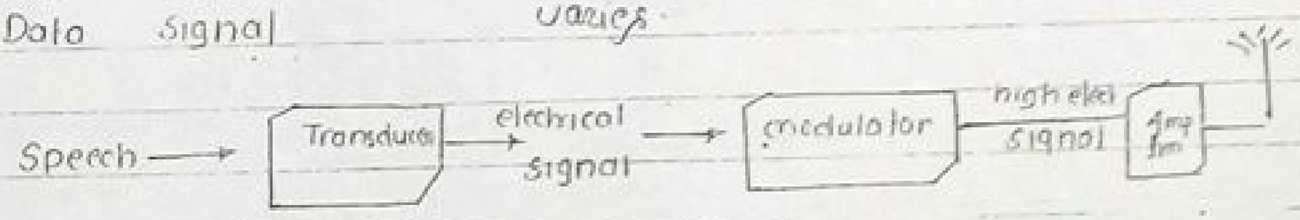
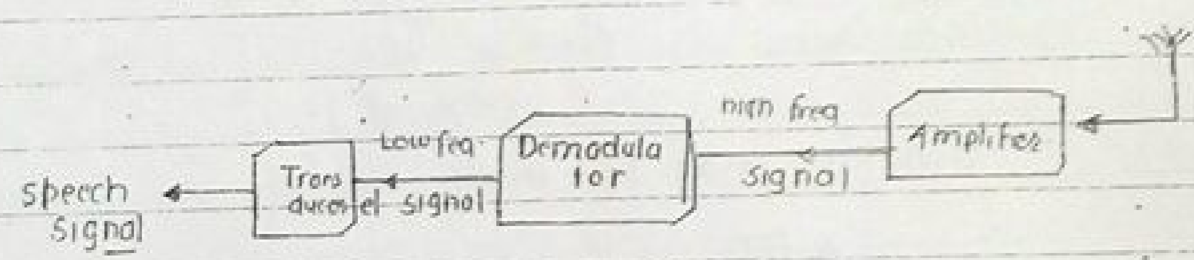
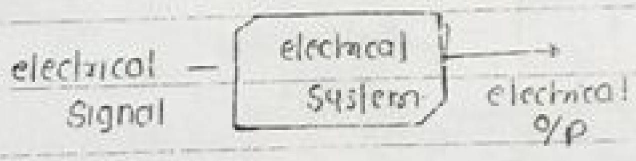
Speech signal — 300 Hz to 3400 Hz.
Audio signal — 20 Hz to 20 KHz.
Video signal — 0 to 4.5 MHz [combination of Audio]
Data signal — varies.







Fourier series
Fourier Transform.
Laplace Transform.
Z- Transform.
Sampling Theorem.

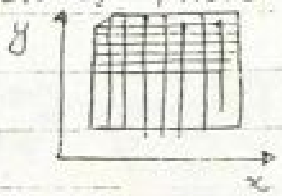
Book.

Signal & System - oppenheim
Signal & system - Symon Haykins.
Signal & System - Schaum's series.

Any Quantity having associated information called as signal electrical signal or either voltages or current which are both function of time

Signal is not alway function of time

Ex :- Information of photo

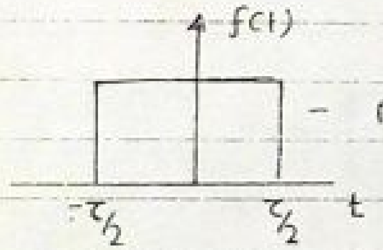


$f(x,y)$
↳ function of pixel of photo is function of x, y

Video signal is function of

$f(x,y,t)$

Signal is may be multi variable.

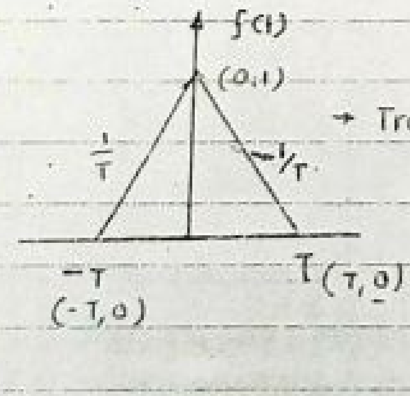


– Rectangular Pulse

In methematical form

$f(t) = 1, \quad -\tau/2 < t < \tau/2$

$\quad\quad 0 \quad$ otherwise



→ Trangular Pulse

$f(t) = mt + c$

where m = slope

$f(t) = \frac{1}{T} t + c$

$0 = \frac{1}{T}(-T) + c$

$c = 1$

$\therefore \boxed{f(t) = \frac{1}{T} t + 1}, \quad -T \le t \le 0$

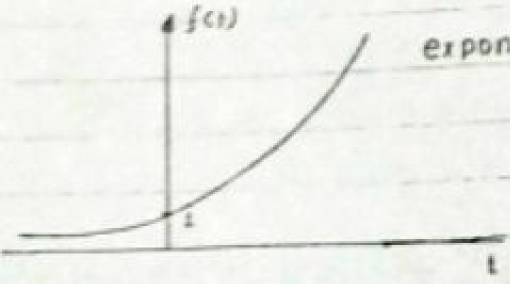
eqn of st. Line

$f(t) = -\frac{1}{T} t + c$

$0 = -\frac{1}{T} T + c$

$c = 1$

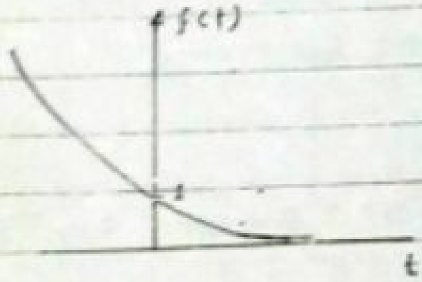
$\boxed{f(t) = -\frac{1}{T} t + 1}$



exponentially increasing signal.

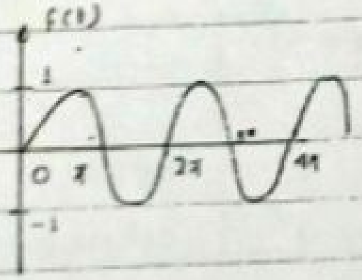
$f(t) = e^{at}$

a : +ve constant



exponentially decreasing signal.

$f(t) = e^{-at}$



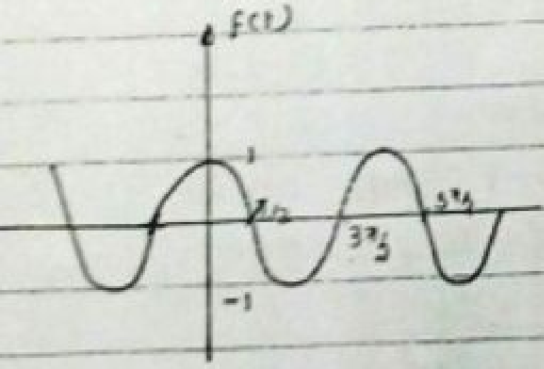
Sine signal. $f(t) = \sin t$

$\omega = 1$

$T = \frac{2\pi}{\omega} = 2\pi$

zero cross over $= k\pi$

where k : Integer



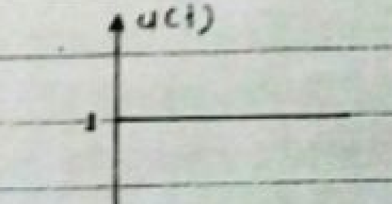
Cosine signal $f(t)$: $\cos t$

zero crossover $= (2k+1)\frac{\pi}{2}$

where :

$k : 0, 1 \ldots$

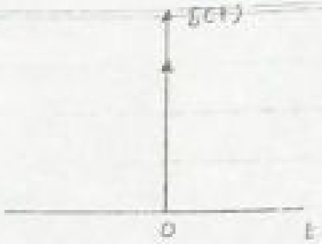
Combination of sine and cosine are Sinusoidal signal



unit step signal.

$u(t) = 1 \quad t \geq 0$

$= 0 \quad t < 0.$



Impulse signal

$\delta(t) = 0 \quad t \neq 0$

$\neq 0 \quad t = 0$

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

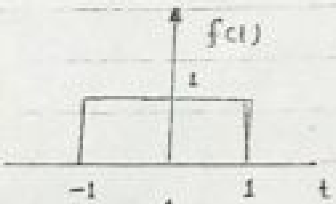
It is also called as unit impulse signal

It is also called as <u>Dirac Delta ~~Funct~~ signal</u>

Sketch the graph of signal

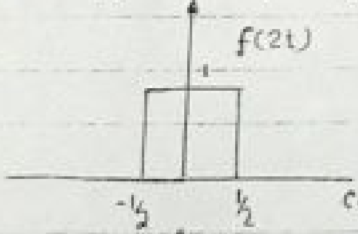
$f(t) = \frac{\sin t}{t} = Sa(t)$: <u>Sampling Function.</u>

<u>Solution</u>:→ $f(t) = \frac{\sin t}{t}$



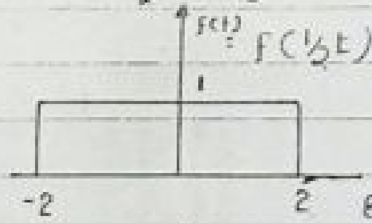
$f(t) = 1 \quad -1 \le t \le 1$

$= 0 \quad$ otherwise

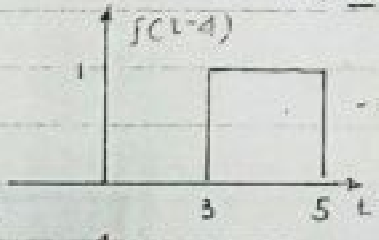


compress

Time scale version
OR/compress version

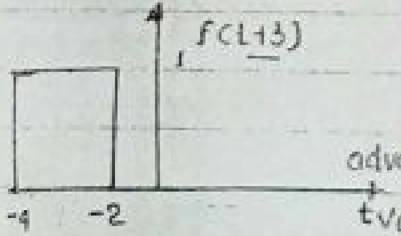


Expended



- Delayed

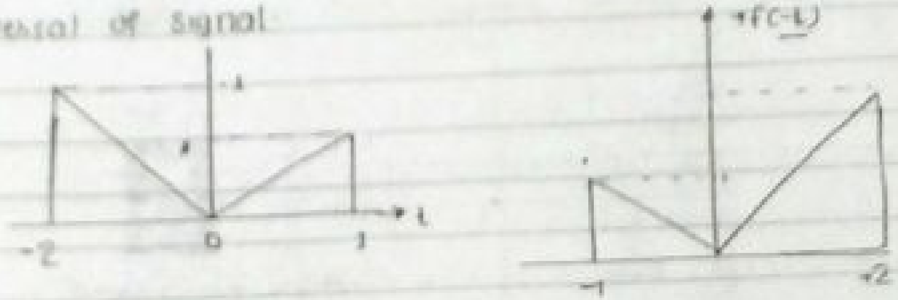
Time Shifted version of Given signal

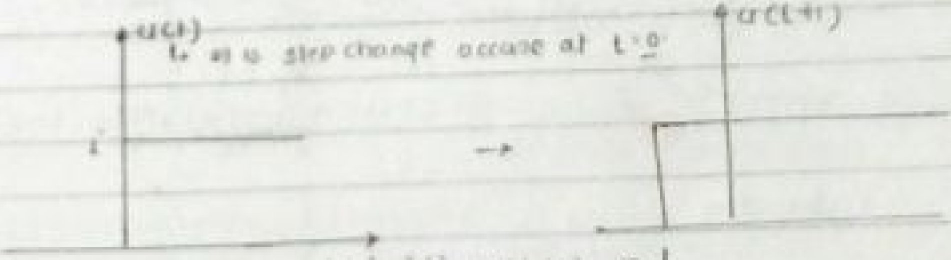


advanced version

Rotation along Y-axis by 180
or/ mirror image across Y-axis
Transmission of $t \to -t$ is also
Add extra -ve sign to all t value.

Time Reversal of signal

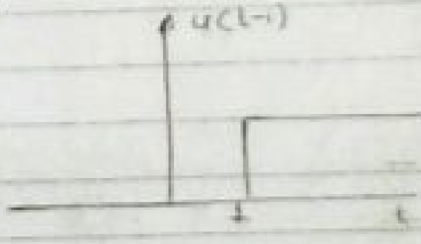




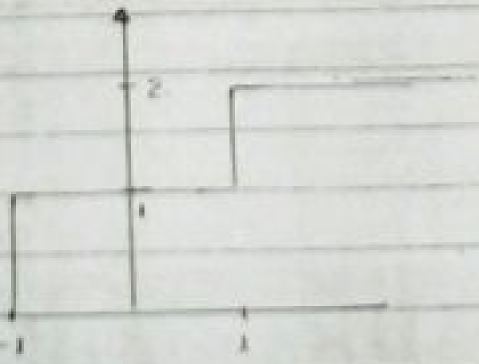
$u(t) \xrightarrow{t \to t+1} u(t+1)$

$u(t-1) = ?$

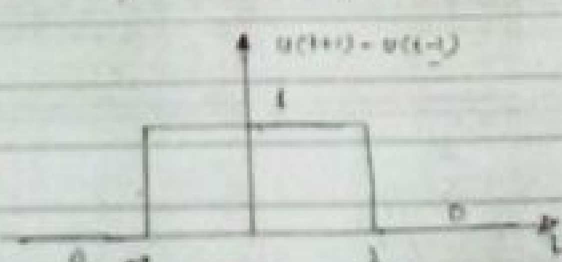
$u(t) \xrightarrow{t \to t-1}$

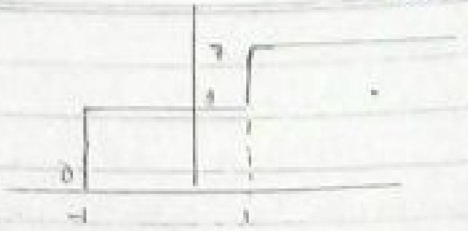


$u(t+1) + u(t-1)$



$u(t+1) - u(t-1)$

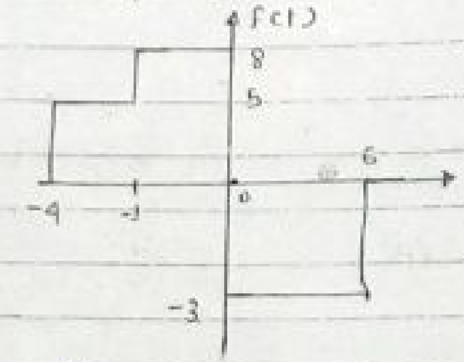




$3u(t+1) + 4u(t-1)$

↳ amount of size change.

Represent following signal $f(t)$ using shifted unit step signal



wrong ← $f(t) = 5u(t+4) + 3u(t+1) + (-3u(t-6))$

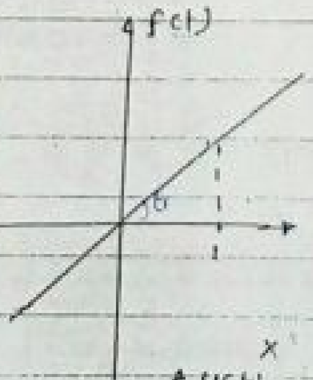
Right ← $f(t) = 5u(t+4) + 3u(t+1) - 11u(t) + 3u(t-6)$

Sum of Co-efficient = 0.

$5+3+3-11 = 0$.

when ever signal have finite duration then sum of co-efficient is zero.

The above rep. sum of co-efficient will be always equal to zero as along as the duration of signal is finite

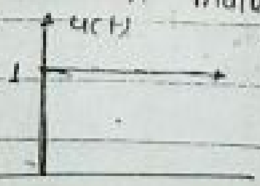


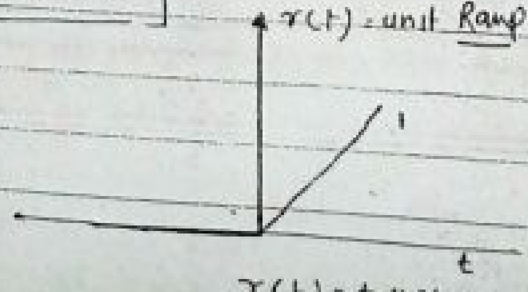
$f(t) = mt$

$= 1t$

$\boxed{f(t) = t}$

× multiply.





$r(t) = t\,u(t)$

$f(t) = 1 \quad -1 \le t \le 1$

$f(2t) = 1 \quad -1 \le 2t \le 1$

$-\frac{1}{2} \le t \le \frac{1}{2}$

$f(\frac{1}{2}t) = 1 \quad , -1 \le \frac{1}{2}t \le 1 .$

$= 0 \quad$ otherwise

$f(\frac{1}{2}t) = 1 \quad -2 \le t \le 2$

$= 0 \quad$ otherwise

Time scaling operation:-

Tranformation of t to at is called Time.S.

$$\boxed{f(t) \xrightarrow{t \to at} f(at)}$$

$a > 1 \to$ it meas compression

$a < 1 \to$ it means expension

$f(t) = 1 \quad -1 \le t \le 1$

$= 0 \quad$ otherwise

$t \to t-4$

$f(t-4) = 1 \quad -1 \le t-4 \le 1$

$-1+4 \le t \le 1+4$

$3 \le t \le 5$

$= 0 \quad$ otherwise

$f(t+3) = 1 \quad -1 \le t+3 \le 1$

$-1-3 \le t \le 1-3$

$-4 \le t \le -2$

$= 0 \quad$ otherwise

8

Time shifting operation:-

change $t \to t-t_0$

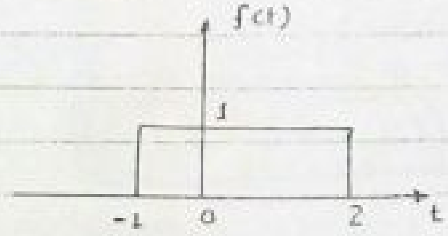
$t \to t+t_0$

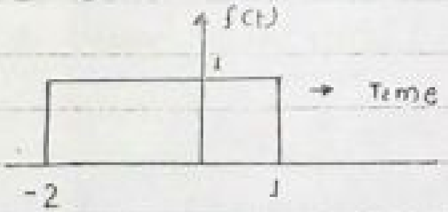
$f(t) \xrightarrow{t \to t-t_0} f(t-t_0) \to$ Delayed shifting or/ Right shift

$f(t) \xrightarrow{t \to t+t_0} f(t+t_0) \to$ Advanced shifting or/ Left shift

→ It also add 't_0' transformation → Delayed.

→ Subtract 't_0' transmission: Advance shifting.





→ Time Reversal version } → Rotate graph along Y-axis by 180

$f(t) = 1, \ -1 \le t \le 2$

$= 0$ otherwise

$f(-t) = 1 \quad -1 \le -t \le 2$

——— multiply by -1

$1 \geq t \geq -2.$

$= 0$ otherwise.

<u>Time Reversal</u>

Transformation of t to $-t$

$f(t) \xrightarrow{t \to -t} f(-t)$

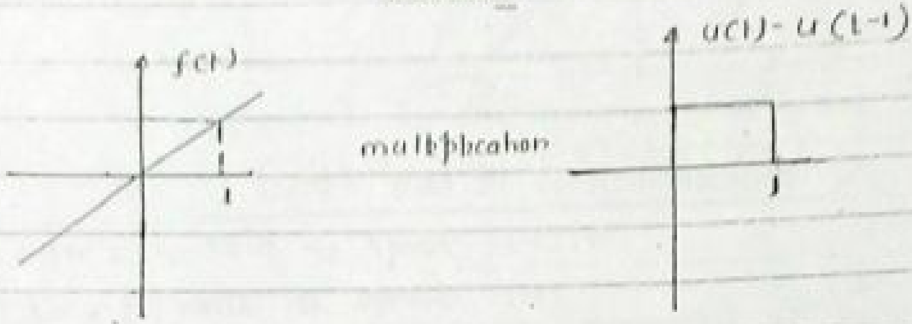
$f(-t) \xrightarrow{t \to -t} f(-(-t)) = f(t)$

$f(t+3) \xrightarrow{t \to -t} f(-t+3)$

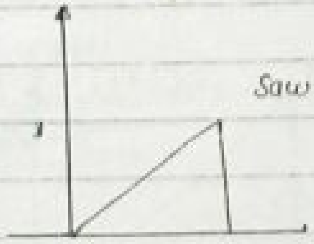
$r(t) = t \quad t \geq 0$

$= 0 \quad t < 0$

multiplication of $u(t)$ the signal retain only in $t>0$ portion



⇓



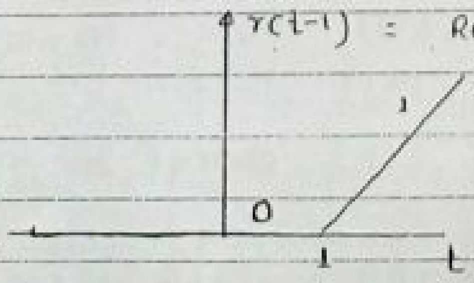
Sawtooth pulse

$t[u(t) - u(t-1)]$

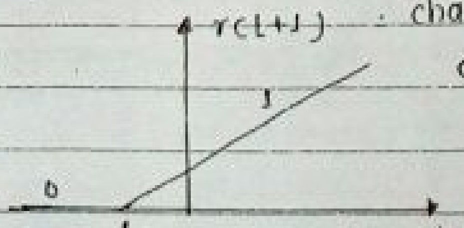
when ever signal is multiply by u(t) the variation occuring for $t>0$ is sustain the variation occuring for $t<0$ is completely remove

A portion of a signal can be considered by multip by a given signal with a Rectangular pulse having a value 1 in the Required portion of the given signal and a value zero in unrequired portion.

$r(t-1)$:



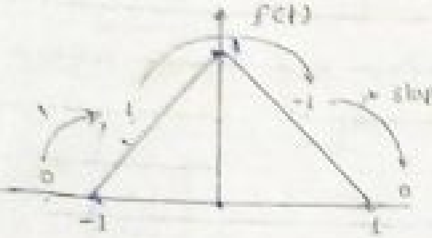
$r(t-1)$: Repersative change in slope at $t=1$



$r(t+1)$: change in slope at $t = -1$

chang slope : 0 to +1

$r(t-t_0)$ = change of slope of 1 at $t = t_0$



Representation of this signal:

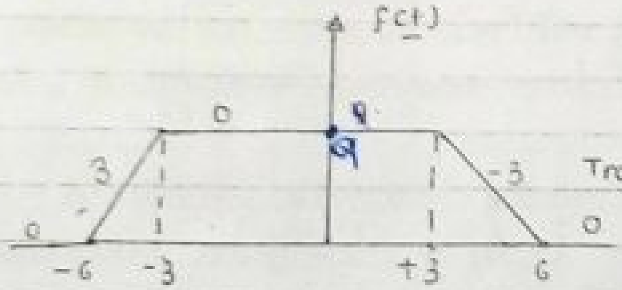
$r(t+1)$: change in slope by 1 at $t=-1$

$r(t)$: change in slope by 2 at $t=0$

$r(t-1)$: change in slope by -1 at $t=1$.

$$f(t) = \underbrace{r(t+1) - 2r(t) + r(t-1)}_{\text{amount of slope change}}$$

Represent the ~~folling~~ following signal using shifted Ramp Function:



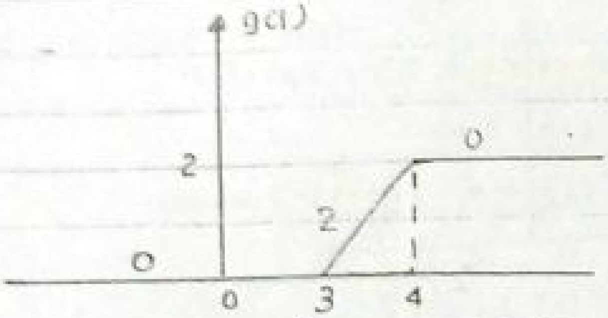
$r(t+6)$: change in slope at $t=6$

$r(t+3)$ change in slope at $t=-3$

$r(t-3)$ change in slope at $t=3$

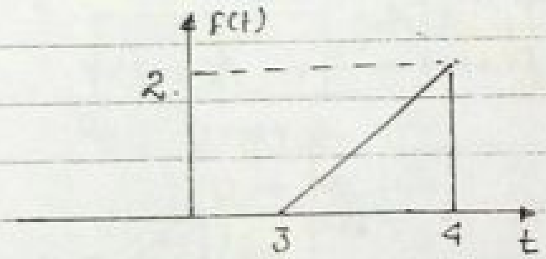
$r(t-6)$ change in slope at $t=6$

$$f(t) = (3-0)r(t+6) + (0-3)r(t+3) + (0-3)r(t-3) + (0-(-3))r(t-6)$$

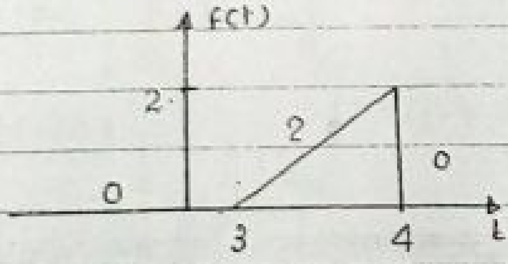


$$\boxed{g(t) = 2r(t-3) - 2r(t-4)}$$

Represent the following sawtooth pulse using shifted Ramp and shifted unit step signal.



For shifted Ramp



0, 2, 0 change in slope

$$f(t) = 2r(t-3) - 2r(t-4) - 2u(t-4).$$

For shifted unit step

For above signal $f(t) + f(-t+7)$ is equal to

(a) $r(t-3) - r(t-4)$

(b) $2[r(t-3) - r(t-4)]$

(c) $u(t-3) - u(t-4)$

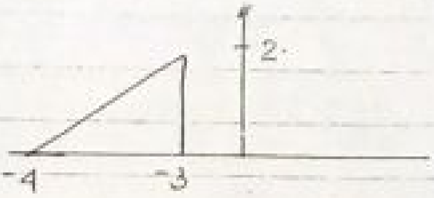
(d) $2[u(t-3) - u(t-4)$

$f(-t+7)$

time shifting + Time Reversal

(i) shifting $\quad t \to t+7$

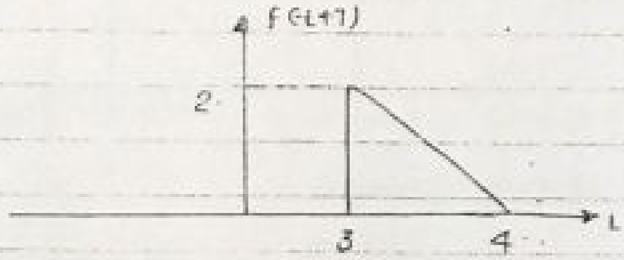
$f(t) \longrightarrow f(t+7)$ · ⇒ subtract ·



(ii) Reversal

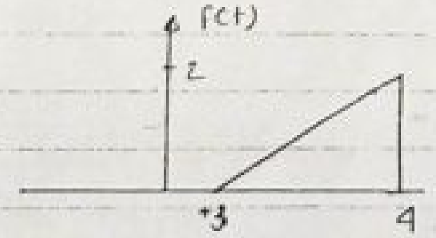
$t \to -t$

$f(t+7) \xrightarrow{-t} f(-t+7)$

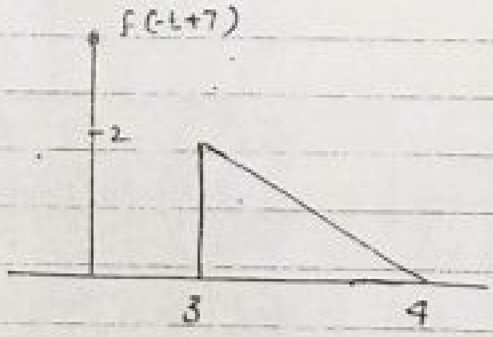


Now

$f(t) + f(-t+7)$



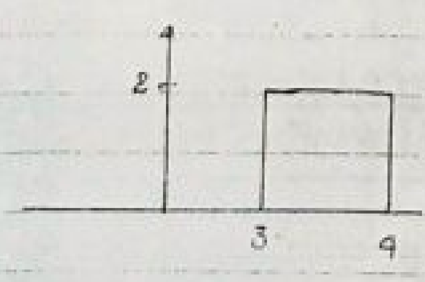
+



$f(t) = g(t)[u(t-3) - u(t-4)]$

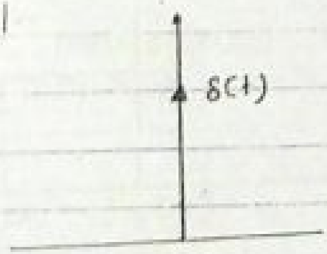
$= (2t)[u(t-3) - u(t-4)]$

⇓



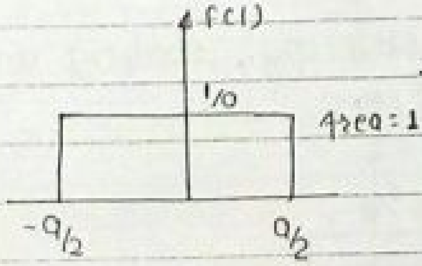
$f(t) + f(-t+7) = 2u(t-3) - 2u(t-4)$

Unit Impulse signal



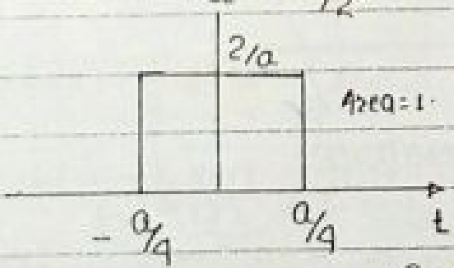
$$\delta(t) = \begin{cases} 0 & t \neq 0 \\ \neq 0 & t = 0 \end{cases}$$

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

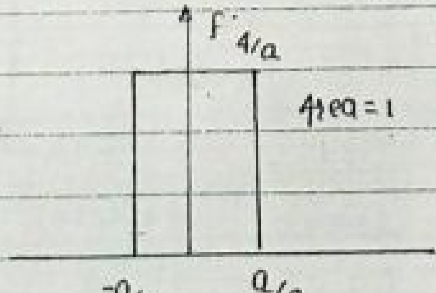


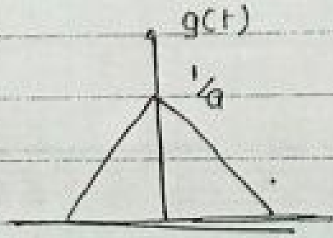
$$\boxed{\lim_{a \to 0} f(t) = \delta(t)}$$

$a \to a/2$



$a \to a/4$





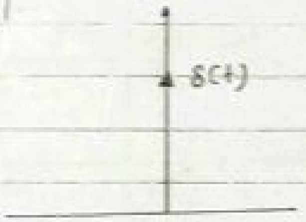
area $= \frac{1}{2} \times 2a \times \frac{1}{a} = 1$.

If

$$\boxed{\lim_{a \to 0} g(t) = \delta(t)}$$

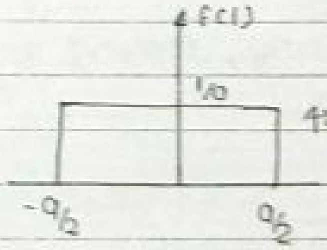
Area = 1

Unit Impulse signal



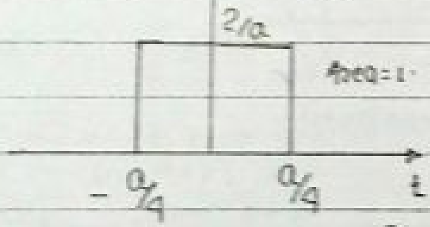
$$\delta(t) = 0 \quad t \neq 0$$
$$\neq 0 \quad t = 0$$

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

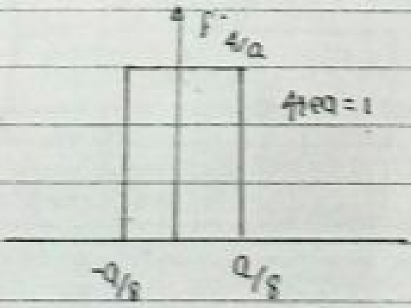


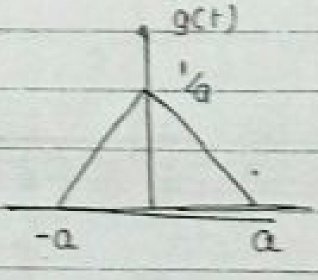
$$\boxed{\lim_{a \to 0} f(t) = \delta(t)}$$

$a \to a/2$.



$a \to a/4$.



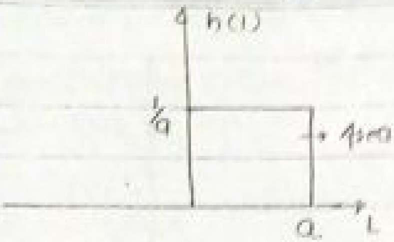


$$\text{area} = \frac{1}{2} \times 2a \times \frac{1}{a} = 1.$$

If

$$\boxed{\lim_{a \to 0} g(t) = \delta(t)}$$

Area = 1

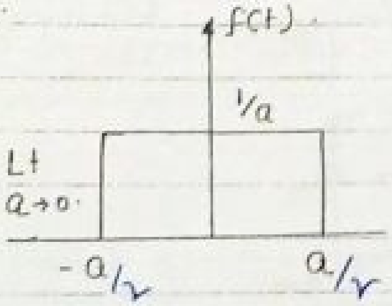


$$\boxed{\lim_{a\to 0} h(t) = \delta(t)}$$

δ(t) signal can be approached by using a wide varity of signal that is δ(t) does not have a unique defination hence it is also called as a Generalised Function.

Operation of Time shifting, Scaling and time Reversal on δ(t).

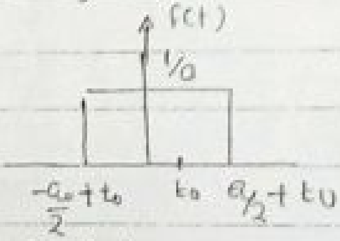
$$\delta(t) = \lim_{a\to 0}$$

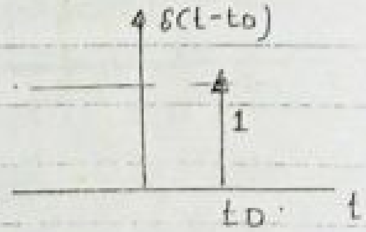


Time shifting operation:-

$$\delta(t-t_0) = \lim_{a\to 0} f(t + t_0)$$

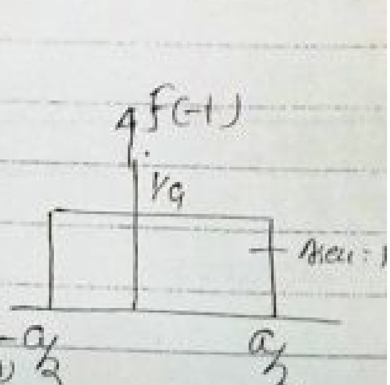
$$= \lim_{a\to 0}$$



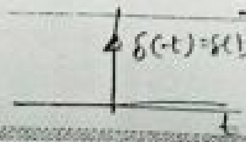


Time Reversal-

$$\delta(-t) = \lim_{a\to 0} f(-t) = \lim_{a\to 0}$$



$$=$$

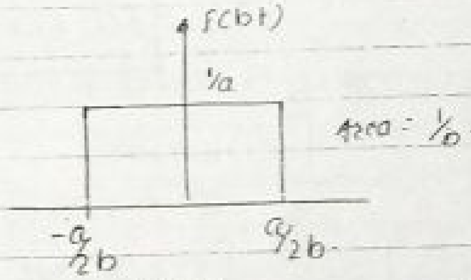


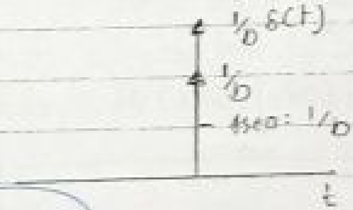
There is no effect of time reversal on the $\delta(t)$.

Time scaling:

$$\delta(bt) = \lim_{a \to 0} f(bt)$$

$$= \lim_{a \to 0}$$





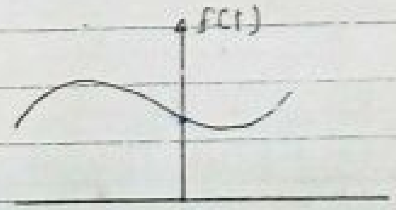
$$\delta(2t) = \frac{1}{2}\delta(t)$$

$$\delta(-2t) = \frac{1}{2}\delta(t)$$ bc'z there is no effect of time Reversal

b is +ve or -ve

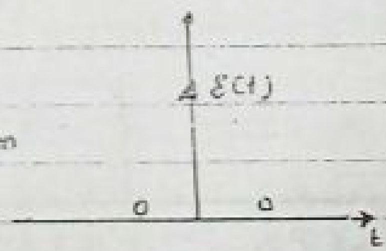
$$\boxed{\delta(bt) = \frac{1}{|b|}\delta(t)}$$

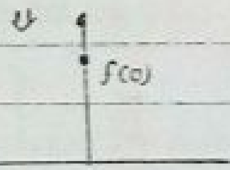
If time scale in impulse it, influence area of corresponding impulse signal



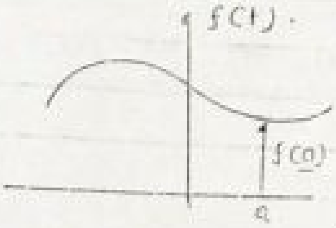
multiplication

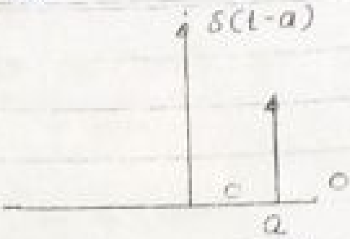
X





$$\boxed{f(t)\,\delta(t) = f(0)\cdot\delta(t)}$$





$$\boxed{f(t)\,\delta(t-a) = f(a)\cdot\delta(t-a)}$$

$$\int_{-\infty}^{\infty} f(t)\,\delta(t)\,dt$$

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

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

$$\boxed{\int_{-\infty}^{\infty} f(t)\,\delta(t)\,dt = f(0)}$$

$$\int_{-\infty}^{\infty} f(t)\cdot\delta(t-a)\,dt = \int_{-\infty}^{\infty} f(a)\,\delta(t-a)$$

$$= f(a)\int_{-\infty}^{\infty} \delta(t-a)\,dt$$

$$= f(a)$$

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

$$\int_{-2}^{3} \delta(t)\,dt = 1$$

$$\int_{3}^{5} \delta(t)\,dt = 0$$

$$\int_{0^-}^{0^+} \delta(t)\,dt = \underline{1}$$

Evaluate the value of following integral

(i) $\int_{-\infty}^{\infty} \sin(t-\pi/2)\,\delta(t)\,dt = \sin(0-\pi/2) = -1$

(ii) $\int_{-\infty}^{\infty} \underbrace{\sin(t-\pi/2)}_{f(t)}\,\delta(t-\pi)\,dt : \sin(\pi-\pi/2) = \sin\pi/2 = 1$

(iii) $\int_{-\infty}^{\infty} \sin(t-\pi/3)\,\delta(3t-\pi)\,dt = \int_{-\infty}^{\infty} \sin(t-\pi/3)\,\delta[3(t-\pi/3)]$

$= \frac{1}{3}\delta(t-\pi/3).$

(iv) $\int_{-\pi/6}^{\pi/6} \sin(t-\pi/2)\,\delta(3t-\pi)\,dt$

$= \frac{1}{3}\int_{-\infty}^{\infty} \sin(t-\pi/3)\,\delta(t-\pi/3)$

$= \frac{1}{3}\sin(\pi/3-\pi/2)$

$= \frac{1}{3}\sin(-\pi/6)$

$= \frac{1}{3}\cdot\frac{1}{2} = -\frac{1}{6}$

(iv) $\int_{-\pi/6}^{\pi/6} \sin(t-\pi/3)\,\delta(3t-\pi)\,dt$

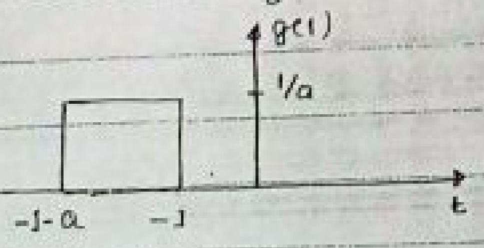
$= \frac{1}{3}\int_{-\pi/6}^{\pi/6} \sin(t-\pi/3)\,\delta(t-\pi/3)\cdot dt$

$= \underline{0}$ Ans

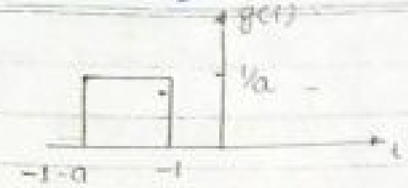
Evaluate the value of following integral

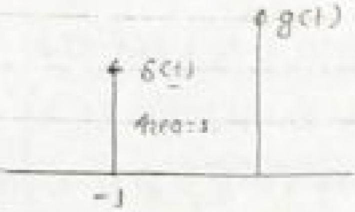
(i) $\int_{-\infty}^{\infty} \frac{\sin\frac{\pi}{2}(t-2)}{t^2+4}\,g(t)\,dt$

where $g(t)$ is following signal as $a \to 0$



$g(t) = \lim_{a \to 0}$





$$\int_{-\infty}^{\infty} f(t)\,\delta(t-a)\,dt = f(a).$$

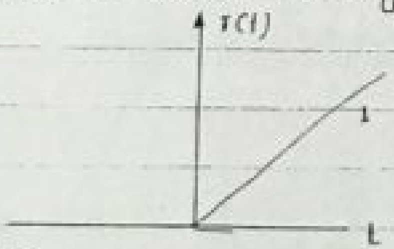
So Now given integral.

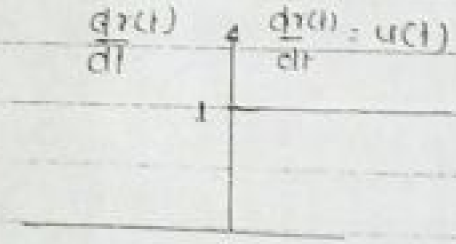
$$\int_{-\infty}^{\infty} \frac{\sin \frac{\pi}{2}(t-2)}{t^2+1} \cdot \delta(t+1)\,dt$$

$$= \frac{\sin\left(\frac{\pi}{2}(-1-2)\right)}{(-1)^2+4}$$

$$= \frac{1}{5}.$$

Derivative and Integral of signal.





$y = mx + c$

$\frac{dy}{dx} = m + 0$

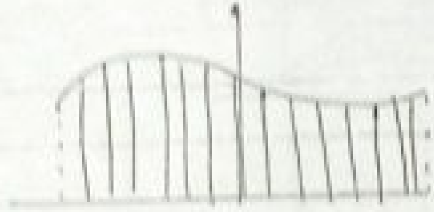
$\frac{dy}{dx} = m$

$\frac{dr(t)}{dt} = 1$ unit step

$u(t) = \frac{d}{dt} r(t)$

$r(t) =$ Integral of $u(t)$

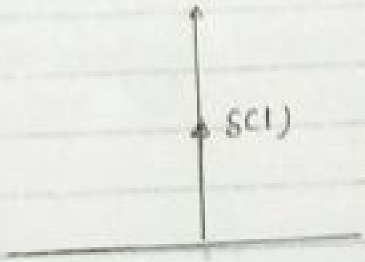
(ii)



$$\int_{-\infty}^{\infty} f(t)\,dt = K \begin{cases} \to \text{finite} \\ \to \text{infinite} \end{cases}$$

$$\int_{-\infty}^{t} f(t)\,dt = g(t) \cdot \text{Integral of } f(t)$$

$$\boxed{\begin{aligned} u(t) &= \frac{d}{dt} r(t) \\ r(t) &= \int_{-\infty}^{t} u(t)\,dt \end{aligned}}$$



$$\int_{-\infty}^{t} \delta(t)\,dt = 0 \quad t<0$$
$$= 1 \quad t \geq 0$$

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

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

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

Derauiteve of Discontineous signal is Defined

Problem:- find entegsal of following signal