Module Title: Fundamental of Electrical Engineering (AC)

Module Code:	UOMU024021

Week (1)

1. AC FUNDAMENTALS: TYPES OF A.C. WAVEFORMS

The waveform of alternating voltage or current is shown purely sinusoidal in the Fig.(b).

But, in practice, a quantity which undergoes variations in its instantaneous values, in magnitude as well as direction with respect to some zero reference is called an alternating quantity. The graph of such quantity against time is called its waveform. Various types of alternating waveforms other than sinusoidal are shown in the Fig.(a), (b) and (c).

Out of all these types of alternating waveforms, purely sinusoidal waveform is preferred

for AC system. There are few advantages of selecting purely sinusoidal as the standard waveform.

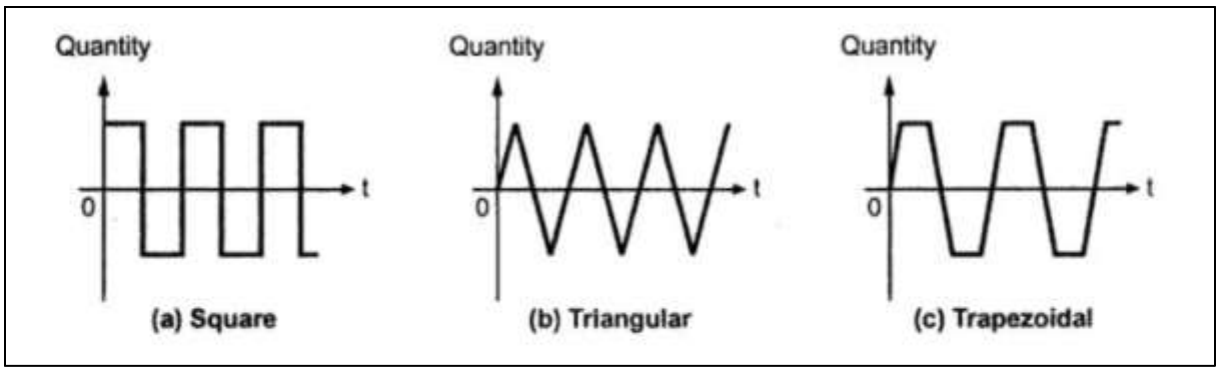

Fig.(a), (b) and (c).

2. Difference Between DC and AC

Direct current (DC) is the flow of electric charge in only one direction. It is the steady state of a constant-voltage circuit. Most well-known applications, however, use a time-varying voltage source. Alternating current (AC) is the flow of electric charge that periodically reverses direction. In another word, electric current flows in two ways as an alternating current (AC) or direct current (DC). The main difference between AC and DC lies in the direction in which the electrons flow. In DC, the electrons flow steadily in a single direction, while electrons keep switching directions, going forward and then backwards in AC. See figure 2, a, b .

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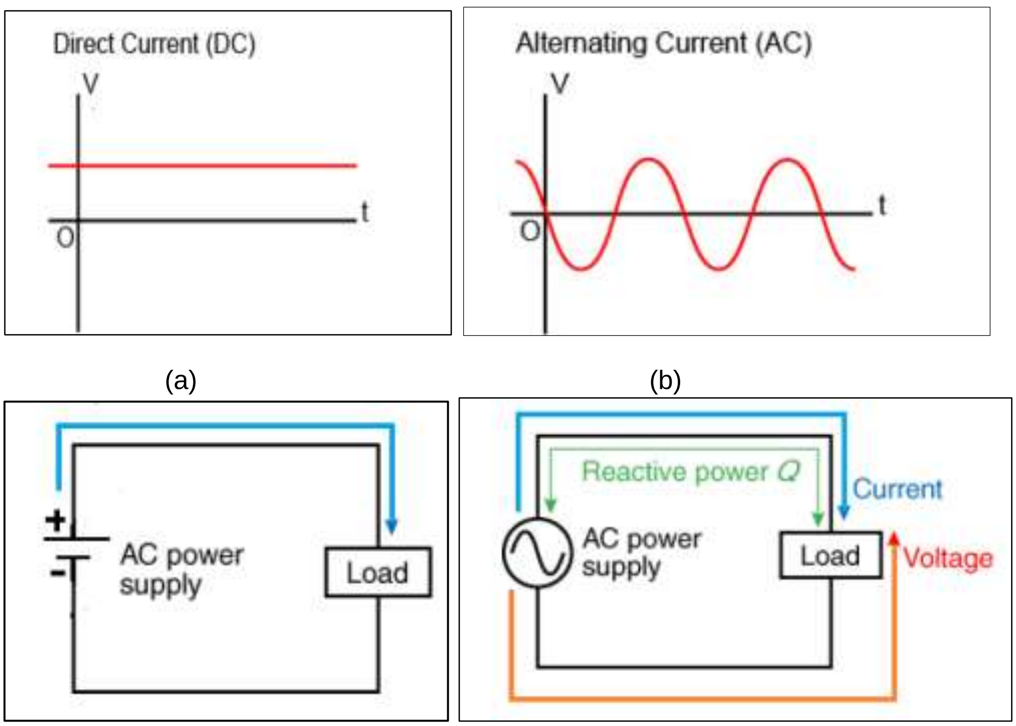

Figure 2, a, b

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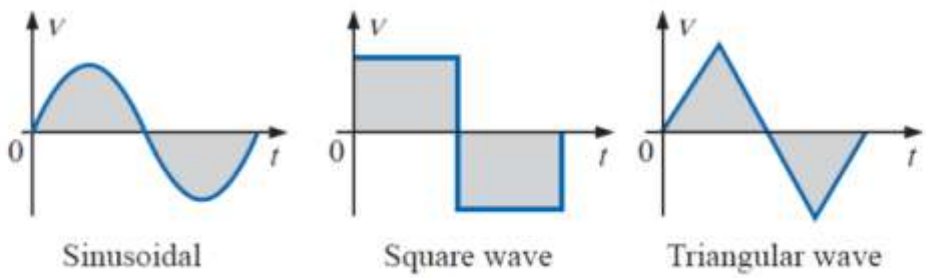
Alternating Current (AC)	Direct Current (DC)
AC is easy to be transferred over longer distances – even between two cities – without much energy loss.	DC cannot be transferred over a very long distance. It loses electric power.
The rotating magnets cause the change in direction of electric flow.	The steady magnetism makes DC flow in a single direction.
The frequency of AC is dependent upon the country. But, generally, the frequency is 50 Hz or 60 Hz.	DC has no frequency or zero frequency.
In AC the flow of current changes its direction forward and backward periodically.	It flows in a single direction steadily.
Electrons in AC keep changing their directions – backward and forward.	Electrons only move in one direction – forward.

3. Sinusoidal Alternating Waveforms:
   The terminology (ac) voltage or (ac) current refers to alternating voltage or current. The term alternating indicates only that waveforms alternate between two prescribed levels in a set time sequence as shown in figure 3, a, b, and c. To be absolutely correct the term sinusoidal, square, triangular must be also applied. The pattern of particular interest is the sinusoidal ac waveform voltage.



a b c

Figure 3, a, b, and c

4. SINUSOIDAL AC VOLTAGE DEFINITIONS:

The vertical scaling is in volts or amperes and the horizontal scaling is always in units of time. See figure 4 below.

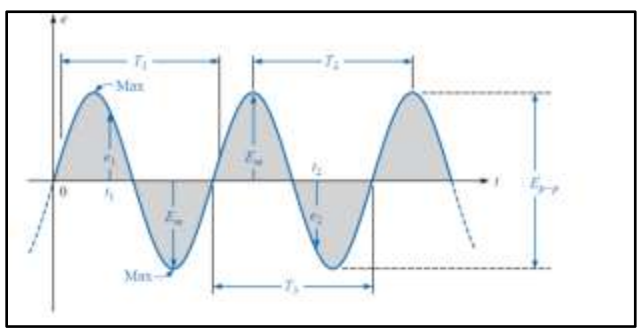


Figure 4

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

2.Instantaneous value: The magnitude of a waveform at any instant of time; denoted by lowercase letters (e1, e2).

3.Peak amplitude: The maximum value of a waveform as measured from its average, or mean, value, denoted by uppercase letters (such as E_m for sources of voltage and V_m for the voltage drop across a load).

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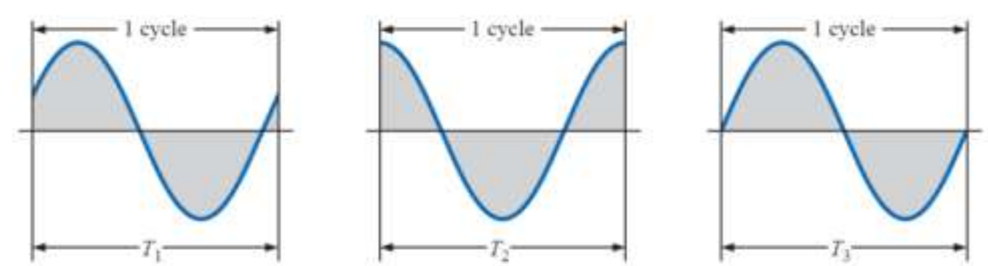
4.Peak value: The maximum instantaneous value of a function as measured from the zero-volt level.

5.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.

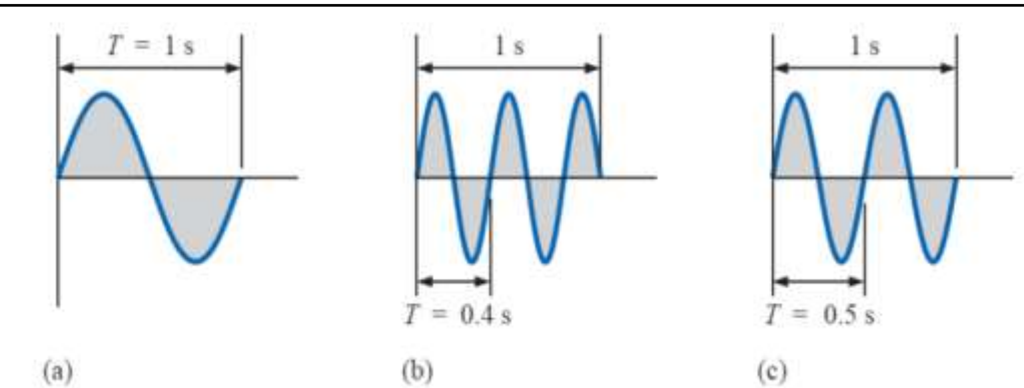
6.Periodic waveform: A waveform that continually repeats itself after the same time interval.

7. Period (T): The time interval between successive repetitions of a periodic waveform (the period T 1 = T 2 = T 3),

8. Cycle: The portion of a waveform contained in one period of time.



Frequency (f): The number of cycles that occur in 1 s.



(a) is 1 cycle per second, and for (b), 2 1⁄2 cycles per second. If a waveform of similar shape had a period of 0.5 s (c), the frequency would be 2 cycles per second.

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1 hertz (Hz) = 1 cycle per second (c/s)

$$f = \frac{1}{T}$$

f = Hz
T = seconds (s)

$$T = \frac{1}{f}$$

EXAMPLE 1: Find the period of a periodic waveform with a frequency of

a. 60 Hz.

b. 1000 Hz.

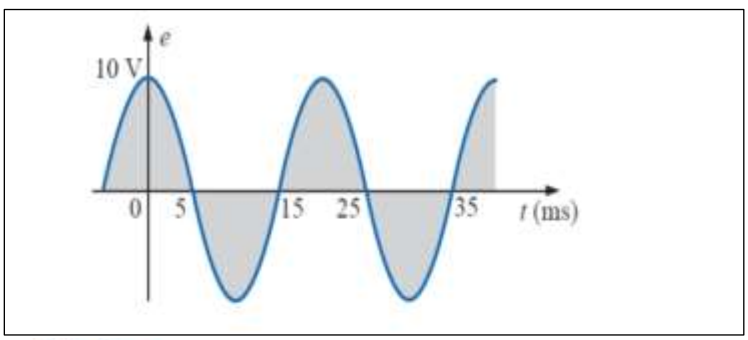
Solutions:

a. $T = \frac{1}{f} = \frac{1}{60\text{ Hz}} \cong 0.01667\text{ s or } \mathbf{16.67\ ms}$

(a recurring value since 60 Hz is so prevalent)

b. $T = \frac{1}{f} = \frac{1}{1000\text{ Hz}} = 10^{-3}\text{ s} = \mathbf{1\ ms}$

EXAMPLE 2 : Determine the frequency of the waveform.



Solutions:

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

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

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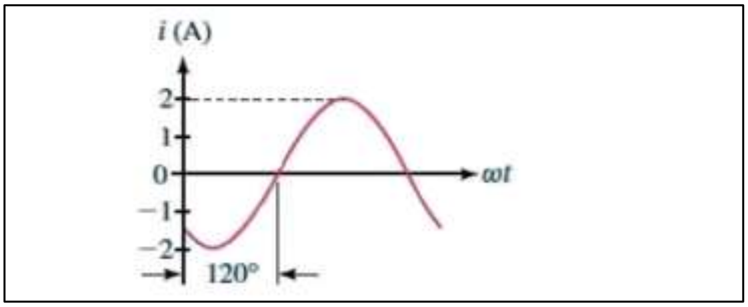
Homework assignment:

Problem 1:

Determine the equation for the waveform shown below, given f =60 Hz.



Problem 2:

The current in an a.c. circuit at any time t seconds is given by:
$i = 120\sin(100\pi t + 0.36)$ amperes. Find:

(a) The peak value, the periodic time, the frequency and phase angle relative to $120 \sin 100\pi t$
(b) The value of the current when t =0
(c) The value of the current when t =8ms
(d) The time when the current first reaches 60A

Solved Problem 3:

Express each of the following frequencies in Hertz, Hint: Frequency is cycle per second

a) 40 cycles in 4.0 seconds

b) 80 cycles in 200 milliseconds

c) 1000 revolutions in 0.5 seconds

d) 600 rotations in 1 minute

Solution:

a) 40/4.0 = 10 cycles per second = 10 Hz

b) 80/0.2 = 400 cycles per second = 400 Hz

c) 1000/0.5 = 2000 cycles per second = 4000 Hz (4 kHz)

d) 600/60 = 10 cycles per second = 10 Hz

Solved Problem 4:

Express each of the following as angular velocity in radians per second

a) 80 rad in 10 s

b) 2.5 krad in 50 s

c) 400 rad in 200 s

d) 40 Mrad in 10 s

Solution:

a) $\omega = 80/10 = 8$ rad/s

b) $\omega = 2500/50 = 500$ rad/s

c) $\omega = 400/200 = 2.0$ rad/s

d) $\omega = (40\times10^6)/10 = 4.0$ rad/s

Solved Problem 5:

Express each of the following frequencies as angular velocity in radians per second

a) 60 Hz

b) 500 Hz

c) 10 kHz

d) 1 MHz

Solution:

a) $\omega = 2\pi\times60 = 377$ rad/s

b) $\omega = 2\pi\times500 = 3141.5$ rad/s

c) $\omega = 2\pi\times(10\times10^3) = 62.83$ krad/s

d) $\omega = 2\pi\times(1.0\times10^6) = 6.28$ Mrad/s

Solved Problem 6:

Express each of the following periods in seconds

a) 500 Hz

b) 90 kHz

c) 900 MHz

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d) 5 Hz

Solution: Hint: The relationship between time (T) and frequency (f) is indicated by the formulas T=1/f

a) T = 2 ms

b) T = 1/(90×10^3) = 11.11 µs

c) T = 1/(900×10^6) = 1.11 ps

d) T = 0.2 s