Department of Electrical Engineering
Assignment Spring 2020
Date: 20/04/2020

Course Details

Course Title: Communication Systems **Module:** ______
Instructor: Dr. Engr. Shahid Latif **Total Marks:** 30

Student Details

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Q1.	**(a)**	**What are major causes for transmission impairments? Describe using example of various degradations.**	**Marks 5**
	(b)	**Suppose the signals $k_1(t)$ and $k_2(t)$ are defined as follows:** $k_1(t) = \begin{cases} 0, & t < 1 \\ 1, & 1 \le t \le 2 \\ 0, & 2 < t < 3 \\ 1, & 3 \le t \le 4 \\ 0, & 4 < t \end{cases}$ and $k_2(t) = \begin{cases} 0, & t < 0 \\ 2, & 0 \le t \le 2 \\ 0, & 2 < t \end{cases}$ Determine $k_3(t) = k_1(t) + k_2(t)$ and $k_4(t) = k_1(t)\, k_2(t)$.	**Marks 5**
Q2.	**(a)**	**Explain how signals can be broadly classified? Describe in detail any five types of signals.**	**Marks 5**
	(b)	**Determine whether the signal $z(t) = t^3 + t^2$ is an odd signal or an even signal or neither; if it is neither, then determine the odd and even parts of it.**	**Marks 5**
Q3.		**Explain main characteristics of Sinusoidal Signals. Describe benefits and applications of Sinusoidal Signals.**	**Marks 10**

Q1.	(a)	**What are major causes for transmission impairments? Describe using example of various degradations.**	**Marks 5**

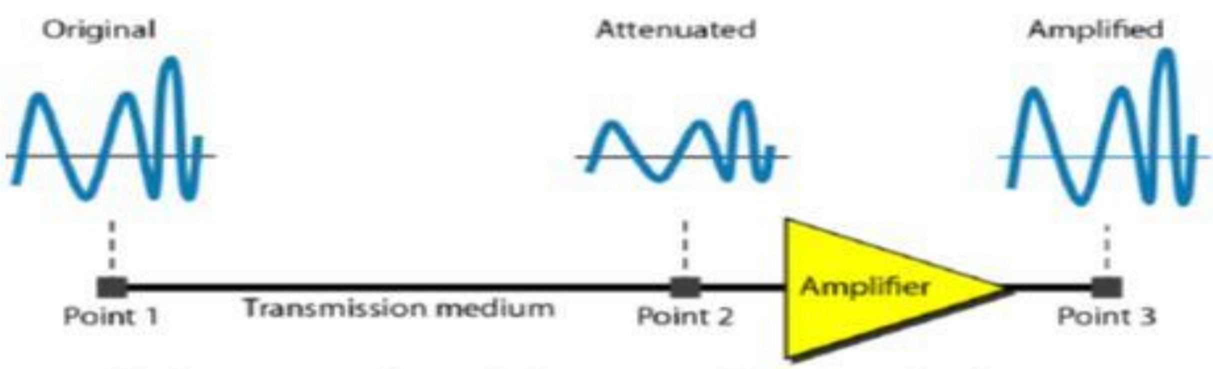
Ans 1(a).

Signals travel through transmission media, which are not perfect. The imperfection causes signal impairment. This means that the signal at the beginning of the medium is not the same as the signal at the end of the medium. What is sent is not what is received.

The three different causes of impairment are attenuation, distortion, and noise.

Attenuation:

Attenuation means a loss of energy. When a signal, simple or composite travels through a medium, it loses some of its energy in overcoming the resistance of the medium. That's why a wire carrying electric signals gets warm, if not hot after a while. Some of the electrical energy in the signal is converted to heat. To compensate for this loss, amplifiers are used to amplify the signal. The given below figure shows the effect of attenuation and amplification.

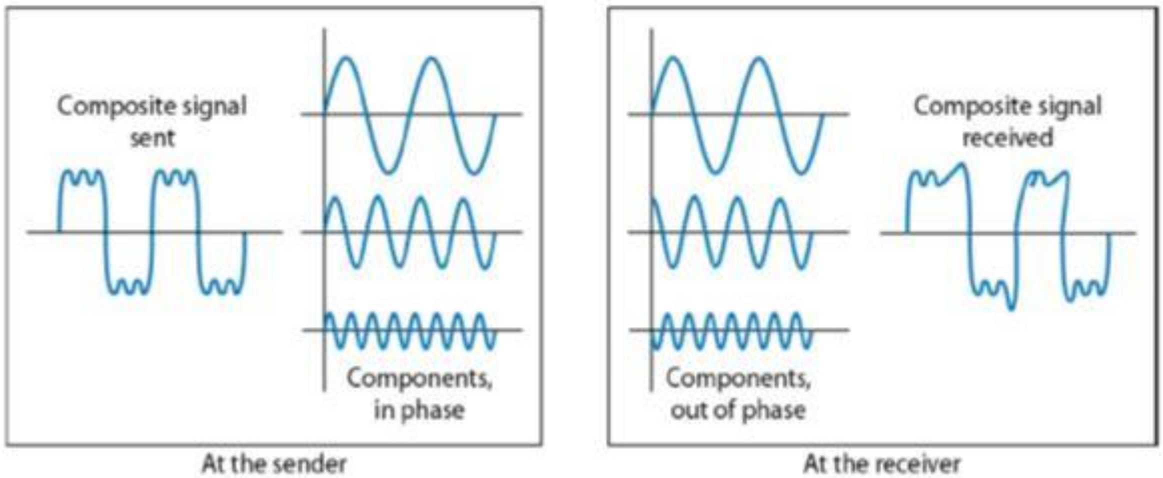


Decibel: Measure the relative power (attenuation)

$$dB = 10 \log_{10} P_2/P_1$$

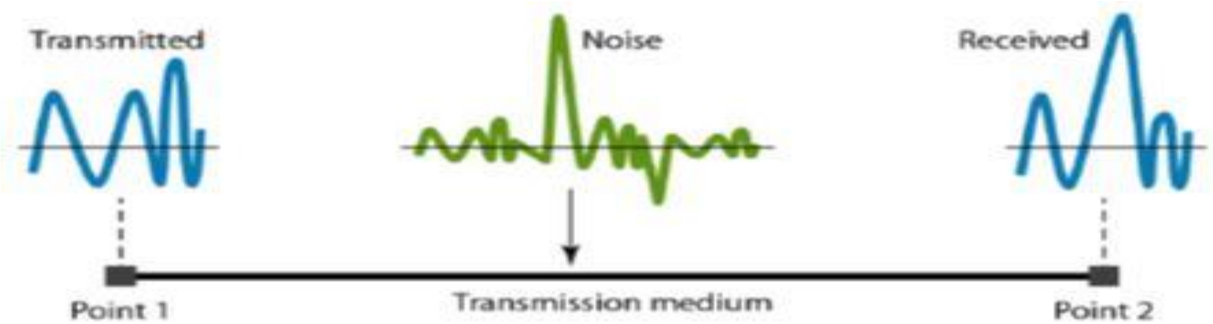
Distortion:

Distortion means that the signal changes its form or shape. Distortion can occur in a composite signal made of different frequencies. Each signal component has its own propagation speed through a medium and, therefore, its own delay in arriving at the final destination. Differences in delay may create a difference in phase if the delay is not exactly the same as the period duration. In other words, signal components at the receiver have phases different from what they had at the sender. The shape of the composite signal is therefore not the same. The given below figures show the effect of distortion on a composite signal.



Noise:

Noise is another cause of impairment. Several types of noise, such as thermal noise, induced noise, crosstalk, and impulse noise, may corrupt the signal. Thermal noise is the random motion of electrons in a wire which creates an extra signal not originally sent by the transmitter. Induced noise comes from sources such as motors and appliances.



These devices act as a sending antenna, and the transmission medium acts as the receiving antenna. Crosstalk is the effect of one wire on the other. One wire acts as a sending antenna and the other as the receiving antenna. Impulse noise is a spike that comes from power lines, lightning, and so on.

Q1. (b) Suppose the signals k1(t) and k2(t) are defined as follows:

$$k_1(t) = \begin{cases} 0, & t < 1 \\ 1, & 1 \le t \le 2 \\ 0, & 2 < t < 3 \\ 1, & 3 \le t \le 4 \\ 0, & 4 < t \end{cases}$$

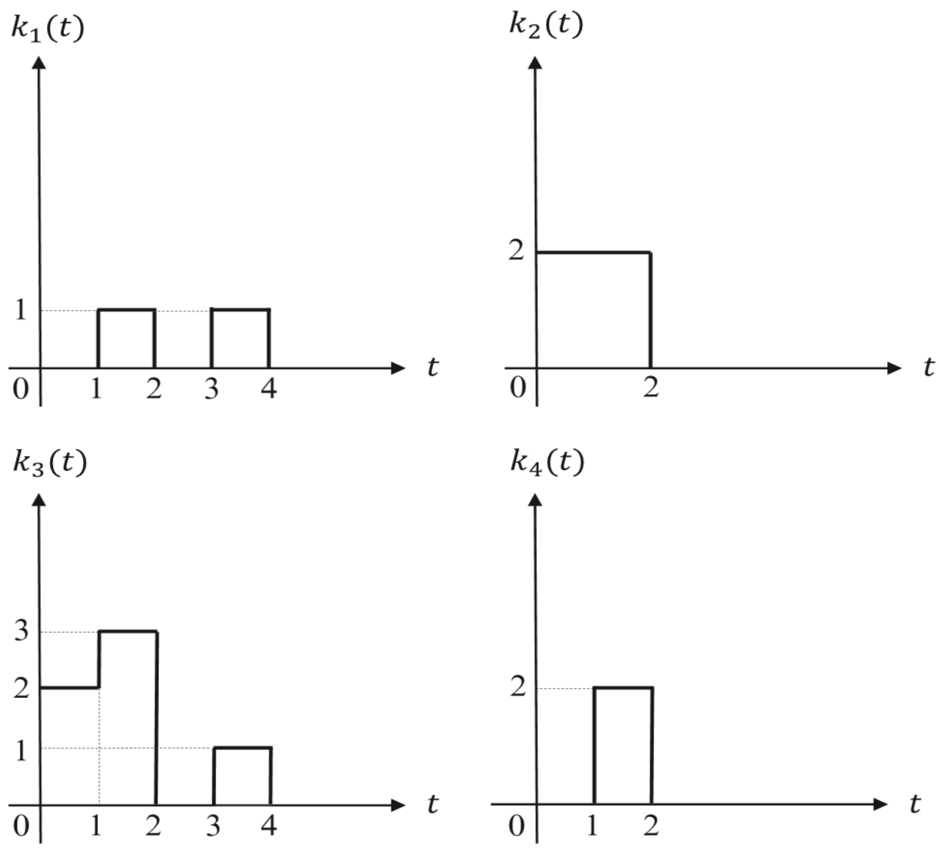
and

$$k_2(t) = \begin{cases} 0, & t < 0 \\ 2, & 0 \le t \le 2 \\ 0, & 2 < t \end{cases}$$

Determine $k_3(t) = k_1(t) + k_2(t)$ and $k_4(t) = k_1(t)\,k_2(t)$.

Solution:

In a piecewise fashion, k_3 (t) and k_4 (t), respectively. All signals are shown below



In differentiation operations, the derivative of the signal g (t) with respect to time t is taken, and thus defined by d

$$Y(t) = \frac{d}{dt} g(t) = g'(t)$$

A physical example is an inductor, as the voltage across the inductor with inductance L is equal to L times the derivative of the current flowing through it.

In integration operations, the integral of the signal g (t) with respect to time t is taken, and thus is defined by

Y (t) =integral of g (t) dt

A physical example is a capacitor, as the voltage across the capacitor with capacitance C is equal to $1/C$ times the integral of the current flowing through it.

Q2.	**(a)**	**Explain how signals can be broadly classified? Describe in detail any five types of signals.**

Ans 2(a).

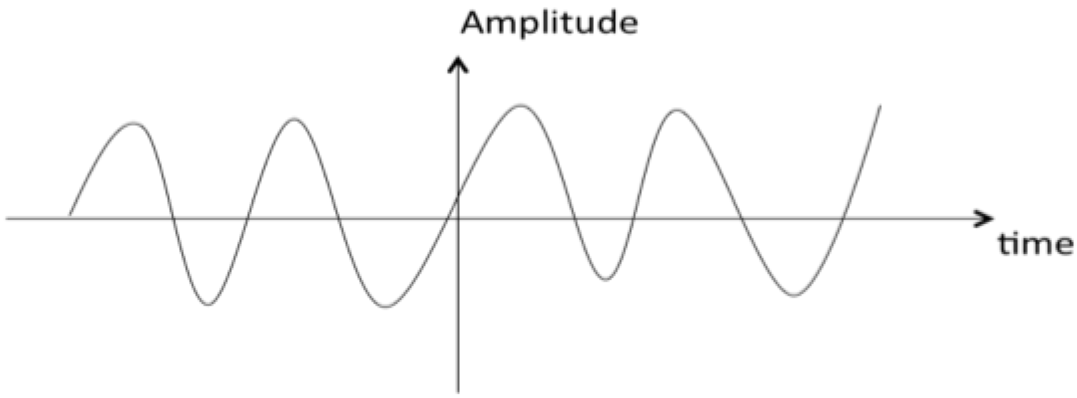
Classification of Signals:

Signals are classified into the following categories:

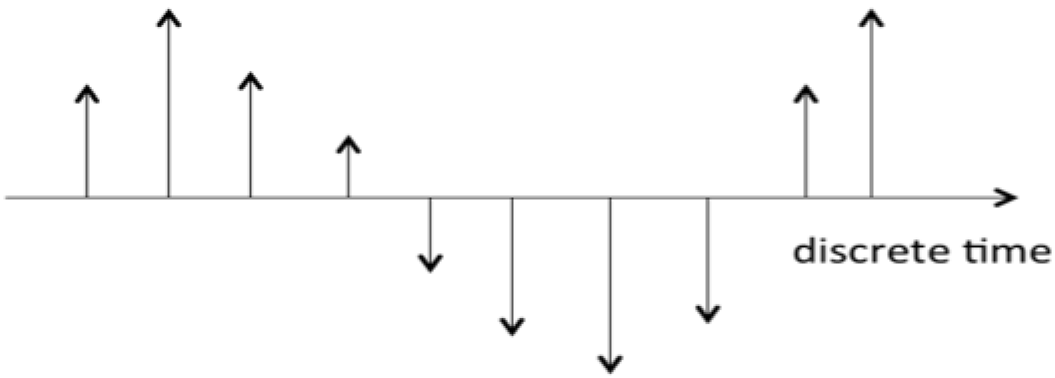
1. Continuous Time and Discrete Time Signals
2. Deterministic and Non-deterministic Signals
3. Even and Odd Signals
4. Periodic and Aperiodic Signals
5. Energy and Power Signals
6. Real and Imaginary Signals

1. Continuous Time and Discrete Time Signals

A signal is said to be continuous when it is defined for all instants of time.

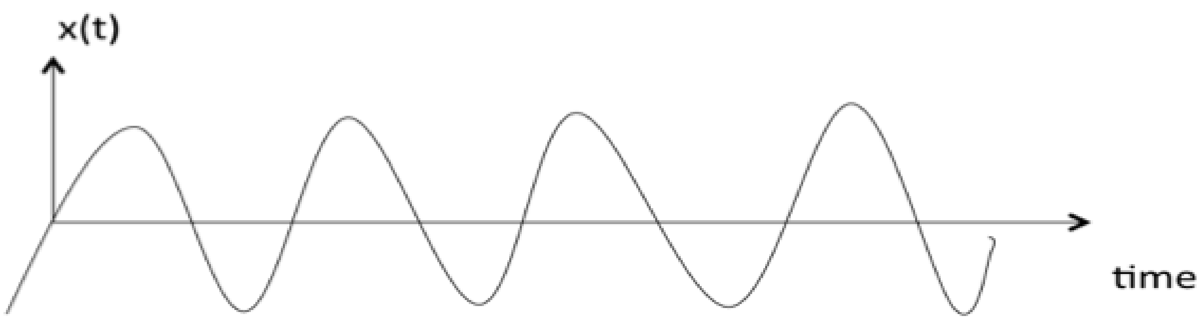


A signal is said to be discrete when it is defined at only discrete instants of time/

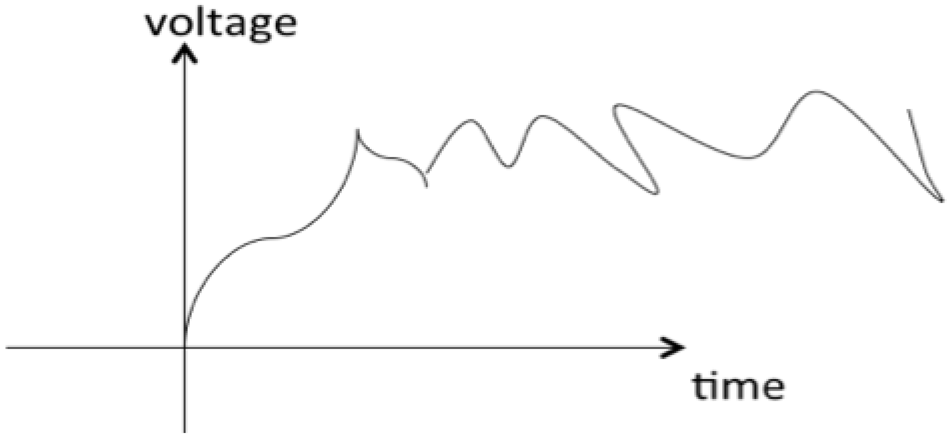


2. Deterministic and Non-deterministic Signals:

A signal is said to be deterministic if there is no uncertainty with respect to its value at any instant of time. Or, signals which can be defined exactly by a mathematical formula are known as deterministic signals.



A signal is said to be non-deterministic if there is uncertainty with respect to its value at some instant of time. Non-deterministic signals are random in nature hence they are called random signals. Random signals cannot be described by a mathematical equation. They are modelled in probabilistic terms.



3. Even and Odd Signals:

A signal is said to be even when it satisfies the condition x (t) = x (-t)

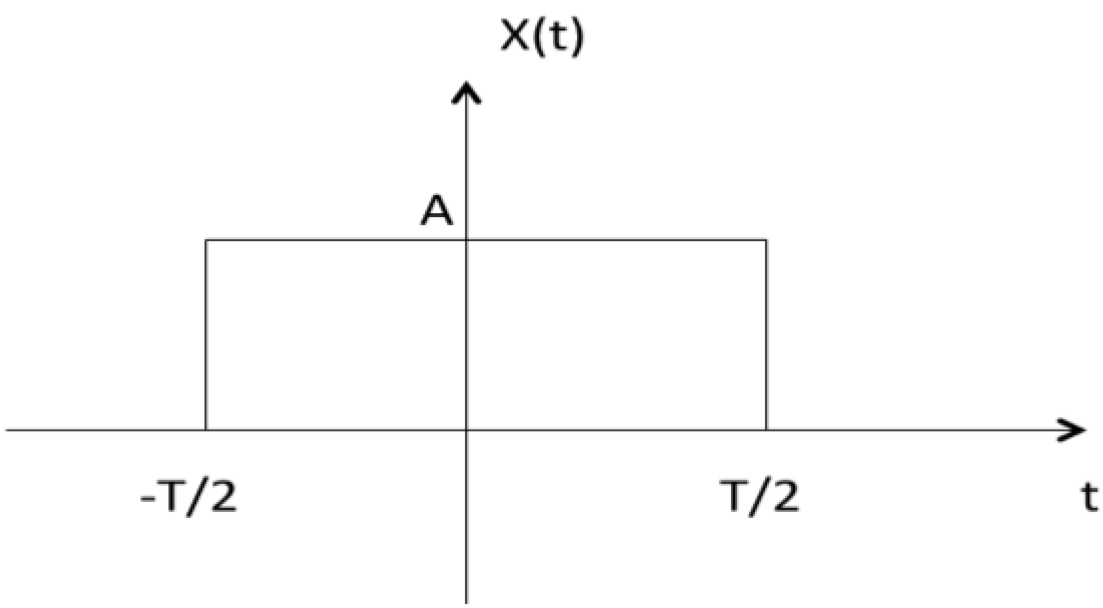
Example 1: t2, t4… cost etc.

Let x (t) = t2

x (-t) = (-t)2 = t2 = x(t)

t2 is even function

Example 2: As shown in the following diagram, rectangle function x(t) = x(-t) so it is also even function.



A signal is said to be odd when it satisfies the condition x (t) = -x(-t)

Example: t, t3 ... And sin t

Let x (t) = sin t

x (-t) = sin(-t) = -sin t = -x(t)

Sin t is odd function.

Any function f (t) can be expressed as the sum of its even function f_e (t) and odd function f_o (t).

$f(t) = f_e(t) + f_0(t)$

Where

$f_e(t) = ½[f(t) + f(-t)]$

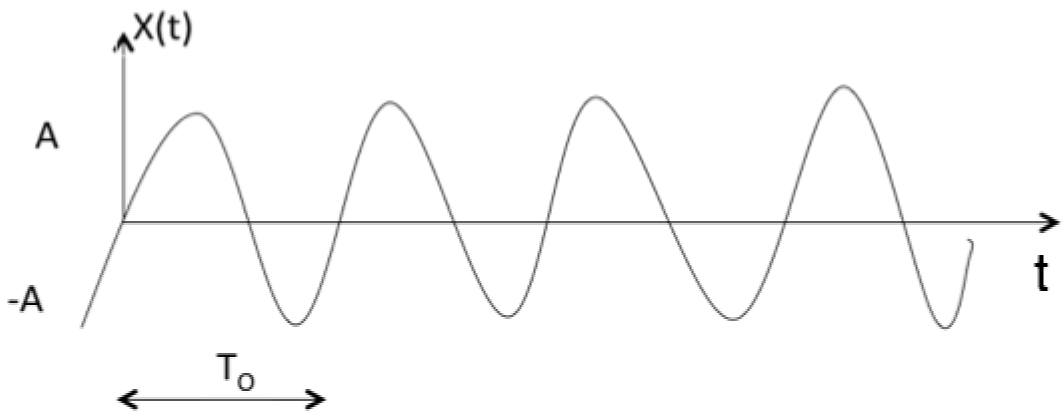
4. Periodic and Aperiodic Signals:

A signal is said to be periodic if it satisfies the condition x(t) = x(t + T) or x(n) = x(n + N).

Where

T = fundamental time period,

1/T = f = fundamental frequency.



The above signal will repeat for every time interval T_0 hence it is periodic with period T_0.

5. Real and Imaginary Signals:

A signal is said to be real when it satisfies the condition x (t) = x*(t)

A signal is said to be odd when it satisfies the condition x (t) = -x*(t)

Example:

If x (t) = 3 then x*(t) =3*=3 here x (t) is a real signal.

If x (t) = 3j then x*(t) =3j* = -3j = -x (t) hence x (t) is an odd signal.

For a real signal, imaginary part should be zero. Similarly for an imaginary signal, real part should be zero.

Q2. (b) Determine whether the signal z(t) = $t^3 + t^2$ is an odd signal or an even signal or neither; if it is neither, then determine the odd and even parts of it.

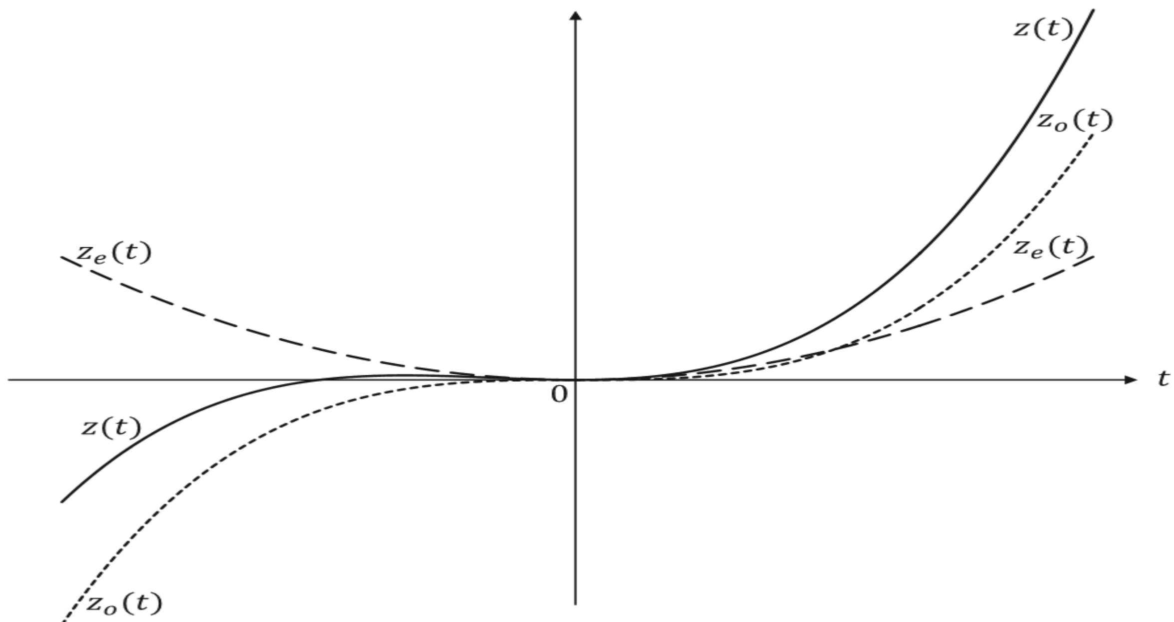
Solution

From z (t), we find z (-t) = $-t^3 + t^2$. Since we have z (t) ≠ z (t) is not an even function, since we have z (t) ≠ –z (-t). Z (t) is not an odd function. We therefore have to find the odd and even parts of z (t). The even and odd parts of z (t) are, respectively

$$z_e(t) = \frac{z(t) + z(-t)}{2} = \frac{t^3 + t^2 - t^3 + t^2}{2} = t^2$$

$$z_o(t) = \frac{z(t) - z(-t)}{2} = \frac{t^3 + t^2 + t^3 - t^2}{2} = t^3$$

This shows z (t), z_e (t), and z_o (t).



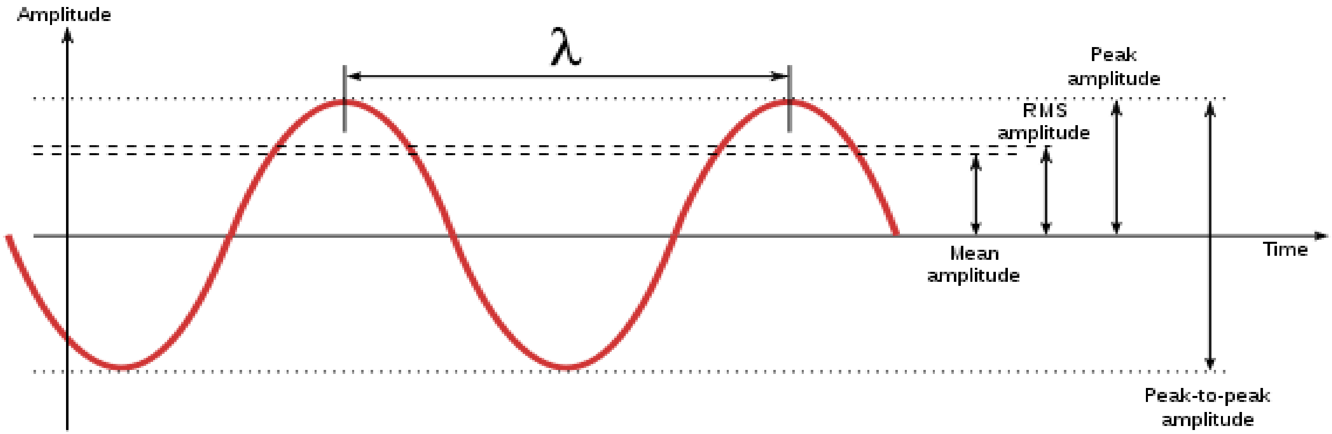
Q3.		**Explain main characteristics of Sinusoidal Signals. Describe benefits and applications of Sinusoidal Signals.**

<u>Ans 3(a).</u>

Characteristics of Sinusoidal Signal:

There are three main characteristics of sinusoidal waveforms

1. Amplitude.
2. Frequency.
3. Phase.



1. Amplitude:

The amplitude is the difference between the high value and the low value. The waveform may have different units, depending upon what the waveform is. If the waveform is measuring a voltage as a function of time, then the amplitude will be in Volts, if it were current as a function of time, amplitude would be in Amps.

2. Frequency:

The frequency is equal to 1/ λ and is a measure of how quickly the waveform cycles. If the waveform is a function of time, then frequency will usually be measured in Hertz (Hz). Since frequency is a measure of how rapidly the waveform cycles, frequency is sometimes (usually in older texts) given as cycles. One cycle is equal to one Hertz. λ is the inverse of frequency and is referred to as the period (usually a "T" is used to indicate the period.)

3. Phase:

Phase is a measure of how "offset" the signal is from some reference signal. Phase only makes sense when comparing signal of the same frequency, as otherwise phase will change as a function of time.

In the second plot, red is a sine wave and green is a cosine wave. As can be seen, these waveforms are identical save that one is a shifted version of the other. Notice how the cosine function reaches a peak at 0, while the sine function reaches a peak at π/2. The cosine function reaches the peak sooner and is said to lead the sine function by π/2 or 90°.

Benefits of Sinusoidal Signals:

Sinusoidal wave form is universally accepted because it has certain advantages. π

1. It produces minimum disturbance in the electrical circuits during operation.

2. It produces less interference to nearby communication lines in the case of transmission of power.

3. It results in low iron as well as copper losses in transformers, and AC rotating power for a given output. So AC machines have higher efficiency with sinusoidal waveform of current and voltage.

Applications of Sinusoidal Signals:

In 1822, French mathematician Joseph Fourier discovered that **sinusoidal** waves can be used as simple building blocks to describe and approximate any periodic waveform, including square waves. Fourier used it as an analytical tool in the study of waves and heat flow.
Here are some other examples of their uses: In the electrical power industry sinusoids are the dominant signal used to transfer power. In communication systems (cellular telephones, radio signals, etc.)