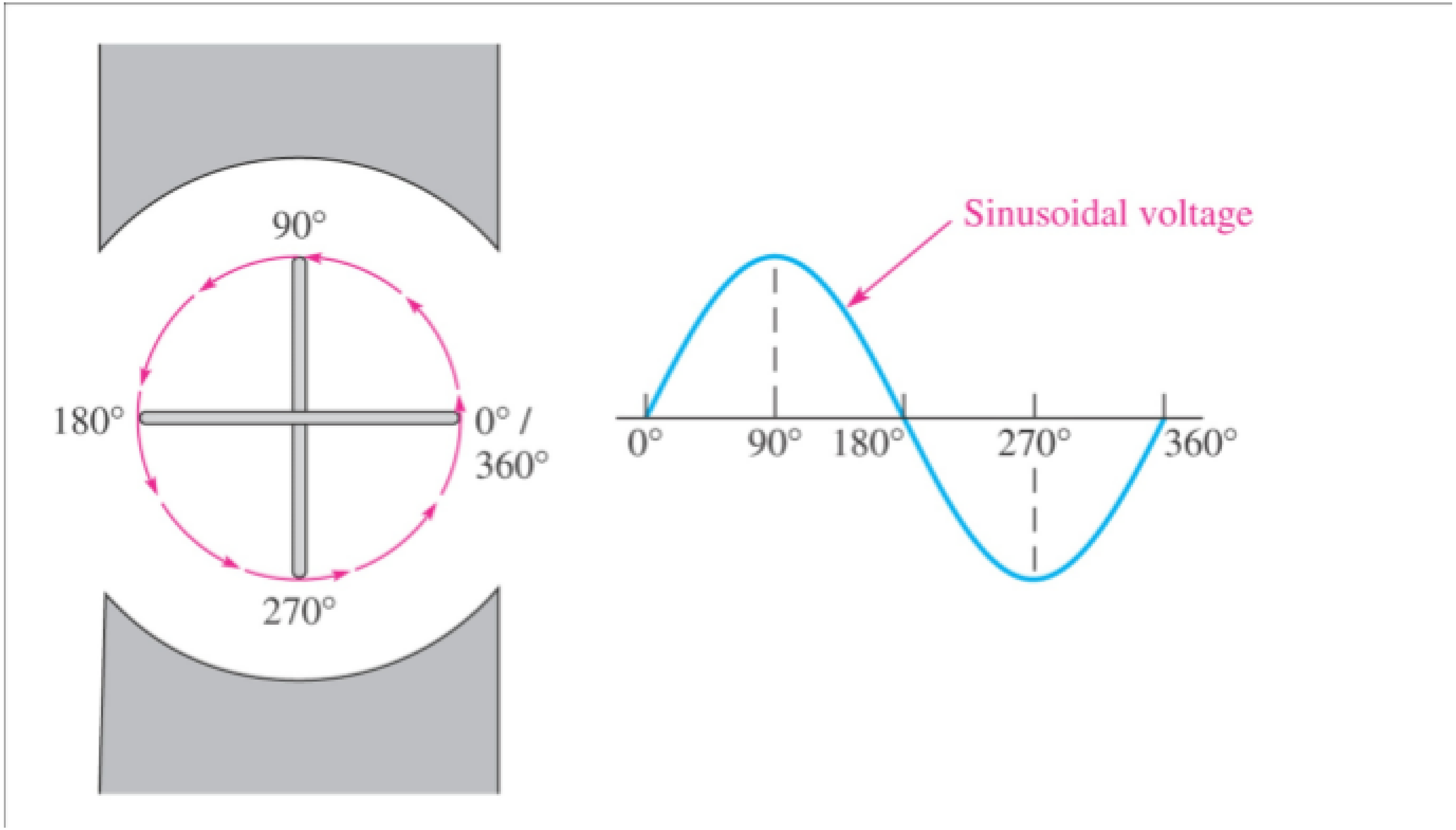
Sine wave
Complex wave
Triangular wave
Square wave
Amplitude
Amplitude
+V
0
-V
time
+V
0
-V
time
+V
0
-V
time
+V
0
-V
time

Sine Wave

- The sine wave is a common type of alternating current (AC) and alternating voltage



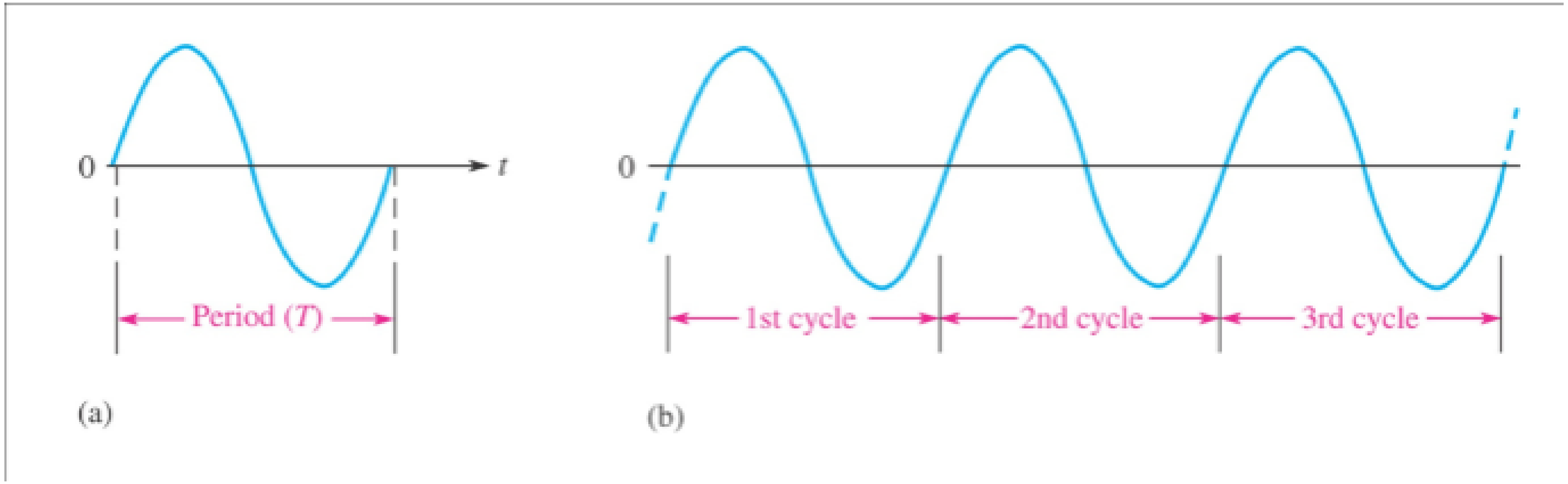
Relationship of a sine wave to the rotational motion in an ac generator



Period of a Sine Wave

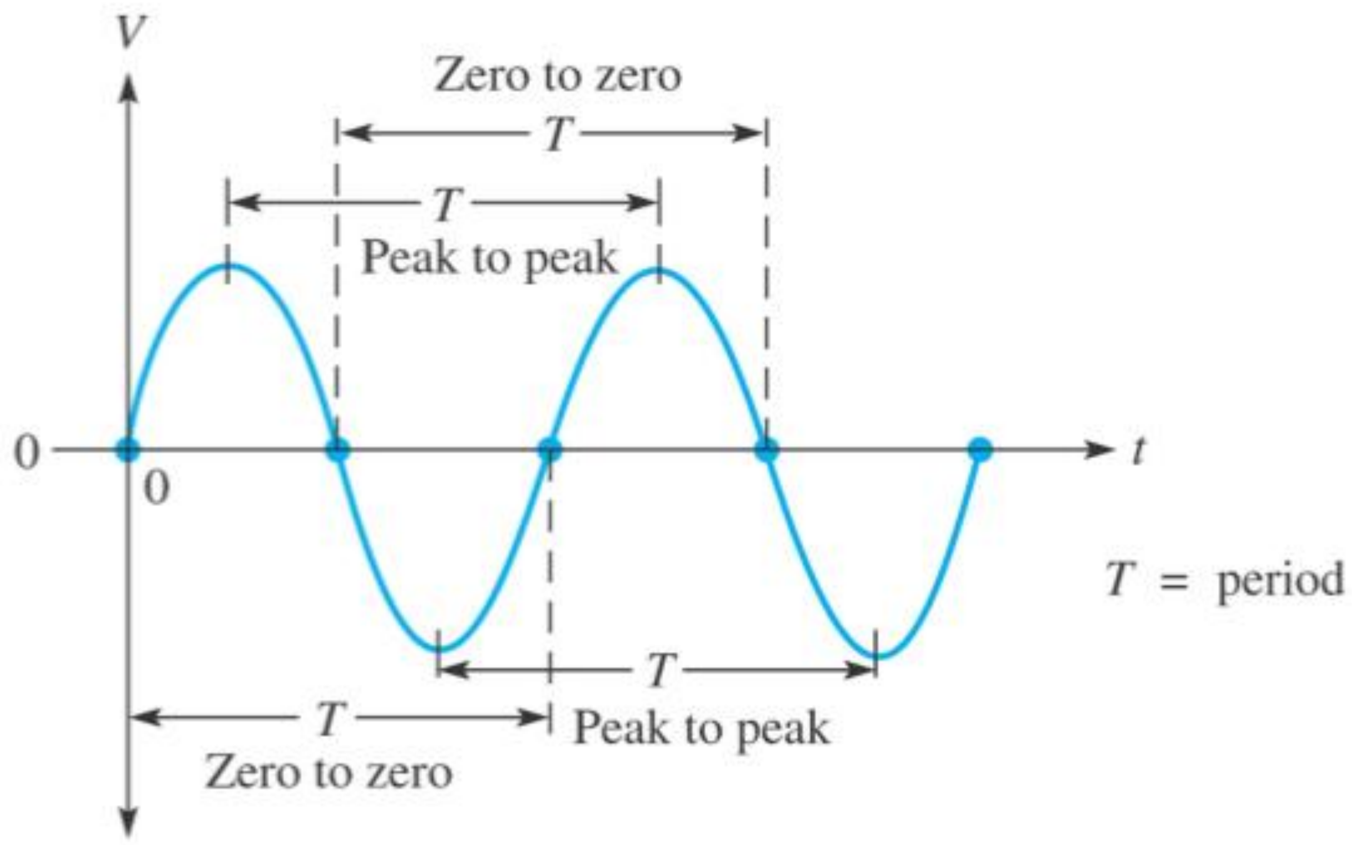
- The time required for a sine wave to complete one full cycle is called the period (T)
- A cycle consists of one complete positive, *and* one complete negative alternation

The period of a given sine wave is the same for each cycle



The period of a sine wave can be measured between any two corresponding points on the waveform

Measurement of the period of a sine wave



The period of a sine wave can be measured between any two corresponding points on the waveform

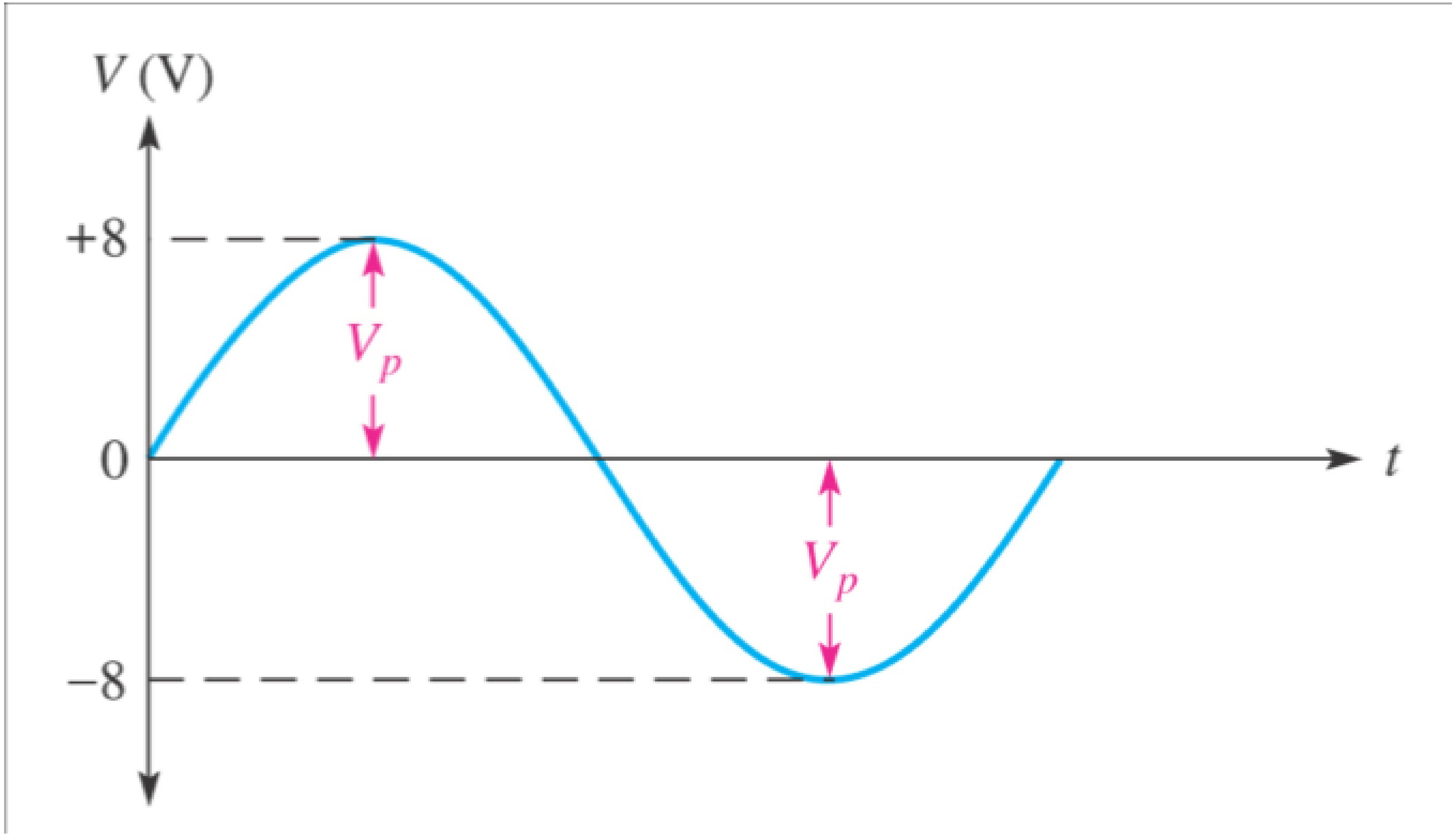
Peak Values of Sine Waves

- The **peak value** of a sine wave is the value of voltage or current at the positive or negative maximum with respect to zero

- Peak values are represented as:

$$V_p \text{ and } I_p$$

Peak values



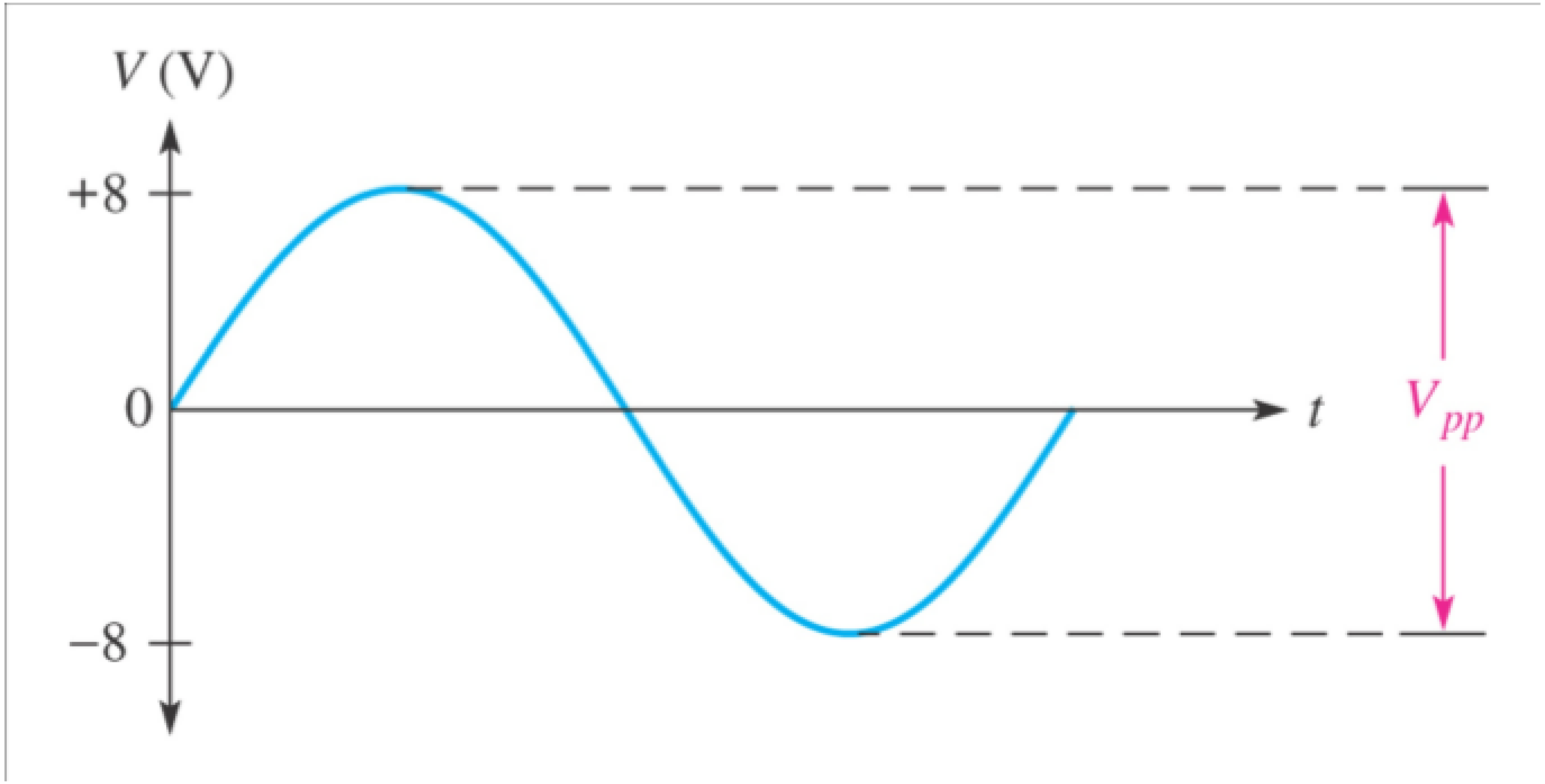
Peak-to-Peak Values

- The **peak-to-peak value** of a sine wave is the voltage or current from the positive peak to the negative peak
- The peak-to-peak value is twice the actual voltage value
- Not Often Used
- The peak-to-peak values are represented as:

$$V_{pp} \text{ and } I_{pp}$$

where: $V_{pp} = 2V_p$ and $I_{pp} = 2I_p$

Peak-to-peak values



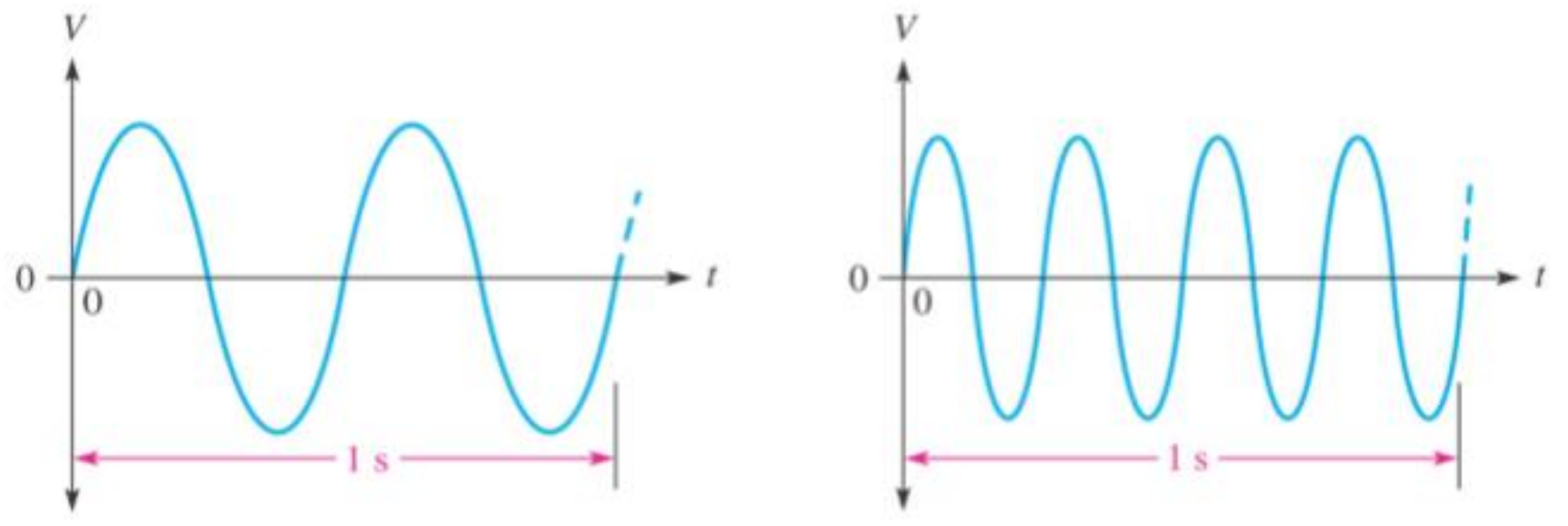
8V Peak (Actual Value) = 16V Peak-To-Peak

Frequency of a Sine Wave

- Frequency (f) is the number of cycles that a sine wave completes in one second
  - The more cycles completed in one second, the higher the frequency
  - Frequency is measured in **hertz** (Hz)
- Relationship between frequency (f) and period (T) is:

$$\boldsymbol{f = 1/T}$$

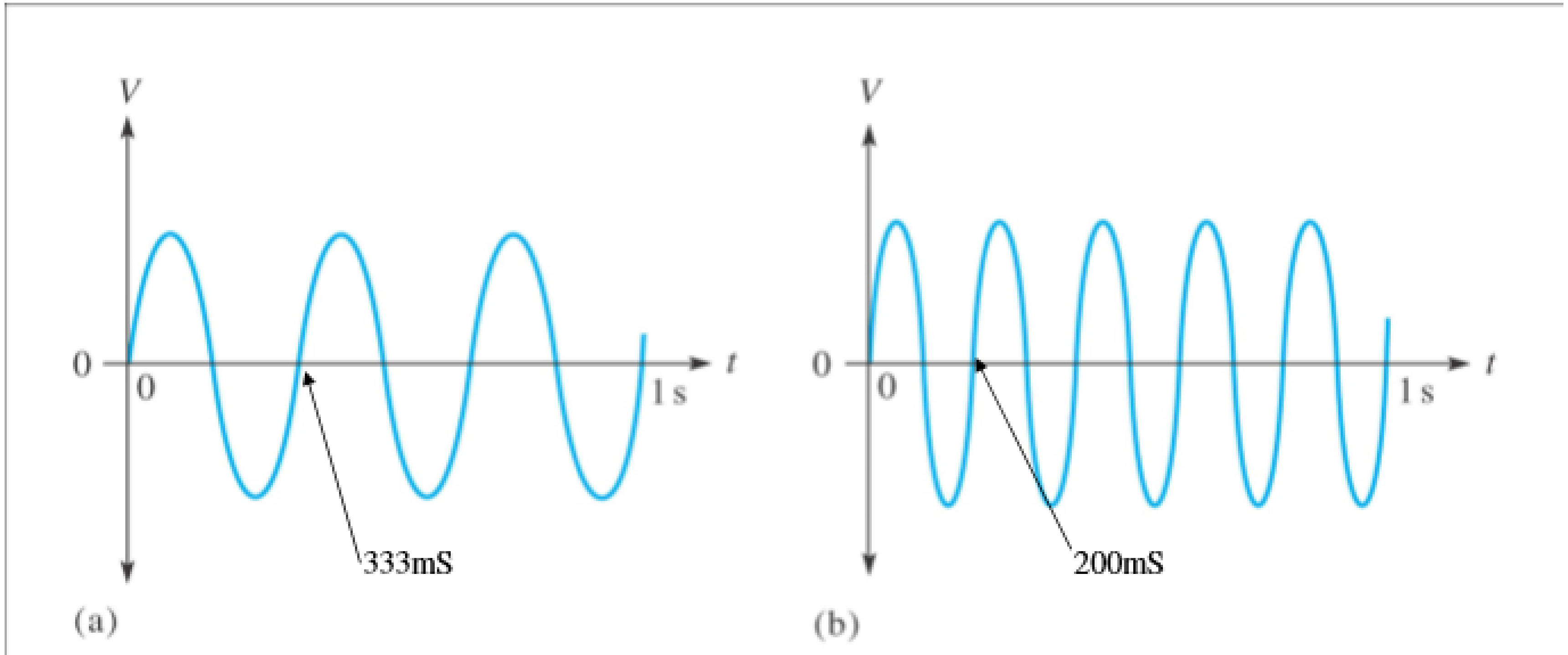
Illustration of frequency



(a) Lower frequency: fewer cycles per second

(b) Higher frequency: more cycles per second

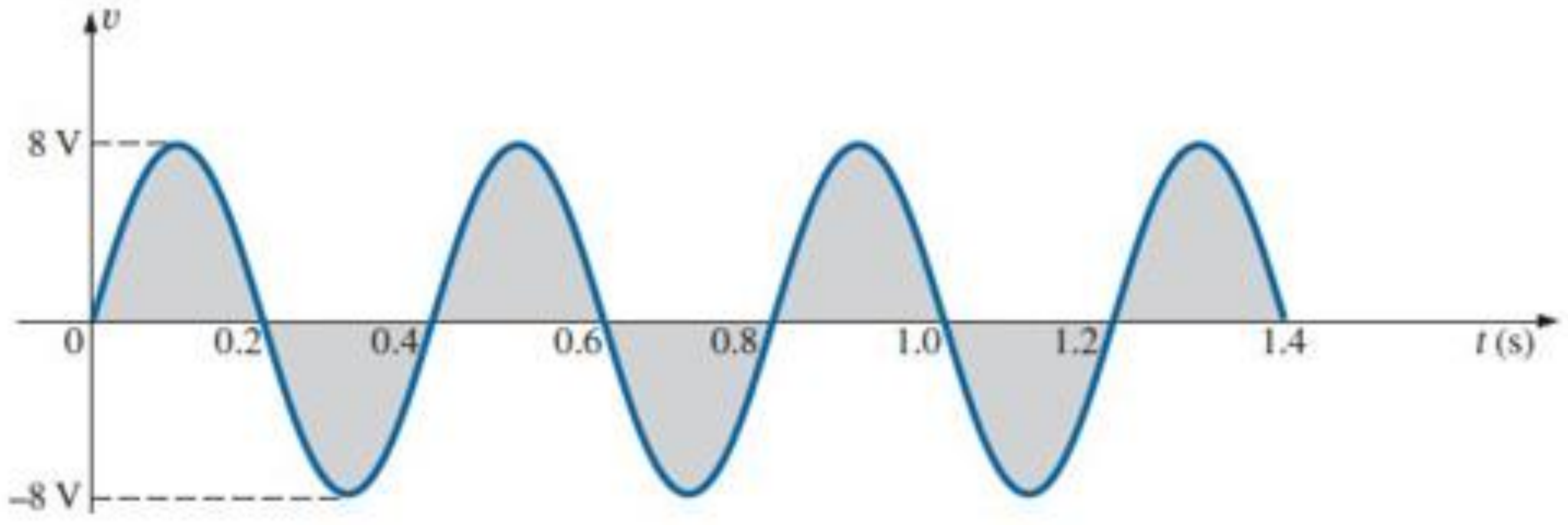
Illustration of frequency



T = 333mS
F = 3Hz
(3 Cycles/Sec)

T = 200mS
F = 5Hz
(5 Cycles/Second)

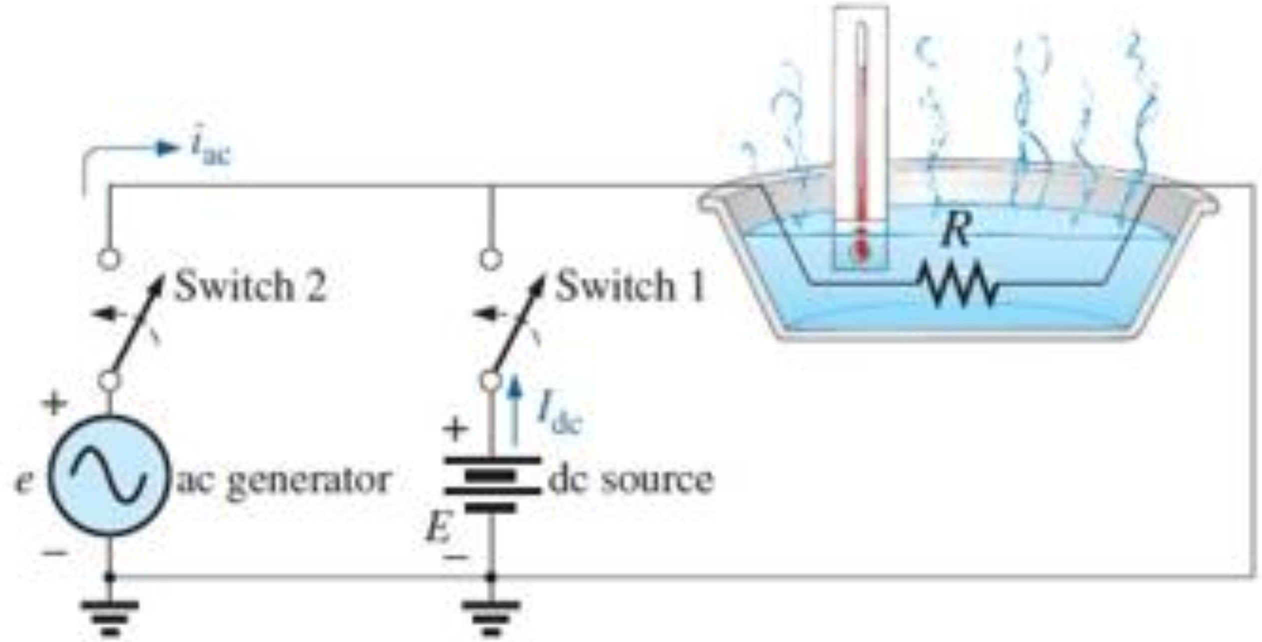
QUESTIONS…..



i. Maximum value
ii. Voltages at 0.3 s & 0.6 s
iii. Time duration between two consecutive peak points
iv. The Periodic time of the wave
v. No. of periods appears in the given wave form.
vi. The frequency of the given wave.

Root Mean Square(RMS) value of AC wave

When the same amount of heat is being produced by the resistor in both setups, the sinusoidal voltage has an rms value equal to the dc voltage



- Most AC sources are specified with the RMS Value
  - **If a voltage source does not specify P or P-P, it is considered RMS**

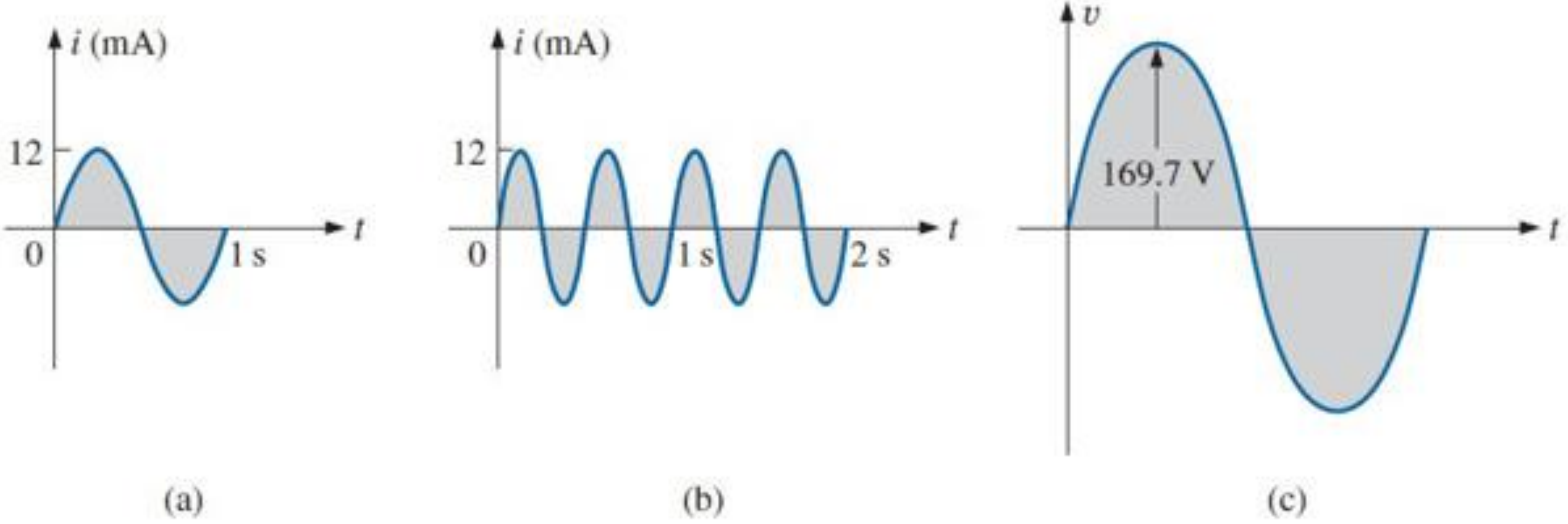
$$I_{\text{rms}} = \frac{1}{\sqrt{2}} I_m = 0.707 I_m$$

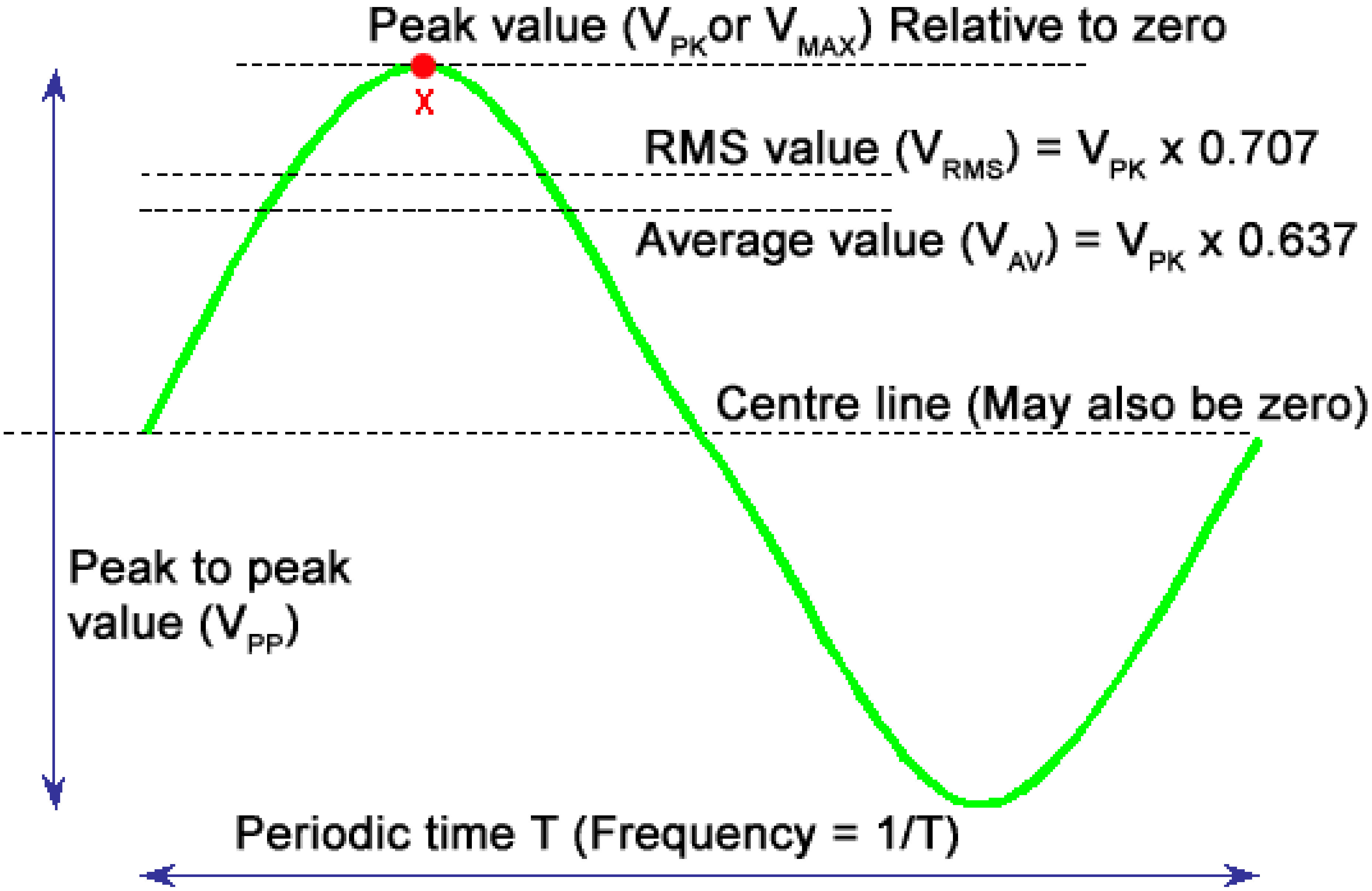
$$E_{\text{rms}} = \frac{1}{\sqrt{2}} E_m = 0.707 E_m$$

$$I_m = \sqrt{2} I_{\text{rms}} = 1.414 I_{\text{rms}}$$

$$E_m = \sqrt{2} E_{\text{rms}} = 1.414 E_{\text{rms}}$$

Find the RMS value of following....





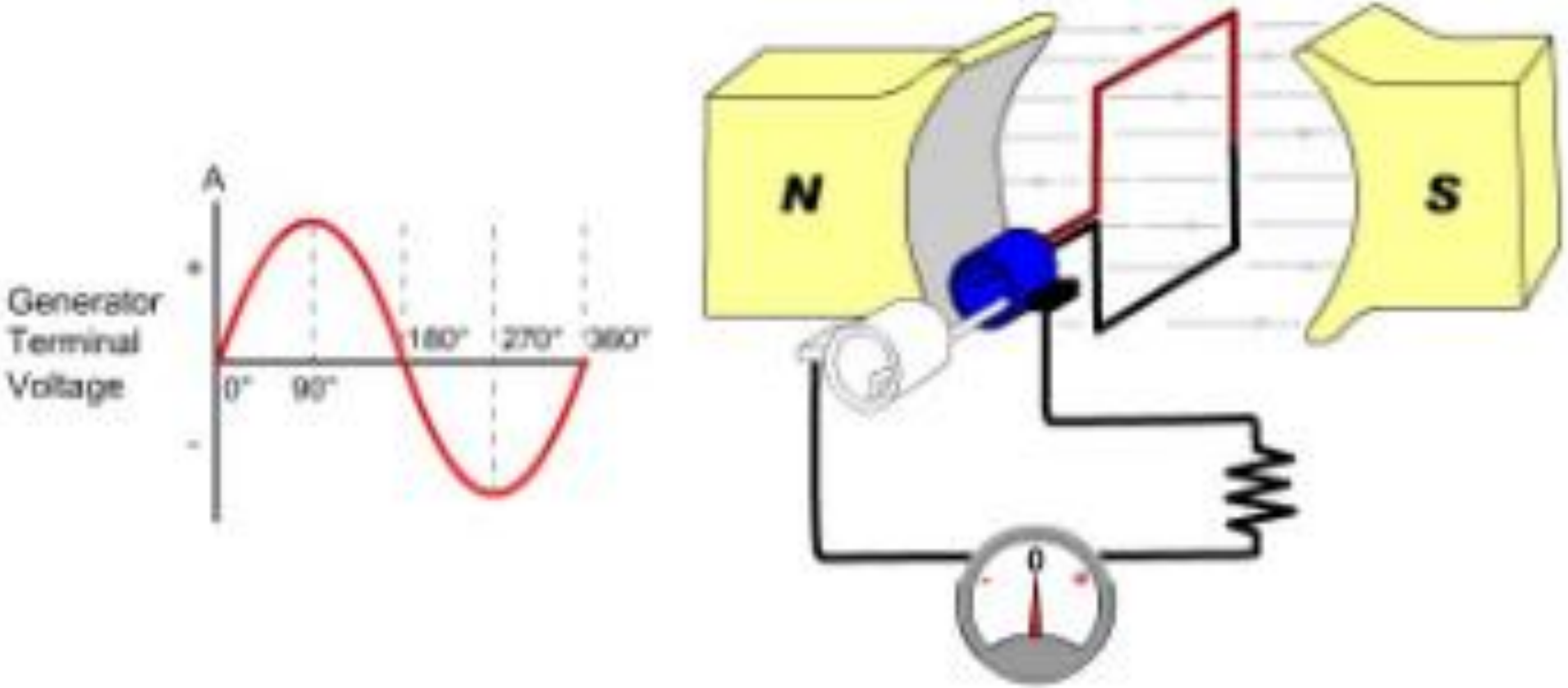
Peak value (V_{PK} or V_{MAX}) Relative to zero
X
RMS value (V_{RMS}) = V_{PK} x 0.707
Average value (V_{AV}) = V_{PK} x 0.637
Centre line (May also be zero)
Peak to peak value (V_{PP})
Periodic time T (Frequency = 1/T)

Angular Measurement of a Sine Wave

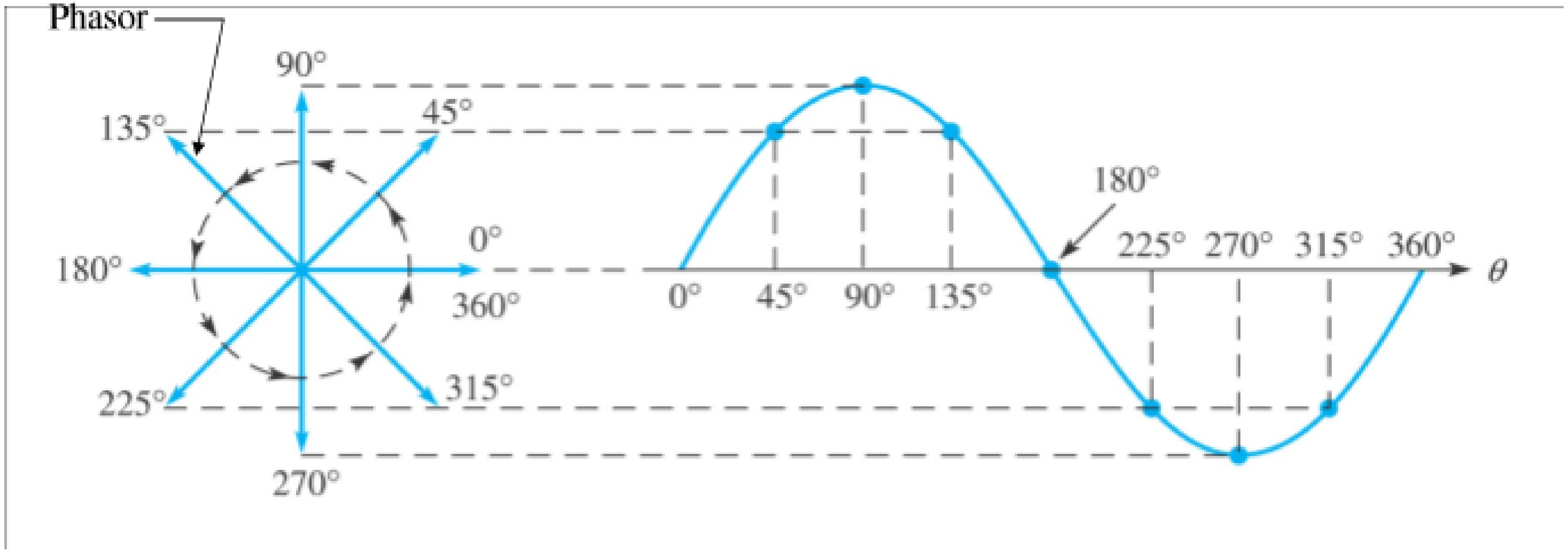
- The angular measure measurement of Sine Waves can be done in Degrees or Radians
  - A **degree** is an angular measurement corresponding to 1/360 of a circle or a complete revolution

•A radian (rad) is the angular measure along the circumference of a circle that is equal to the radius of the circle

•There are 2π radians or 360° in one complete cycle of a sine wave

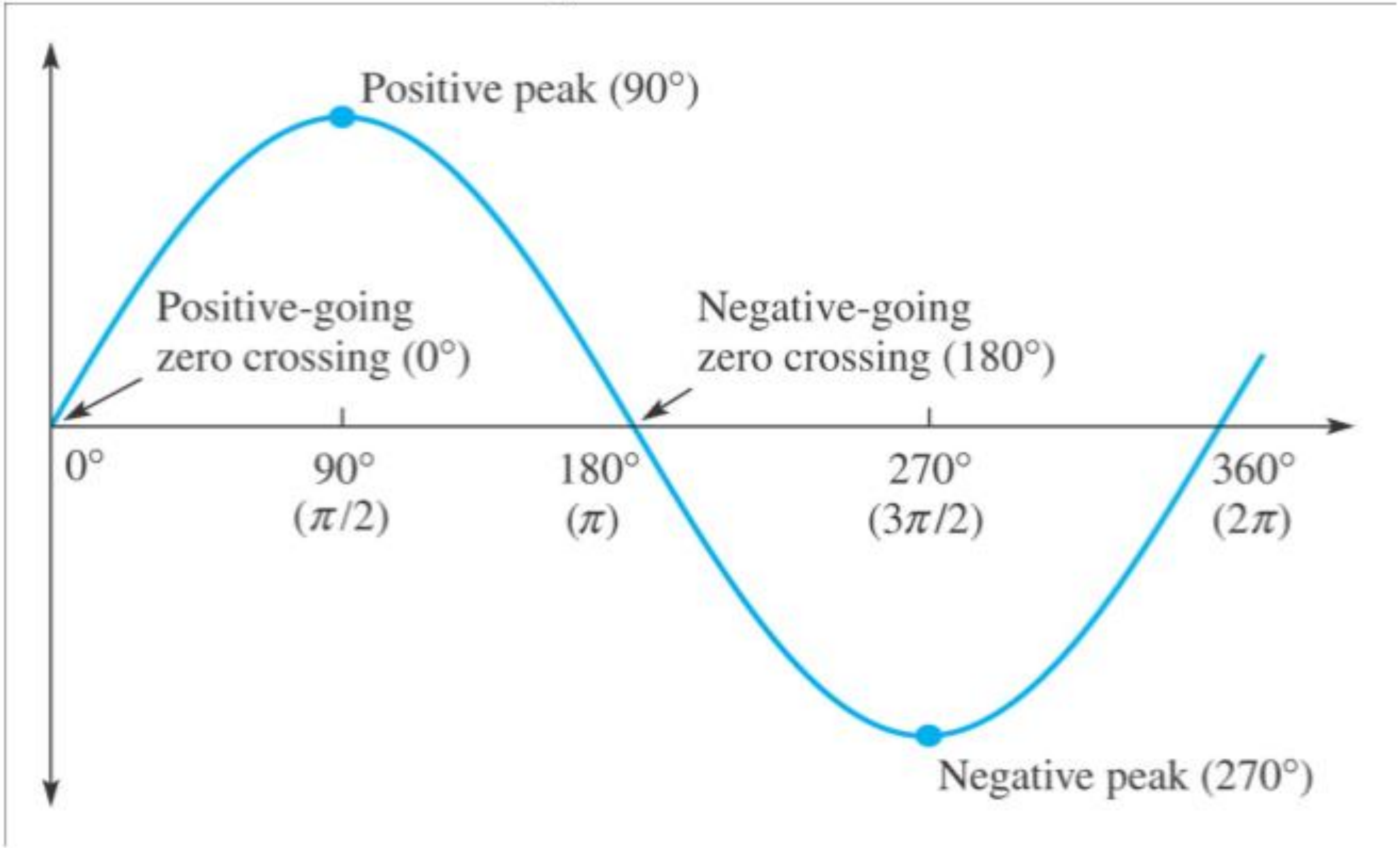

A
+
Generator
Terminal
Voltage
180°
270°
360°
0°
90°
-
N
S
0

Sine wave values represented by a rotating phasor



- Think of the arrow (phasor) rotating counter-clockwise around the center 360^0 each cycle of the sine wave
- $\boldsymbol{\theta}$ is the rotation angle
- The instantaneous value at any angle can be determined by simple trigonometry

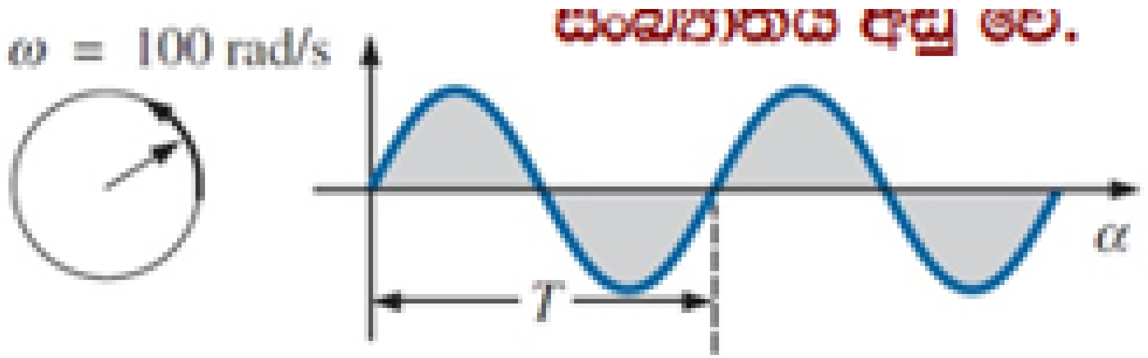
Major Phase References

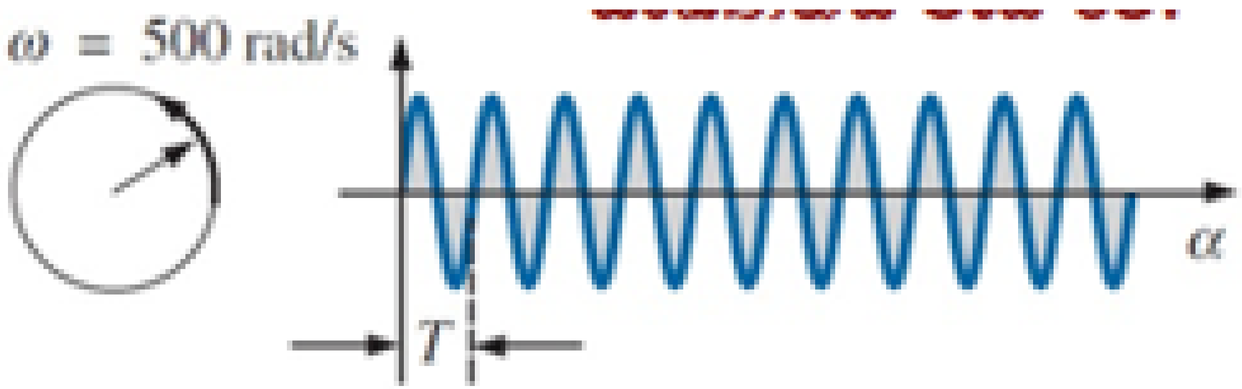


Angular velocity…’Omega’

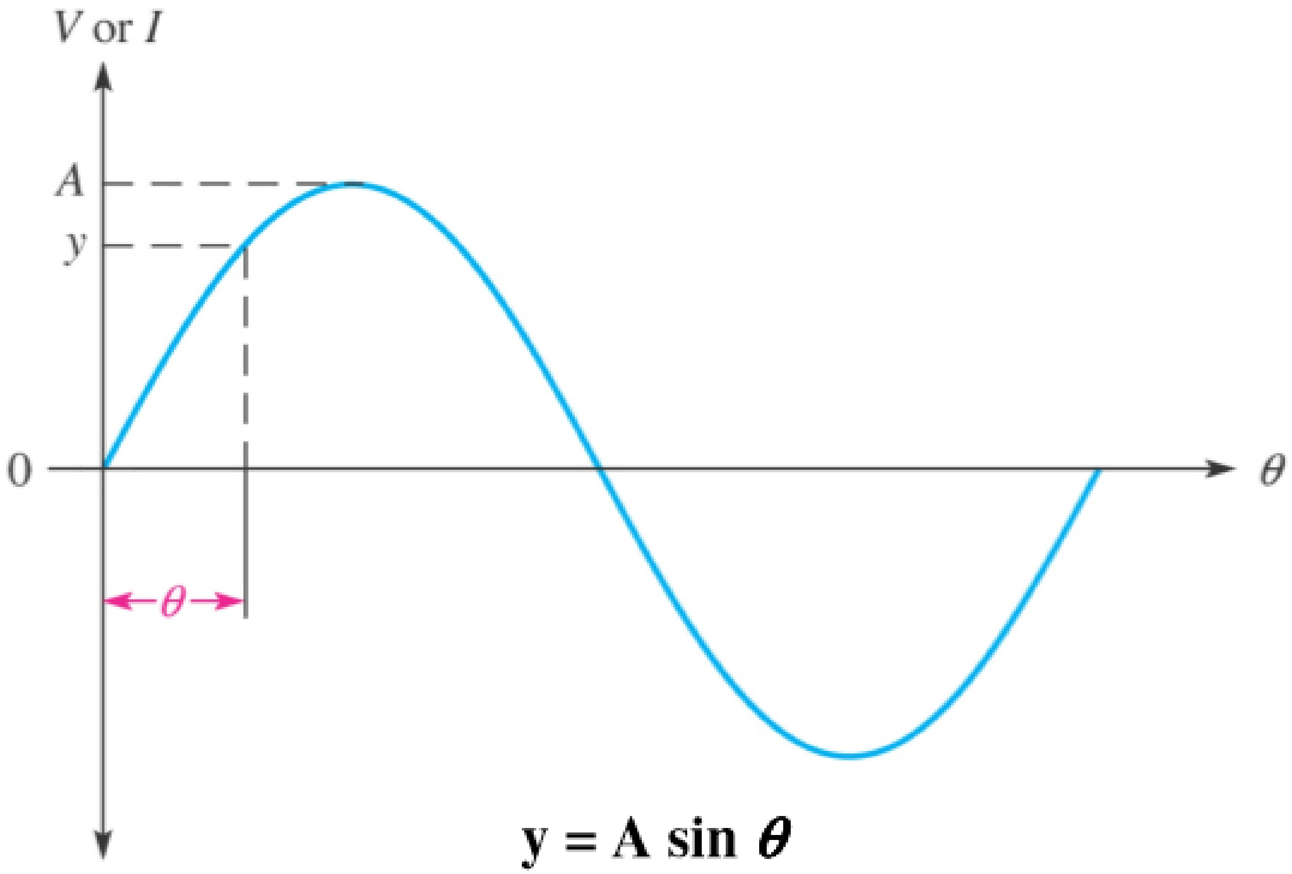
- See the hand written note

Demonstrating the effect of Angular velocity over Frequency and Period



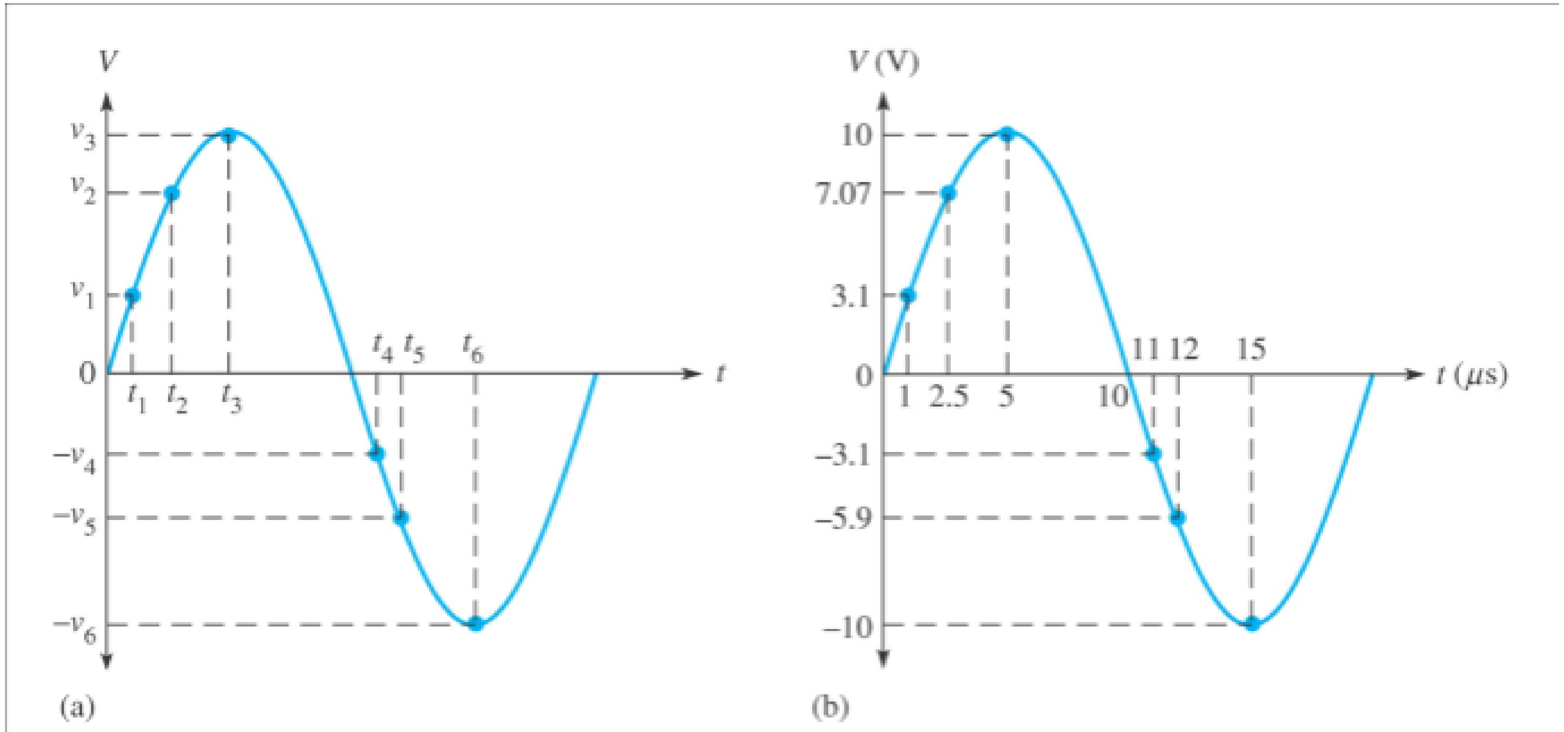


Instantaneous Values
Determined through a Formula



$$y = A \sin \theta$$

Instantaneous Voltage Values
Determined Graphically



Example:

t_1: 3.1V @ 1 uS

t_2:7.01V @ 2.5 uS

t_5: -5.9V @ 12 uS

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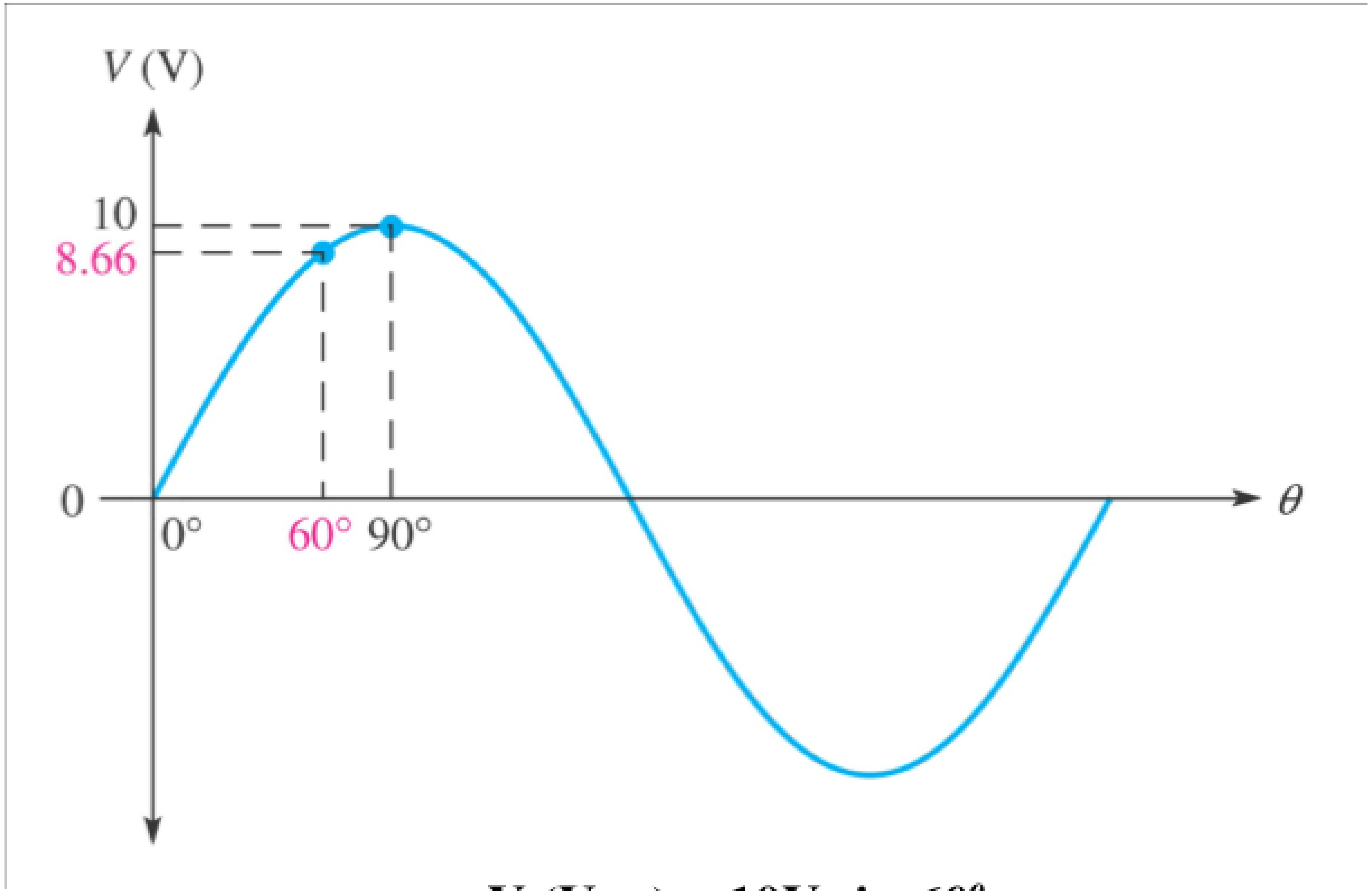
Illustration of the instantaneous value of a voltage sine wave at $\boldsymbol{\theta} = 60^o$



$$Y\ (V_{inst}) = 10V \sin 60^0$$

$$y = 8.66V$$

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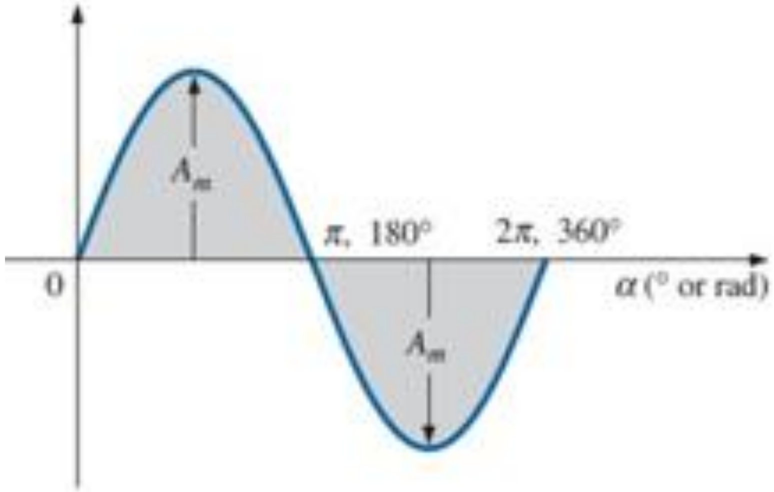
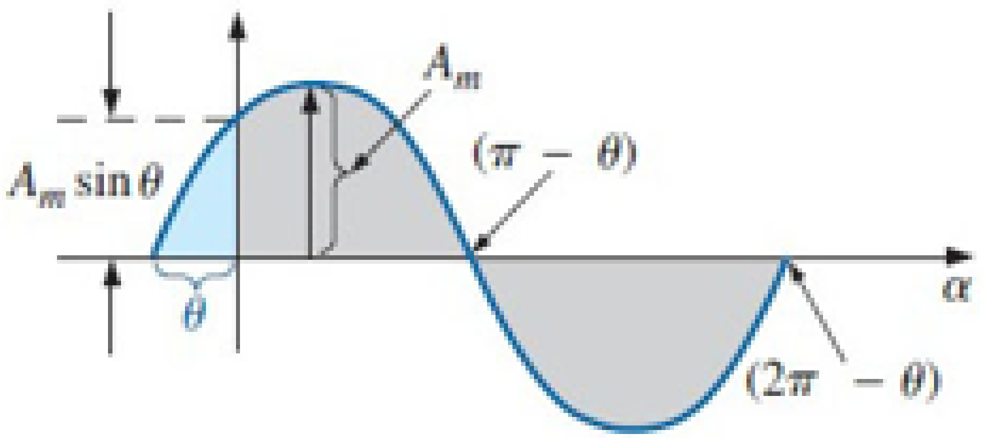
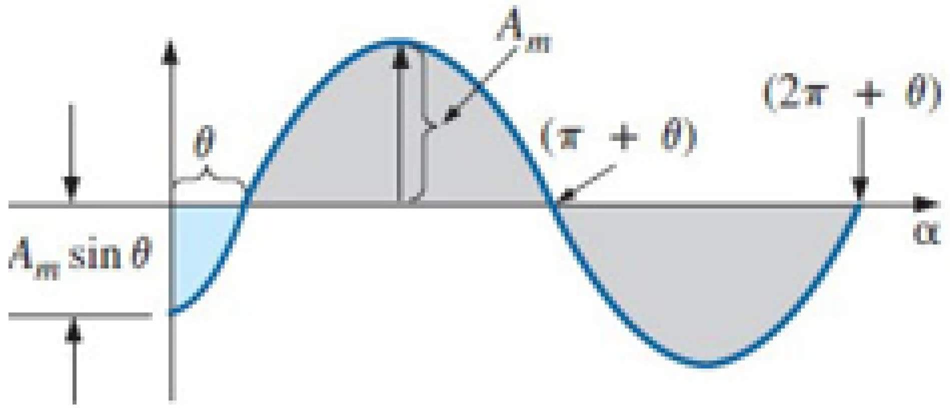


Basic sinusoidal function.

$$i = I_m \sin \alpha = I_m \sin \omega t$$
$$e = E_m \sin \alpha = E_m \sin \omega t$$

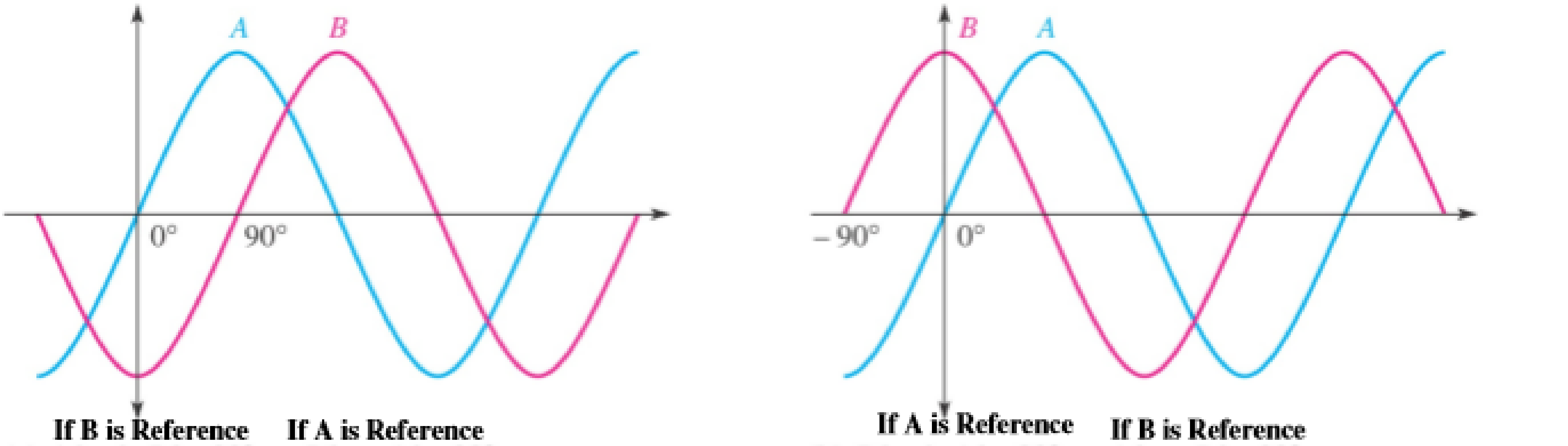


$$A_m \sin(\omega t + \theta)$$



$$A_m \sin(\omega t - \theta)$$

Phase shift between two waveforms

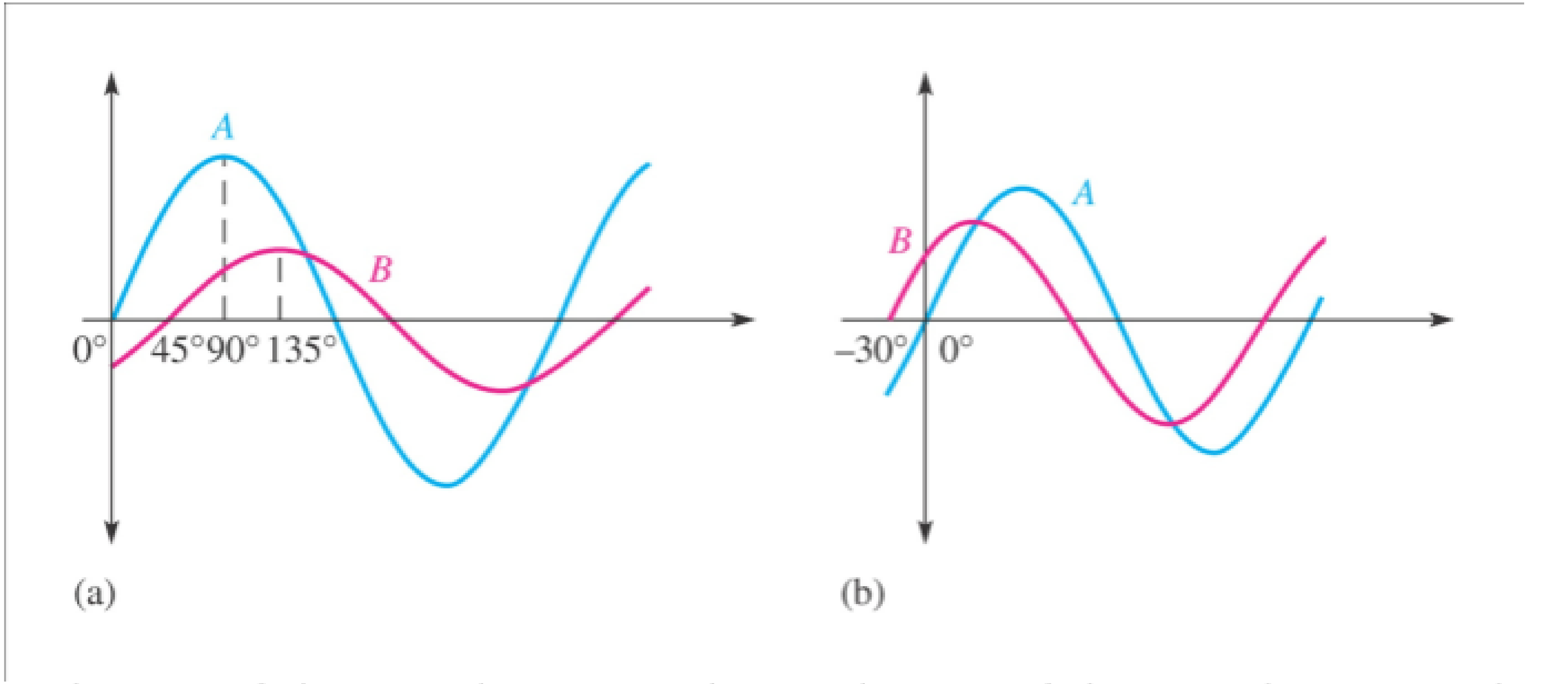


(a) *A* leads *B* by 90°, or *B* lags *A* by 90°.

(b) *B* leads *A* by 90°, or *A* lags *B* by 90°.

- Generally, one waveform is considered the *reference* waveform and other waveform *leads* or *lags* that waveform
- Or:
    - Look for which waveform passes *positively* through 0V *first* to find the waveform that *leads*
    - Look for which waveform passes *positively* through 0V *last* to find the waveform that *lags*

Phase shift between two waveforms



There is a 45^0 phase angle between A and B

- If A is reference, B is lagging
- If B is Reference, A is leading

There is a 30^0 phase angle between A and B

- If A is Reference, B is leading
- If B is the Reference, A is lagging