AL-MUSTAQBAL UNIVERSITY COLLEGE

Department of Biomedical Engineering

Faculty of Engineering

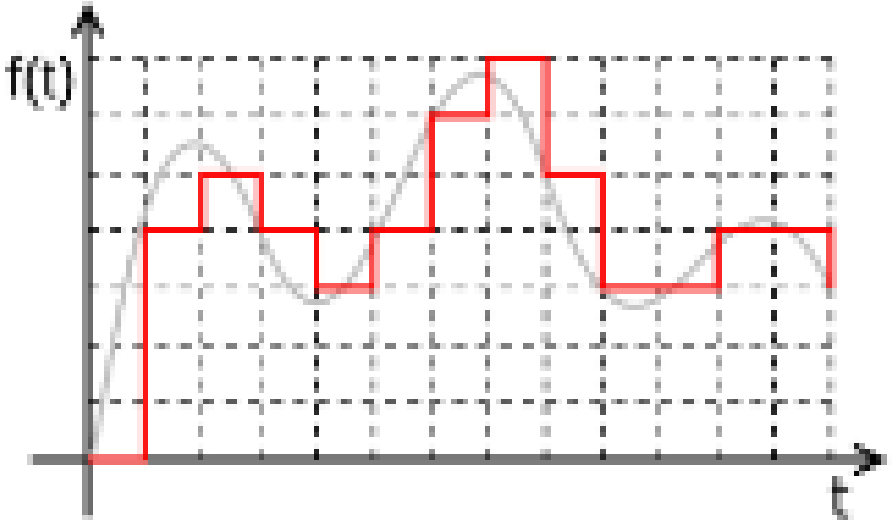
Dr. Zaidoon AL-Shammari

BME 322
Signals and Systems for BME

- 2 -
Continuous Time Signal

Babylon – Iraq – May 2021

CONTINUOUS-TIME SIGNALS



Dr. Zaidoon AL_Shammari
Lecturer / Researcher
Department of Biomedical Engineering
Faculty of Engineering
AL-MUSTAQBAL UNIVERSITY COLLEGE

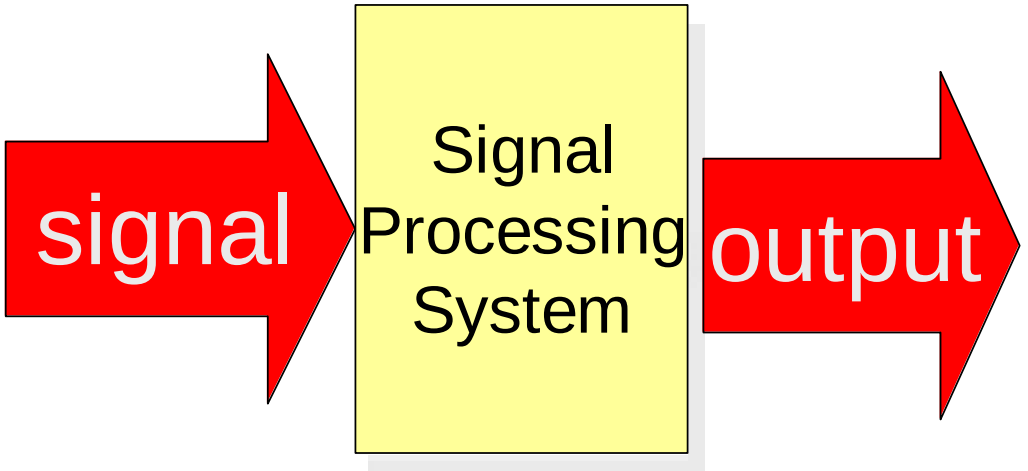
Functional Notation

- For functions whose independent variable is either real numbers or complex numbers, the independent variable will be enclosed in parentheses .( )
- For functions whose independent variable is integers the independent variable will be enclosed in brackets [ ].

Revision on Numbers

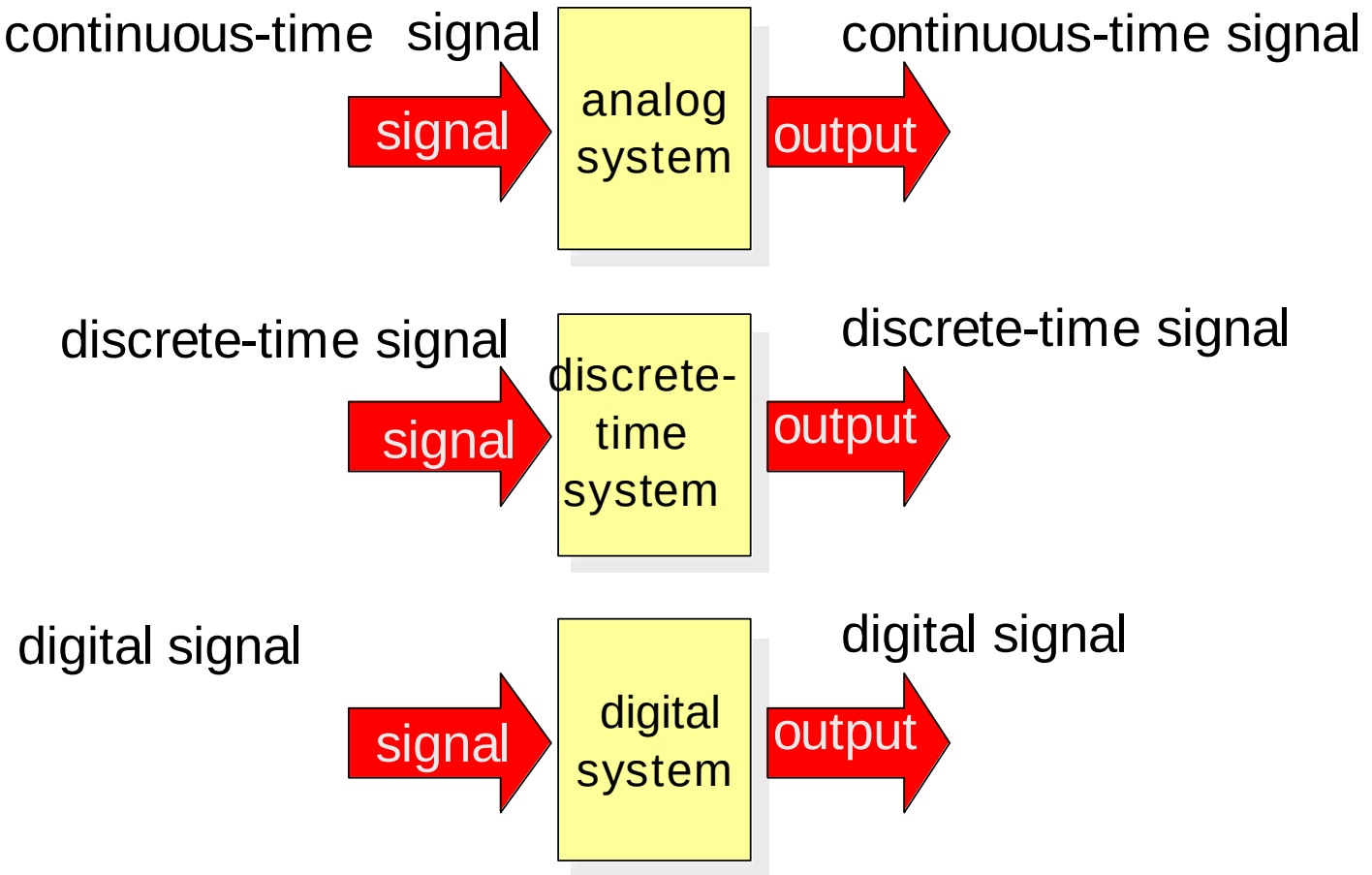
- Real numbers are the numbers that we normally use and apply in real-world applications.
- Real Numbers include:
  Whole Numbers (like 0, 1, 2, 3, 4, etc)
  Rational Numbers (like 3/4, 0.125, 0.333, 1.1, etc)
  Irrational Numbers (like π, $\sqrt{2}$, etc)
- Real Numbers can also be positive, negative or Zero.

Signal Processing Systems



- Facilitate the extraction of desired information.

Signal Processing Systems - cont



Classification of CT Signals

- Periodic signals.

- Non periodic signals.

Periodic Signals

- A continuous-time signal, x(t) is a periodic signal if $x(t + nT) = x(t)$, where T is the period of the signal and n is an integer.

- Sinusoidal, square and triangular waves are periodic signals.

Periodic Signals - cont

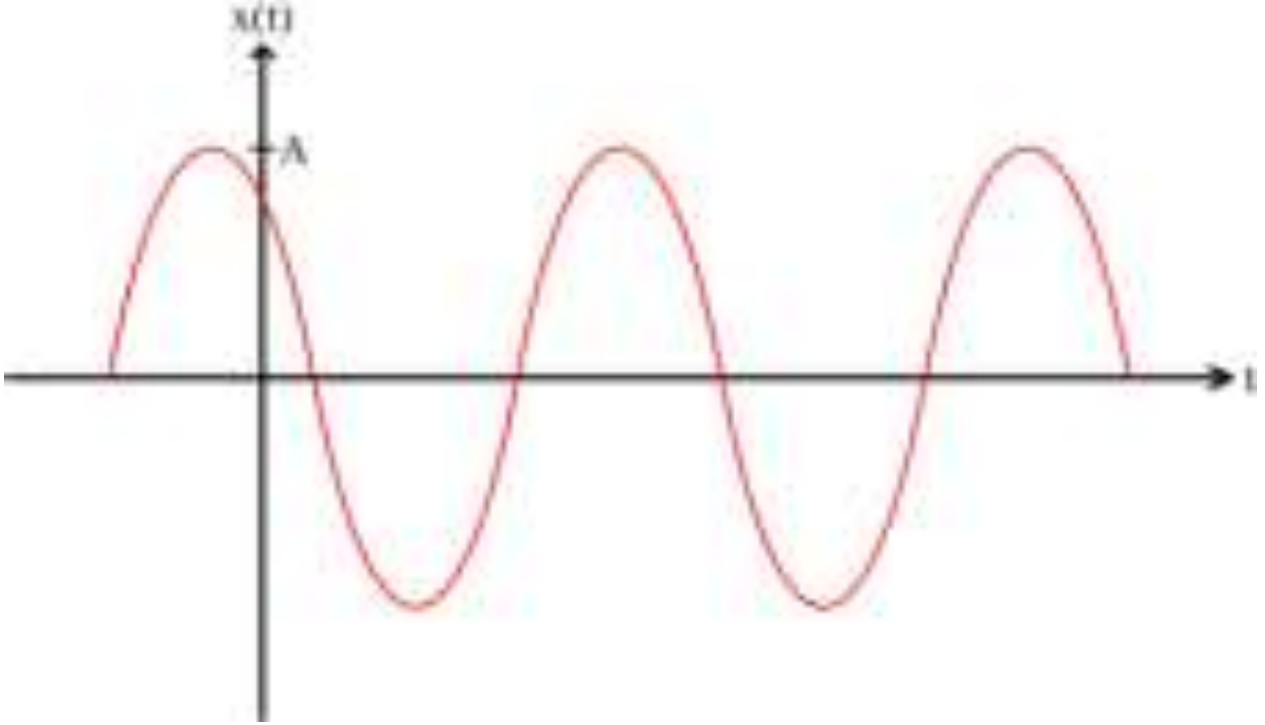
- For $x(t) = x_1(t) + x_2(t)$, where $x_1(t)$ and $x_2(t)$ are two periodic signals with fundamental T_1 and T_2 respectively, $x(t)$ is a periodic signal if T_1/T_2 = a rational number.
- The fundamental period, T for $x(t)$ is the least common multiples (LCM) of T_1 and T_2.

Least Common Multiples

- The smallest positive number that is a multiple of two or more numbers.
- The multiples of 4 are: 4, 8, 12, 16, 20, 24, 28, 32,36, 40, 44,...
- The multiples of 5 are: 5, 10, 15, 20, 25, 30, 35, 40,45, 50, ...
- So, the common multiples of 4 and 5 are: 20, 40, (and 60, 80, etc ..., too.)
- The smallest of the common multiples is 20, so the least common multiple (LCM) of 4 and 5 is 20

Sinusoidal Signal

Time domain representation

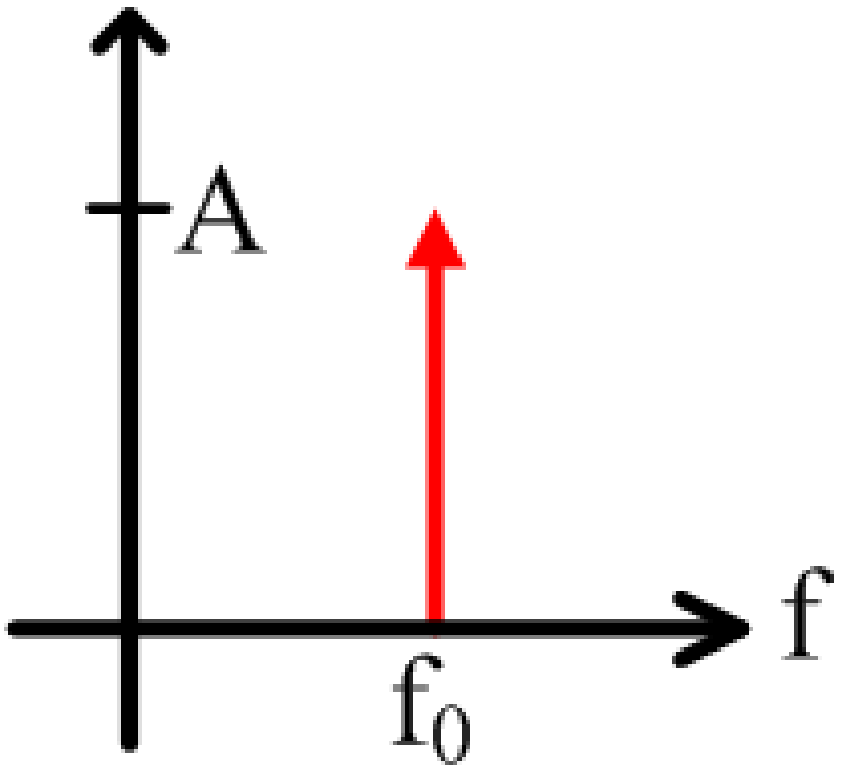


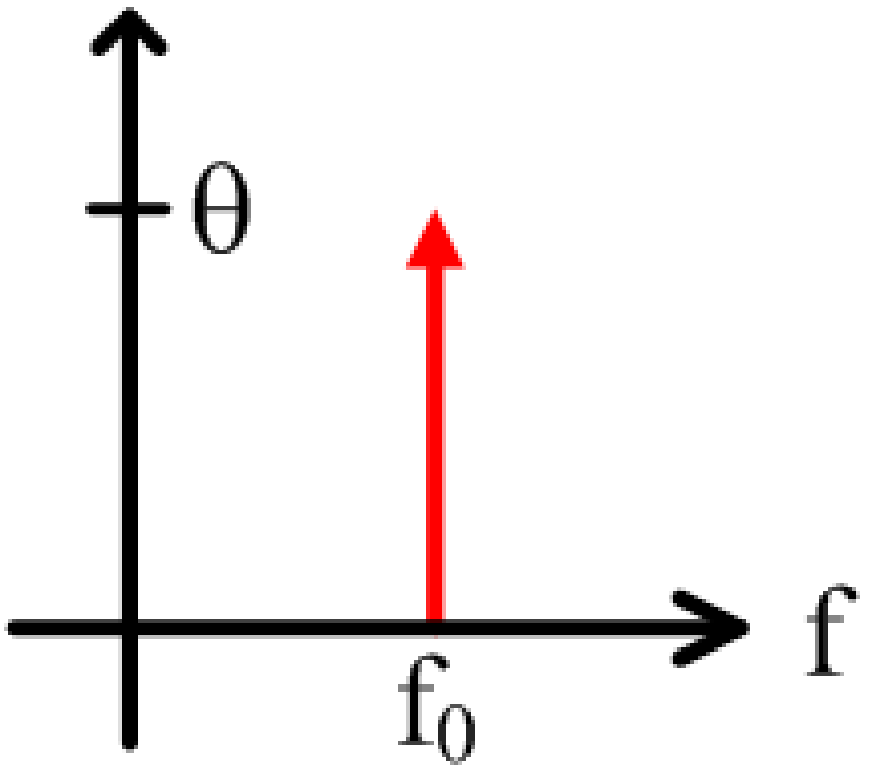
$$x(t) = A\cos(\omega_0 t + \theta) = A\cos(2\pi f_0 t + \theta)$$

Sinusoidal Signal Properties

- Frequency.
- Period.
- Peak (maximum) value.
- Peak-to-peak value.

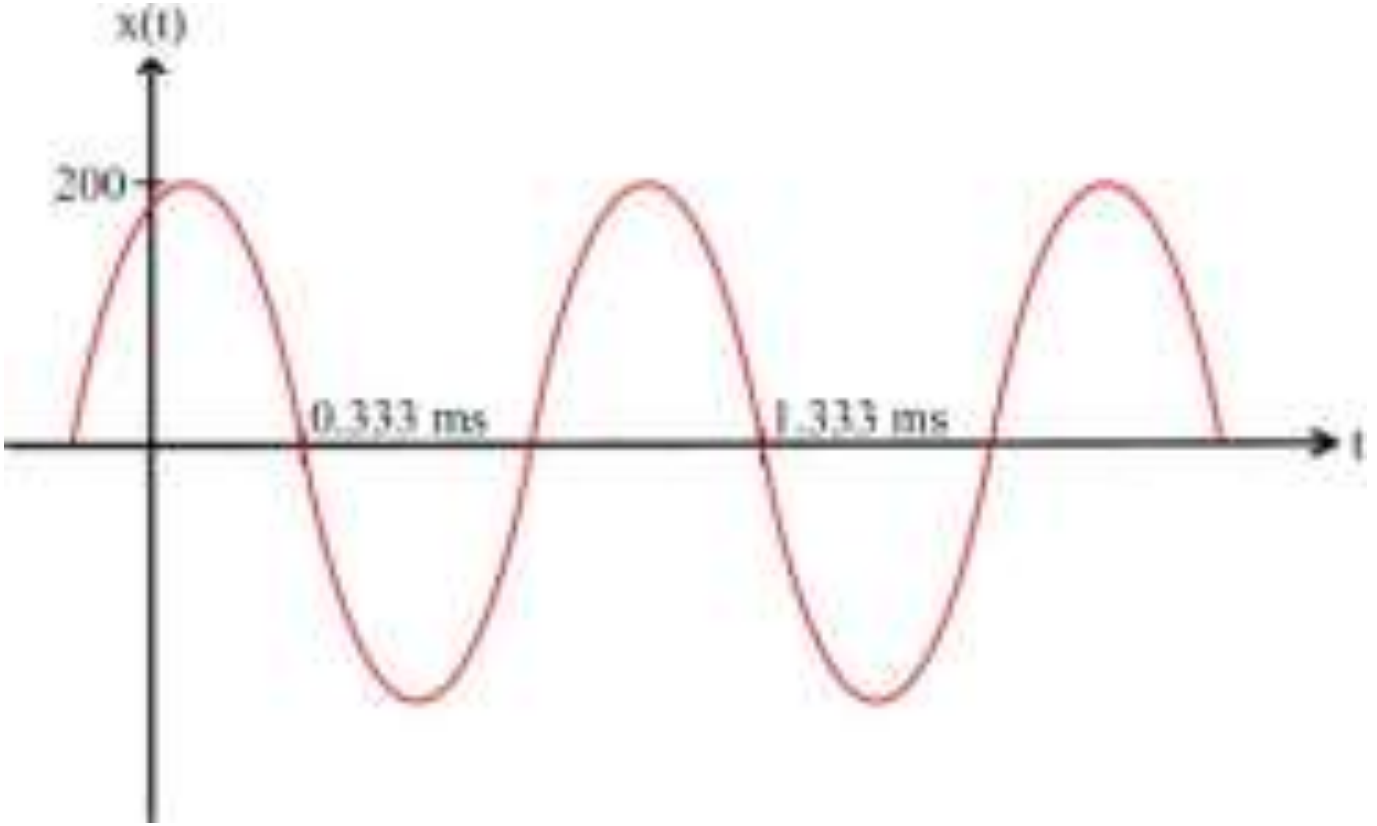
Amplitude & Phase Spectrums





Example 1

Write the analytical expression for the signal with the phase angle in degrees.



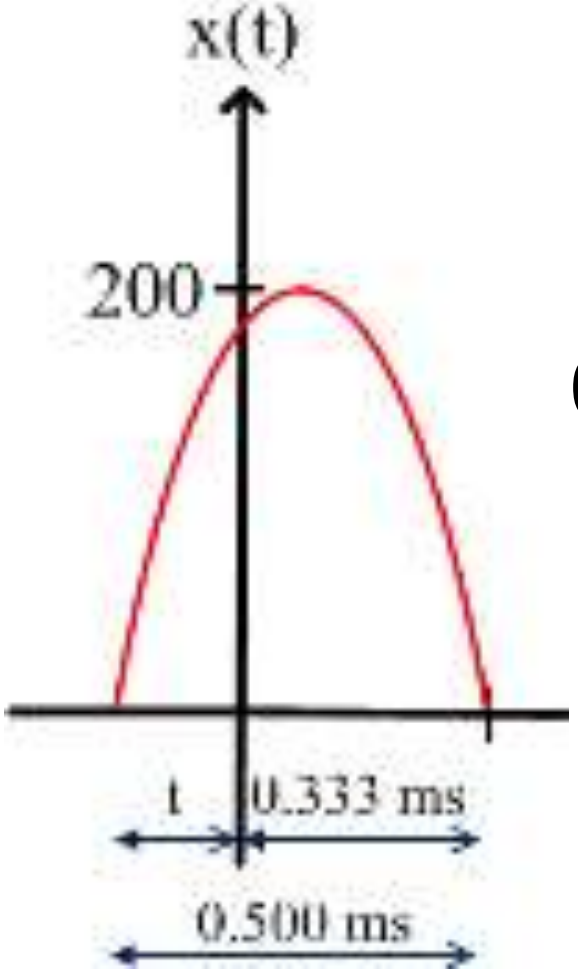
Example 1 - cont

Peak (maximum) value, $A_{(p)} = 200$.

Period, T = 1.333 ms – 0.333 ms = 1 ms.

Frequency = 1/T = 1/1 ms = 1 kHz.

Example 1 - cont



$$t = 0.500 \text{ ms} - 0.333 \text{ ms}$$
$$= 0.167 \text{ ms}$$

$$0.167 \text{ ms} = (0.167 \text{ ms} / 0.500 \text{ ms})180^0$$
$$= 60.12^0$$

$$x(t) = 200\sin(2\pi 1000t + 60.12^0)$$

Example 2

Sketch a waveform for a signal, x(t) = 5sin754t with the :

(a) time in seconds.

(b) angle in degrees.

(c) angle in radians.

Example 2 - cont

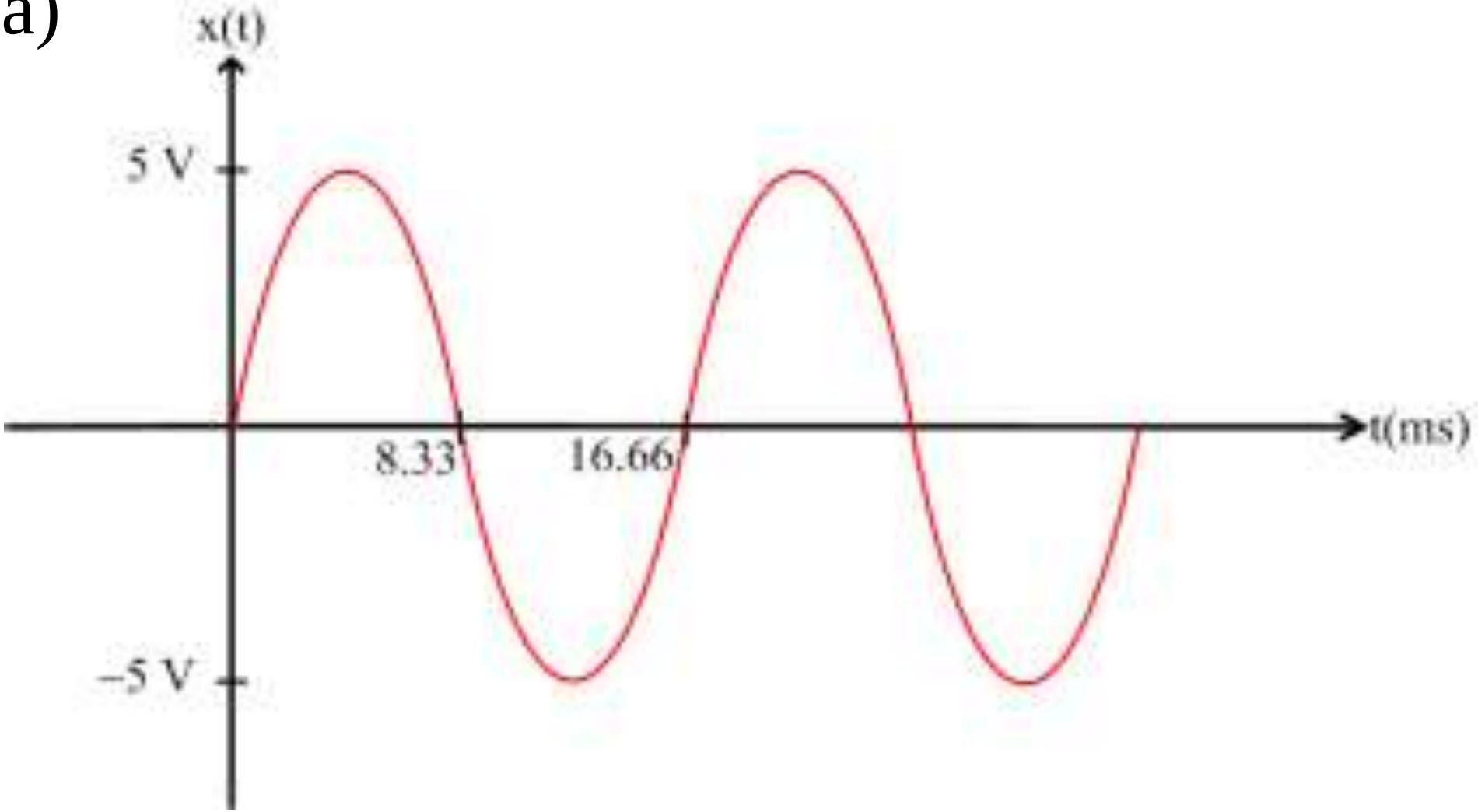
Peak (maximum) value, $A_{(p)} = 5$.

Frequency, $f = 754/(2\pi) = 120$ Hz.

Period, $T = 1/f = 1/120$ Hz $= 8.33$ ms.

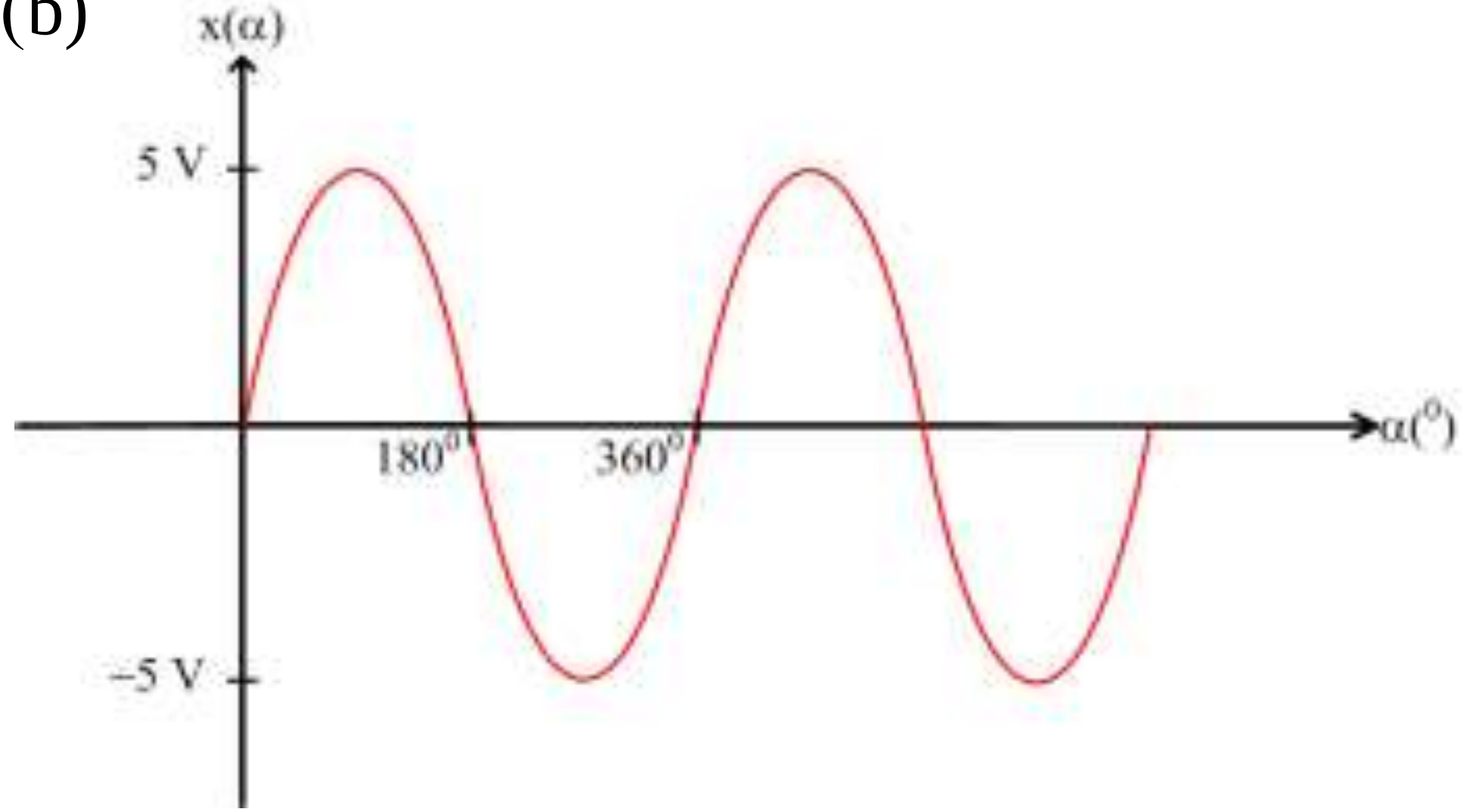
Example 2 - cont

(a)



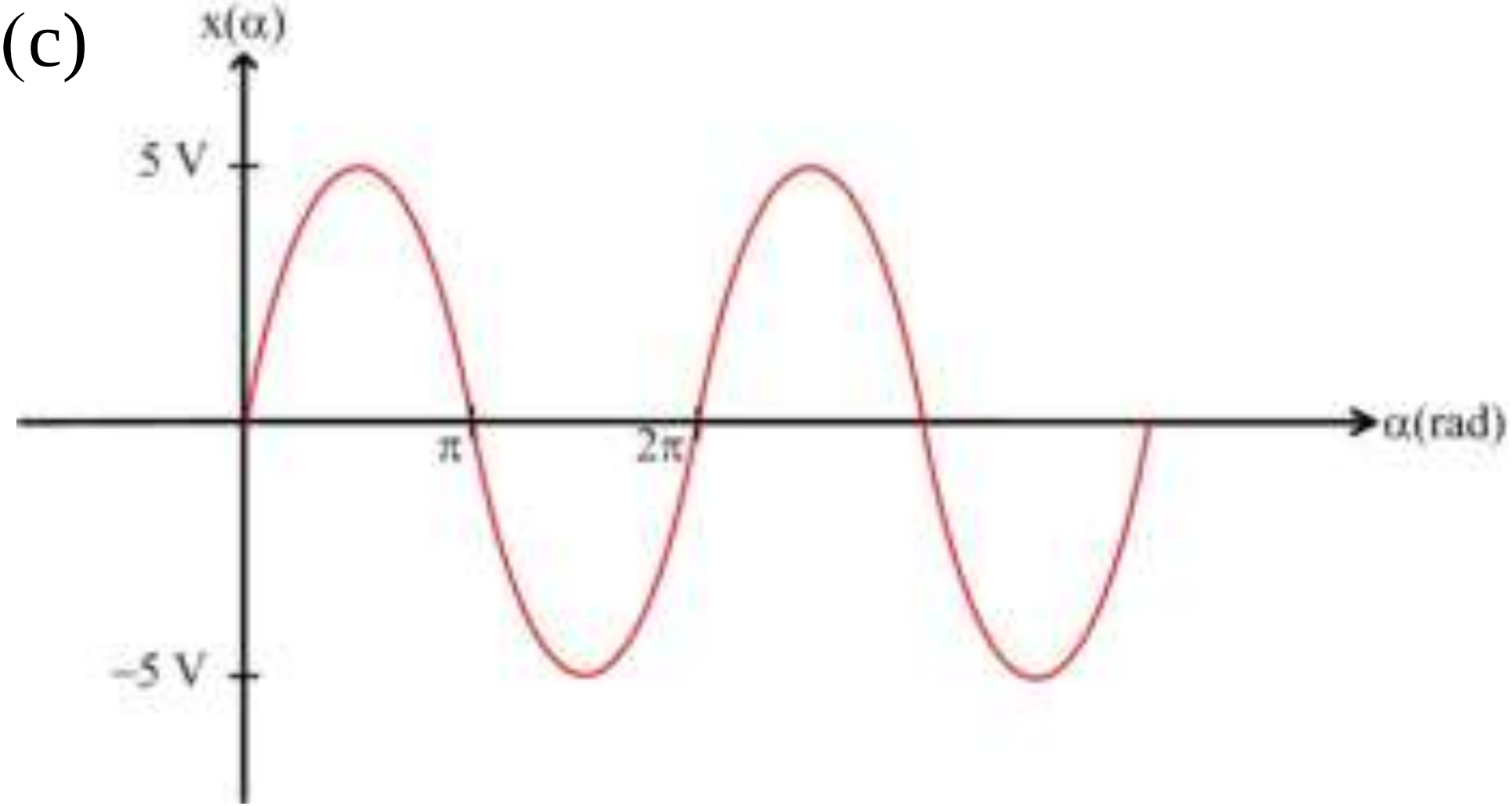
Example 2 - cont

(b)



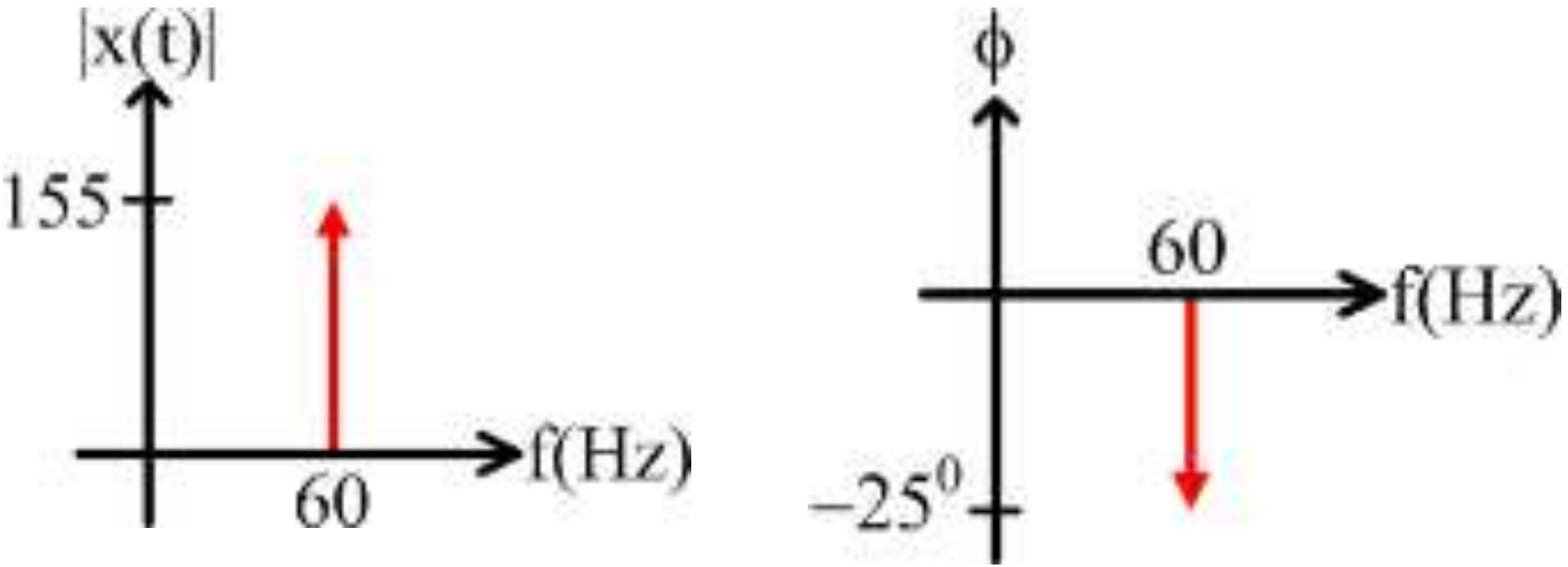
Example 2 - cont

(c)



Example 6

Represent $x(t) = 155\cos(377t - 25^0)$ in frequency domain.



Example 7

Determine whether each of the following signal is periodic. If a signal is periodic, determine its fundamental period.

(a) $x(t) = \cos(t + \pi/4)$

(b) $x(t) = \cos(\pi/3)t + \sin(\pi/4)t$

Example 7 - cont

(a) $x(t) = \cos(t + \pi/4)$

$x(t(= \cos(t + \pi/4)$ is in the form $A\cos(2\pi f_0 t)$ where f_0 is the fundamental frequency. In this case, $f_0 = 1/(2\pi)$. Therefore, the fundamental frequency, $T_0 = 1/f_0 = 2\pi$

Example 7 - cont

(b) $x(t) = \cos(\pi/3)t + \sin(\pi/4)t$

This is the sum of two functions that are both periodic. Their fundamental periods are T_1 = 6 seconds and T_2 = 8 seconds respectively. T1/T2 = 6/8 is a rational number, therefore x(t) is a periodic signal.

The fundamental frequency, T_0 is the least common multiples (LCM) which is 24 seconds.