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

* If you want to change the time / operation that can be performed on time —

  ① Shifting

  ② Scaling

  ③ Reversal .

Let us take an example —

$$x(t) = \boxed{A}\cos t \boxed{(t)}$$

If you are performing operations on amplitude then the parameter 'A' will change, not 't'

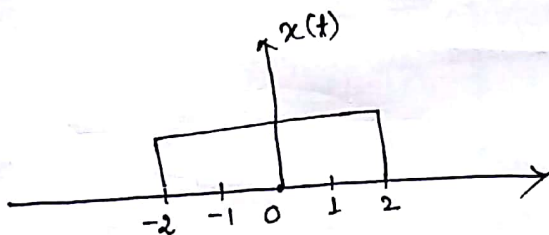But in time operation, shifting, or scaling of time period is done.

① TIME SHIFTING :—

$$x(t) \longrightarrow x(t-t_0) \quad \text{+ve shift}$$

↳ if you want to shift in the right direction

$$x(t) \longrightarrow x(t+t_0) \quad \text{—'ve shift}$$
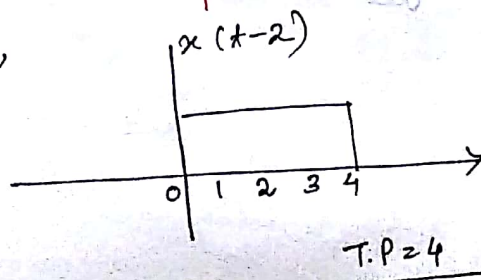
↳ shift to '—ve axis

Ex:—

$x(t)$
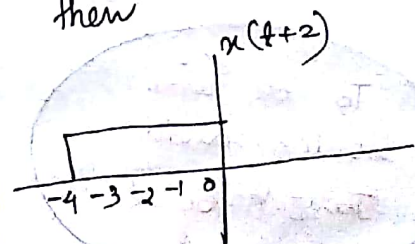
-2 -1 0 1 2

Time period = 4

Say, it's given $x(t-2)$

⇓

shift 2 positions right

So,

$x(t-2)$

0 1 2 3 4

T.P = 4

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

$x(t+2)$

-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.

⑪ **TIME SCALING :—**

In time scaling, we are going to change the time period also.
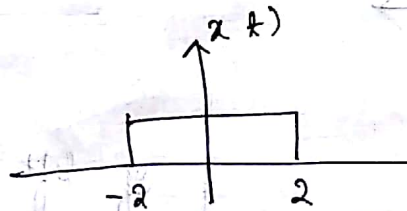
$$x(t) \longrightarrow x(at)$$

'a' is always '+'ve

$|a| > 1 \longrightarrow$ Compression of signal.

$|a| < 1 \longrightarrow$ Expansion of signal.

$\downarrow$

(eg: 0.1, 0.3, 0.35, etc.)
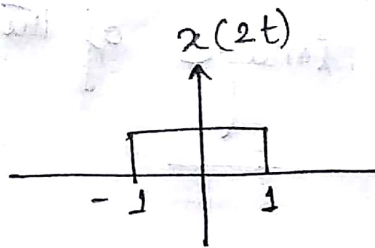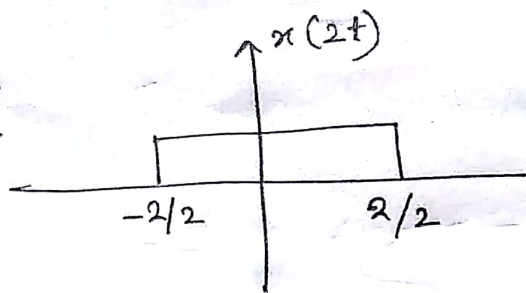
We cannot do -ve scaling

We can do +ve scaling

Ex:—

x t)

-2   2

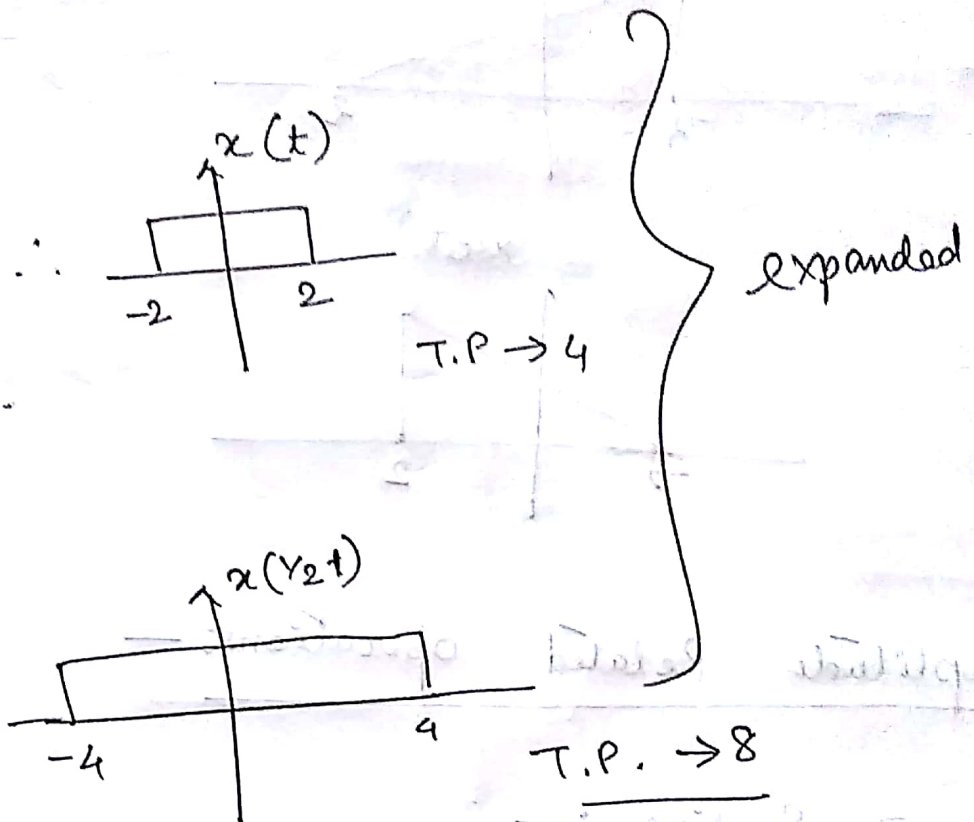T.P → 4

To do time scaling divide the T.P. by 'a'

Let a = 2.

$x(2t)$

$-2/2$ $2/2$

$x(2t)$

-1 1

$\therefore$ Compressed

$T.P. \rightarrow 2$

Let, $a = 1/2$

Let, $a = 1/2$

$x(t)$

−2   2

T.P → 4

} expanded

$x(1/2\,t)$

−4   4

T.P. → 8

①

NB.

Unit step s/g dont have time scaling.

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(III) TIME REVERSAL :—

This is just the mirror image of the s/g.

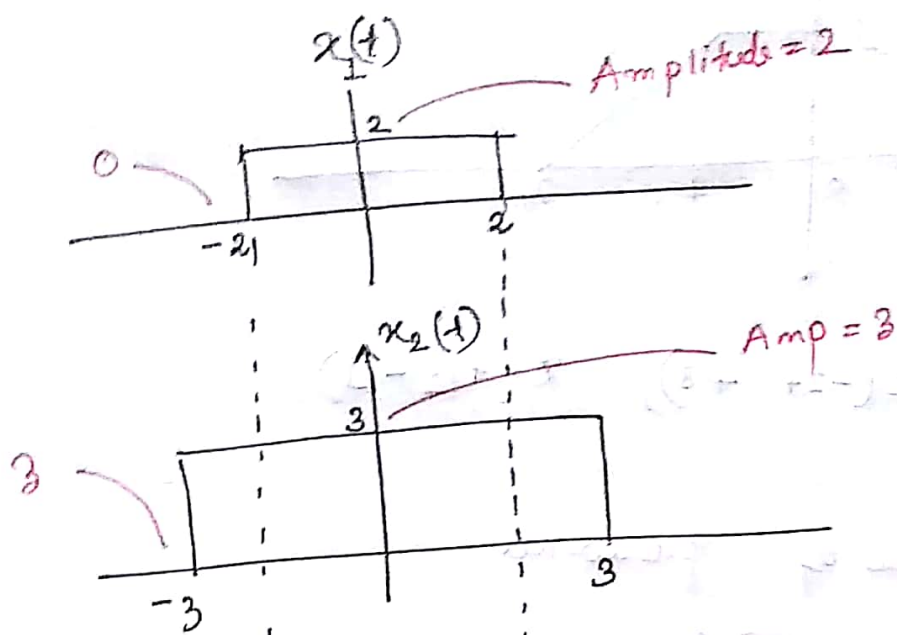$$x(t) \longrightarrow x(-t)$$
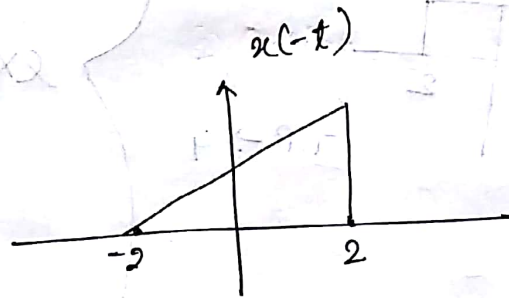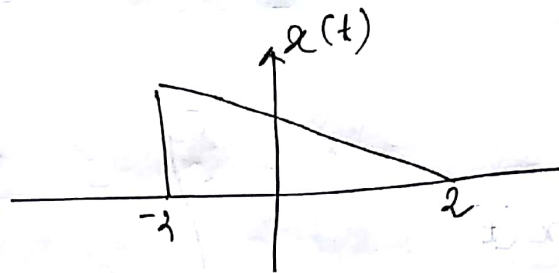
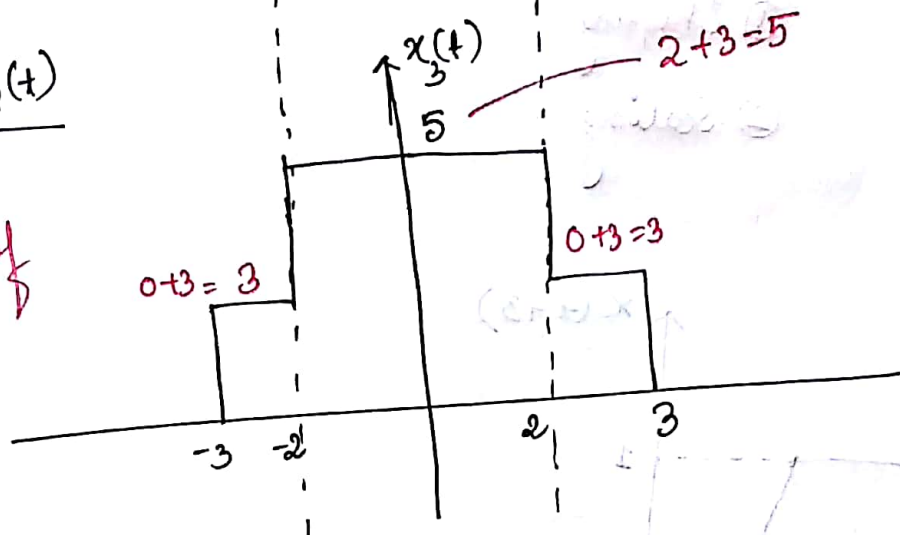## Amplitude Related operations :—

① Scaling :—

$$y(t) = C \cdot x(t)$$
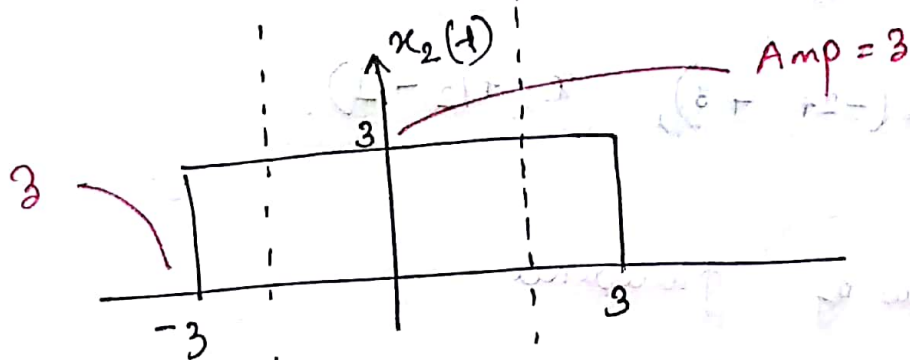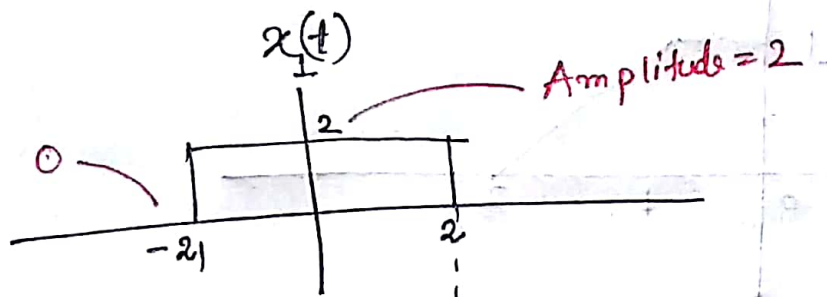
Ex:- $x(t) = 4 \cos t$

What is the value of $y(t) = 2x(t)$

$$= 2 \cdot 4 \cos t$$

$$= 8 \cos t .$$

① Addition :—
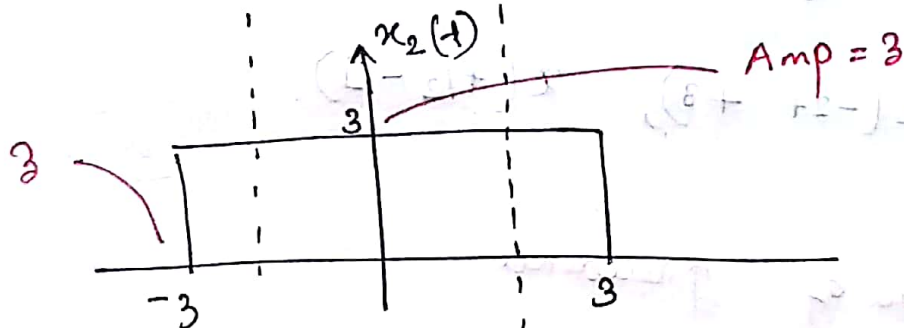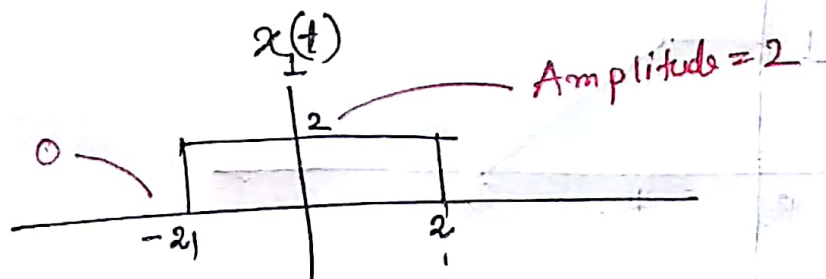
$x_1(t)$

Amplitude = 2

$x_2(t)$

Amp = 3

⑪ Addition :—

$x_1(t)$

Amplitude = 2

2

0

−2   2

$x_2(t)$

Amp = 3

3

3

−3   3

$x_3(t)$
$= x_1(t) + x_2(t)$

(addⁿ of amplitudes of 2 s/gs)

$x_3(t)$

2+3 = 5

5

0+3 = 3

0+3 = 3

−3 −2   2   3

⑪ Addition :—

$x_1(t)$

Amplitude = 2

2

O

-2 2

$x_2(t)$

Amp = 3

3

3

-3 3

$x_3(t)$
$= x_1(t) + x_2(t)$

(add^n of
amplitudes of
2 s/gs)

$x_3(t)$

2+3=5

5

0+3 = 3

0+3 =3

-3 -2 2   3

⑫ Subtraction :—

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

$x_4(t)$

-3 -2 0   2   3

① Addition :—

$x_1(t)$

Amplitude $= 2$

2

-2 2

$x_2(t)$

Amp $= 3$

3

-3 3

$x_3(t)$
$= x_1(t) + x_2(t)$

(addⁿ of amplitudes of 2 s/gs)

$x_3(t)$

$2+3=5$

5

$0+3=3$

$0+3=3$

-3 -2 2 3

③ Subtraction :—

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

$x_4(t)$

-3 -2 0   2   3
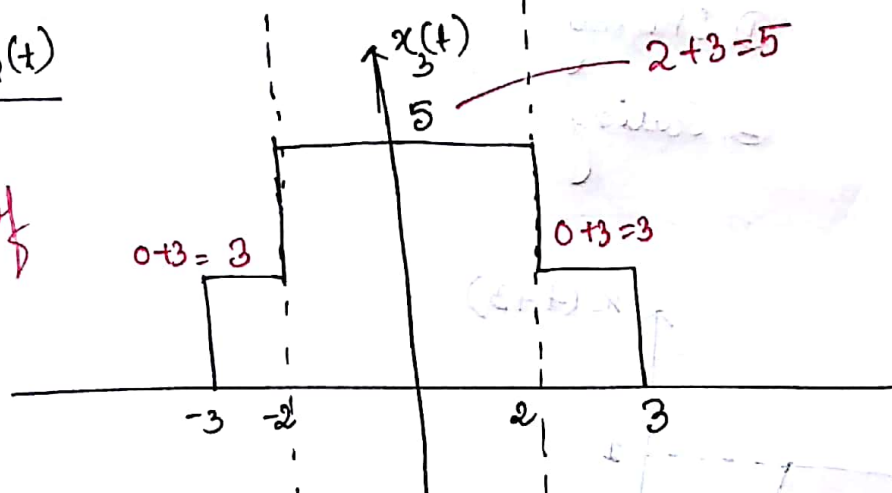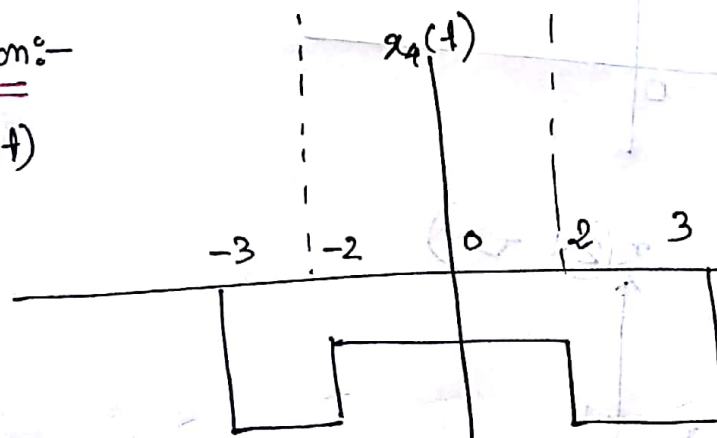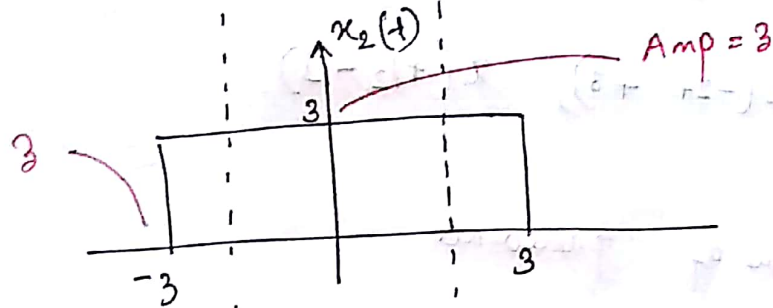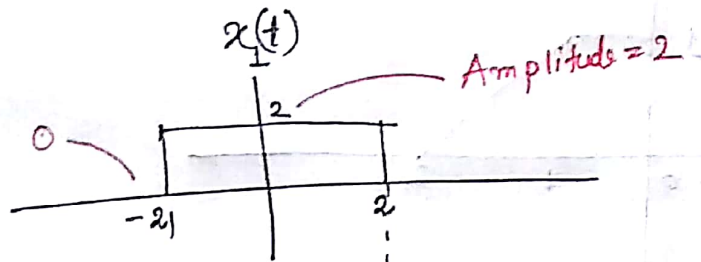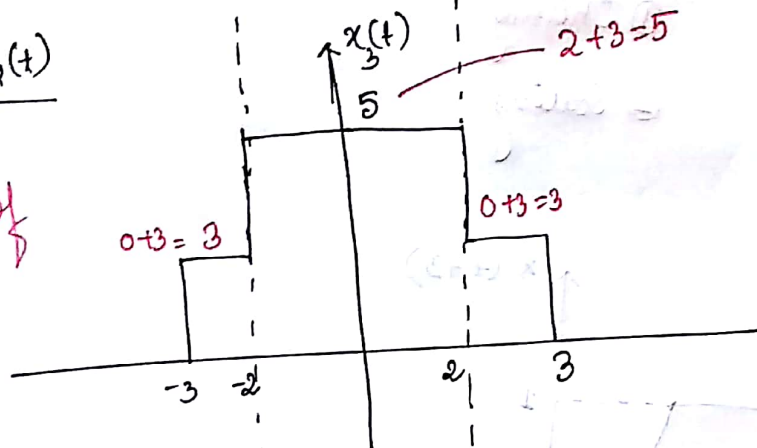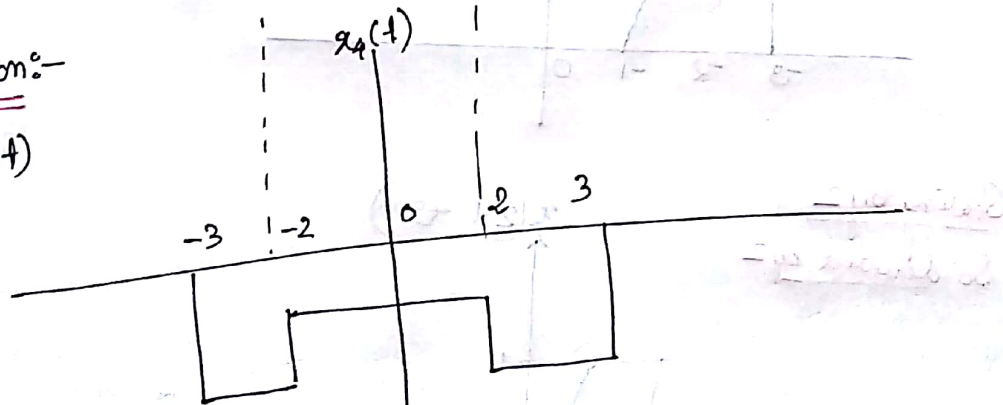
④ Multiplication :—

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

o Amplitude

$x_5(t)$

6
5
4
3
2
1

o Amplitude

-3 -2 0   2   3

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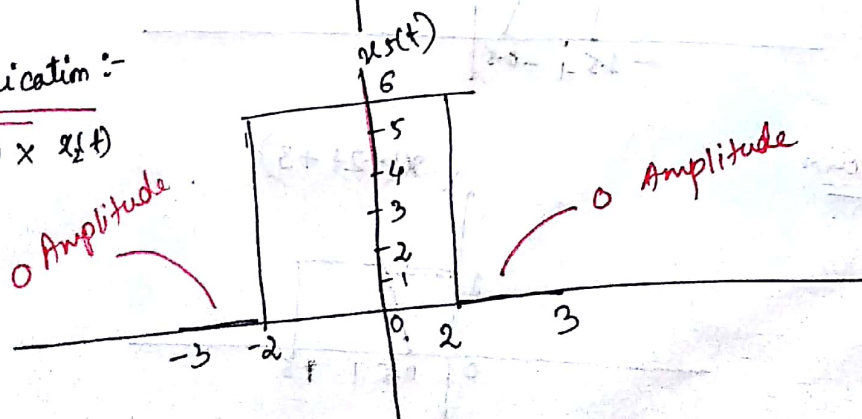
Q. Given, $x(t)$
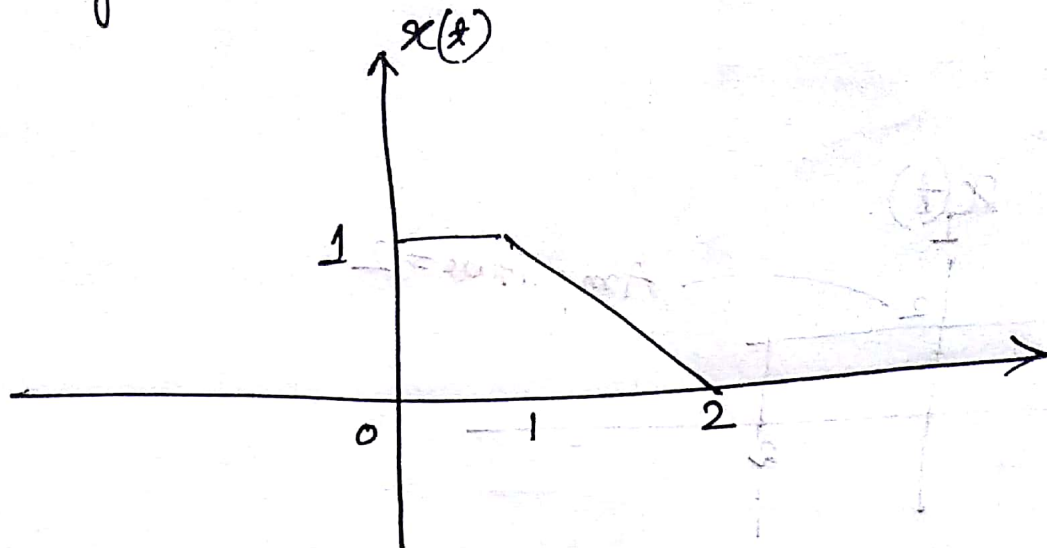
Plot $x(-2t + 3)$, $x\left(t/2 - 1\right)$.
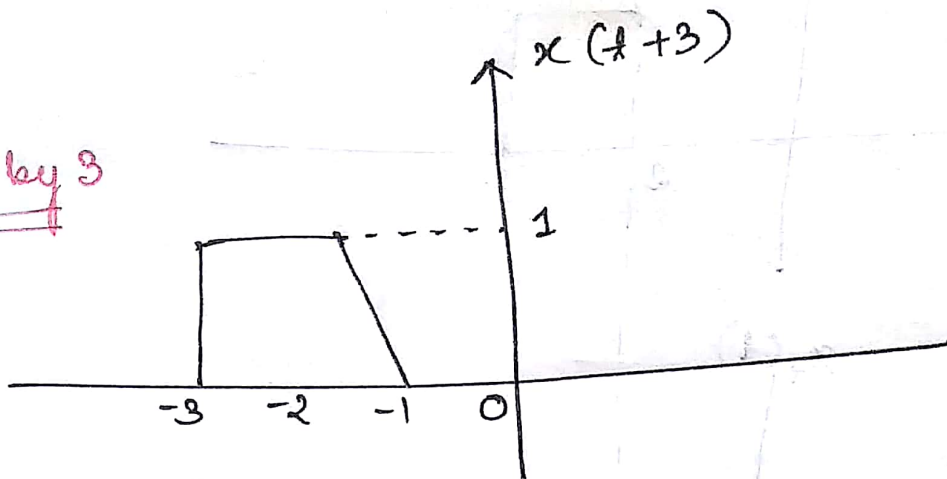
* NB   Law of precedence
       ① Shifting
       ② Scaling

<u>Sol^m</u>.

<u>-ve shifted by 3</u>

$x(t+3)$

1

-3   -2   -1   0

Scaling by 2
So devided by 2

$$x\left(2t + +3\right)$$

1

-1.5 -1 -0.5

reflection

$$x(-2t + 3)$$

1

0   0.5   1   1.5