
بسم الله الرحمن الرحيم

Ministry of Higher Education and Scientific Research
Foundation of Technical Education
Technical College / Al-Najaf

Training package in
Signals
For students of second class

Lecturer
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1/ Over view

1 / A –Target population :-

For students of second class in

Communications Techniques Engineering Department

1 / B –Rationale :-

A signal is a set of information or data. Examples include a telephone or a television signal, for this reason I have designed this modular unit to discuss basic aspects of signals

1 / C –Central Idea :-

1 – Definition
2. Signals and Symmetry
3. Periodic Signals
4. Singularity functions:
   a. Unit impulse function   b. Unit step function

1 / D –Objectives:-

Representation of signals in time domain

2/ Pre test :-

Multiple Choice Questions With Answer

١ The unit step function is defined by

a. $f(t)=\begin{cases}1 & t=0\\ 0 & t\neq 0\end{cases}$

b. $f(t)=\begin{cases}1 & t>0\\ 0 & t<0\end{cases}$

c. $f(t)=\begin{cases}t & t>0\\ 0 & t<0\end{cases}$

٢ A periodic signal f(t) is defined by the fact

a. f(t)=1/2[f(t)+f(-t)]

b. f(t)=1/2[f(t)-f(-t)]

c. f(t+T0)

3/ Performance Objectives :-

Signals

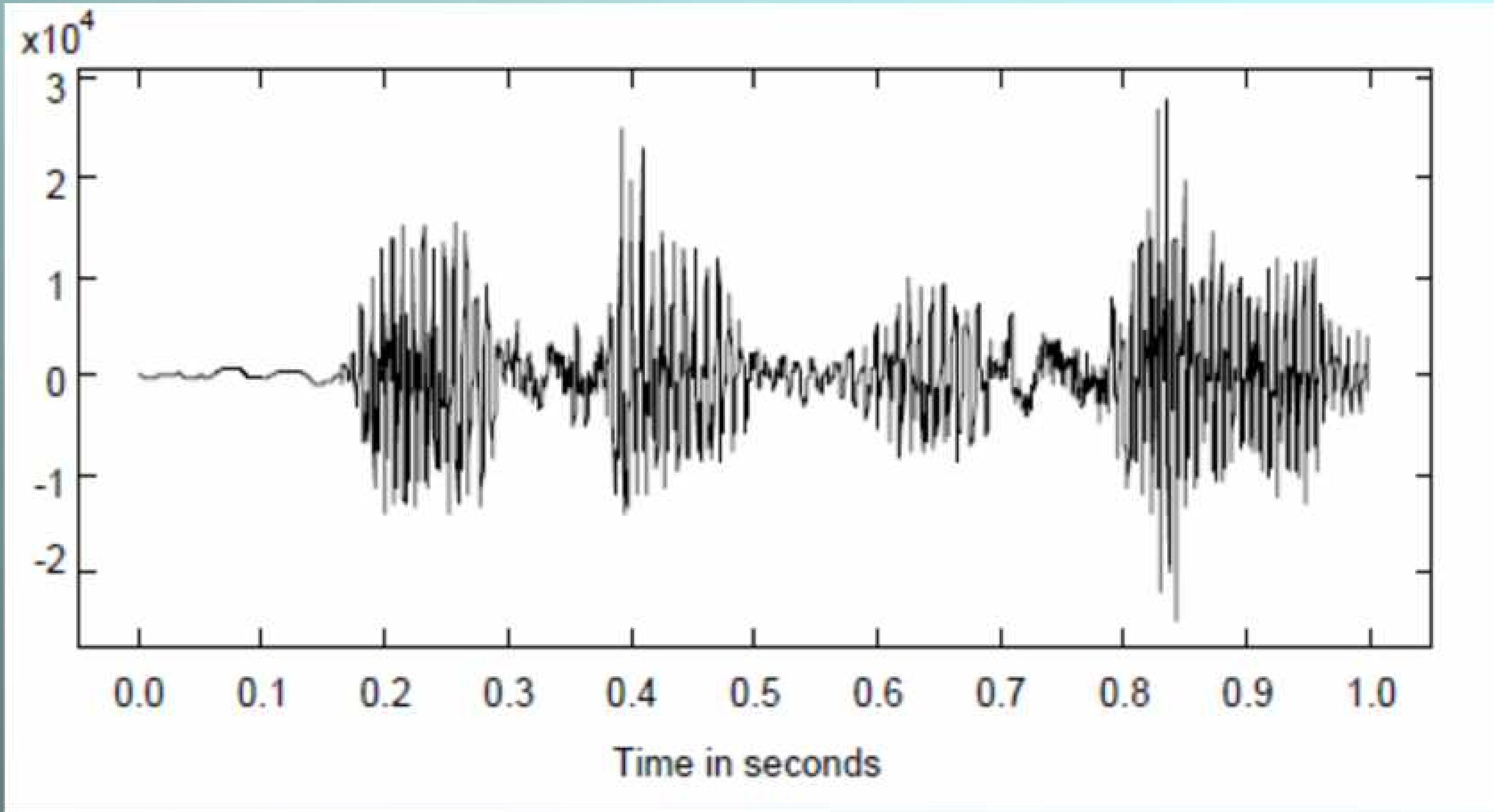
Signals are functions that carry information, often in the form of temporal and spatial patterns. These patterns may be embodied in different media; radio and broadcast TV signals are electromagnetic waves, and images are spatial patterns of light intensities of different colors.

Audio signals

Our ears are sensitive to sound, which is physically just rapid variations in air pressure. Thus sound can be represented as a function

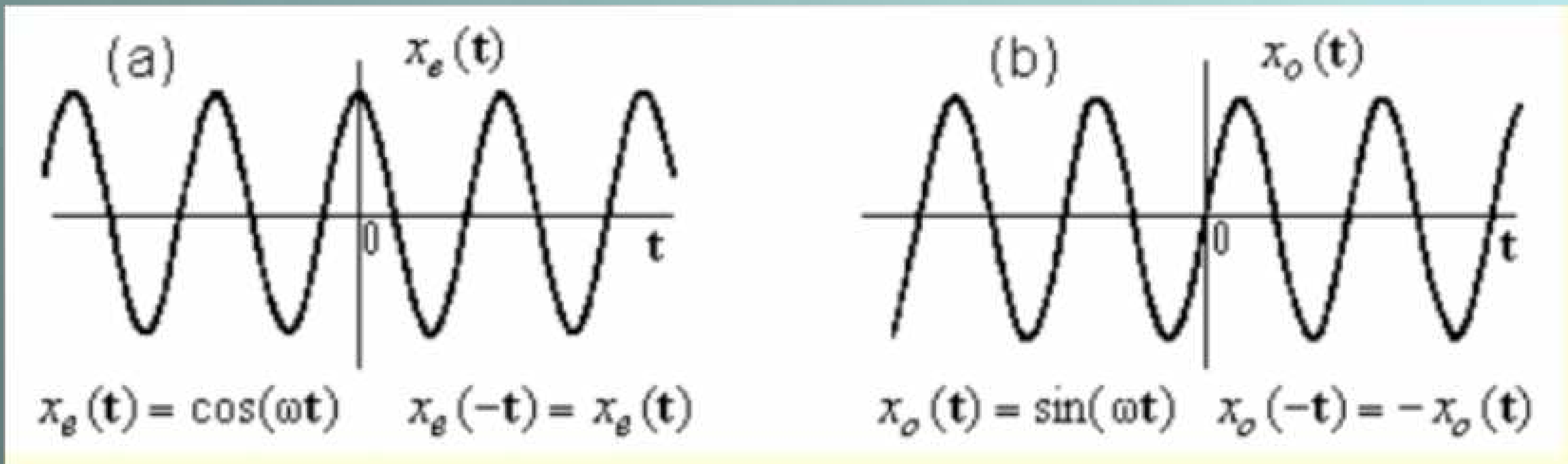
Sound*: *Time → Pressure

Figure : Waveform of a speech fragment



Signals and Symmetry

Many signals have important symmetry properties. The familiar cosine and sine are good examples.
Note that both describe the same sinusoidal waveform, except that "sin" lags "cos" by a quarter cycle (which is ® /2 = 1.57 radians).
This means that sin(wt) = cos(wt − ® /2).



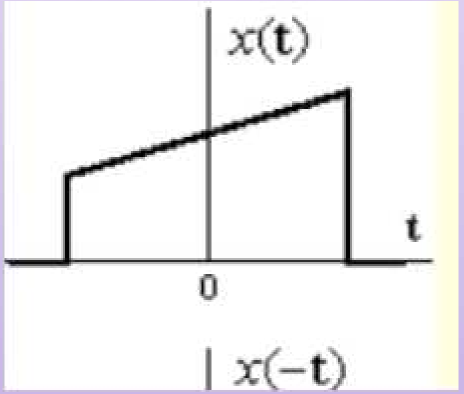
We've called the cosine wave *xe*(t) because of its *even* symmetry about the vertical zero−axis.

We've called the sine wave *xo*(t) because of its *odd* symmetry about the same axis.

These symmetries are defined by saying:

$$x_e(-t) = x_e(t) \quad \text{and} \quad x_o(-t) = -x_o(t)$$

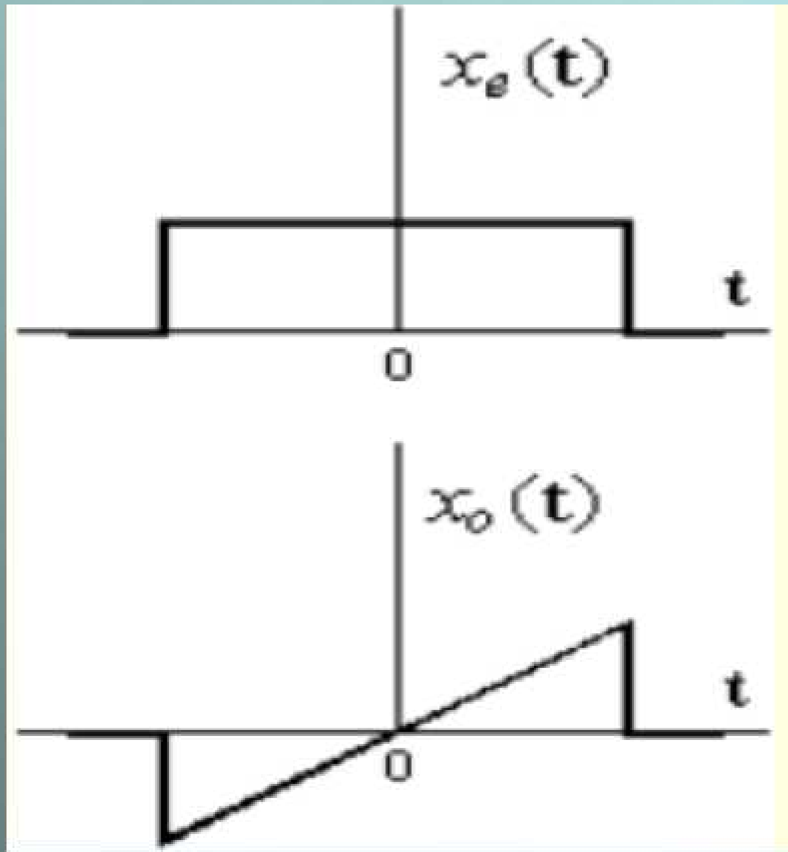
A given (real−valued) x(t), such as this one (Fig), might have neither symmetry, but we can routinely decompose it into even and odd parts. Its even part is:



$$x_e(t) = ½[x(t) + x(-t)]$$

The odd part of *x*(**t**) is found as:

$$x_o(\mathbf{t}) = \tfrac{1}{2}[x(\mathbf{t}) - x(-\mathbf{t})]$$



Some properties of even and odd functions

even and odd functions have the following property:

1. ***even function*** ò ***odd function = odd function***
2. ***odd function***ò ***odd function= even function***
3. ***even function*** ò ***even function = even function***

3/ Performance Objectives :-

1. Unit impulse function :

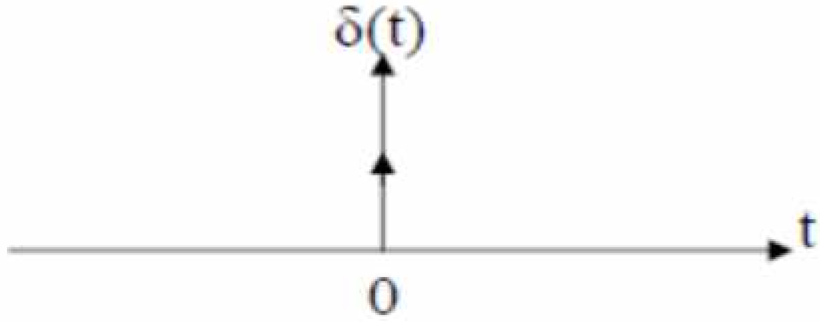
The unit impulse function, also known as the Dirac delta function, δ(t), is defined by :

$$\int_{-\infty}^{\infty} s(t)\delta(t)dt = s(0)$$

An alternative definition is :

$$\int_{-\infty}^{\infty} \delta(t)\,dt = 1 \ldots\ldots\ldots and$$

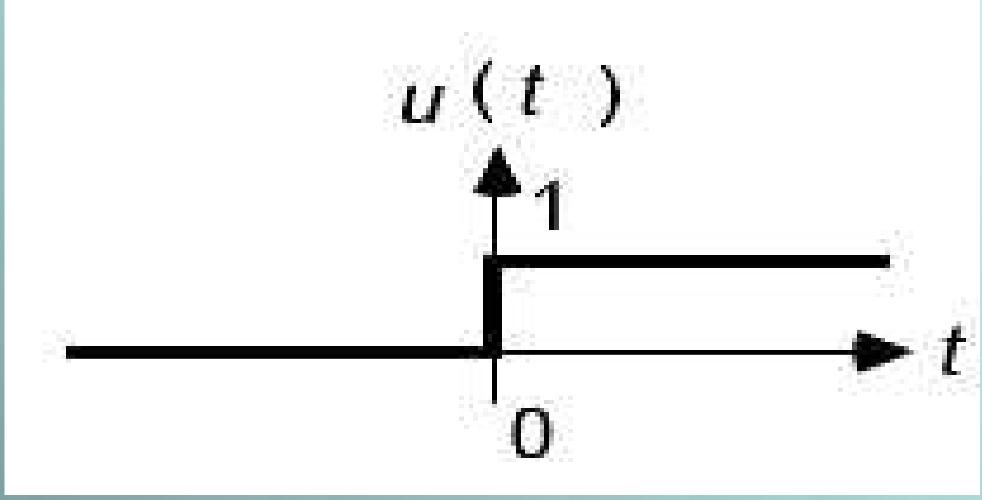
$$\delta(t) = \begin{cases} \infty, \ldots\ldots t = 0 \\ 0, \ldots\ldots\ldots t \neq 0 \end{cases}$$



2. Unit step function :

The unit step function u(t) is :

$$u(t) = \begin{cases} 1, & t > 0 \\ 0, & t < 0 \end{cases}$$



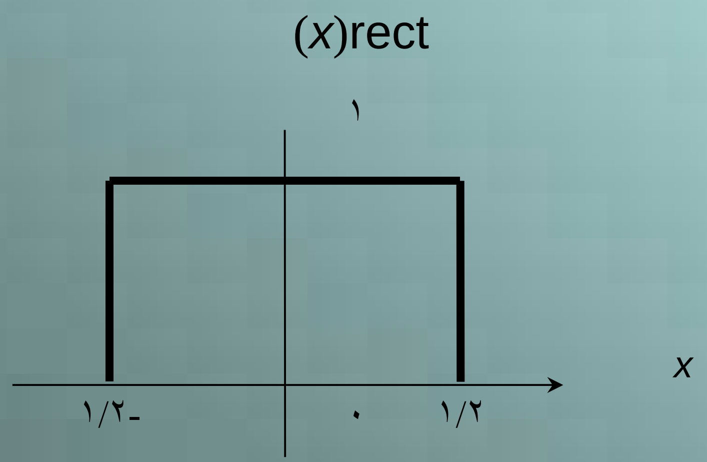
and the unit step function is related to the unit impulse function by :

$$u(t) = \int_{-\infty}^{\infty} \delta(t)\, d\, t$$

and

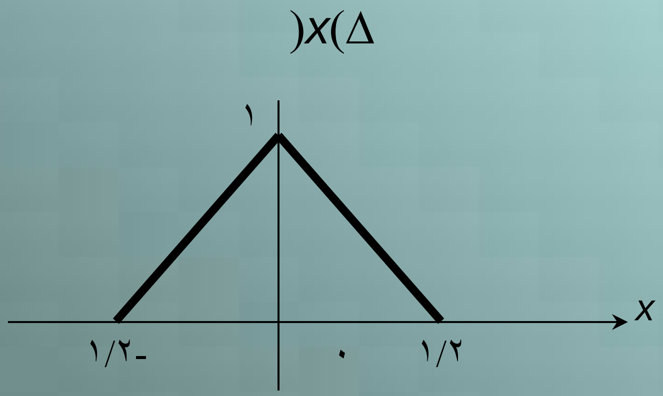
$$\frac{du(t)}{dt} = \delta(t)$$

Unit gate function (a.k.a. unit pulse function)



$$\operatorname{rect}\left(x\right)=\begin{cases}0 & \left|x\right|>\dfrac{1}{2}\\ \dfrac{1}{2} & \left|x\right|=\dfrac{1}{2}\\ 1 & \left|x\right|<\dfrac{1}{2}\end{cases}$$

Unit triangle function



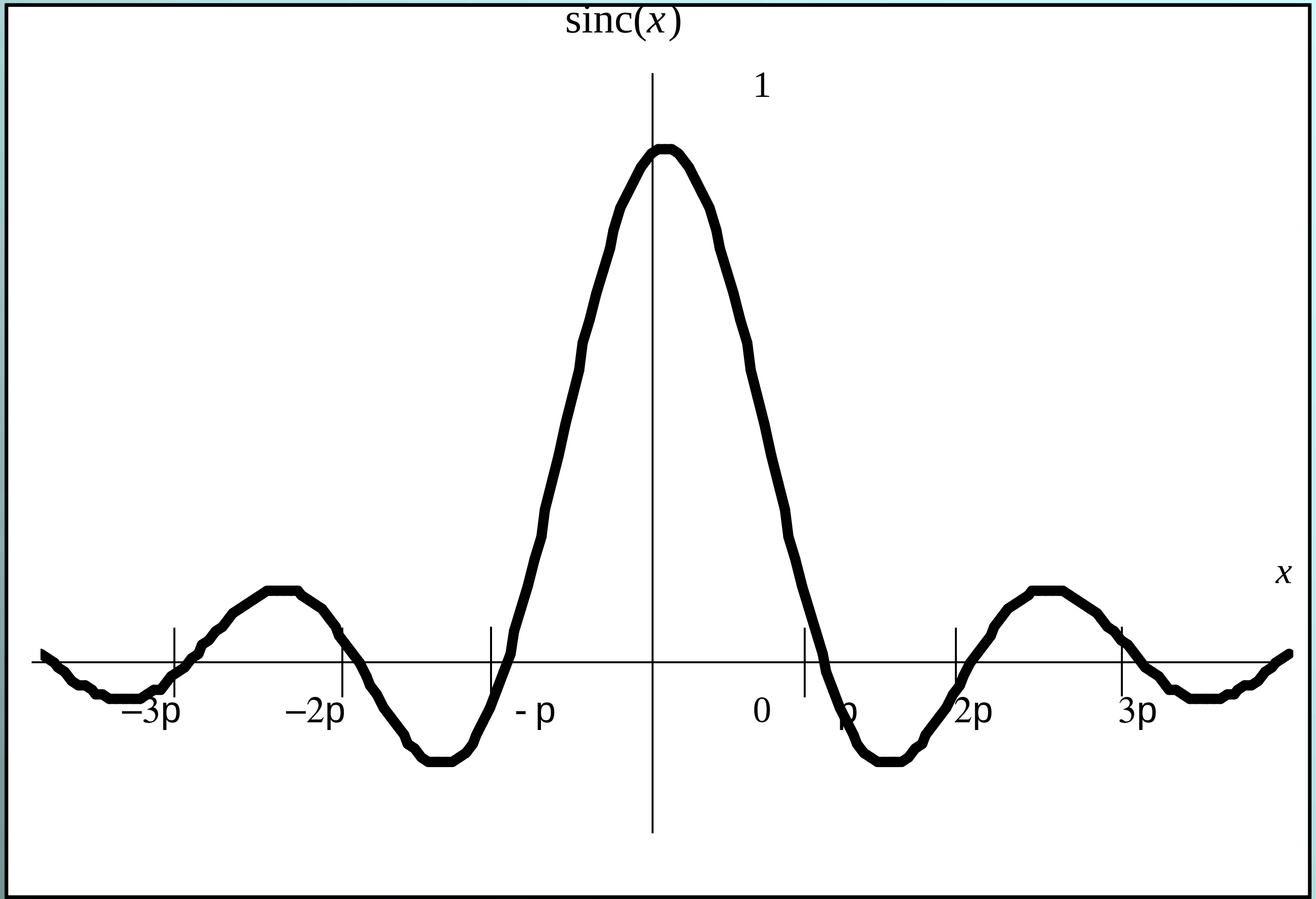
$$\Delta(x) = \begin{cases} 0 & |x| > \frac{1}{2} \\ 1 - 2|x| & |x| < \frac{1}{2} \end{cases}$$

Sinc function

$$\text{sinc}(x) = \frac{\sin(x)}{x}$$

How to compute sinc(0)?

As $x \to 0$, numerator and denominator are both going to 0. How to handle it?



Even function

Zero crossings at $x = \pm \text{®}, \pm 2\text{®}, \pm 3\text{®}, \ldots$

Amplitude decreases proportionally to 1/x

Periodic Signals

- ***f*(*t*)** is periodic if, for some positive constant $\boldsymbol{T_0}$
  - For all values of t, $f(t) = f(t + T_0)$
  - Smallest value of T_0 is the period of $f(t)$.
  - $\sin(2\pi f_o t) = \sin(2\pi f_0 t + 2\pi) = \sin(2\pi f_0 t + 4\pi)$: period 2π.
- A periodic signal ***f*(*t*)**
  - Unchanged when time-shifted by one period
  - Two-sided: extent is $t \in (-\infty, \infty)$
  - May be generated by periodically extending one period
  - Area under $f(t)$ over any interval of duration equal to the period is the same; e.g., integrating from 0 to T_0 would give the same value as integrating from $-T_0/2$ to $T_0/2$

Sinusoids

- $f_0(t) = C_0 \cos(2\pi f_0 t + \theta_0)$
- $f_n(t) = C_n \cos(2\pi n f_0 t + \theta_n)$
- The frequency, $n f_0$, is the nth harmonic of f_0
- Fundamental frequency in Hertz is f_0
- Fundamental frequency in rad/s is $\omega = 2\pi f_0$
- $C_n \cos(n\omega_0 t + \theta_n) =$
  $C_n \cos(\theta_n) \cos(n\omega_0 t) - C_n \sin(\theta_n) \sin(n\omega_0 t) =$
  $a_n \cos(n\omega_0 t) + b_n \sin(n\omega_0 t)$

Quiz /

Fill in the blank for question 1

١ A **signal** is a set of information or data. Examples include a telephone or a television signal.

٢ List two properties of even and odd functions

1. even function $\times$ odd function = odd function
2. odd function $\times$ odd function= even function

5/ Post test :-

Multiple Choice Questions With Answer

1. The even signal f(t) is defined by the fact

a. f(t)=1/2[f(t)+f(-t)]　　b. f(t)=1/2[f(t)-f(-t)]　　c. f(t+T0)

2. The odd signal f(t) is defined by the fact

a. f(t)=1/2[f(t)+f(-t)]　　b. f(t)=1/2[f(t)-f(-t)]　　c. f(t+T0)

3. The unit ramp function is defined by

$a.\ f(t)=\begin{cases}1 & t=0\\ 0 & t\neq 0\end{cases}$ $b.\ f(t)=\begin{cases}1 & t>0\\ 0 & t<0\end{cases}$ $c.\ f(t)=\begin{cases}t & t>0\\ 0 & t<0\end{cases}$

4. The unit sample function is defined by

$a.\ f(t)=\begin{cases}1 & t=0\\ 0 & t\neq 0\end{cases}$ $b.\ f(t)=\begin{cases}1 & t>0\\ 0 & t<0\end{cases}$ $c.\ f(t)=\begin{cases}t & t>0\\ 0 & t<0\end{cases}$

References

1. Ferrel G. Stremler :
"Introduction to communication systems"

2. Sanjay Sharma: "Communication Systems (Analog and Digital) "

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