Ministry of Higher Education and Scientific Research
Almustaqbal University, College of Engineering
And Engineering Technologies
Computer Technology Engineering Department

One week :
Alternating Current Network

Course Name : Fundamentals of Electricity
Stage : One
Academic Year : 2024
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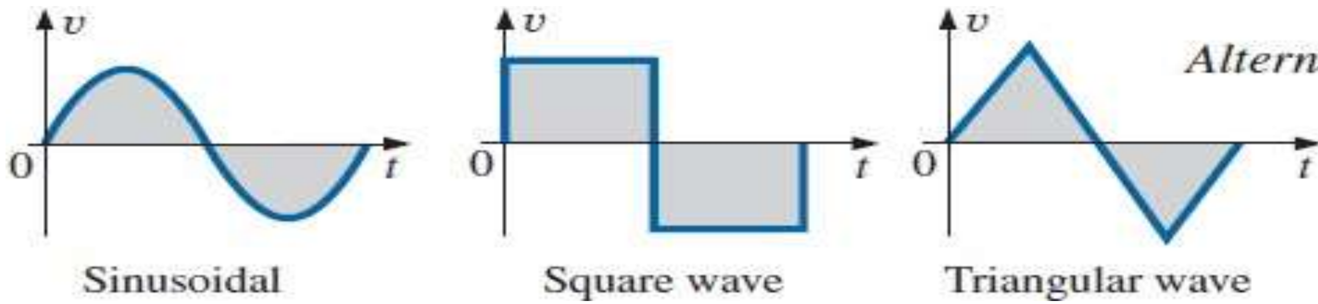
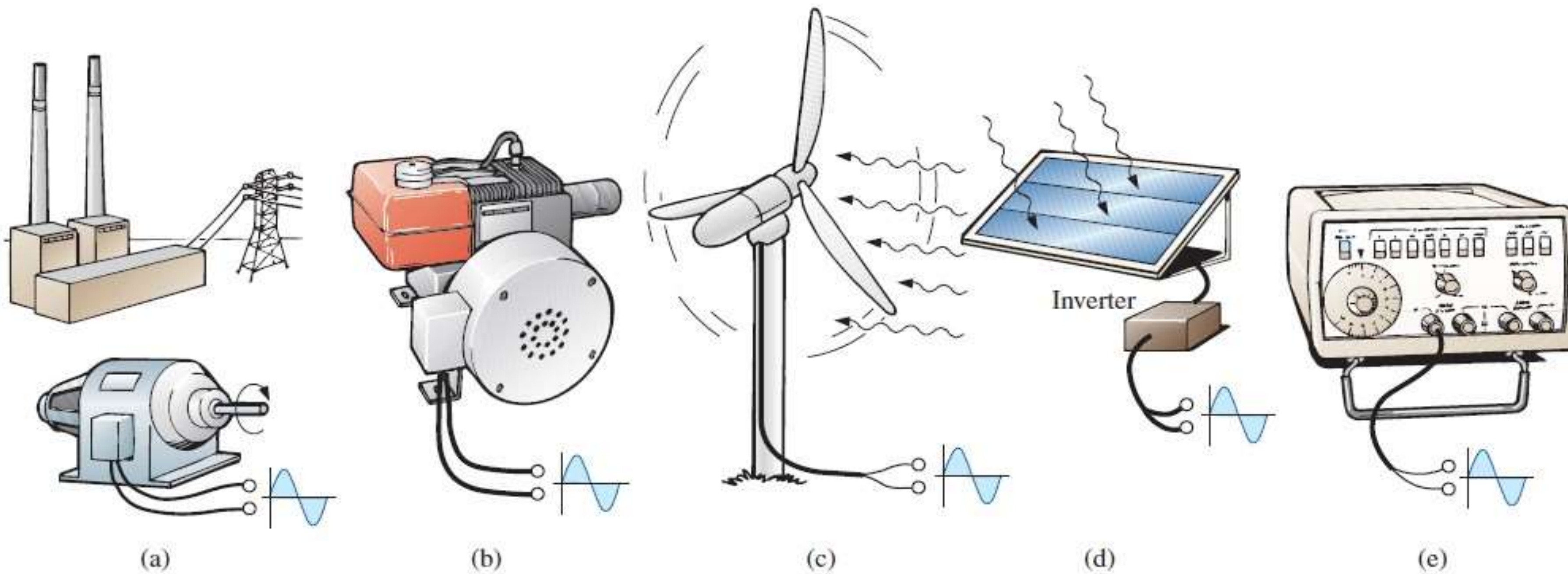
AC FUNDAMENTALS

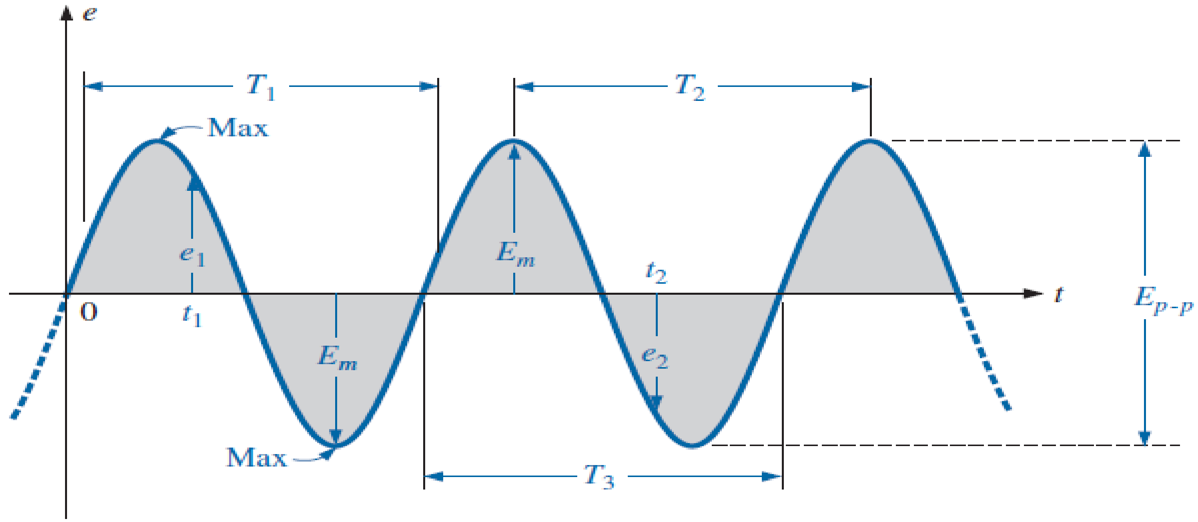


Alternating waveforms.



Various sources of ac power: (a) generating plant; (b) portable ac generator; (c) wind-power station; (d) solar panel; (e) function generator.

Definitions:



Waveform: The path traced by a quantity, such as the voltage in Fig., plotted as a function of some variable such as time (as above), position, degrees, radians, temperature, and so on.

Instantaneous value: The magnitude of a waveform at any instant of time; denoted by lowercase letters (e_1, e_2 in Fig.).

Peak amplitude: The maximum value of a waveform as measured from its average, or mean, value, denoted by uppercase letters [such as Em for sources of voltage and Vm for the voltage drop across a load]. For the waveform in Fig., the average value is zero volts, and Em is as defined by the figure

.

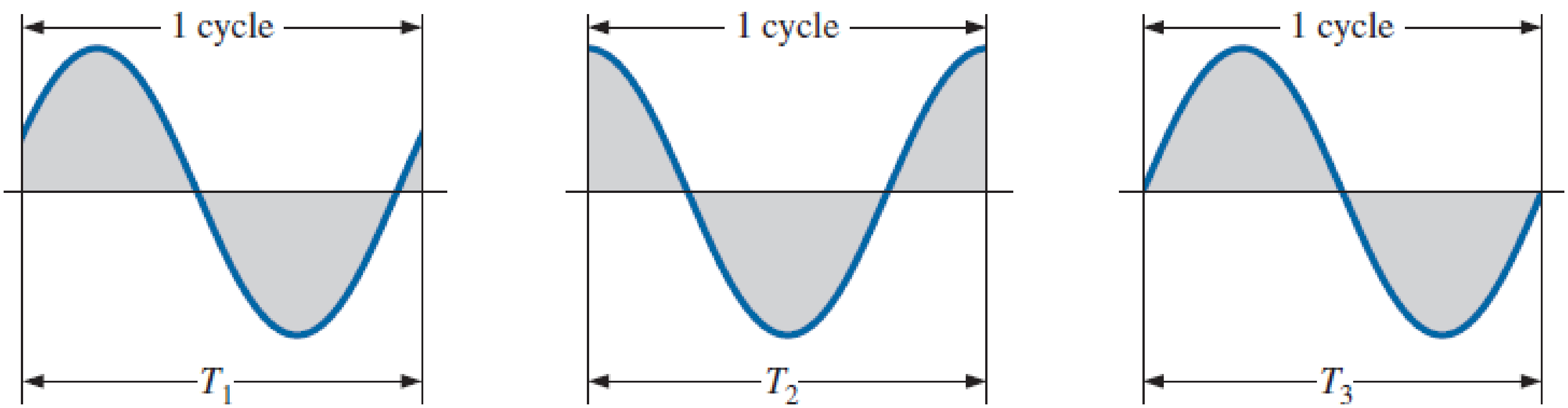
Peak value: The maximum instantaneous value of a function as measured from the zero volt level. For the waveform in Fig., the peak amplitude and peak value are the same, since the average value of the function is zero volts.

Peak-to-peak value: Denoted by Ep-p or (Vp-p), the full voltage between positive and negative peaks of the waveform, that is, the sum of the magnitude of the positive and negative peaks.

Periodic waveform: A waveform that continually repeats itself after the same time interval. The waveform in Fig. is a periodic waveform.

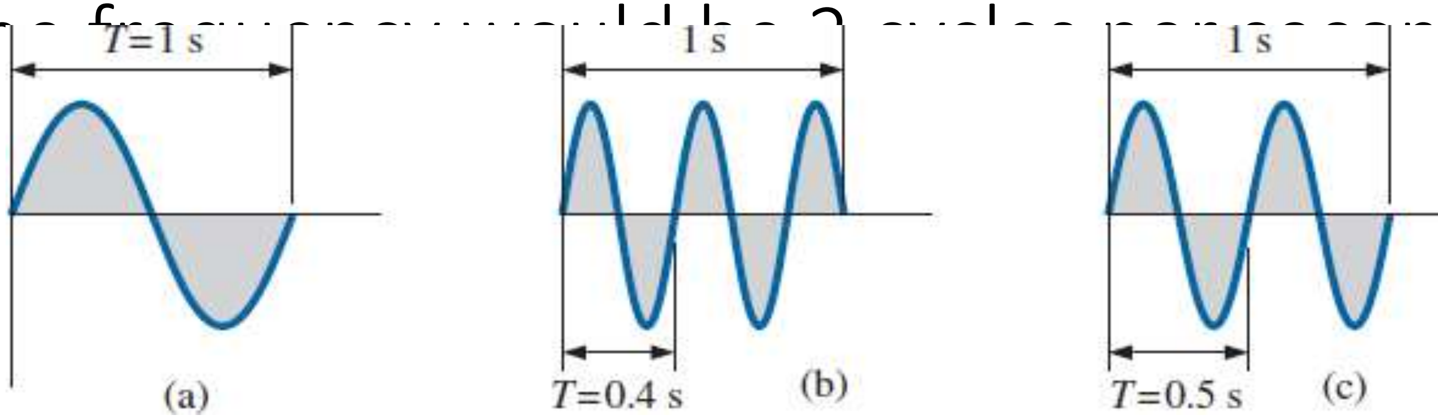
Period Time (T): The time of a periodic waveform.

Cycle: The portion of a waveform contained in one period of time. The cycles within T_1, T_2, and T_3 in Fig. may appear different, but they are all bounded by one period of time and therefore satisfy the definition of a cycle.



Frequency (f): The number of cycles that occur in 1 s. The frequency of the waveform in Fig. (a) is 1 cycle per second, and for Fig. (b), 2 cycles per second. If a waveform of similar shape had a period of 0.5 s [Fig. (c)], the frequency would be 2 cycles per second.

$$\boxed{1 \text{ hertz (Hz)} = 1 \text{ cycle per second (cps)}}$$



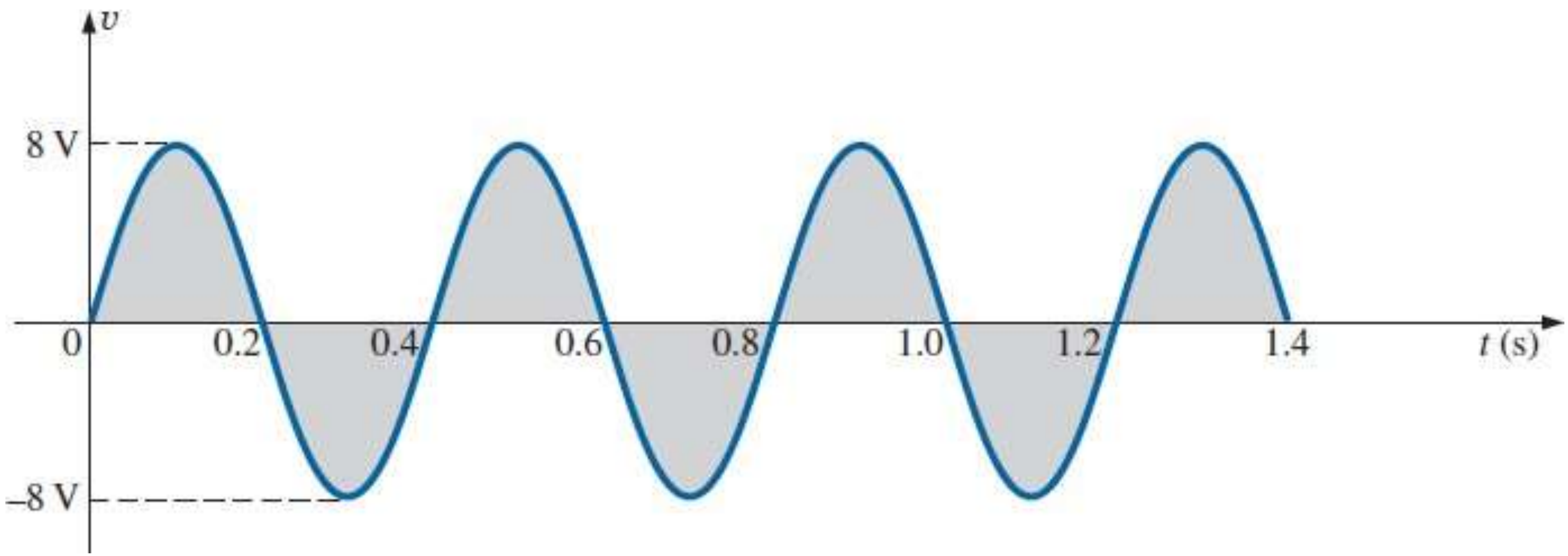
Since the frequency is inversely related to the period—that is, as one increases, the other decreases by an equal amount—the two can be related by the following equation:

$$\boxed{T = \frac{1}{f}} \qquad \boxed{f = \frac{1}{T}} \qquad \begin{aligned} f &= \text{Hz} \\ T &= \text{seconds (s)} \end{aligned}$$

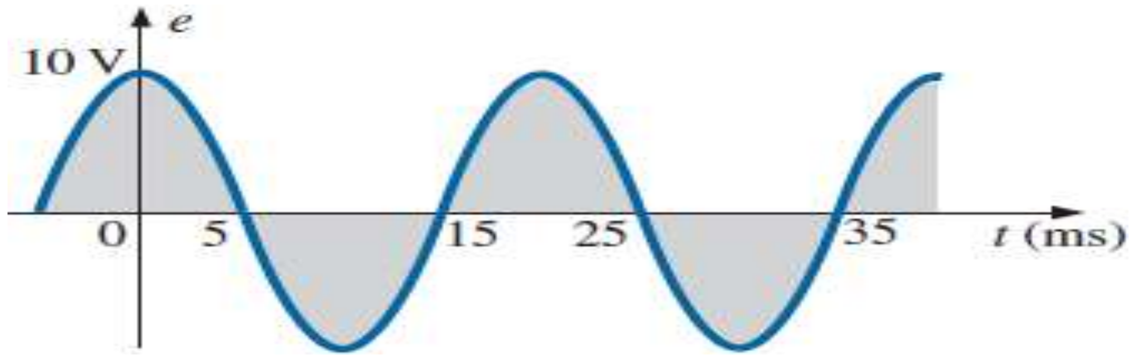
EXAMPLE 13.1 For the sinusoidal waveform in Fig.

a. What is the peak value?
b. What is the instantaneous value at 0.3 s and 0.6 s?
c. What is the peak-to-peak value of the waveform?
d. What is the period of the waveform?
e. How many cycles are shown?
f. What is the frequency of the waveform?

a. **8 V.**
b. At 0.3 s, **−8 V;** at 0.6 s, **0 V.**
c. **16 V.**
d. **0.4 s.**
e. **3.5 cycles.**
f. **2.5 cps,** or **2.5 Hz.**



EXAMPLE 13.3 Determine the frequency of the waveform in Fig.

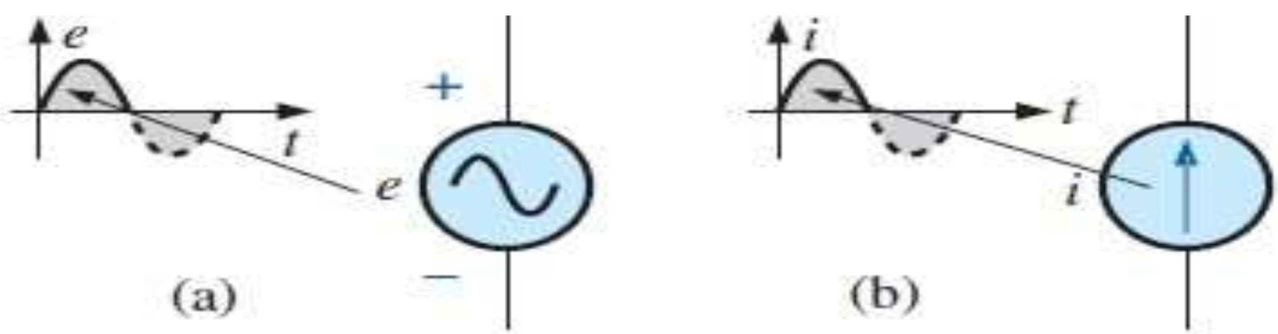


From the figure, $T = (25 \text{ ms} - 5 \text{ ms})$ or $(35 \text{ ms} - 15 \text{ ms}) = 20 \text{ ms}$, and

$$f = \frac{1}{T} = \frac{1}{20 \times 10^{-3}\text{ s}} = \mathbf{50\ Hz}$$

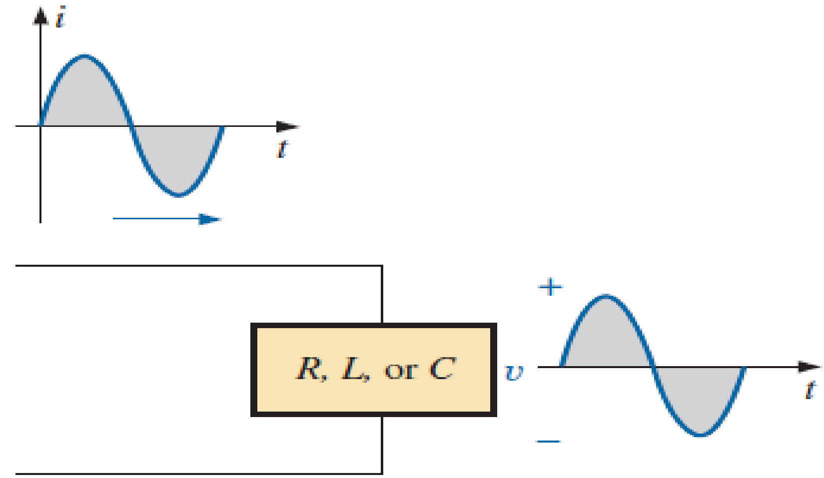
Defined Polarities and Direction

A positive sign is applied if the voltage is above the axis, as shown in Fig. (a). For a current source, the direction in the symbol corresponds with the positive region of the waveform, as shown in Fig. (b).



(a) Sinusoidal ac voltage sources; (b) sinusoidal current sources.

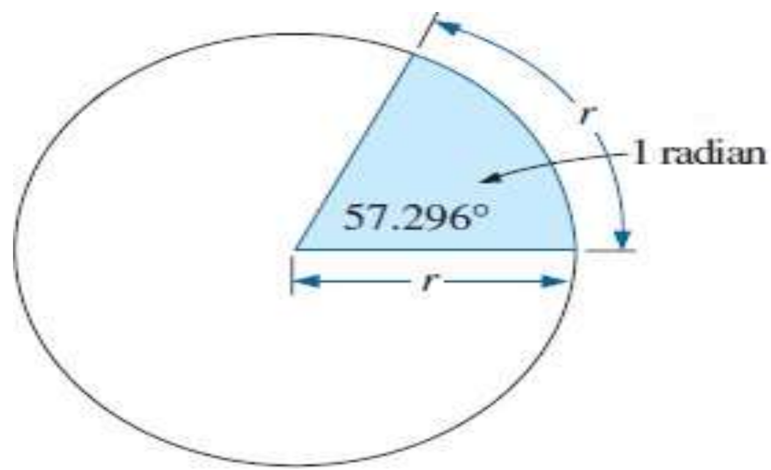
13.4 THE SINUSOIDAL WAVEFORM



The sinusoidal waveform is the only Alternating waveform whose unaffected shape is characteristics of R, L, and C elements. by the response

The unit of measurement for the horizontal axis can be **time** (as appearing in the figures thus far), **degrees, or radians.**

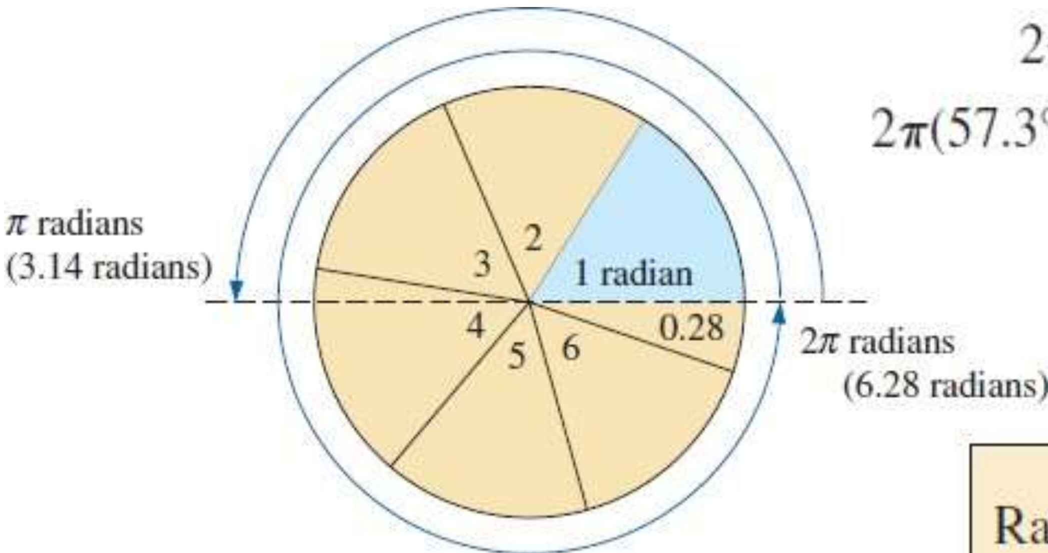
The term **radian** can be defined as follows: If we mark off a portion of the circumference of a circle by a length equal to the radius of the circle, as shown in Fig., the angle resulting is called 1 radian. The result is



$$\boxed{1\ \text{rad} = 57.296^\circ \cong 57.3^\circ}$$

One full circle has 2π radians, as shown in Fig. That is,

$$\boxed{2\pi \text{ rad} = 360^\circ}$$



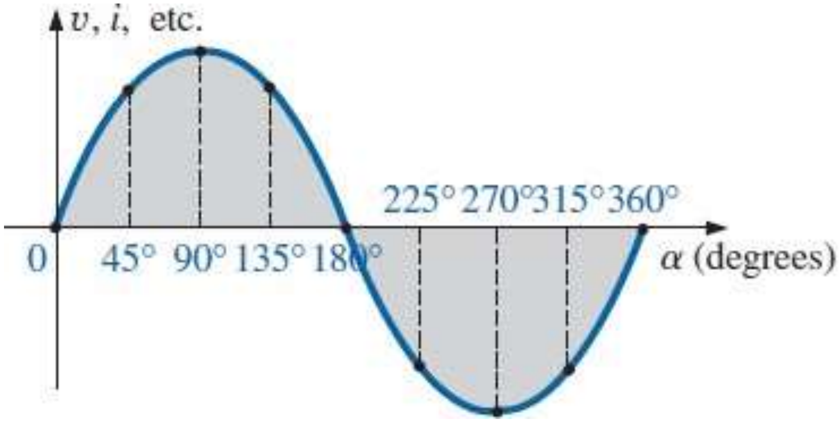
$$2\pi = 2(3.142) = 6.28$$

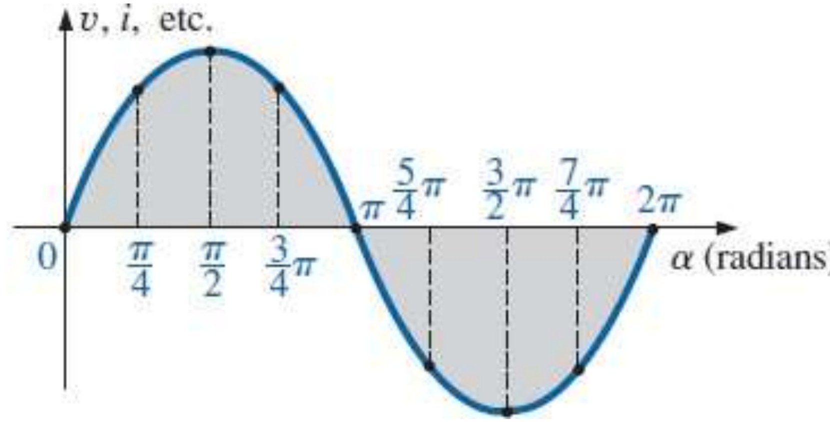
$$2\pi(57.3^\circ) = 6.28(57.3^\circ) = 359.84^\circ \cong 360^\circ$$

$$\boxed{\text{Radians} = \left(\frac{\pi}{180^\circ}\right) \times (\text{degrees})}$$

$$\boxed{\text{Degrees} = \left(\frac{180^\circ}{\pi}\right) \times (\text{radians})}$$

$$\pi = 3.14159\ 26535\ 89793\ 23846\ 26433\ \ldots$$





It is of particular interest that the sinusoidal waveform can be derived from the length of the vertical projection of a radius vector rotating in a uniform circular motion about a fixed point. Starting as shown in Fig.(a) and plotting the amplitude (above and below zero) on the coordinates drawn to the right [Figs. (b) through (i)],

The velocity with which the radius vector rotates about the center, called the **angular velocity,** can be determined from the following equation:

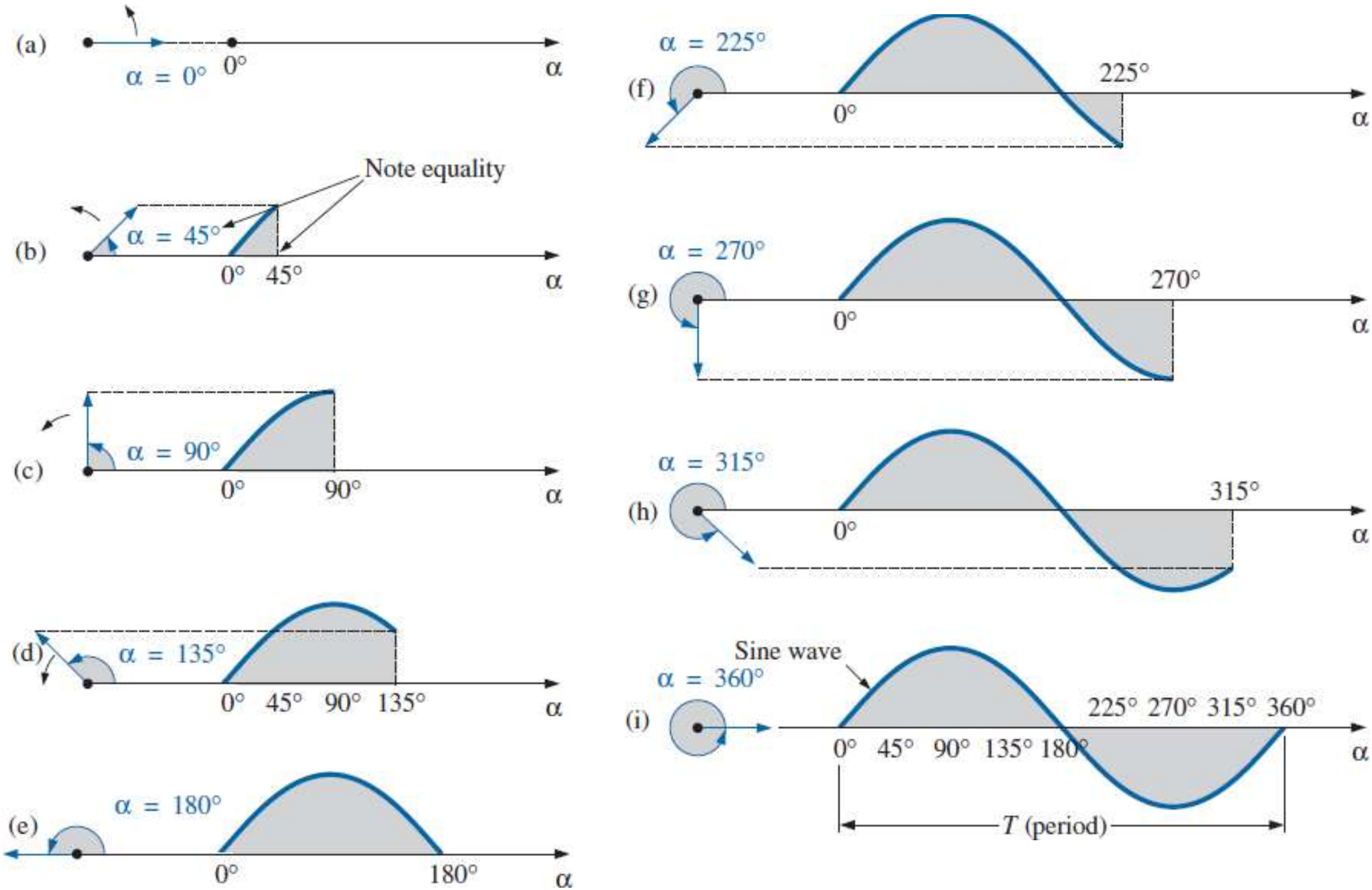
$$\boxed{\text{Angular velocity} = \frac{\text{distance (degrees or radians)}}{\text{time (seconds)}}}$$

$$\boxed{\omega = \frac{\alpha}{t}}$$

$$\boxed{\omega = \frac{2\pi}{T}} \quad \text{(rad/s)}$$

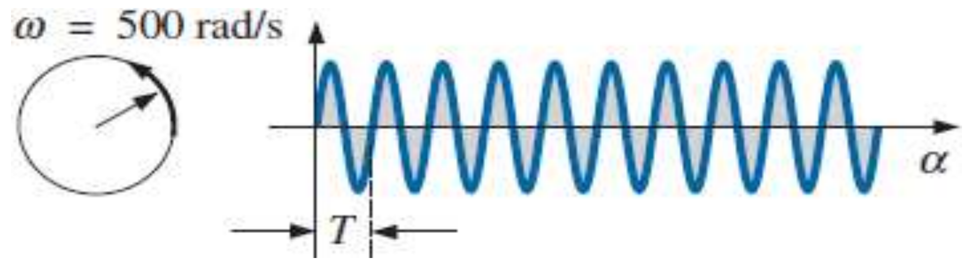
$$\boxed{\omega = 2\pi f} \quad \text{(rad/s)}$$

$$\boxed{\alpha = \omega t}$$



Generating a sinusoidal waveform through the vertical projection of a rotating vector.

EXAMPLE 13.5 Determine the frequency and period of the sine wave in Fig.



Since $\omega = 2\pi/T$,

$$T = \frac{2\pi}{\omega} = \frac{2\pi \text{ rad}}{500 \text{ rad/s}} = \frac{2\pi \text{ rad}}{500 \text{ rad/s}} = \mathbf{12.57\ ms}$$

$$f = \frac{1}{T} = \frac{1}{12.57 \times 10^{-3}\text{ s}} = \mathbf{79.58\ Hz}$$

EXAMPLE 13.6 Given ω = 200 rad/s, determine how long it will take the sinusoidal waveform to pass through an angle of 90°.

$$\alpha = \omega t, \text{ and } \quad t = \frac{\alpha}{\omega}$$

$$t = \frac{\alpha}{\omega} = \frac{\pi/2 \text{ rad}}{200 \text{ rad/s}} = \frac{\pi}{400}\text{ s} = \mathbf{7.85\ ms}$$

EXAMPLE 13.7 Find the angle through which a sinusoidal waveform of 60 Hz will pass in a period of 5 ms.

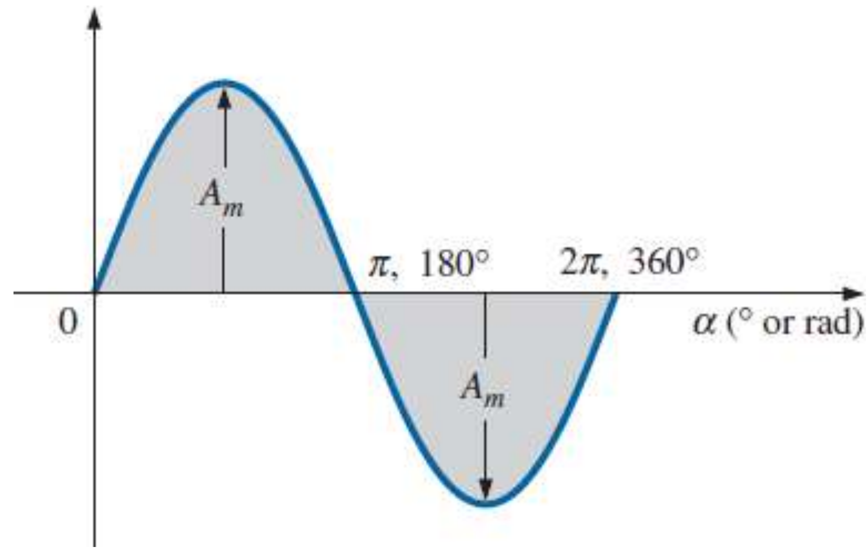
$$\alpha = \omega t, \text{ or}$$

$$\alpha = 2\pi f t = (2\pi)(60 \text{ Hz})(5 \times 10^{-3} \text{ s}) = \mathbf{1.885 \text{ rad}}$$

$$\alpha\,(^\circ) = \frac{180^\circ}{\pi \cancel{\text{rad}}}(1.885 \cancel{\text{rad}}) = \mathbf{108^\circ}$$

13.5 GENERAL FORMAT FOR THE SINUSOIDAL VOLTAGE OR CURRENT

$$\boxed{A_m \sin \alpha} \quad \boxed{A_m \sin \omega t}$$



For electrical quantities such as current and voltage, the general format is

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

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

EXAMPLE 13.8 Given $e = 5 \sin \alpha$, determine e at $\alpha = 40°$ and $\alpha = 0.8\pi$.

For $\alpha = 40°$,

$$e = 5 \sin 40° = 5(0.6428) = \mathbf{3.21\ V}$$

For $\alpha = 0.8\pi$,

$$\alpha\,(°) = \frac{180°}{\pi}(0.8\pi) = 144°$$

and $\quad e = 5 \sin 144° = 5(0.5878) = \mathbf{2.94\ V}$

$$e = E_m \sin \alpha \qquad \sin \alpha = \frac{e}{E_m}$$

which can be written

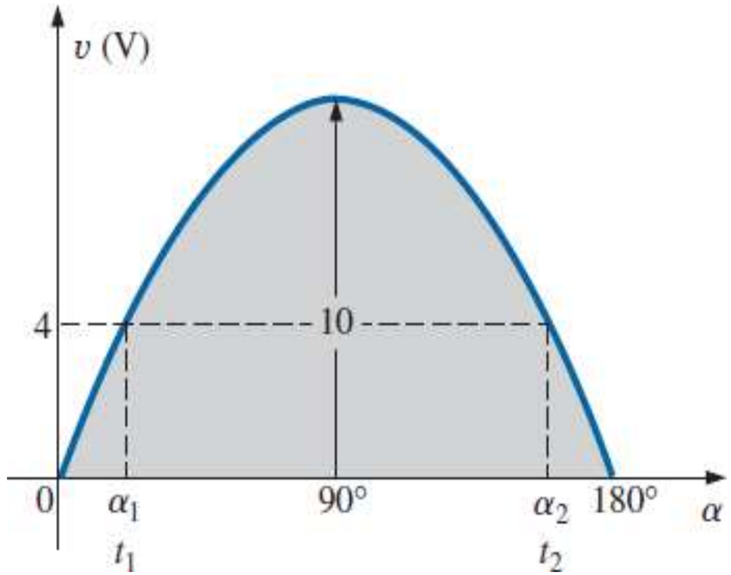
$$\boxed{\alpha = \sin^{-1} \frac{e}{E_m}}$$

Similarly, for a particular current level,

$$\boxed{\alpha = \sin^{-1} \frac{i}{I_m}}$$

EXAMPLE 13.9

a) Determine the angle at which the magnitude of the sinusoidal function
   v = 10 sin 377t is 4 V.
a) Determine the time at which the magnitude is attained.



$$\alpha_1 = \sin^{-1}\frac{v}{E_m} = \sin^{-1}\frac{4\text{ V}}{10\text{ V}} = \sin^{-1}0.4 = \mathbf{23.58°}$$

$$\alpha_2 = 180° - 23.578° = \mathbf{156.42°}$$

$$\alpha\ (\text{rad}) = \frac{\pi}{180°}(23.578°) = 0.412\text{ rad}$$

and
$$t_1 = \frac{\alpha}{\omega} = \frac{0.412\text{ rad}}{377\text{ rad/s}} = \mathbf{1.09\ ms}$$

For the second intersection,

$$\alpha\ (\text{rad}) = \frac{\pi}{180°}(156.422°) = 2.73\text{ rad}$$

$$t_2 = \frac{\alpha}{\omega} = \frac{2.73\text{ rad}}{377\text{ rad/s}} = \mathbf{7.24\ ms}$$

THANK YOU