COLLEGE OF ENGINEERING AND TECHNOLOGIES
ALMUSTAQBAL UNIVERSITY

Digital Signal Processing (DSP)

CTE 306

Lecture 3

- Basic Operations on Signals -

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Basic Operations on Signals

These operations can be classified into two categories,

- Operations performed on the dependent variable and
- Operations performed on the independent variable.

- **Amplitude scaling:**

Let $x(t)$ denote a continuous-time signal. The signal $y(t)$ resulting from amplitude scaling applied to $x(t)$ is defined by

- $y(t) = c\,x(t)$

Where c is the scaling factor. According to above equation the value of $y(t)$ is obtained by multiplying the corresponding value of $x(t)$ by the scalar c.

Operations performed on the dependent variable

- Addition:

Let $x_1(t)$ and $x_2(t)$ denote a pair of continuous-time signals. The signal y(t) obtained by the addition of $x_1(t)$ and $x_2(t)$ is defined by

- $y(t) = x_1(t) + x_2(t)$

- Multiplication:

Let $x_1(t)$ and $x_2(t)$ denote a pair of continuous-time signals. The signal y(t) resulting from the multiplication of $x_1(t)$ and $x_2(t)$ is defined by

- $y(t) = x_1(t)\, x_2(t)$

Operations performed on the independent variable

- Time scaling:
  - This transformation is defined by x(n) = Mn or f(n) = n/N
  - Where M and N are positive integers.
  - In the case of f(n) = Mn,
  - The sequence x(Mn) is formed by taking every Mth sample of x(n) (this operation is known as down-sampling).
  - With f(n) = n/N the sequence y(n) = x(f (n)) (This operation is known as up-sampling).

Operations performed on the independent variable

- Time scaling:

  Let x(t) denote a continuous-time signal. The signal y(t) obtained by scaling the independent variable, time t, by a factor a is defined by

  - $y(t) = x(at)$

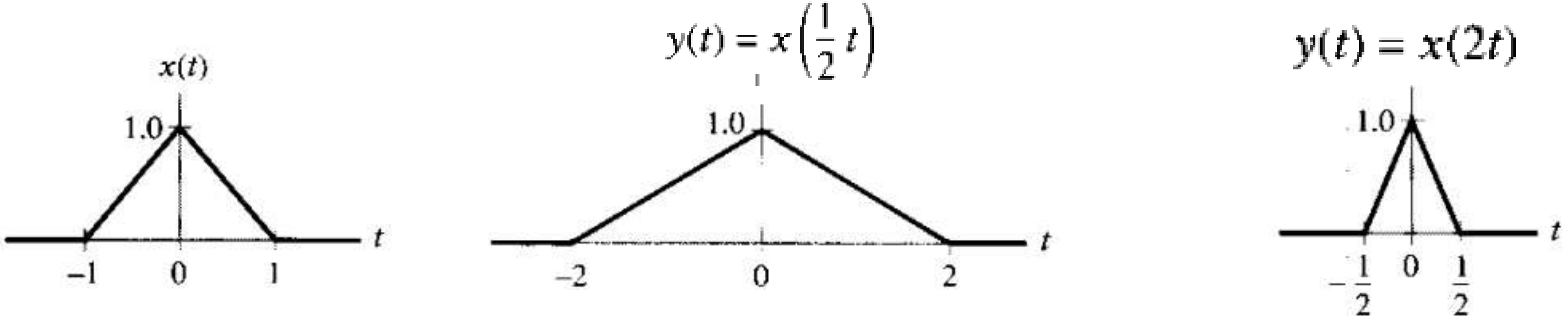


Fig:

(a) Continuous-time signal x(t), **(b)** Time expanded version of signal x(t) by factor 2 (= 1/2)
(c) Compressed version of signal x(t) by factor 2 (= 2),

Operations performed on the independent variable:

- Time Reversal (Reflection):

  - This transformation is given by $f(n) = -n$
  - simply involves "flipping" the signal $x(n)$ with respect to the index n.

- Time Reversal (Reflection):

Let x(t) denote a continuous-time signal. Let y(t) denote the signal obtained by replacing time t with -t, as shown by

- $y(t) = x(-t)$

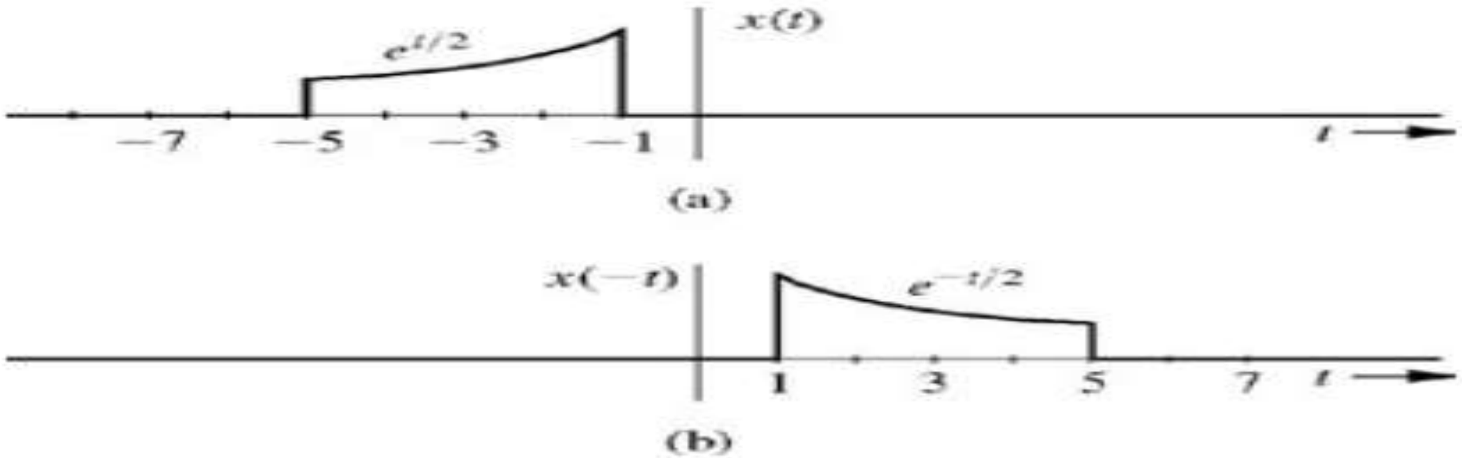


Fig: Operation of reflection:
(a) Continuous-time signal x(t) and **(b)** Reflected version of x(t) about the origin x(-t)

- Time shifting:

  - This is the transformation defined by
  - $f(n) = n - n_o$. If $y(n) = x(n - n_o)$,
  - $x(n)$ is shifted to the right by n_o samples
  - If n_o is positive (this is referred to as a delay),
  - And it is shifted to the left by n_o samples
  - If n_o is negative (referred to as an advance).

- Time shifting:

Let x(t) denote a continuous-time signal. The time-shifted version of x(t) is defined by

- $y(t) = x(t - t_o)$

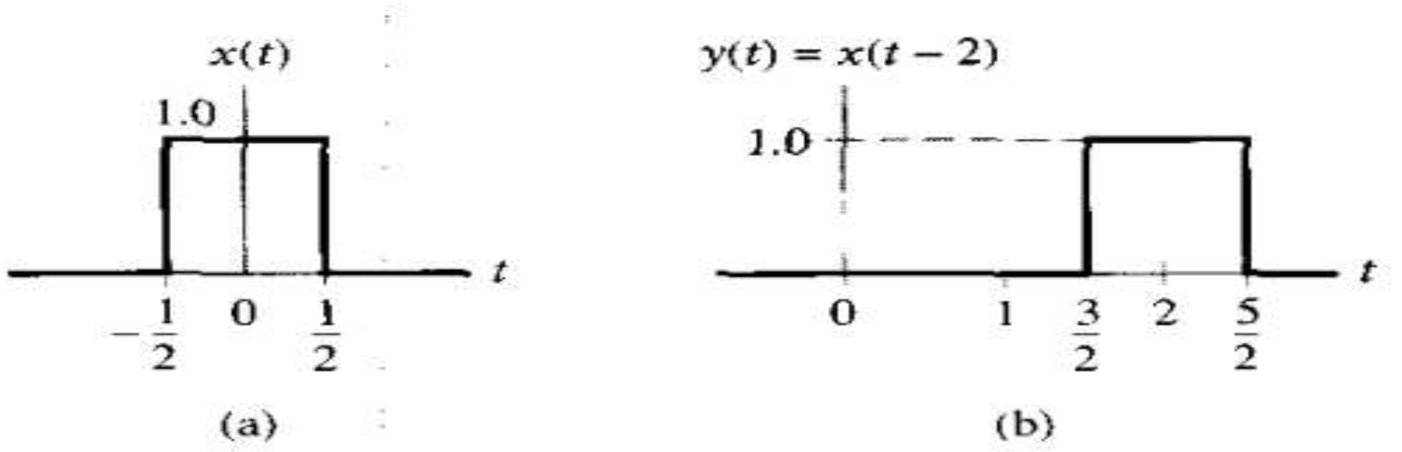
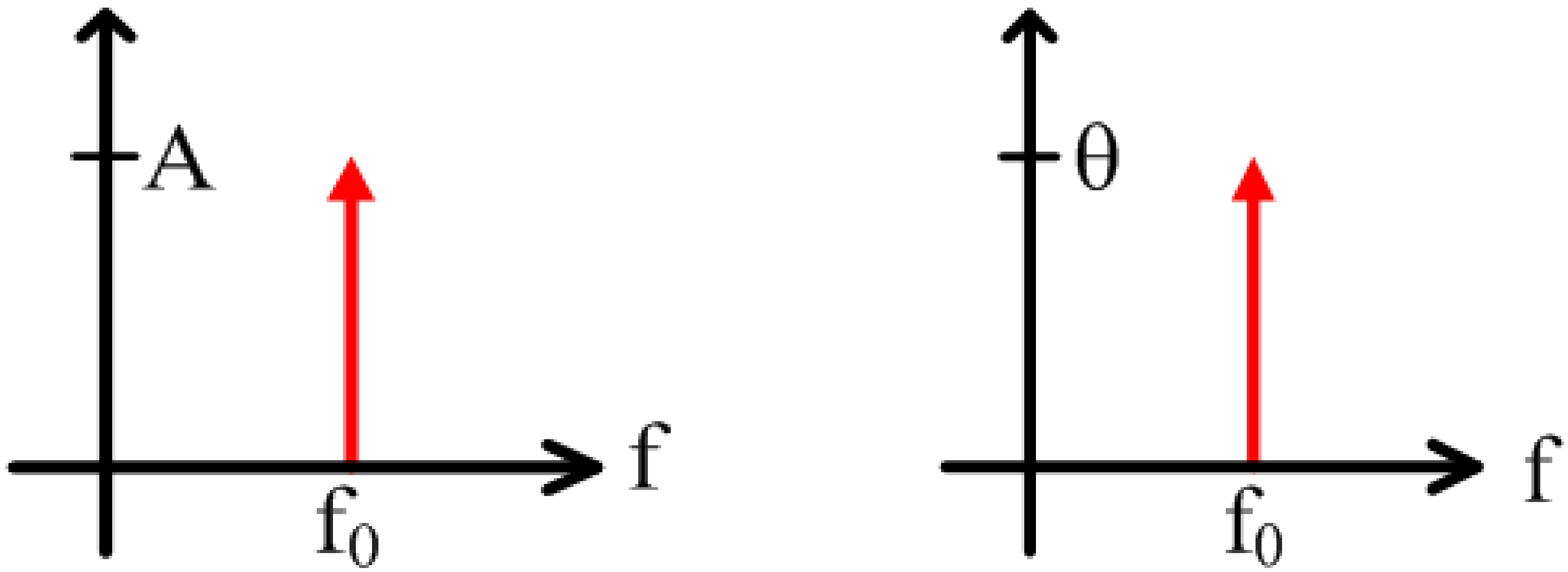


Fig: Time-shifting operation:
(a) Continuous-time signal x(t); and **(b)** Time-shifted version of x(t) by 2 time units

Sinusoidal Signal Properties

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

Amplitude & Phase Spectrums



Example

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