UNIT-II

FUNDAMENTAL OF AC CIRCUITS

Lecture 8

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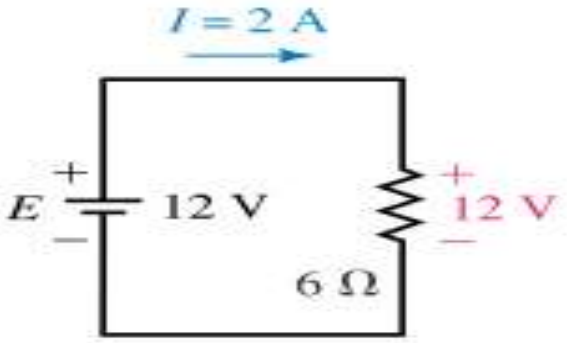
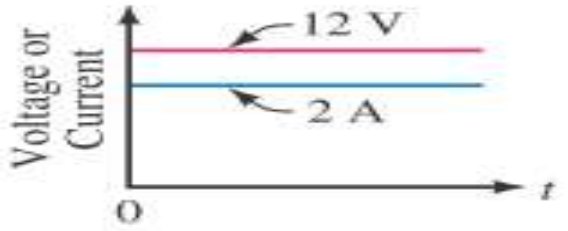
Assistant Professor and Head

AC Fundamentals

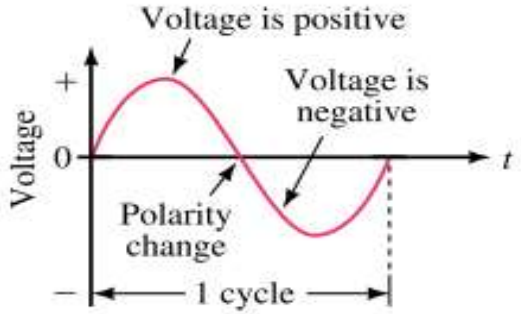
- Previously you learned that DC sources have fixed polarities and constant magnitudes and thus produce currents with constant value and unchanging direction





(b) Voltage and current versus time for dc

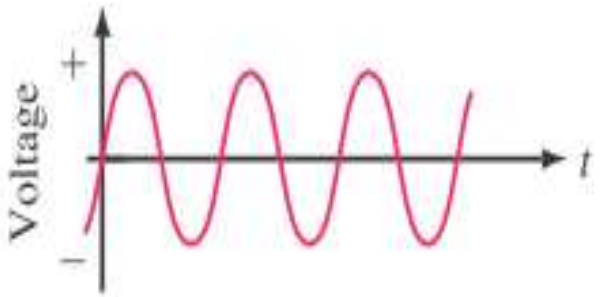
- In contrast, the voltages of ac sources alternate in polarity and vary in magnitude and thus produce currents that vary in magnitude and alternate in direction.



➢ Sinusoidal ac Voltage

One complete variation is referred to as a cycle.

Starting at zero,
the voltage increases to a positive peak amplitude,
decreases to zero,
changes polarity,
increases to a negative peak amplitude,
then returns again to zero.



(b) A continuous stream of cycles

➢ Since the waveform repeats itself at regular intervals, it is called a **periodic signal**.

➢ Symbol for an ac Voltage Source

Lowercase letter e is used
to indicate that the voltage varies with time.

Sinusoidal ac Current

- During the first half-cycle, the source voltage is positive
- Therefore, the current is in the clockwise direction.

- During the second half-cycle, the voltage polarity reverses
- Therefore, the current is in the counterclockwise direction.

- Since current is proportional to voltage, its shape is also sinusoidal

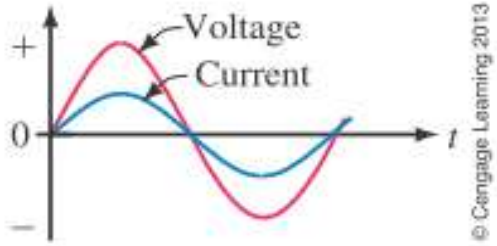


FIGURE 15–5 Current has the same wave-shape as voltage.

Quick Quiz (Poll 1)

The frequency of domestic power supply in India is

(A) 200 Hz

(B) 100 Hz

(C) 60 Hz

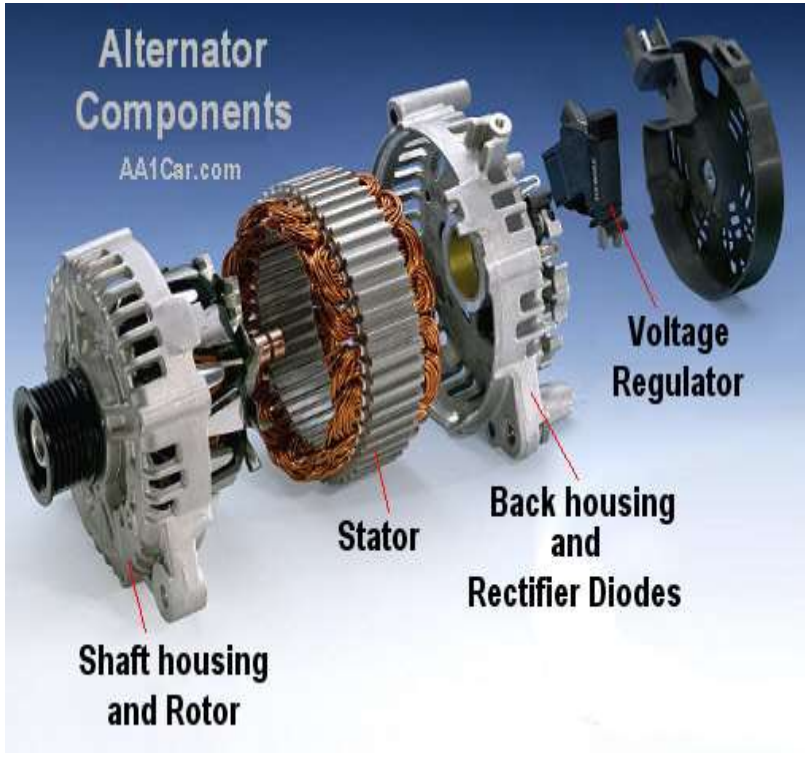
(D) 50 Hz

GENERATION OF AC VOLTAGE

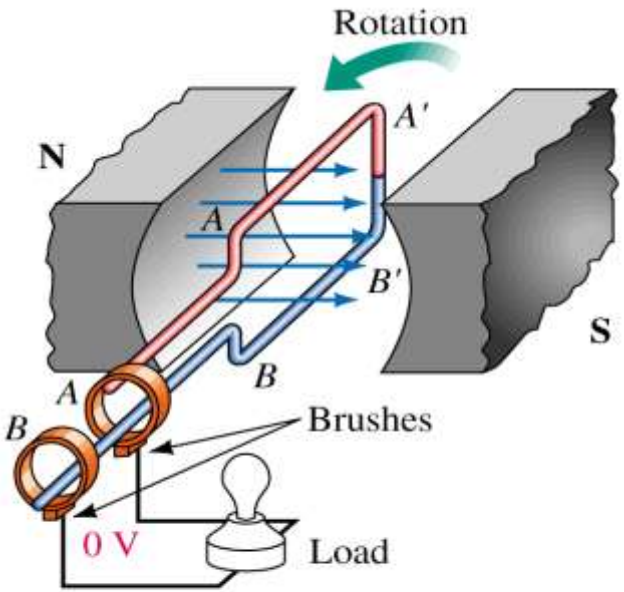
An **alternator** is an electrical generator that converts mechanical energy to electrical energy in the form of alternating current

Principle: A conductor moving relative to a magnetic field develops an electromotive force (EMF) in it. (Faraday's Law).

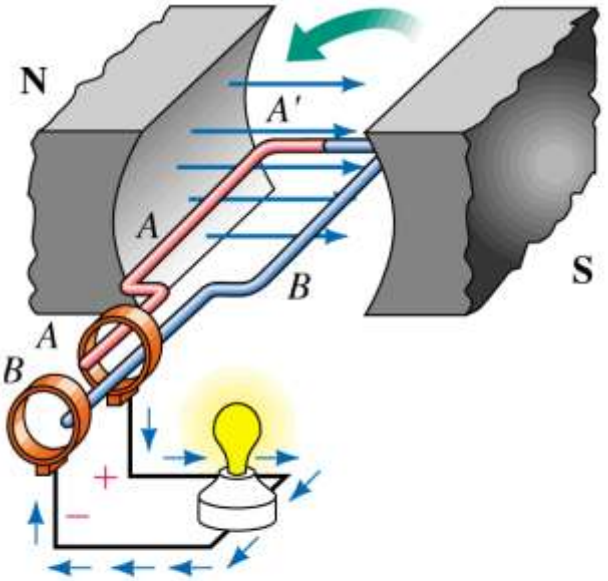
This emf reverses its polarity when it moves under magnetic poles of opposite polarity.



Generating AC Voltages

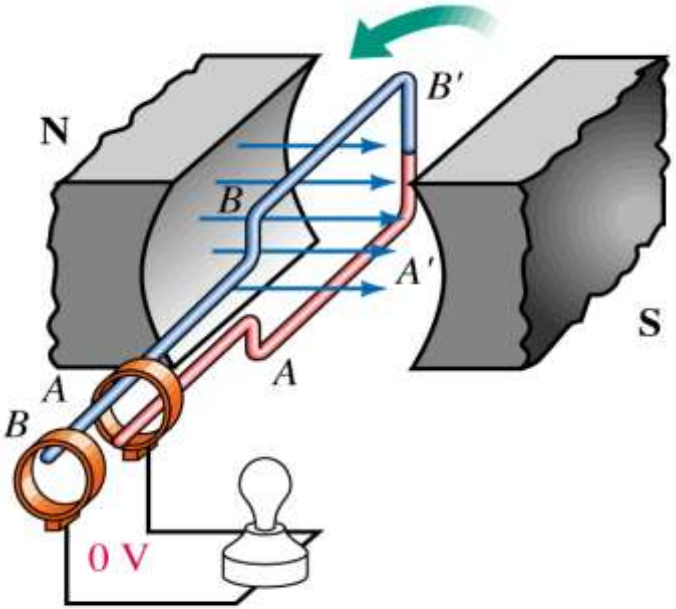


(a) 0° Position: Coil sides move parallel to flux lines. Since no flux is being cut, induced voltage is zero.

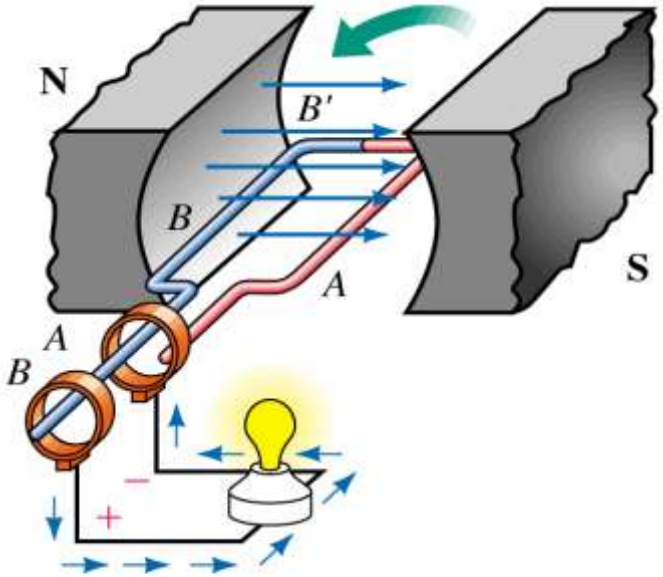


(b) 90° Position: Coil end *A* is positive with respect to *B*. Current direction is out of slip ring *A*.

Generating AC Voltages



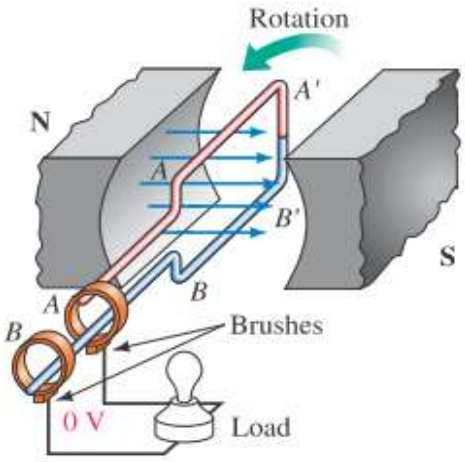
(c) 180° Position: Coil again cutting no flux. Induced voltage is zero.



(d) 270° Position: Voltage polarity has reversed, therefore, current direction reverses.

Generating ac Voltages (Method A)

- One way to generate an ac voltage is to rotate a coil of wire at constant angular velocity in a fixed magnetic field



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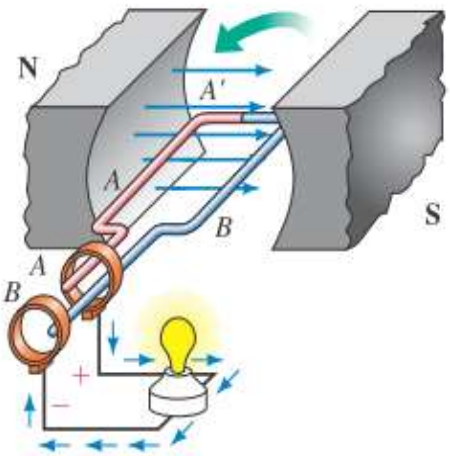
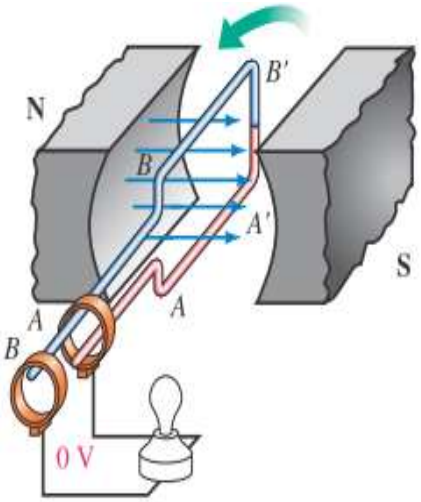
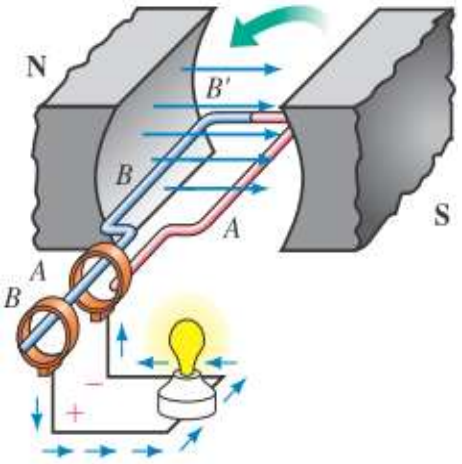


(b) 90° Position: Coil end *A* is positive with respect to *B*. Current direction is out of slip ring *A*.



(c) 180° Position: Coil again cutting no flux. Induced voltage is zero.



(d) 270° Position: Voltage polarity has reversed, therefore, current direction has also reversed.

- The magnitude of the resulting voltage is proportional to the rate at which flux lines are cut

- its polarity is dependent on the direction the coil sides move through the field.

Generating ac Voltages

- Since the coil rotates continuously, the voltage produced will be a repetitive,

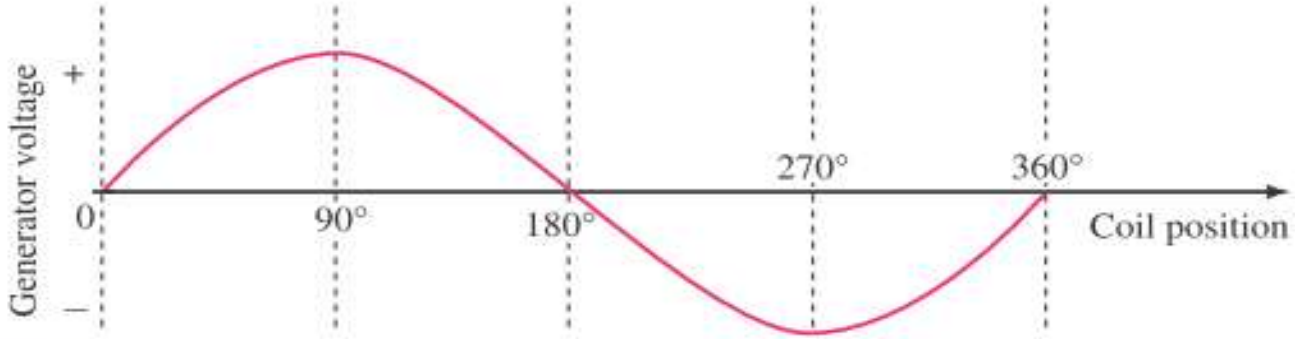


FIGURE 15–7 Coil voltage versus angular position.

Time Scales

- Often we need to scale the output voltage in time.
- The length of time required to generate one cycle depends on the velocity of rotation.

600 revolutions in 1 minute = 600 rev / 60 s
= 10 revolutions in 1 second.

The time for 1 revolution = one-tenth of a second
= 100 ms

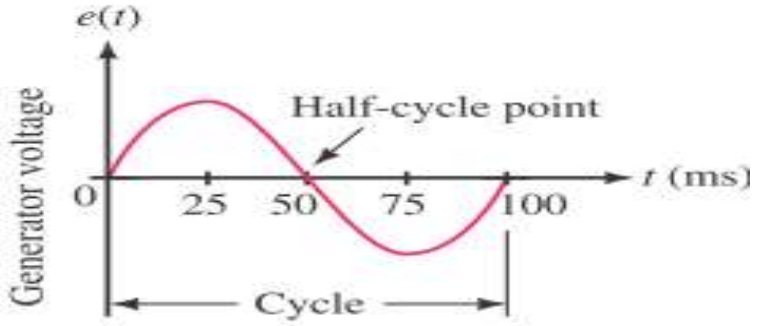


FIGURE 15–8 Cycle scaled in time. At 600 rpm, the cycle length is 100 ms.

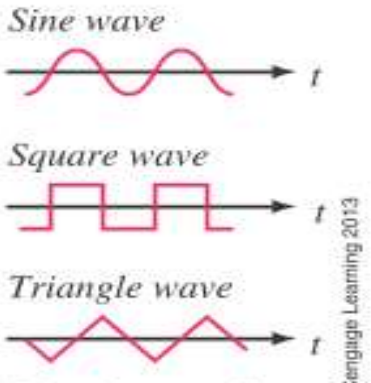
Generating ac Voltages (Method-2)

- AC waveforms may also be created electronically using function (or signal) generators.
- With function generators, you are not limited to sinusoidal ac. gear.

- The unit of Figure can produce a variety of variable-frequency waveforms, including sinusoidal, square wave, triangular, and so on.
- Waveforms such as these are commonly used to test electronic

(a) Model 4045 Function Generator

Photo courtesy B&K Precision



(b) Sample waveforms

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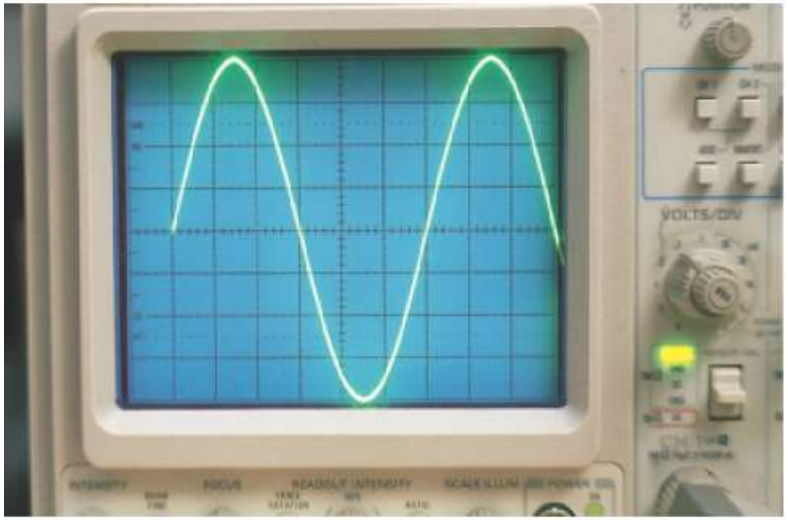
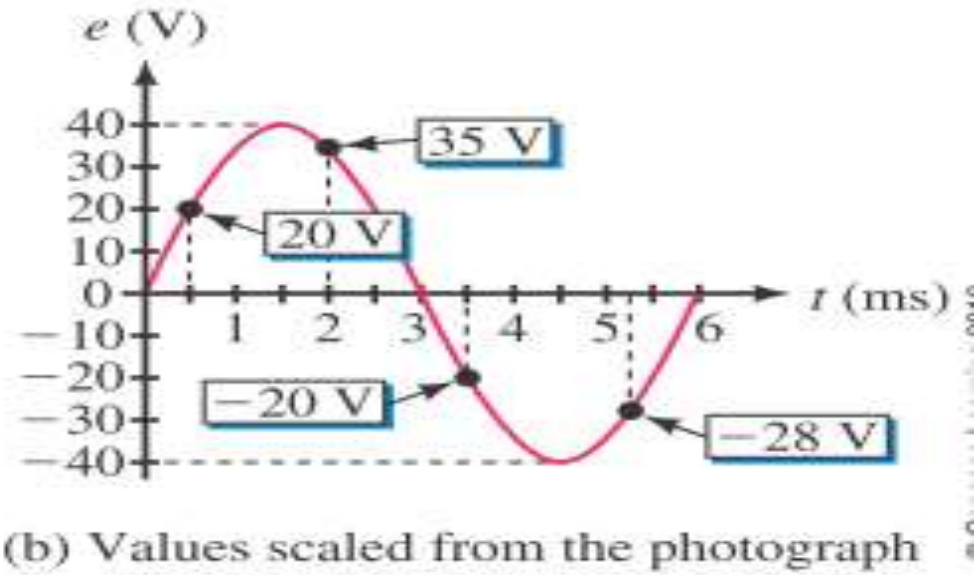
0 Electronic function generators provide a variety of variable-frequency, variable-amplitude waveforms.

Instantaneous Value

- As the coil voltage changes from instant to instant. The value of voltage at any point on the waveform is referred to as its **instantaneous value.**





(b) Values scaled from the photograph

- The voltage has a peak value of 40 volts
- The cycle time of 6 ms.

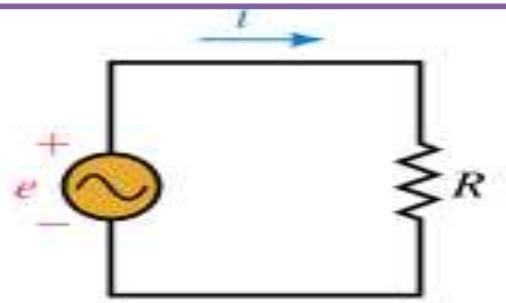
- ✓ at t = 0 ms, the voltage is zero.
- ✓ at t=0.5 ms, the voltage is 20V.

Voltage and Current Conventions for ac

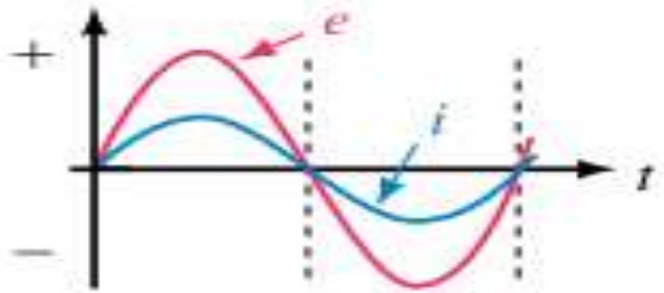
- First, we assign reference polarities for the source and a reference direction for the current.

- We then use the convention that, when e has a positive value, its actual polarity is the same as the reference polarity, and when e has a negative value, its actual polarity is opposite to that of the reference.

- For current, we use the convention that when i has a positive value, its actual direction is the same as the reference arrow,
- and when i has a negative value, its actual direction is opposite to that of the reference.

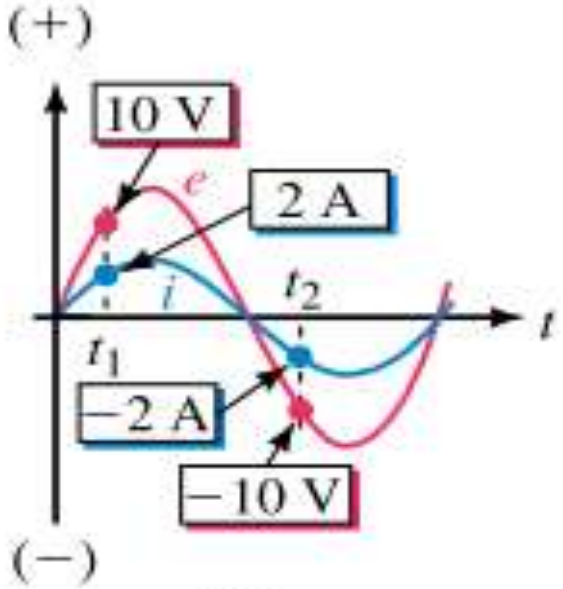


(a) References for voltage and current.

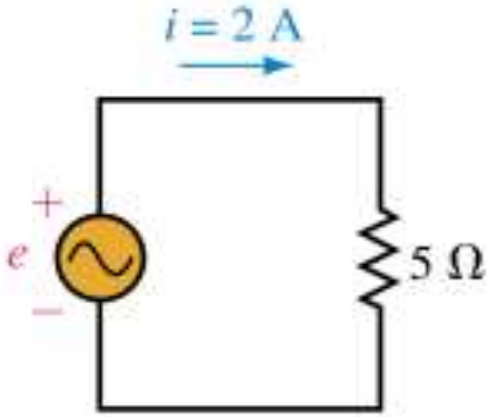


(b) During the first half-cycle, voltage polarity and current direction are as shown in (a). Therefore, *e* and *i* are positive. During the second half-cycle, voltage polarity and current direction are opposite to that shown in (a). Therefore, *e* and *i* are negative.

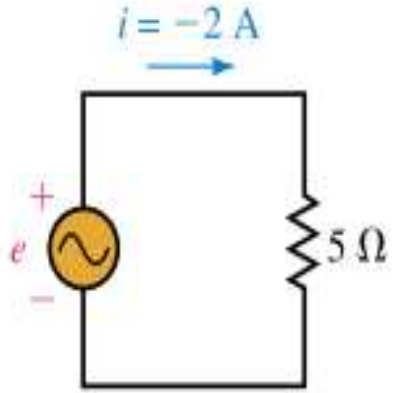
Voltage and Current Conventions for ac



(a)



(b) Time t_1: $e = 10$ V and $i = 2$ A. Thus voltage and current have the polarity and direction indicated

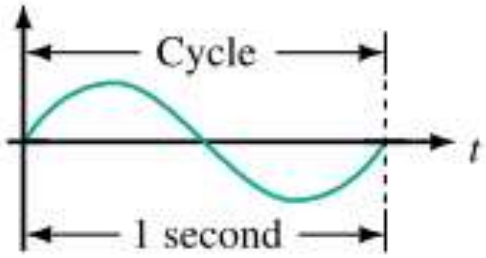


(c) Time t_2: $e = -10$ V and $i = -2$ A. Thus, voltage polarity is opposite to that indicated and current direction is opposite to the arrow direction.

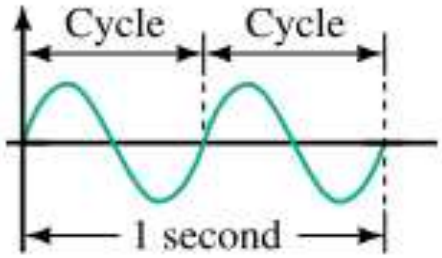
Attributes of Periodic Waveforms

- Periodic waveforms (i.e., waveforms that repeat at regular intervals), regardless of their wave shape, may be described by a group of attributes such as:
  - ✓ **Frequency, Period, Amplitude, Peak value.**

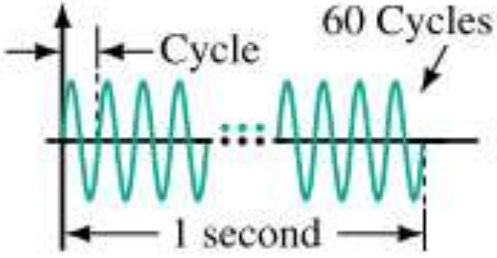
Frequency: The number of cycles per second of a waveform is defined



(a) 1 cycle per second = 1 Hz



(b) 2 cycles per second = 2 Hz



(c) 60 cycles per second = 60 Hz

- Frequency is denoted by the lower-case letter f.
- In the SI system, its unit is the hertz (Hz, named in honor of pioneer researcher Heinrich Hertz, 1857–1894).

$$1\ \text{Hz} = 1\ \text{cycle per second}$$

Attributes of Periodic Waveforms

➢ Period:

➢ The period, T, of a waveform, is the duration of one cycle.

➢ It is the inverse of frequency.

$$T = \frac{1}{f} \quad (\text{s})$$

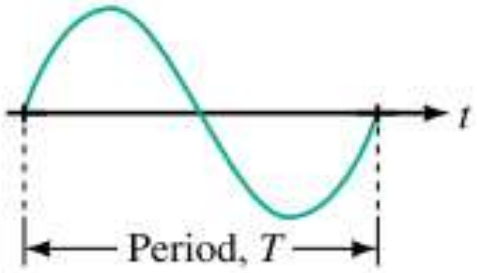


FIGURE 15–15 Period T is the duration of one cycle, measured in seconds.

➢ The period of a waveform can be measured between any two corresponding points (Often it is measured between zero points because they are easy to establish on an oscilloscope trace).

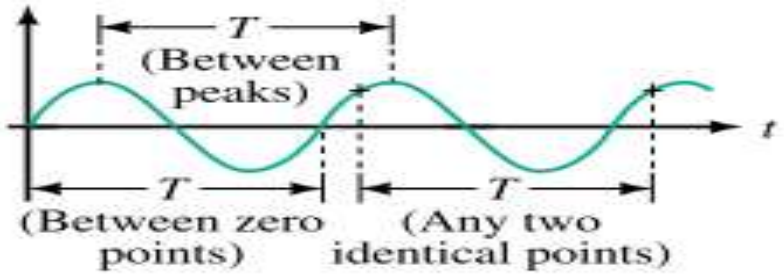


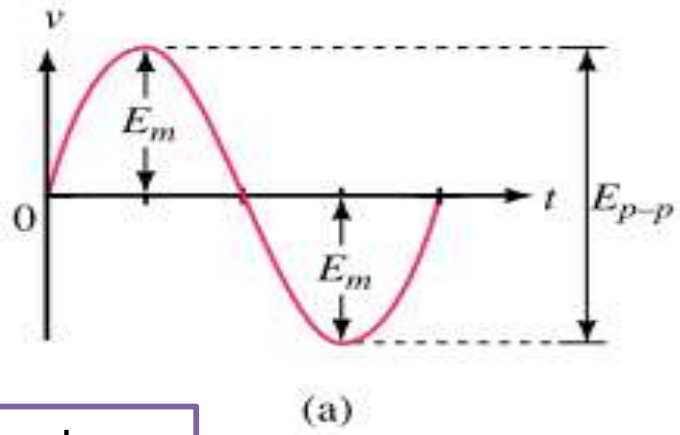
FIGURE 15–17 Period may be measured between any two corresponding points.

Attributes of Periodic Waveforms

Amplitude , Peak-Value, and Peak-to-Peak Value

Amplitude (E_m):

The amplitude of a sine wave is the distance from its average to its peak.



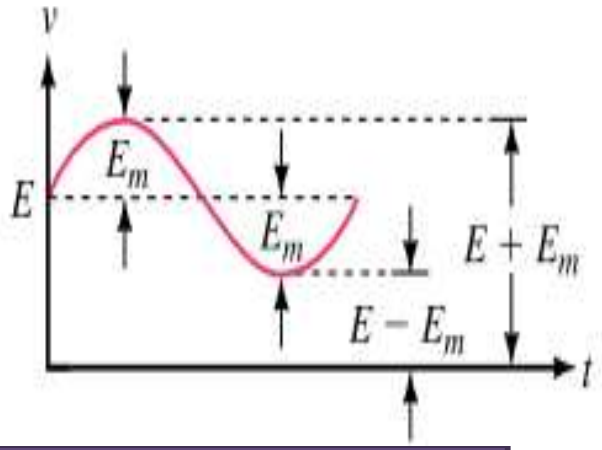
(a)

Peak-to-Peak Value (E_{p-p}):

It is measured between minimum and maximum peaks.

Peak Value

The peak value of a voltage or current is its maximum value with respect to zero.



In this figure : Peak voltage = E + Em

Quick Quiz (Poll 2)

Peak to peak value of a sine wave is

a. Equal to the maximum or phase value of sine wave
b. Twice the maximum or phase value of sine wave
c. Half of the maximum or phase value of sine wave
d. Four times the maximum or phase value of sine wave

Quick Quiz (Poll 3)

The most common waveforms of ac is

a. Square
b. Triangular
c. Sinusoidal
d. Saw tooth