Lecture - 6

Operations on signals :-

* In general, we can vary two parameters, i.e. —
    ① Amplitude
    ② Time

* Operations that can be performed on amplitude are —
    ① Scaling
    ② Addition
    ③ Subtraction
    ④ Multiplication

* Operations that can be performed on time are —
    ① Shifting
    ② Scaling
    ③ Reversal

Let us take an example,
$$x(t) = A\cos t.$$
, A → amplitude
t → time.

① Time Shifting :-

$x(t) \longrightarrow x(t - t_0)$ +ve shift

                shift in 'right' dir^n
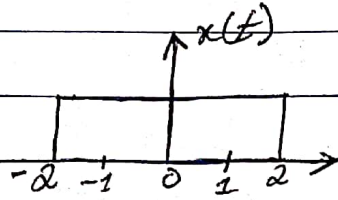
$x(t) \longrightarrow x(t + t_0)$ -ve shift
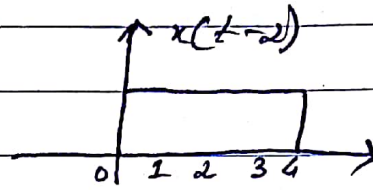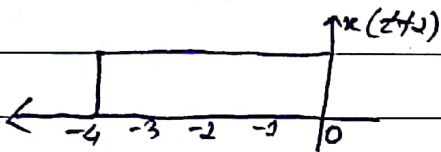
                shift towards left.

Ex.

$x(t)$

-2 -1 0 1 2

Time period = 4

If its given $x(t-2)$
shift two positions right

$x(t-2)$

0 1 2 3 4

T.P = 4

If $x(t+2)$ then shift left,

$x(t+2)$

-4 -3 -2 -1 0

T.P = 4

So, we are not changing the time period.

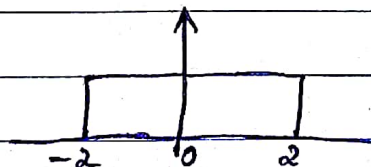[* Time period :- One complete cycle of vibration to pass a given point]

② Time scaling :-

In time scaling, we are going to change the time period also.

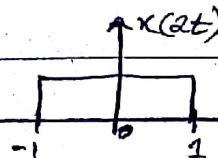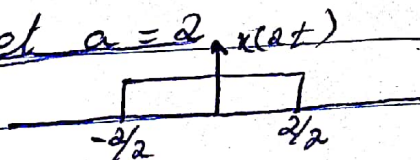$$x(t) \longrightarrow x(at)$$, a is always +ve

$|a| > 1$ → Compression of signal

$|a| < 1$ → Expansion of signal.

Ex:-

-2 0 2

T.P = 4

* To do time scaling, divid T.P. by 'a'.

Let $a = 2$, $x(at)$

-2/2 2/2

$x(2t)$

-1 0 1

T.P. = 2

Compressed.

Let a = ½

T·P = 8

$-\frac{2}{0}(2)$ 0 $\frac{2}{0}(½)$ -4   0   4
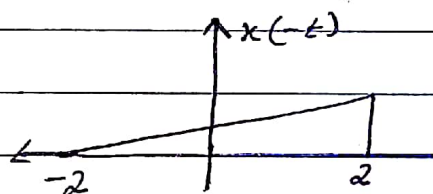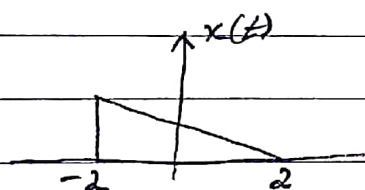
Expanded
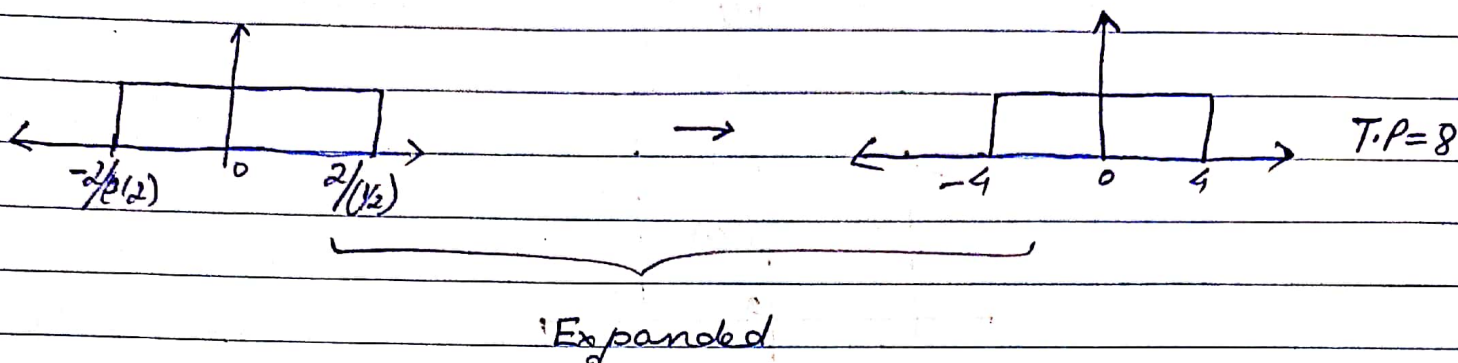
N.B. Unit step s/g do not have time scaling.

③ Time reversal :-
            This is just the mirror image of the s/g.

$$te \boxed{x(t) \longrightarrow x(-t)}$$

Eg:

$x(t)$ -2   2 $x(-t)$ -2   2

Amplitude Related Operations :-

① Scaling :-
            $$y(t) = c \cdot x(t)$$

Ex. $x(t) = 4\cos t$. Then wahat is the value of $y(t) = 2x(t)$!

→ $y(t) = 2 x(t)$
              $= 2 \cdot 4 \cos t$
              $= 8 \cos t$

② Addition :-

$\uparrow x_1(t)$ → Amplitude = 2

2

-2 | 0 | 2

$\uparrow x_2(t)$ → Amplitude = 3

3

-3 | 0 | 3
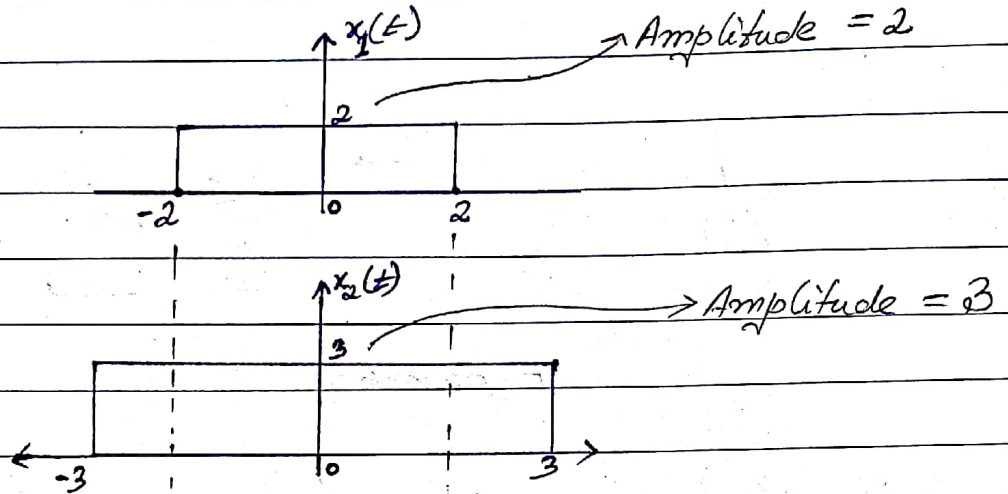
$x_3(t) = x_1(t) + x_2(t)$

[Add^n of amplitudes of two signals]

$\uparrow x_3(t)$ → 2+3 = 5

5

0+3=3   0+3=3

-3 | -2 | 0 | 2 | 3
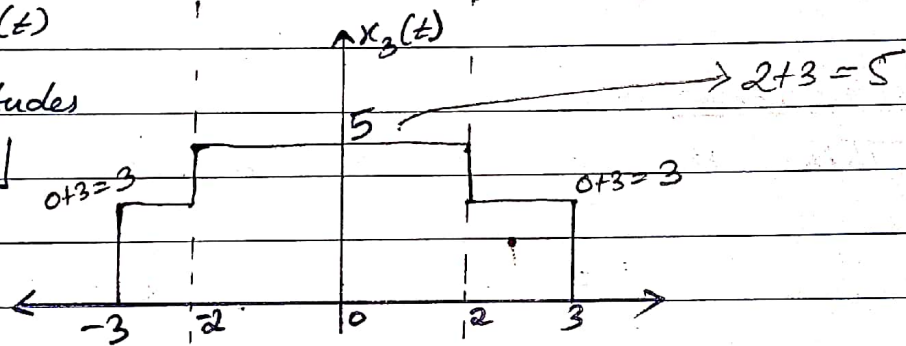
③ Subtraction :-

$x_4(t) = x_1(t) - x_2(t)$

$\uparrow x_4(t)$

-3 | -2 | 0 | 2 | 3

3 | -1 | 3
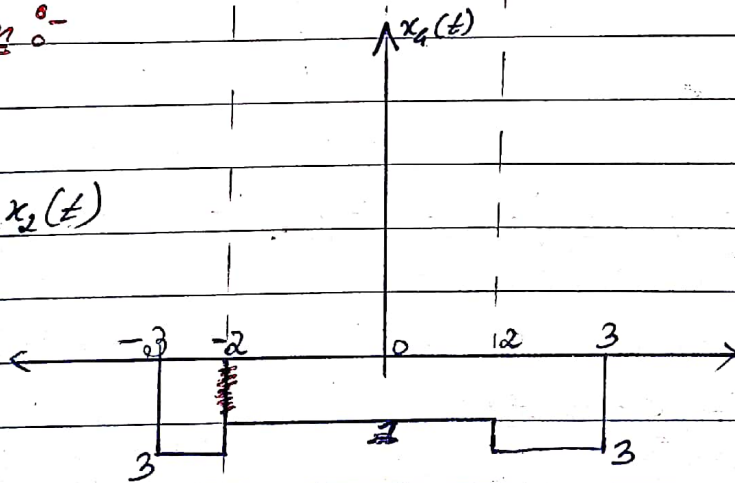
④ Multiplication :-

$x_5(t) = x_1(t) \times x_2(t)$

$x_5(t)$ → 2×3 = 6

6

0×3 = 0

0 amplitude

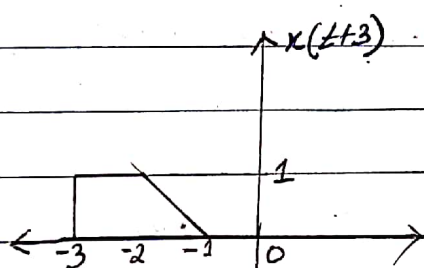-3 | -2 | 0 | 2 | 3
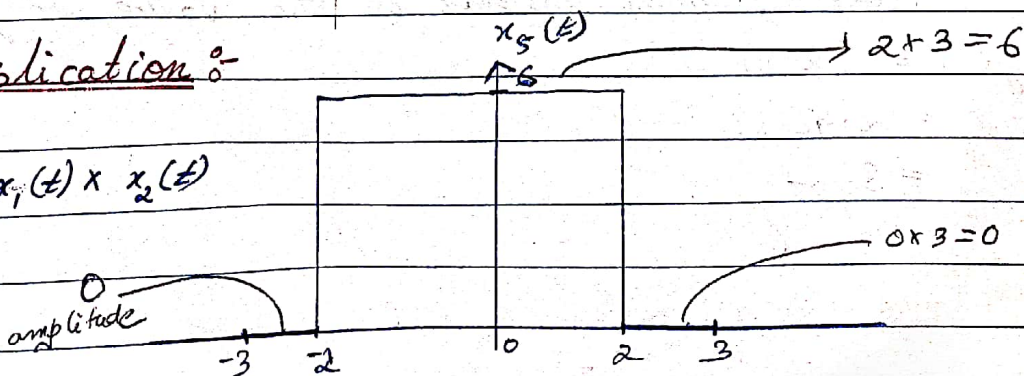
* Law of precedence
— ① Shifting
② Scaling.

Q. Given, $x(t)$. Plot $x(-2t + 3)$, $x(t/2 - 1)$
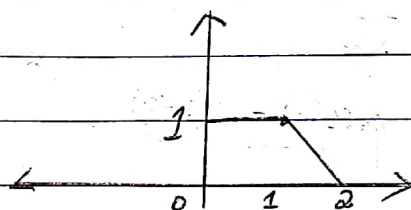
Sol^n :-
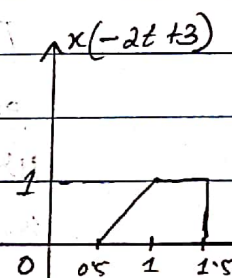
For $x(-2t + 3)$
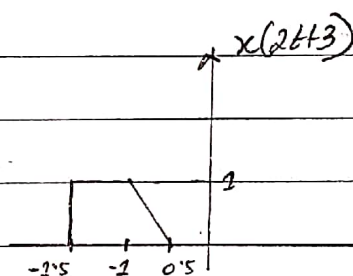
-ve shifted by '3'   Scaling by 2   Reflection
               so, dividing by 2.

for $x(t/2 - 1)$
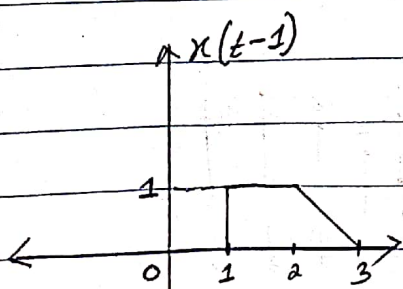
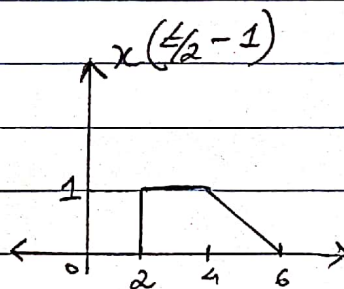+ve shifted by '1'   Scaling by 1/2
            i.e. dividing by 1/2