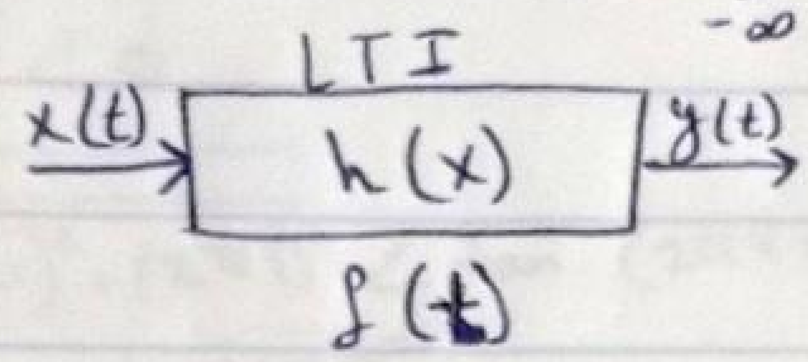
$$\boxed{LTI} \Rightarrow y(t) = x(t) * h(t)$$

Convolution

$$\int_{-\infty}^{\infty} x(t-\lambda)\, h(\lambda)\, d\lambda = \int_{-\infty}^{\infty} x(\lambda)\, h(t-\lambda)\, d\lambda$$



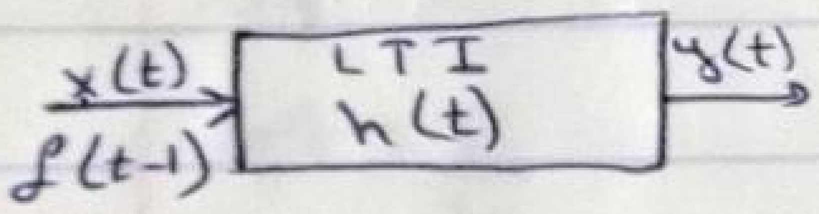
$$* \; y(t) = \int_{-\infty}^{\infty} x(t) * h(t)$$
$$= \int_{-\infty}^{\infty} x(t-\lambda)\, h(\lambda) = \int_{-\infty}^{\infty} x(t-\lambda)\, \delta(\lambda)\, d\lambda$$
$$t_0 = 0 \Rightarrow \lambda_0 = 0$$
$$= x(t-0) = x(t)$$

---

* Impulse response :-

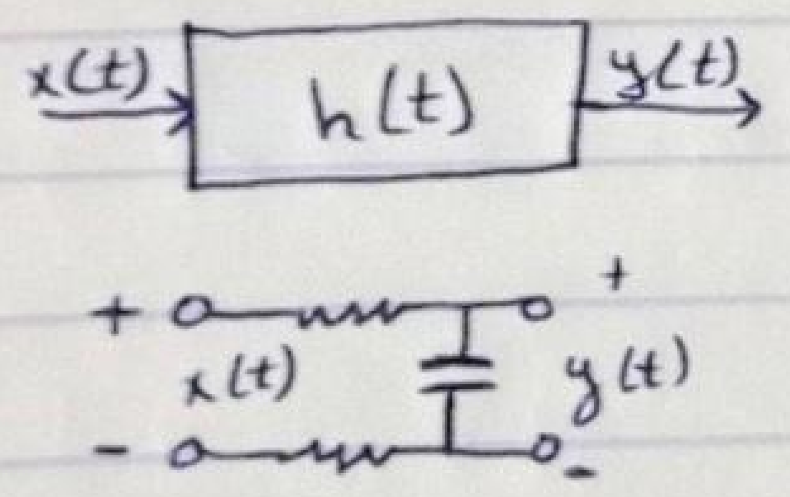
$x(t) = \delta(t)$ for LTI system , $y(t) = h(t)$

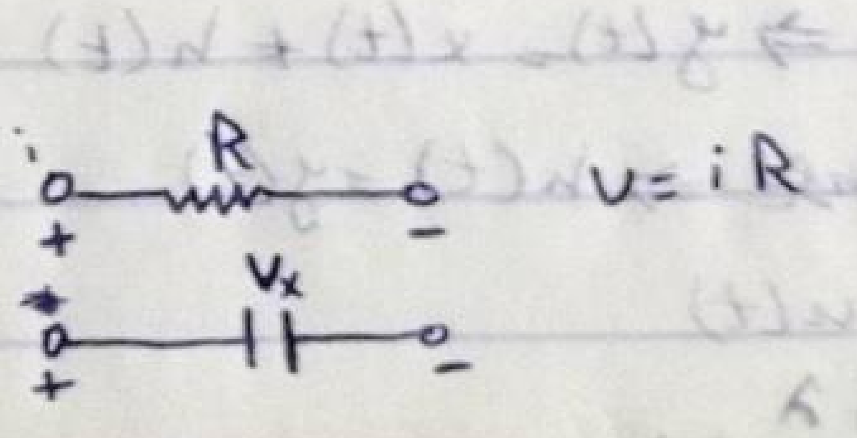
$\delta(t-1)$, $h(t-1)$



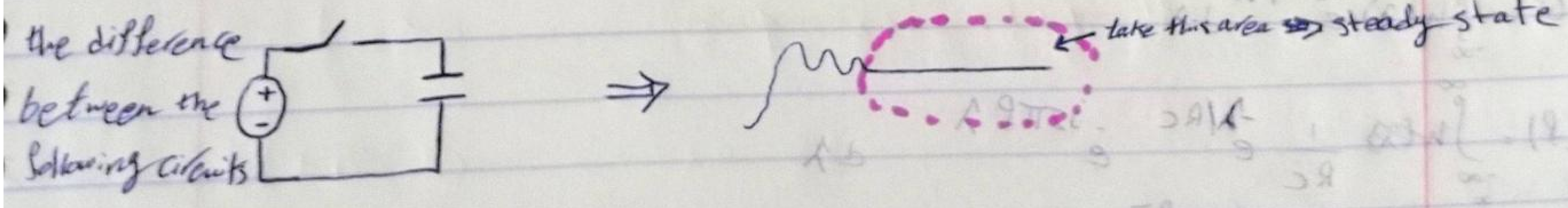
$$y(t) = x(t) * h(t) \rightarrow \int_{-\infty}^{\infty} \delta(\lambda-1) \cdot h(t-\lambda)\, d\lambda = h(t-1)$$

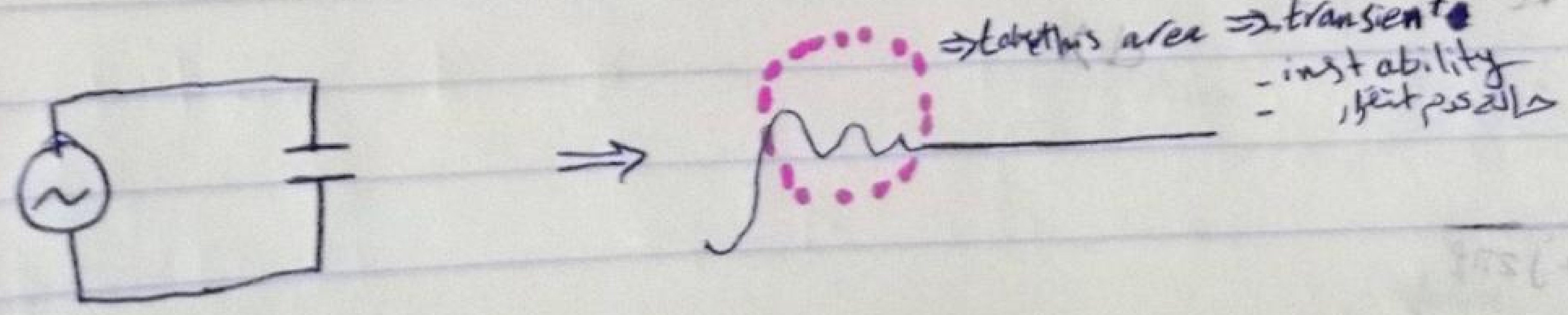
* Note: the convolution between any function with delta always equal the function





the difference between the following circuits





$$v_L(t) = L\,\frac{dy(t)}{dt}$$

$$x(t) + C_R R + y(t) = 0$$

and $I_R = I_C = C\,\dfrac{dy(t)}{d(t)} = C$

$$RC\,\frac{dy(t)}{dt} + y(t) = x(t)$$

$$y(t) = \frac{1}{RC}\,e^{-t/RC}\,u(t)$$

---

[*] Converting the system from time domain to frequency domain

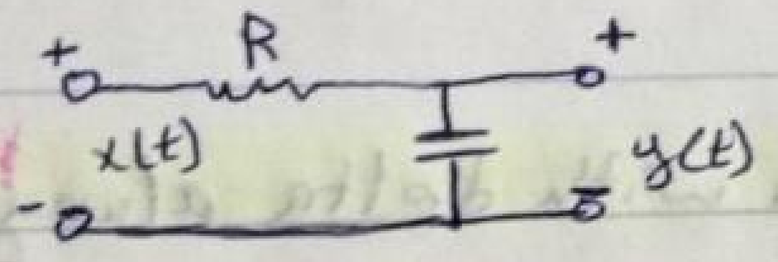
$$y(t) = x(t) * h(t)$$

$$= \int_{-\infty}^{\infty} e^{j\omega_0(t-\lambda)}\,h(\lambda)\,d\lambda$$

$$= e^{j\omega_0 t}\underbrace{\int_{-\infty}^{\infty} h(\lambda)\,e^{-j\omega_0\lambda}\,d\lambda}_{H(\omega)}$$

$H(f)$

Ex: consider LTI system



$$Z_C\,\frac{dy(t)}{dt} + y(t) = x(t)$$

Evaluate the impulse response :-

Ans: for LTI system $\Rightarrow y(t) = x(t) * h(t)$

Impulse response $\Rightarrow h(t) = y(t)$

$$h(t) = \frac{1}{RC}\,e^{-t/RC}\,u(t)$$

$$H(f) = \int_{-\infty}^{\infty} h(\lambda)\,e^{-j2\pi f\lambda}\,d\lambda$$

$$H(f) = \int_{-\infty}^{\infty} \frac{1}{RC}\,e^{-\lambda/RC}\,e^{-j2\pi f\lambda}\,d\lambda$$

$$= \int_{-\infty}^{\infty} \frac{1}{RC}\,e^{-\left[\frac{1}{RC} + j2\pi f\right]\lambda}\,d\lambda$$

$$= \frac{1}{RC}\cdot\frac{1}{\frac{1}{RC} + j2\pi f}$$

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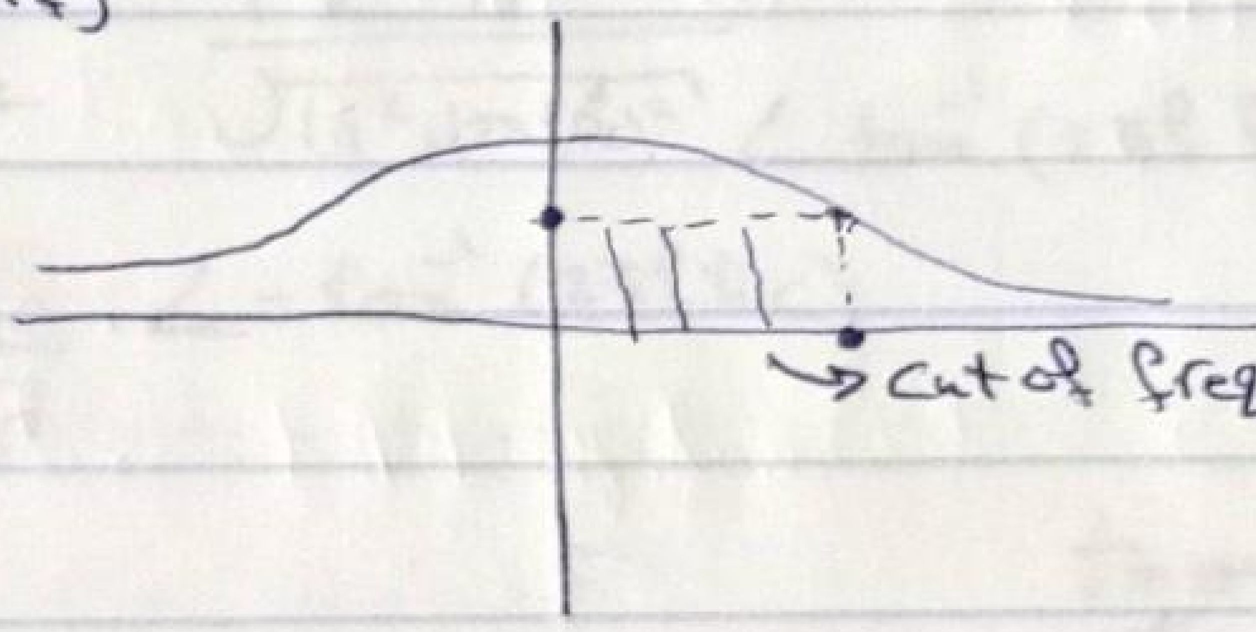
$H(f) = |H(f)| \angle \theta_H(f)$

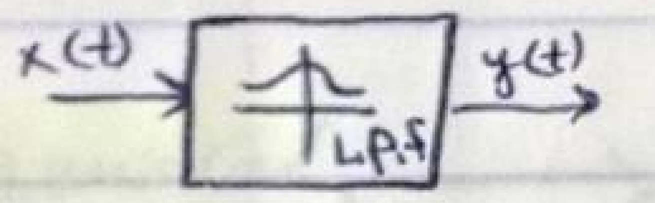
$$H(f) = \frac{1/RC}{\frac{1}{RC} + j2\pi f}$$

$$H(f) = \frac{\frac{1}{RC} \angle 0}{\sqrt{(1/RC)^2 + (2\pi f)^2} \angle \tan^{-1}(2\pi f RC)}$$

$\tan^{-1}\left(\frac{2\pi f}{1/RC}\right) \Rightarrow$

$$= \frac{1/RC}{\sqrt{(1/RC)^2 + (2\pi f)^2}} \angle -\tan^{-1}(2\pi f RC)$$

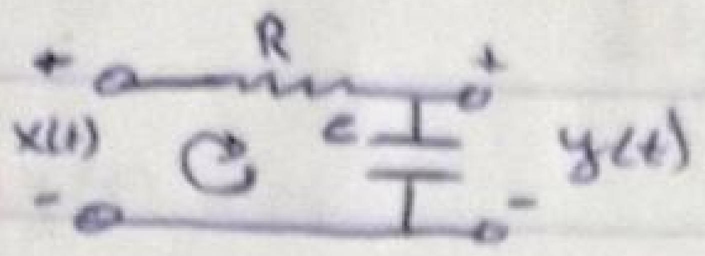




$\log x \frac{Z}{y}$

$$\frac{|H(f)|}{|H(0)|} = \frac{1}{\sqrt{(\frac{1}{RC})^2 + (2\pi f)^2}} = \frac{1}{\sqrt{2}}$$

Ex: consider LTI system which has the following DFE



$$-x(t) + R\,i(t) + y(t) = 0$$

Since $i_R(t) = i_c(t) = C\dfrac{dy(t)}{dt} = C\dfrac{dv_c(t)}{dt}$

$$-x(t) + Rc\,\frac{dy(t)}{dt} + y(t) = 0$$

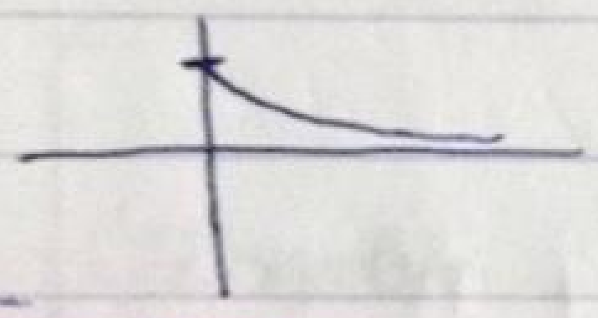
$$Rc\,\frac{dy(t)}{dt} + y(t) = x(t)$$

if we Assume impulse response

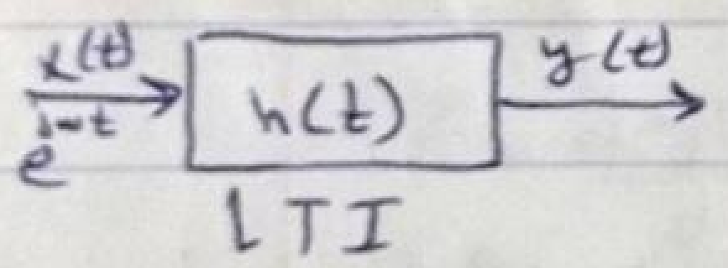
$x(t) = \delta(t)$ and $y(t) = h(t)$

$$\Rightarrow Rc\,\frac{dh(t)}{dt} + h(t) = \delta(t)$$

$$h(t) = \frac{1}{RC} e^{-t/Rc}\, u(t)$$



* **for frequency response**



$$\Rightarrow y(t) = x(t) * h(t)$$

$$= \int_{-\infty}^{\infty} e^{j\omega(t-\lambda)}\, h(\lambda)\, d\lambda = e^{j\omega t} \underbrace{\int_{-\infty}^{\infty} e^{-j\omega\lambda}\, h(\lambda)\, d\lambda}_{H(f)}$$

* to convert from time domain to freq. domain:-

$$H(f) = \int_{-\infty}^{\infty} h(\lambda)\, e^{-j2\pi f\lambda}\, d\lambda$$

$$\Rightarrow \text{if } h(t) = \frac{1}{Rc} e^{-t/Rc}\, u(t)$$

$$H(f) = \int_{-\infty}^{\infty} \frac{1}{Rc} e^{-\lambda/Rc}\, u(\lambda)\, e^{-j2\pi f\lambda}\, d\lambda$$

$$H(f) = \int_0^{\infty} \frac{1}{RC} e^{-\left(\frac{1}{RC} + j2\pi f\right)\lambda} \, d\lambda$$

$$= \frac{1/RC}{\frac{1}{RC} + j2\pi f} = \frac{1}{1 + j2\pi f RC}$$

In general:

$|X(f)| = |H(f)| \angle \theta_{H(f)}$

where...

$|H(f)| = |H(-f)|$ even

$\angle \theta_{H(f)} = -\angle \theta_{H(-f)}$ odd

$$\Rightarrow H(f) = \frac{1}{1 + j2\pi f RC} = \frac{1 \angle 0}{\sqrt{(1)^2 + (2\pi f RC)^2} \angle \tan^{-1}(2\pi f RC)}$$

$$= \frac{1}{\sqrt{1 + (2\pi f RC)^2}} \angle -\tan^{-1}(2\pi f RC)$$

In general → Power signal $\quad P_{avg} = \frac{1}{T_0} \int^{T_0} |x(t)|^2 \, dt$; $\frac{1}{2T}$ *

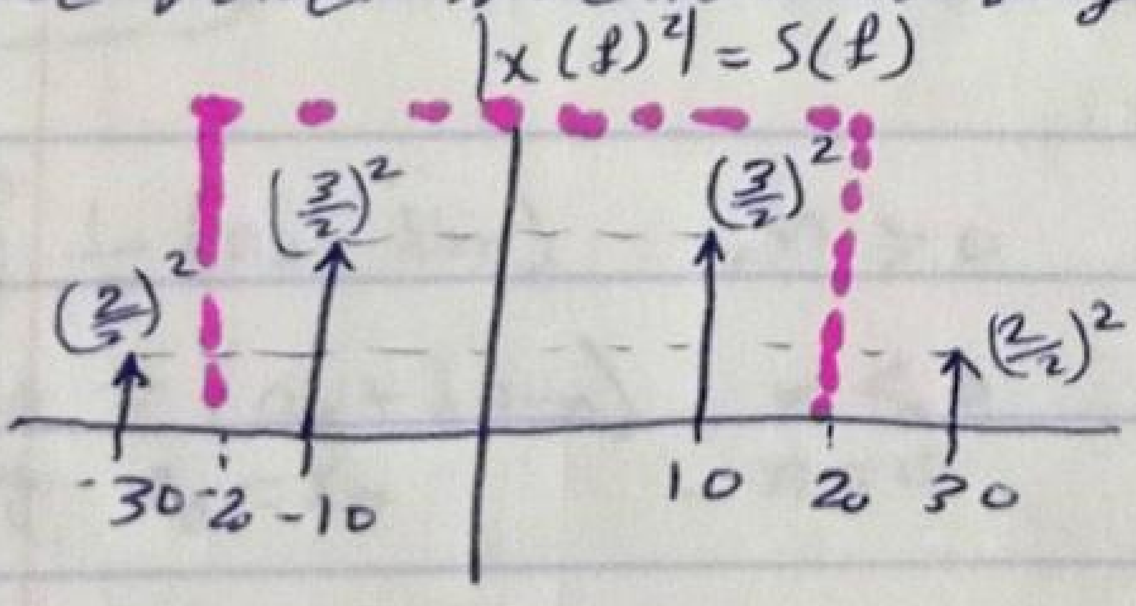
→ Energy signal $\quad E = \int_{T_0} |x(t)|^2 \, dt$

In freq. domain $P = \int_{-\infty}^{\infty} S(f) \, df$, $E = \int_{-\infty}^{\infty} G(f) \, df$, $G(f) = |H(\omega)|^2$

Power spectral density :-

$x(t) = 3 \sin(2\pi(10)t) - 2\cos(2\pi(30)t)$

- Evaluate Power spectral density (PSD) ; $S(f)$



$$S(f) = (1)^2 \delta(f+30) + (1.5)^2 \delta(f+10) + (1.5)^2 \delta(f-10) + (1)^2 \delta(f-30)$$

- To evaluate total Power

$$P_{TOT} = (1)^2 + (1.5)^2 + (1.5)^2 + (1)^2 = 6.5$$

0 - 20Hz ⇒ نصها

- To evaluate power at (-20Hz - 20Hz)

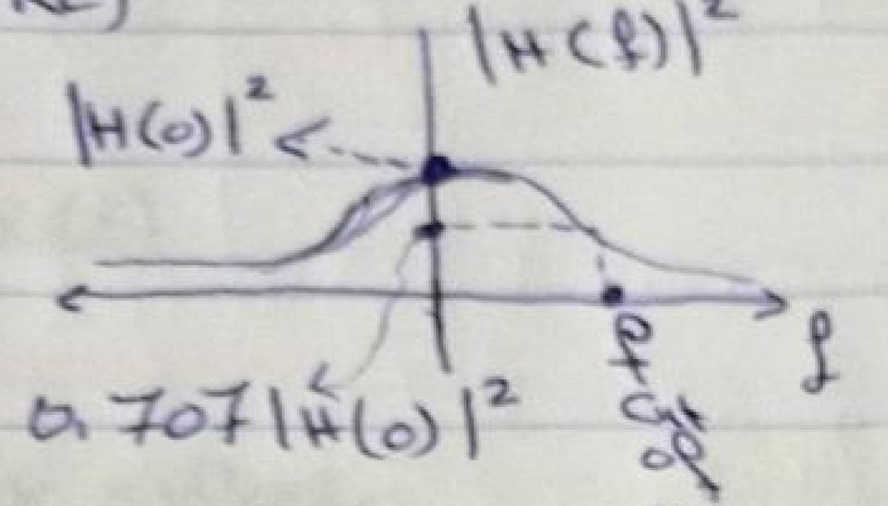
$$P = (1.5)^2 + (1.5)^2 = 4.5$$

- But for energy spectral density (ESD)

$$E = \int_{-\infty}^{\infty} G(f)\,df = \int_{-\infty}^{\infty} |X(f)|^2\,df$$

$$|H(f)| = \frac{1}{\sqrt{1+(2\pi f RC)^2}}$$

$$|H(f)|^2 = \frac{1}{1+(2\pi f RC)^2} = G(f) \quad [ESD]$$



frequency $\equiv f_{3dB}$

$$0.707\,|H(0)|^2 = |H(f_{3dB})|^2$$

$$\frac{|H(f_{3dB})|^2}{|H(0)|^2} = 0.707$$

In general

$x = 1 \longrightarrow 10\log(x)$

$P = x^2 \longrightarrow 20\log(x) \Rightarrow 10\log(P) = 10\log(x^2)$

$$20\log\left(\frac{|H(f_{3dB})|}{|H(0)|}\right) = 20\log(0.707)$$

$$20\log\left(\frac{1}{\sqrt{1+(2\pi f_{3dB} RC)^2}}\right) = -3$$

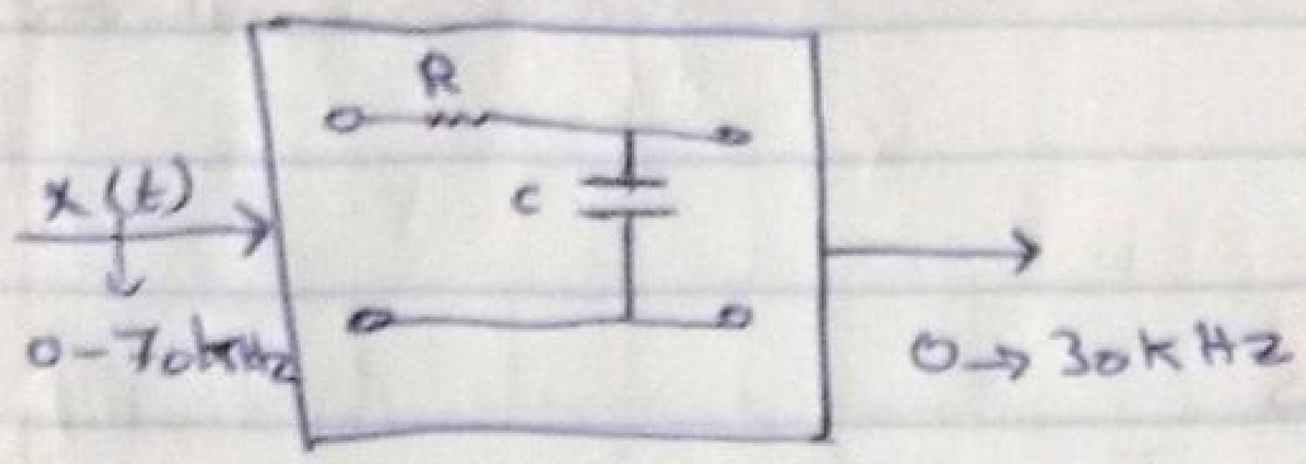
$$20\log\left[\left(1+(2\pi f_{3dB}RC)^2\right)^{-\frac{1}{2}}\right] = -3$$

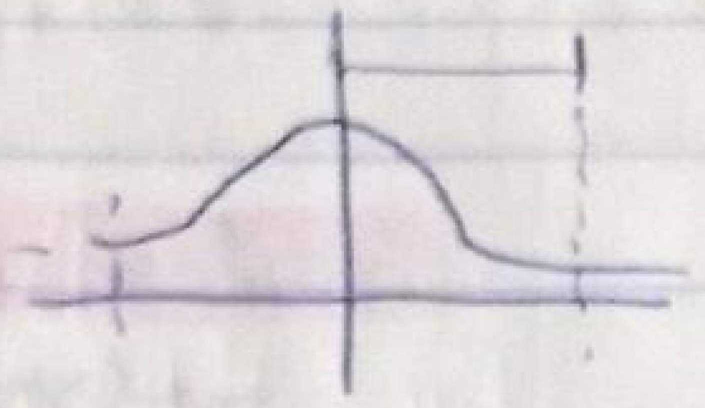
$$+\frac{10}{10}\log\left(1+(2\pi f_{3dB}RC)^2\right) = +\frac{3}{10}$$

$$1+(2\pi f_{3dB}RC)^2 = 10^{0.3}$$

$$f_{3dB} = \frac{1}{2\pi RC}$$

$\Rightarrow$





Bandwidth (BW)

$30kHz = \frac{1}{2\pi RC}$

if $R = 1k\Omega$

$30kHz = \frac{1}{2\pi(1k)C}$

---

* **fourier series :-**

Trigonometric fourier series

$x(t) = a_0 + \sum_{n=1}^{\infty} a_n \cos(n\omega_0 t) + \sum_{n=1}^{\infty} b_n \sin(n\omega_0 t)$

$a_0 = \frac{1}{T_0}\int x(t)\,dt \equiv$ average value $\equiv$ dc value

$a_n = \frac{2}{T_0}\int_{T_0} x(t)\cos(n\omega_0 t)\,dt$

$b_n = \frac{2}{T_0}\int_{T_0} x(t)\sin(n\omega_0 t)\,dt$

complex Exponential fourier series

$x(t) = \sum_{n=-\infty}^{\infty} X_n e^{j2\pi n f_0 t}$

$X_n = \frac{1}{T_0}\int_{T_0} x(t) e^{-j2\pi n f_0 t}\,dt$

In general :-

$$X_n = \begin{cases} \frac{1}{2}(a_n - jb_n) & , n > 0 \\ \frac{1}{2}(a_n + jb_{-n}) & , n < 0 \\ a_0 = X_0 & , n = 0 \end{cases}$$

$a_n = 2\,\mathrm{Re}\{X_n\}$

$b_n = -2\,\mathrm{Im}\{X_n\}$

if $x(t)$ even $\Rightarrow a_n ✓, b_n = 0$

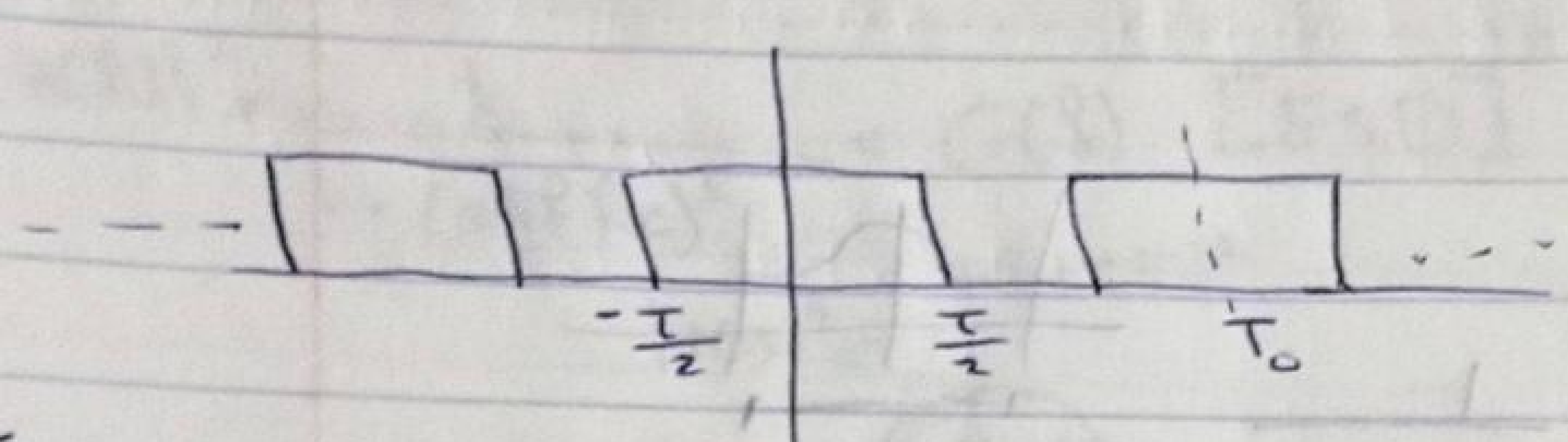
" $x(t)$ odd $\Rightarrow a_n = 0, b_n ✓$

if $x(t)$ even $\Rightarrow X_n$ real

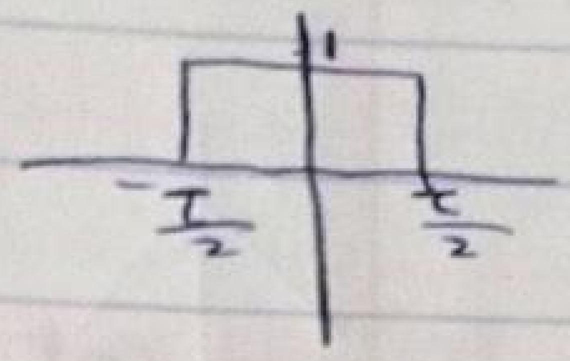
and if $x(t)$ odd $\Rightarrow X_n$ imaginary

extra

$\boxed{Ex}$:- consider the following signal shown below



- Evaluate Complex Exponential fourier series



$$X_n = \frac{1}{T_0} \int_{-T/2}^{T/2} (1)\, e^{-j2\pi n f_0 t}\, dt$$

$$= \frac{1}{T_0} \cdot \frac{-1}{j2\pi n f_0} \left(e^{-j2\pi n f_0 \frac{T}{2}} - e^{j2\pi n f_0 \frac{T}{2}} \right)$$

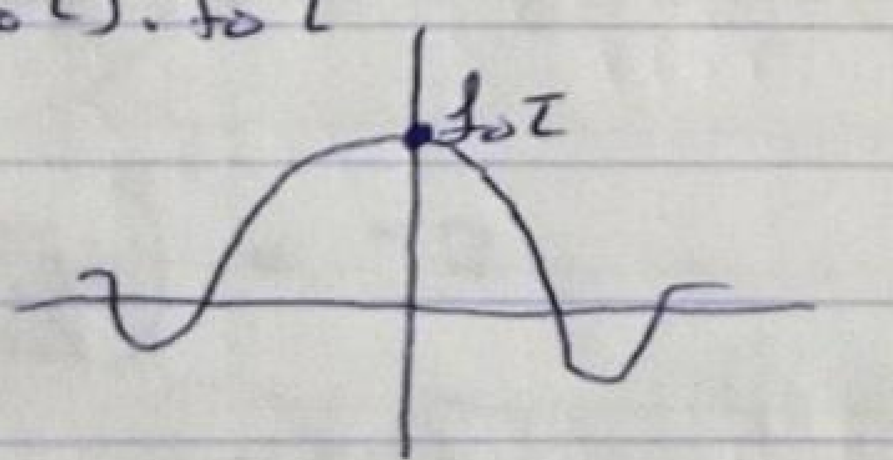
fourier series

*Note: $\sin(\theta) = \frac{e^{j\theta} - e^{-j\theta}}{j2}$ and $\cos(\theta) = \frac{e^{j\theta} + e^{-j\theta}}{2}$

$$X_n = \frac{1}{n\pi} \sin(n\pi f_0 T) \cdot \frac{f_0 T}{f_0 T}$$

* In general $\operatorname{sinc}(\theta) = \frac{\sin(\theta\pi)}{\theta\pi}$

$\Rightarrow X_n = \operatorname{sinc}(n f_0 T) \cdot f_0 T$



- Evaluate Trigonometric Coefficient fourier series

$$a_n = 2\, \mathrm{Re}\{X_n\}$$
$$= 2 f_0 T \operatorname{sinc}(n f_0 T)$$

$$b_n = -2\, \mathrm{Im}\{X_n\}$$
$$= 0$$

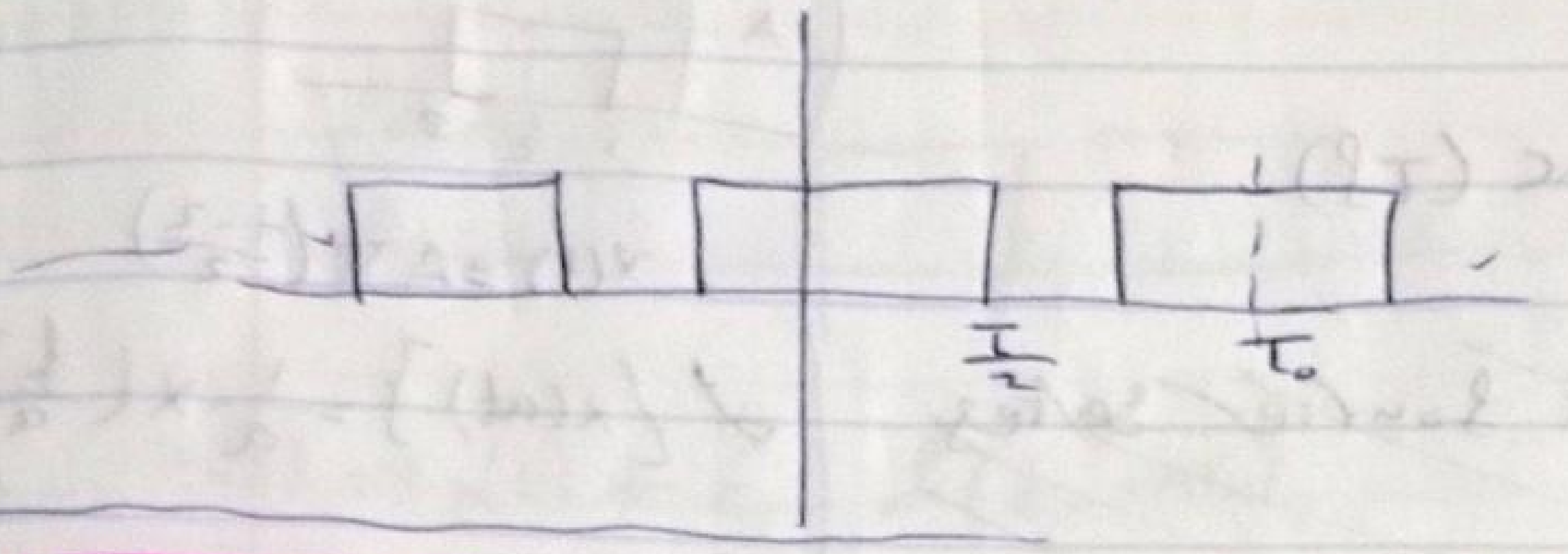
to find the average value

$a_0 = X_0$

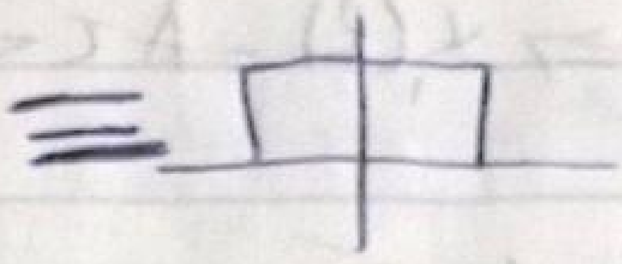
$$X_0 = \frac{1}{T_0} \int x(t)\, dt$$

$$a_0 = \frac{1}{T_0} \int_{T_0} x(t)\, dt = \frac{1}{T_0} \int_{-T_0/2}^{T/2} 1\, dt = T f_0$$

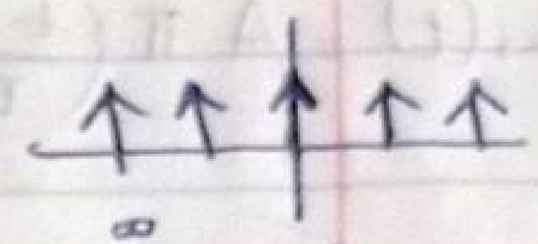
Ex:- consider the following signal shown below :-



$\equiv$



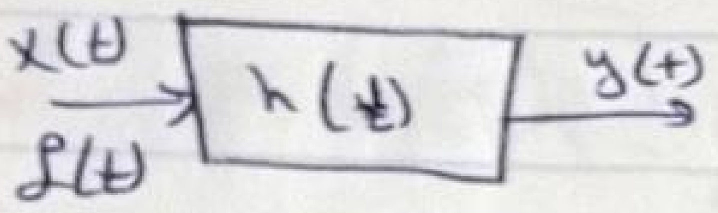
$*$



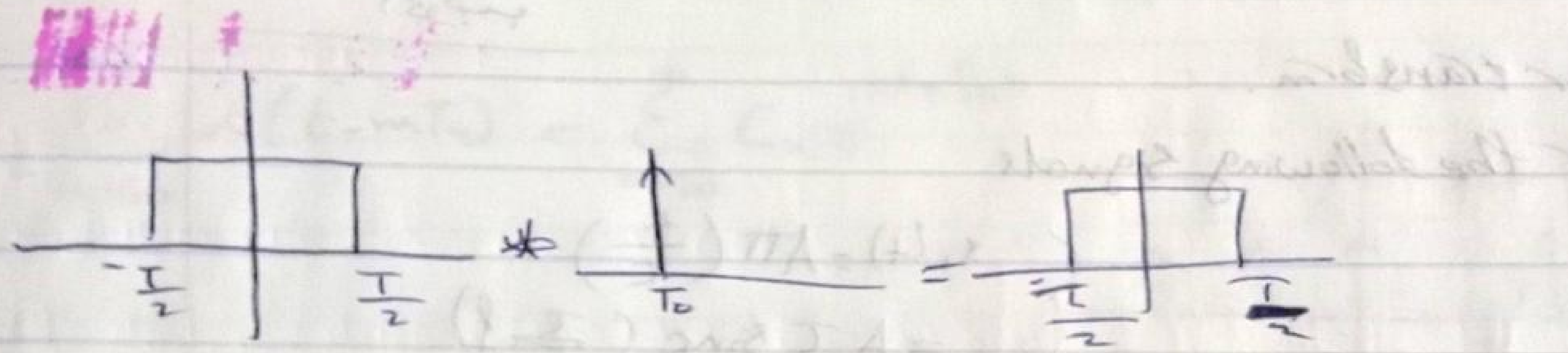
$$\sum_{m=\infty}^{\infty} \delta(t - mT_o)$$

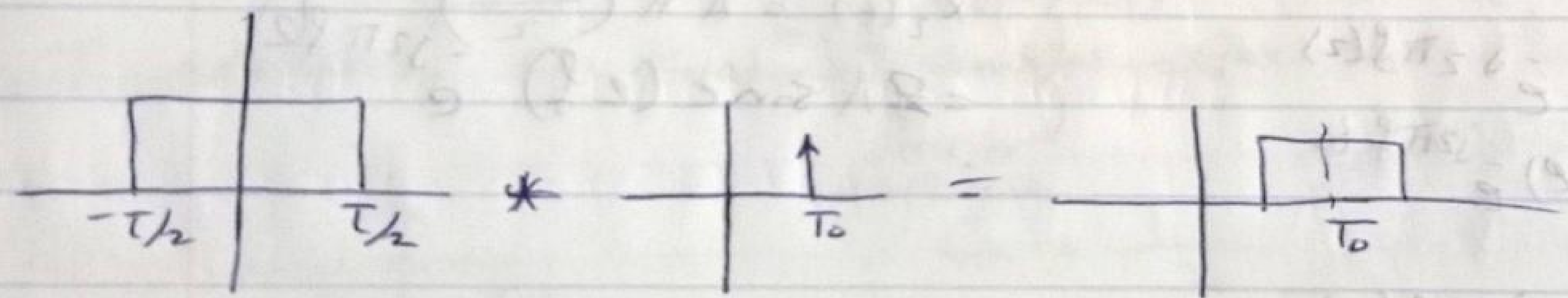
* Fourier transform :-

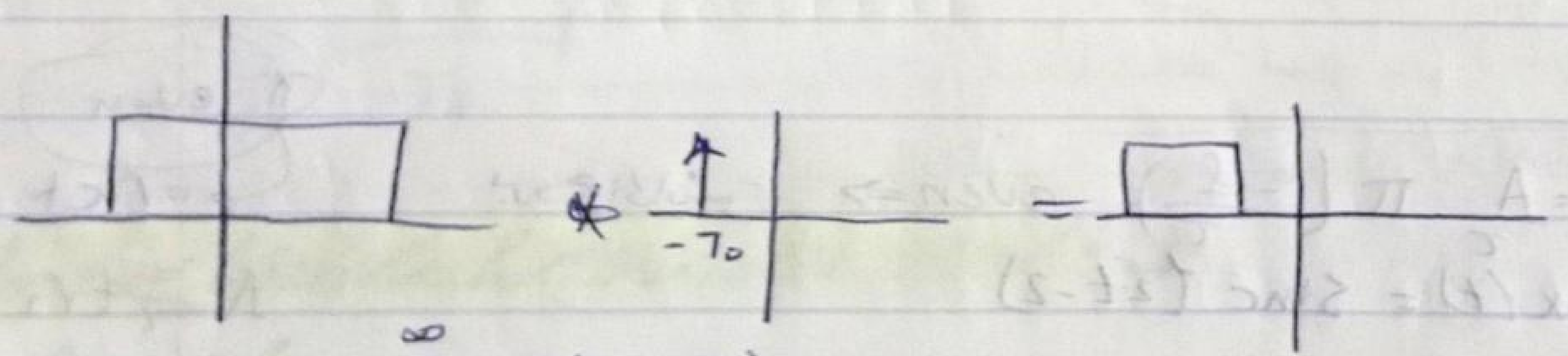
for LTI system



$$y(t) = x(t) * h(t)$$
$$= \delta(t) * h(t)$$
$$= h(t)$$



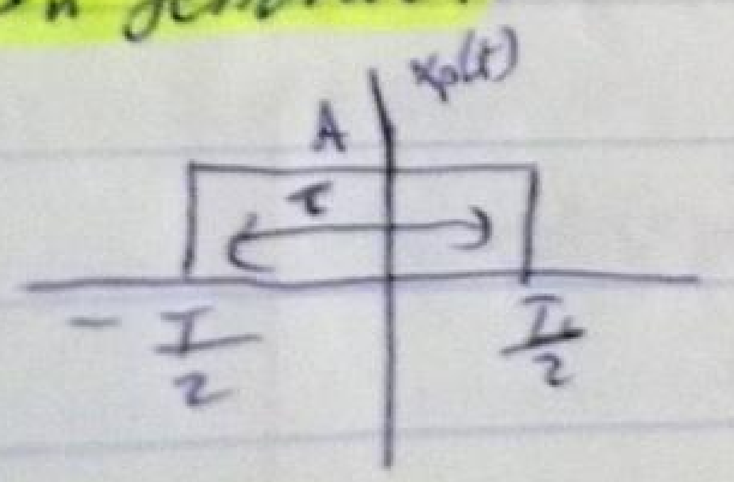




$$x(t) = x_p(t) * \sum_{n=\infty}^{\infty} \delta(t - mT_o)$$

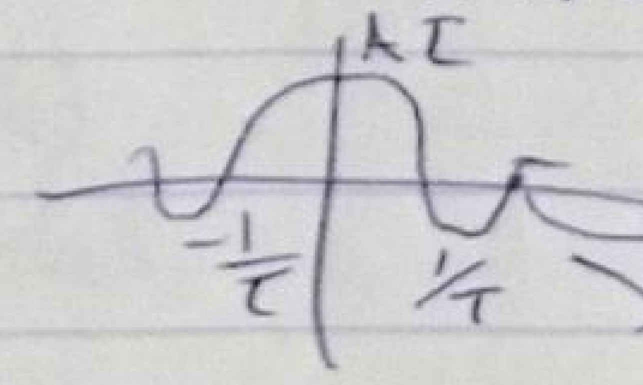
$$\mathcal{F}[x(t)] = \mathcal{F}[x_p(t)] . \mathcal{F}\left[\sum_{n=\infty} \delta(t - mT_o)\right]$$

In general:-



$x_1(t) = A\Pi\left(\frac{t}{\tau}\right)$ $\xleftrightarrow{\mathcal{F}}$ $X_1(f) = A\tau \,\text{sinc}(\tau f)$

duality



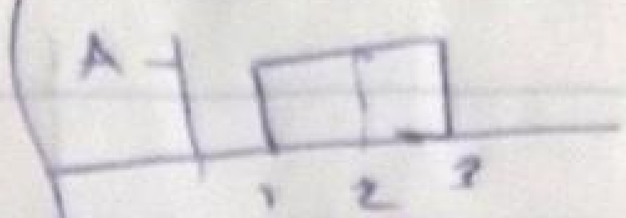
عند ال Null الصفر $\frac{2}{\tau}$ ⟹ عند ال Null اللي بعدها → $\frac{3}{\tau}$

العرض الكلي للحزمة الاصلية

$\boxed{Ex}$:- $x(3t) = \frac{1}{3} X\left(\frac{f}{3}\right)$

$x_1(t) = A\,\Pi\left(\frac{t}{\tau}\right) \Rightarrow X_1(f) = A\tau \operatorname{sinc}(\tau f)$

In general



$x(t) = A\,\Pi\left(\frac{t-2}{2}\right)$

$\mathcal{F}\{x(at)\} = \frac{1}{a} X\left(\frac{f}{a}\right)$

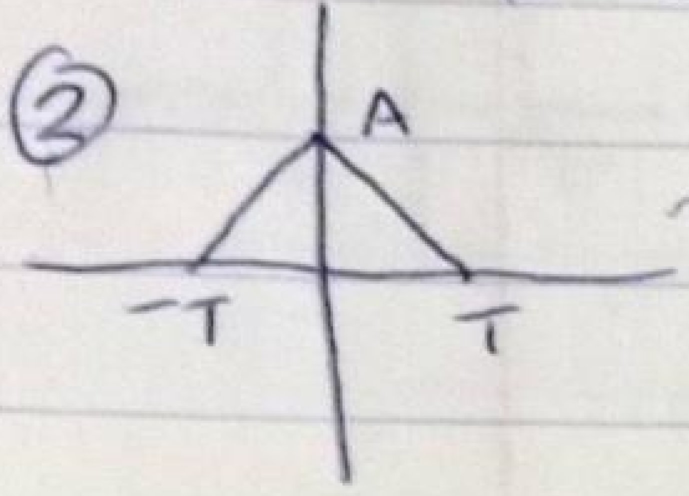
~~- Evaluate the trigonometric coefficient fourier series~~

~~$a_n = 2\,\mathrm{Re}\{x_n\}$~~

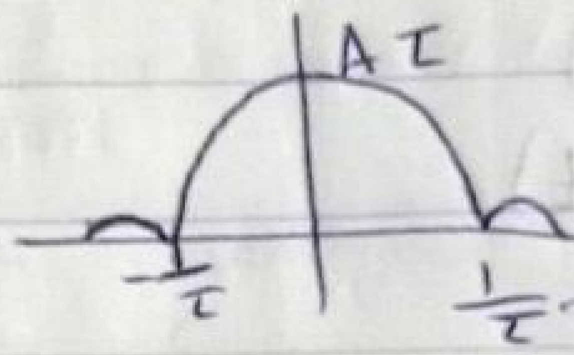
~~$= 2 f_0 \tau \operatorname{sinc}(n f_0 \tau)$~~

~~$b_n = -2\,\mathrm{Im}\{x_n\}$~~

~~$= 0$~~

② 

$x_2(t) = A\,\Lambda\left(\frac{t}{\tau}\right)$



$\Rightarrow X(f) = A\tau \operatorname{sinc}^2(\tau f)$

$\frac{1}{\tau} \Rightarrow$ بأخذ الجزء الموجب

$\boxed{Ex}$:- Evaluate FT (fourier transform) for the following signals

① $x_a(t) = 3\Pi(2t-4)$

$= 3\Pi(2(t-2))$
scale delay

$x_1(t) = A\Pi\left(\frac{t}{\tau}\right)$

$= A\tau \operatorname{sinc}(\tau f)$

$x_2(t) = A\,\Pi\left(\frac{t-2}{2}\right)$

$= 2A \operatorname{sinc}(2f)\, e^{-j2\pi f(2)}$

$X_a(f) = 3 \cdot \frac{1}{2} \operatorname{sinc}\left(\frac{f}{2}\right) e^{-j2\pi f(2)}$

$\mathcal{F}[x(t-t_0)] = X(f)\, e^{-j2\pi f t_0}$

② $x_b(t) = 2\Lambda\left(\frac{t-3}{2}\right)$

$X_b(f) = (2)(2) \operatorname{sinc}^2(2f)\, e^{-j2\pi f(2)}$

Π : even $\Rightarrow$ = rect

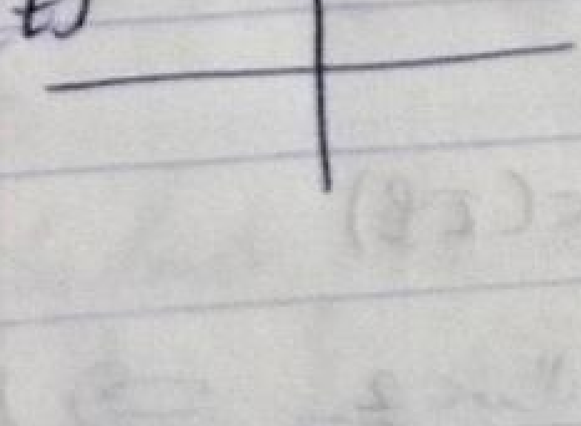
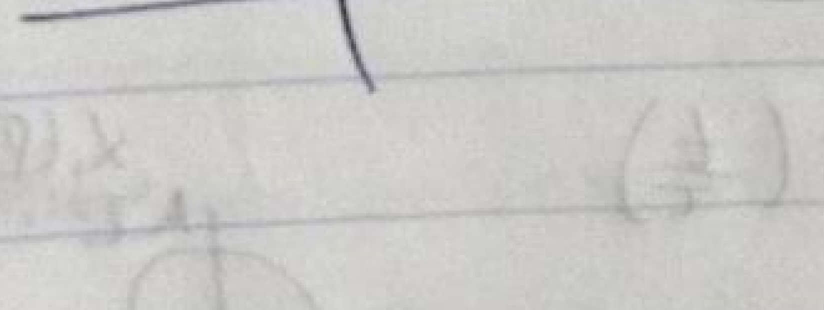
$\Lambda \Rightarrow$ tri triangle

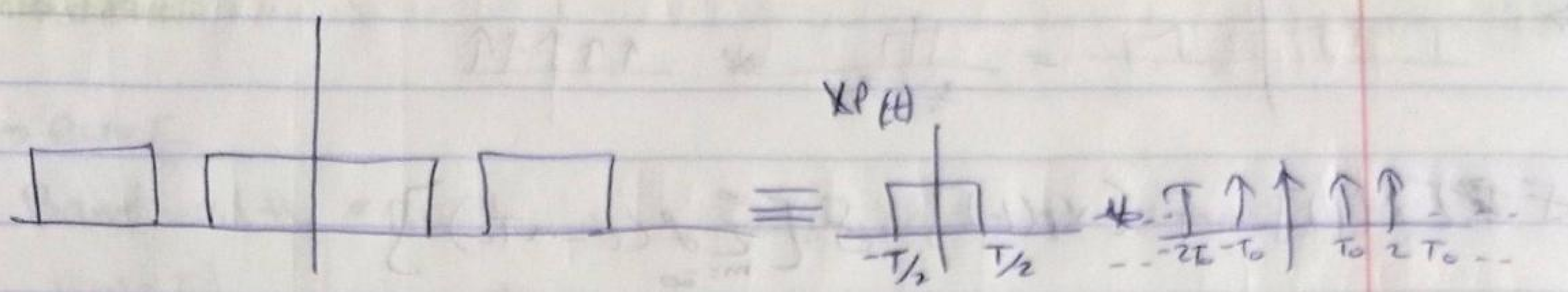
$\mathcal{F}[A \operatorname{sinc}(\tau t)] = \frac{A}{\tau}\Pi\left(-\frac{f}{\tau}\right)$ even $\Rightarrow$ بروح الكاينس

$\boxed{Ex:}$ Evaluate FT for $x(t) = \operatorname{sinc}(2t-2)$

$x(t) = \operatorname{sinc}(2(t-1))$

$X(f) = \frac{1}{2}\Pi\left(\frac{f}{2}\right) e^{-j2\pi f(1)}$

③ $x_c(t)$  $\longleftrightarrow$ 



$$x(t) = x_p(t) * \sum_{m=-\infty}^{\infty} \delta(t - mT_0)$$

In general:-
$x(t) * \delta(t) = x(t)$
$x(t) * \delta(t-t_0) = x(t-t_0)$

$$\mathcal{F}\left[\sum_{m=-\infty}^{\infty} \delta(t - mt_0)\right] = \sum_{n=-\infty}^{\infty} \delta(f - nf_0)$$

$$X(f) = X_p(f)\, \mathcal{F}\left[\sum_{m=-\infty}^{\infty} \delta(t - mT_0)\right]$$

$\mathcal{F}$ ال fourier transform

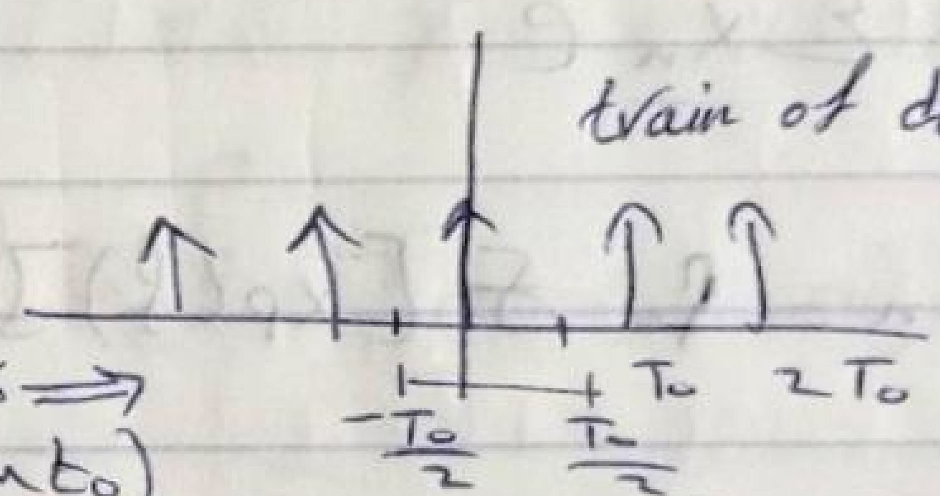
$$= \mathcal{F}\left[\Pi\left(\frac{t}{\tau}\right)\right] \quad \mathcal{F}\left[\sum_{m=-\infty}^{\infty} \delta(t - mT_0)\right]$$

train of delta

$$= \tau \operatorname{sinc}(\tau f) \quad f_0 \sum_{n=-\infty}^{\infty} \delta(f - nf_0)$$

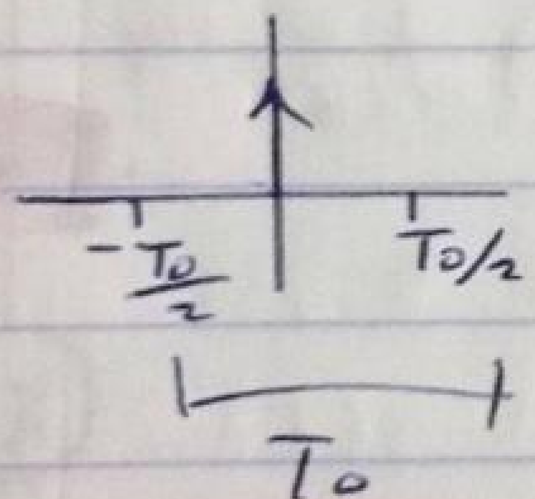
$$\sum_{m=-\infty}^{\infty} \delta(t - mT_0) = \sum_{n=-\infty}^{\infty} C_n e^{j2\pi n f_0 t}$$

train of delta



Ex: consider the following signal: $\sum_{m=-\infty}^{\infty} \delta(t - mt_0)$ Periodic ال $\delta \Longrightarrow$

To evaluate C_n / Evaluate complex exponential fourier series.



fourier transform

$$C_n = \frac{1}{T_0} \int_{-T_0/2}^{T_0/2} \delta(t)\, e^{-j2\pi n f_0 t}\Big|_{n=0} dt$$

$= f_0$

1 ← دايمًا وابدًا

Fourier tranform for Periodic signal:

In general:-

complex exponential for delta function $\Rightarrow f_0$

$$\mathcal{F}\left[\sum_{m=-\infty}^{\infty} \delta(t - mt_0)\right] = \mathcal{F}\left[\sum_{n=-\infty}^{\infty} f_0\, e^{j2\pi n f_0 t}\right]$$

$$\mathcal{F}\left[\sum_{m=-\infty}^{\infty} \delta(t - mT_0)\right] = f_0 \sum_{n=-\infty}^{\infty} \delta(f - nf_0)$$

In general :-

$$\mathcal{F}\left[x(t)\, e^{j2\pi f_0 t}\right] = X(f - f_0)$$

$$e^{-j2\pi f_0 t} \longrightarrow X(f + f_0)$$

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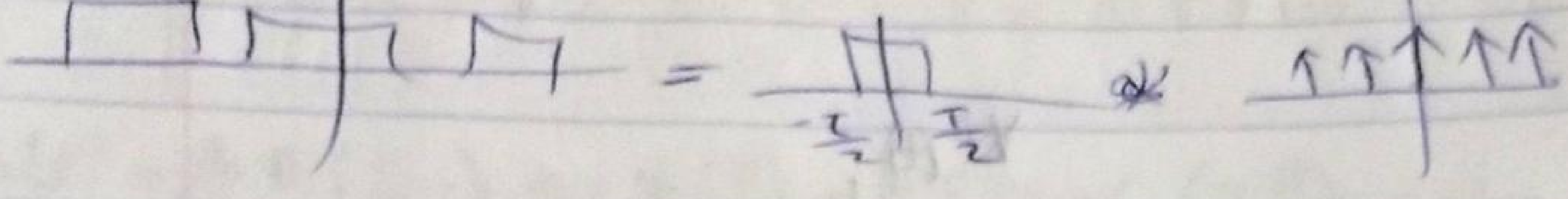
⇒



$$\mathcal{F}[x(t)] = \mathcal{F}[x_p(t)]\ \mathcal{F}\Big[\sum_{m=-\infty}^{\infty}\delta(t-mT_0)\Big]$$

$$x(f) = \tau\,\mathrm{sinc}(\tau f)\ .\ f_0\sum_{n=-\infty}^{\infty}\delta(f-nf_0)$$

$$= \tau f_0\sum_{n=-\infty}^{\infty}\underbrace{\mathrm{sinc}(\tau f)\ \delta(f-nf_0)}_{\text{sampling theorem}}$$

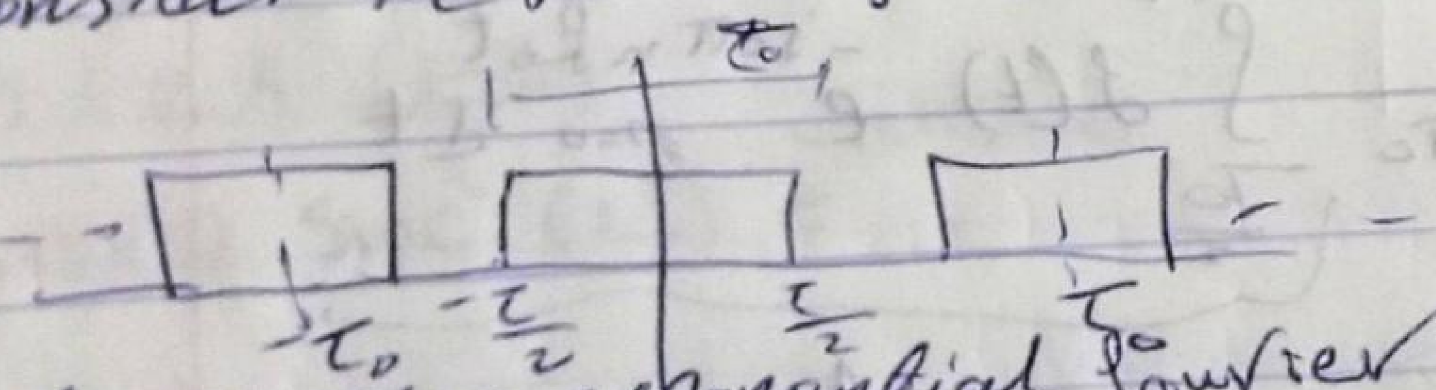
$$= \tau f_0\sum_{m=-\infty}^{\infty}\mathrm{sinc}(n\tau f_0)\ \delta(f-nf_0)$$

$$x(t) = \underline{\tau f_0}\sum_{n=-\infty}^{\infty}\underline{\mathrm{sinc}(n\tau f_0)}\ e^{j2\pi n f_0 t}$$

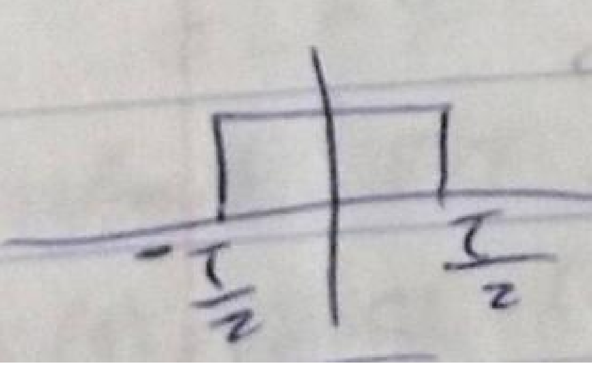
$$= \sum x_n\, e^{j2\pi n f_0 t}$$

In general $x_n = f_0\ \mathcal{F}[x_p(f)]\Big|_{f=nf_0}$

Ex: consider the following signal

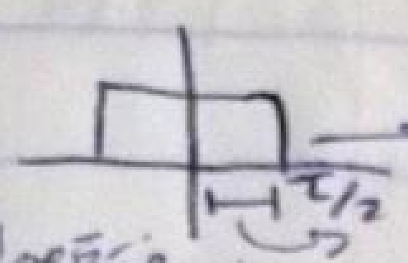


Evaluate complex exponential fourier series:-



$\longrightarrow \tau\,\mathrm{sinc}(\tau f) \Longleftrightarrow x_n = f_0\ \tau\,\mathrm{sinc}(\tau n f_0)$, $f_0 \to \frac{1}{T_0}$

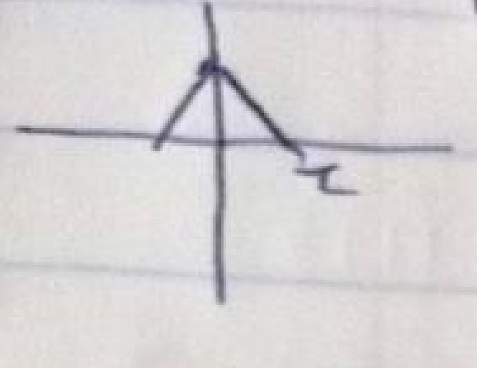
* modulation theorem:-



$\rightarrow BW = \frac{\tau}{2}$

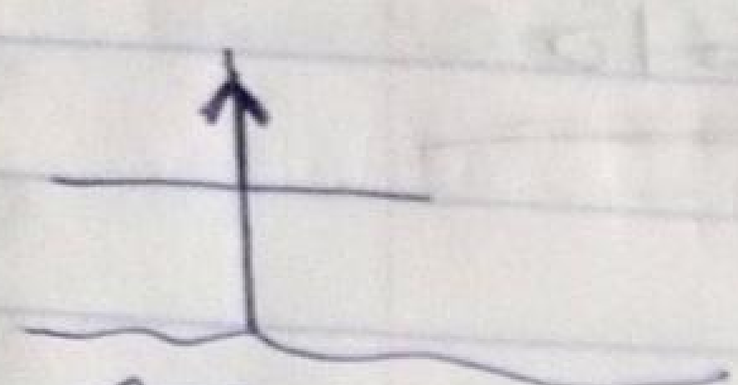
من نقطة الأصل

Band width "BW" ⇒ بنحسبها من نقطة ال origin لحد نقطة نهاية الإشارة



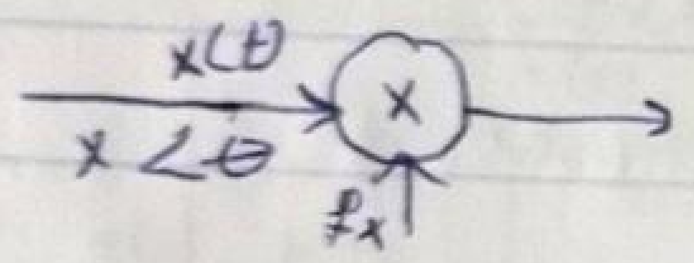
$BW = \tau$

⇒  Noise



~~Base~~ Base Band signal

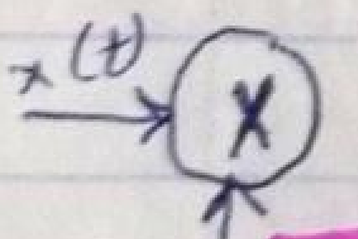
Modulation techniques:-



$$x(t) = |x|\, e^{j\phi} \cdot e^{j\omega t} = |x|\, e^{j(\omega t+\theta)} = Re\left\{ |x| \left[\cos(\omega t+\theta) + j\sin[\omega t+\theta] \right] \right\}$$

$$= |x| \cos(\omega t + \theta)$$

In general:-



ex $c(t) = 2\cos(200\pi t)$ ⇒ modulation side ⇒ carrier signal

$x(t) = 3\cos(20\pi t)$ (10) ال أخذناها 10

$f = 10$

message signal

fig. 1

* بعدما أتحكم في ال frequency لل carrier

Ex: consider the following system shown in fig. 1

(a) Plot the spectrum of the message signal of carrier signal

Ans:

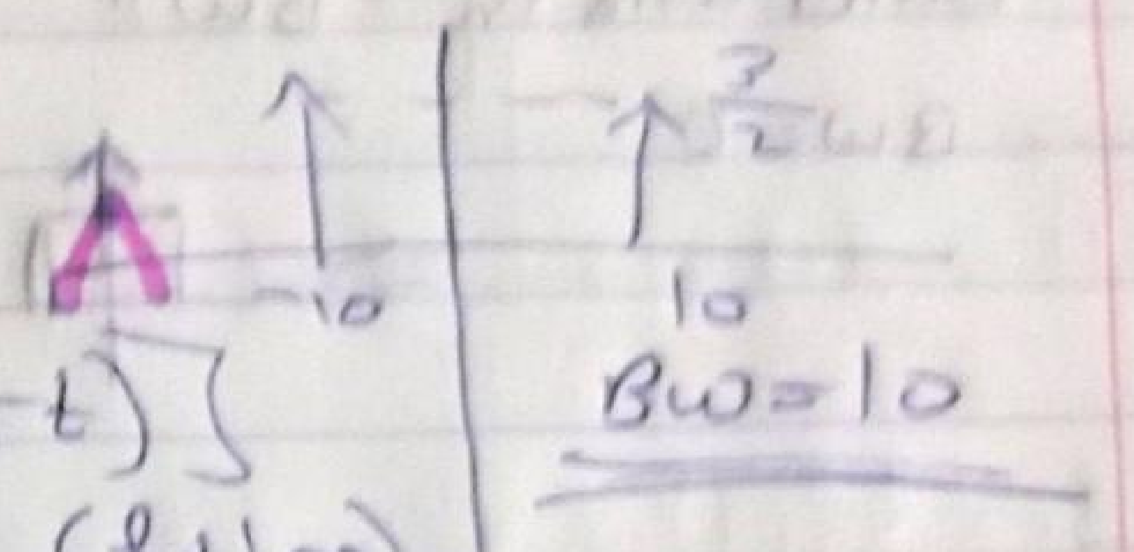
$x(t) = 3\cos(20\pi t)$

$$\mathcal{F}[x(t)] = 3\left[\frac{e^{j20\pi t} + e^{-j20\pi t}}{2}\right] = \frac{3}{2} e^{j20\pi t} + \frac{3}{2} e^{-j20\pi t}$$

*In general:-

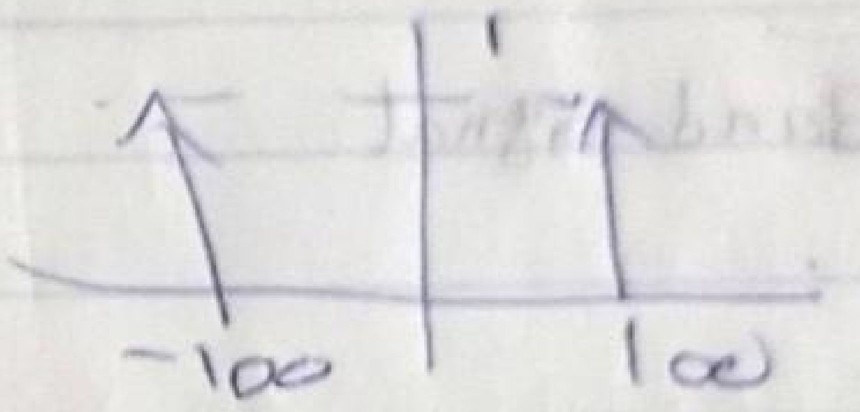
$$\mathcal{F}[x(t)e^{j2\pi f_0}] = x(f-f_0)$$

$$x(f) = \frac{3}{2}\delta(f-10) + \frac{3}{2}\delta(f+10)$$



BW=10

$$c(f) = \mathcal{F}[c(t)] = \mathcal{F}[2\cos(200\pi t)]$$
$$= \frac{2}{2}\delta(f-100) + \frac{2}{2}\delta(f+100)$$



BW=100

ⓑ evaluate & plot the spectrum of $s(t)$

$$s(t) = 3\cos(20\pi t) \cdot 2\cos(200\pi t)$$

In general:-

Ⓐ $\cos(\alpha)\cos(\beta) = \frac{1}{2}\cos(\alpha+\beta) + \frac{1}{2}\cos(\alpha-\beta)$

$\sin(\alpha \mp \beta) = \sin(\alpha)\cos(\beta) \mp \sin(\beta)\cos(\alpha)$ ①

$\sin(\alpha-\beta) = \sin(\alpha)\cos(\beta) - \sin(\beta)\cos(\alpha)$ ②

sin * cos
بنجمع هدول
المعادلتين

$$\sin(\alpha)\cos(\beta) = \frac{1}{2}\sin(\alpha+\beta) + \frac{1}{2}\sin(\alpha-\beta)$$

$$\cos(\alpha)\sin(\beta) = \frac{1}{2}\sin(\alpha+\beta) - \frac{1}{2}\sin(\alpha-\beta)$$

بنطرح
المعادلتين

Ⓑ اذا بدي $\cos(\beta)\cos(\alpha)$ بشتغل كل هدول

① $\cos(\alpha+\beta) = \cos(\alpha)\cos(\beta) - \sin(\alpha)\sin(\beta)$

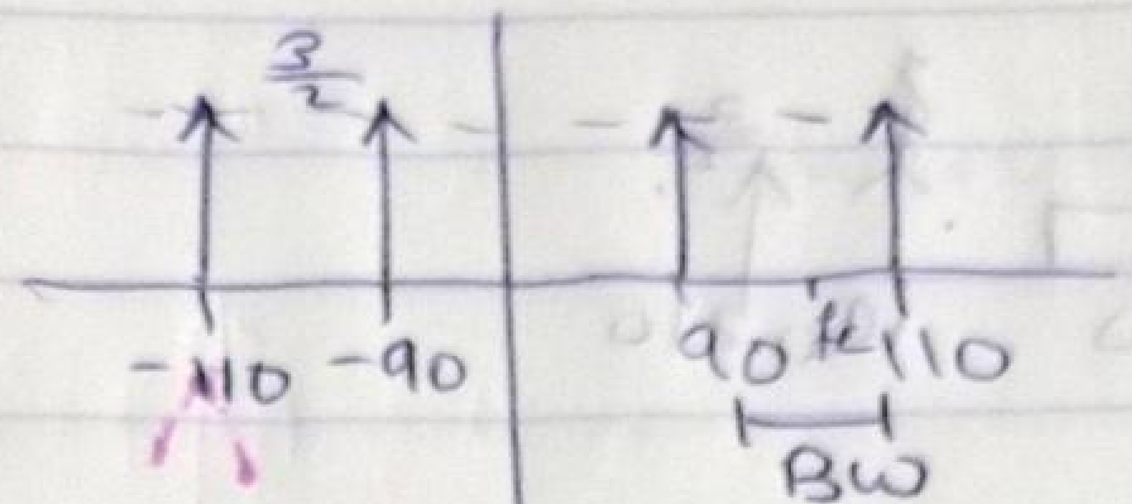
$\cos(\alpha-\beta) = \cos(\alpha)\cos(\beta) + \sin(\alpha)\sin(\beta)$

بنجمع $\Rightarrow \cos(\alpha)\cos(\beta) = \frac{1}{2}\cos(\alpha+\beta) + \frac{1}{2}\cos(\alpha-\beta)$

بنطرح $\Rightarrow$ ~~cos(α~~ $\sin(\alpha)\sin(\beta) = \frac{1}{2}\cos(\alpha-\beta) - \frac{1}{2}\cos(\alpha+\beta)$

$s(t) = 3\cos(220\pi t) + 3\cos(180\pi t)$

$S(f) = \frac{3}{2}\delta(f-110) + \frac{3}{2}\delta(f+110) + \frac{3}{2}\delta(f-90) + \frac{3}{2}\delta(f+90)$

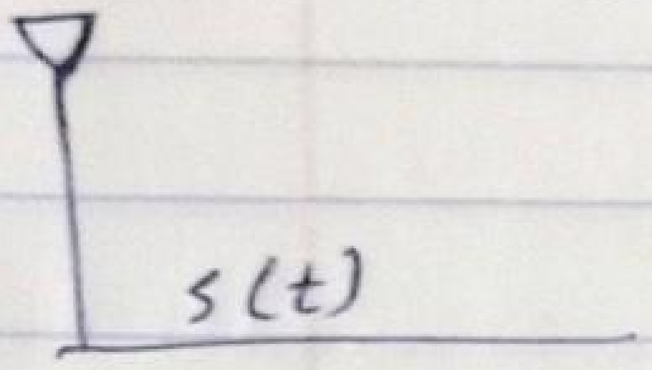


$BW = 110 - 90 = 20$

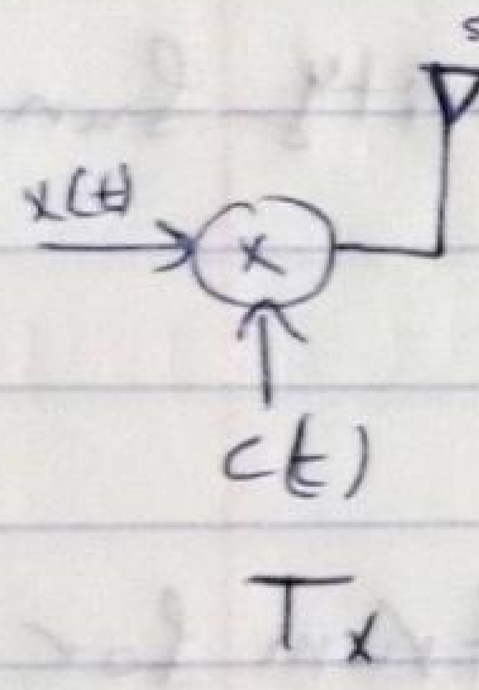
power $= (1.5)^2 \times 4$

عشان BW أبعد عن منطقة الـ origin بيصير اسمها

Band Bass signal



$s(t) = x(t)\,c(t) + \cancel{\text{noise}}$

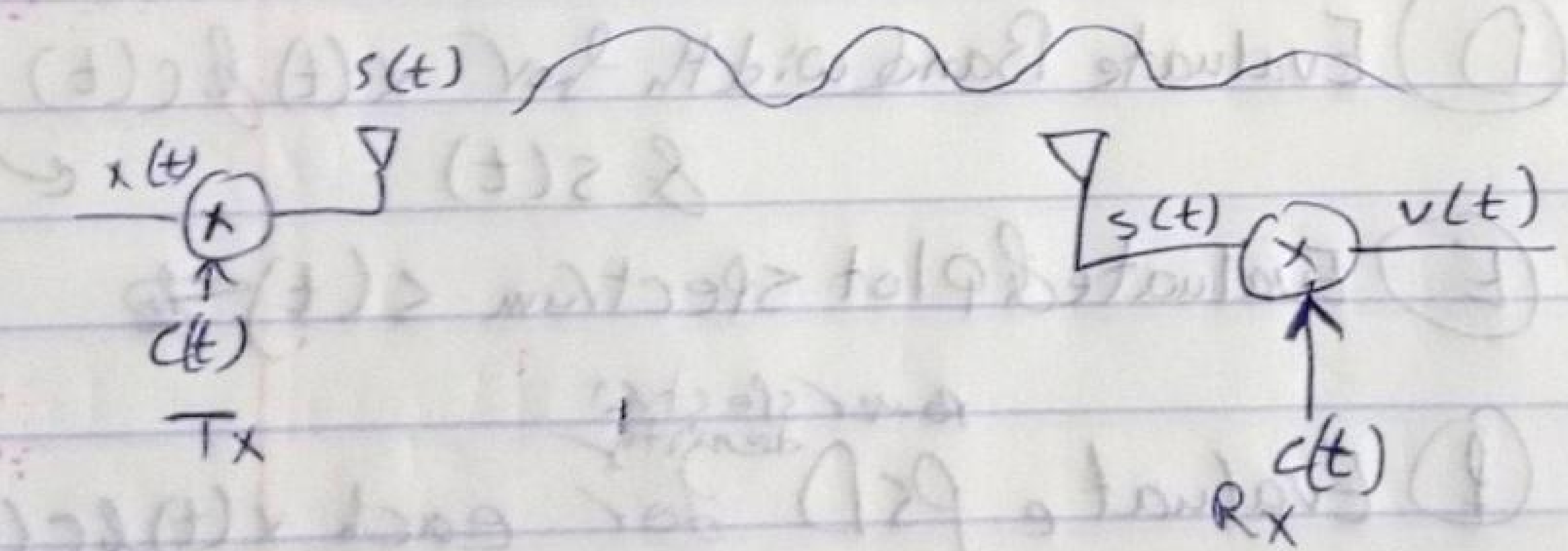


$\underline{h(t)\,x(t)\,c(t)} + \text{noise}$

fading

therminal noise

Rx



$v(t) = s(t)\,c(t) = x(t)\,c(t)\,c(t)$

$= 3\cos(20\pi t)\left[4\cos^2(200\pi t)\right]$

$v(t) = 3\cos(20\pi t)\left[\frac{4}{2} + \frac{4}{2}\cos(400\pi t)\right]$

$= 6\cos(20\pi t) + 6\cos(20\pi t)\cos(400\pi t)$

$= 6\cos(20\pi t) + 3\cos(420\pi t) + 3\cos(380\pi t)$

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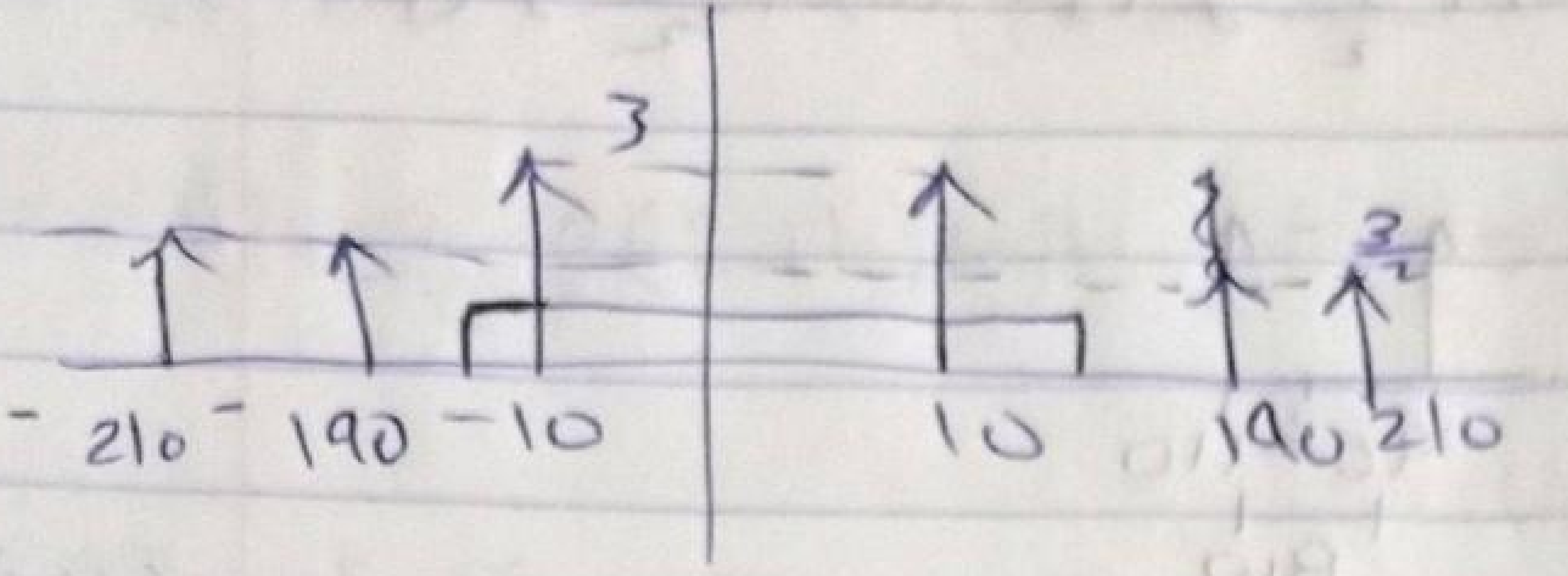
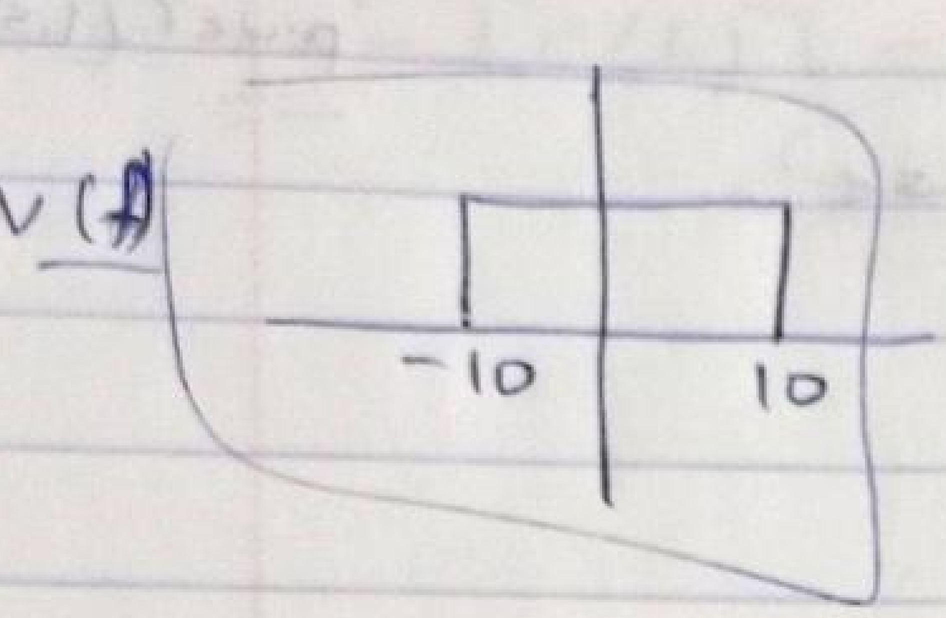
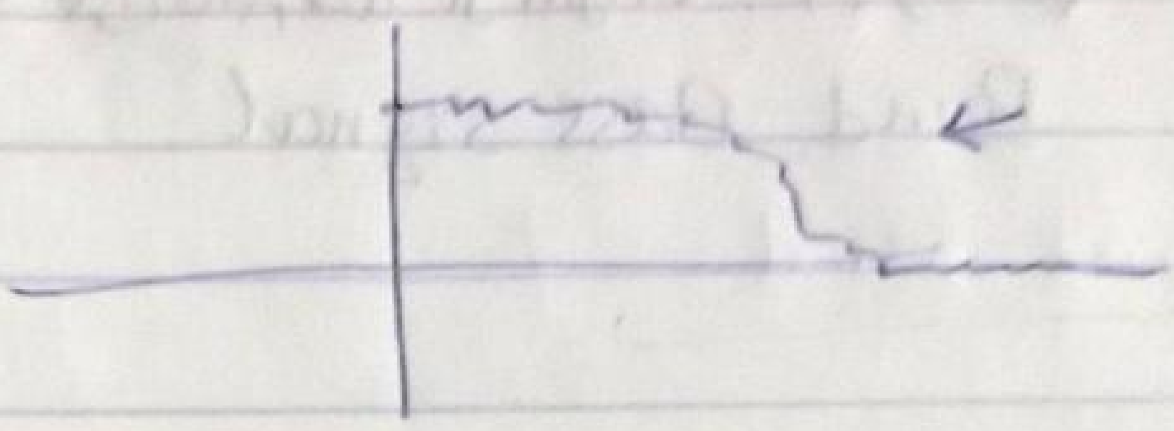
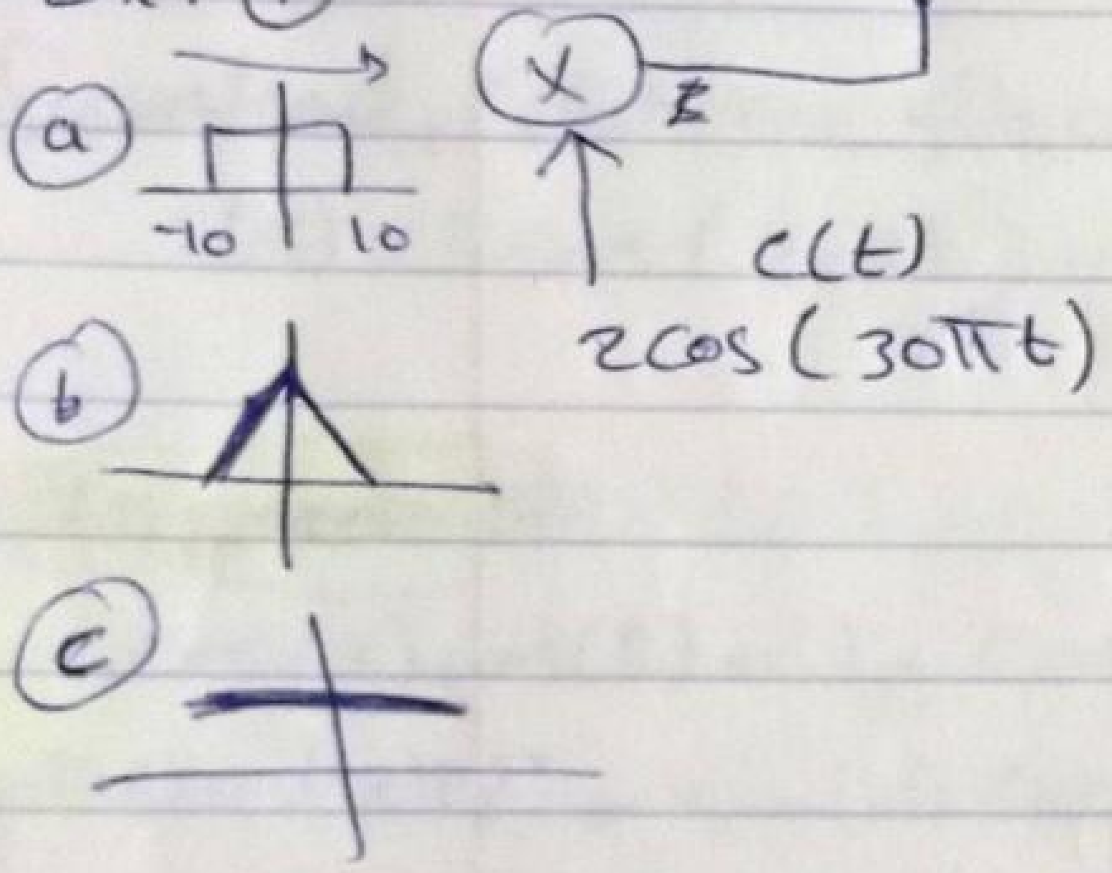
$$V(f) = 3\delta(f-10) + 3\delta(f+10) + \frac{3}{2}\delta(f-210) + \frac{3}{2}\delta(f+210) + \frac{3}{2}\delta(f-190) + \frac{3}{2}\delta(f+190)$$







Ex: (1)



(a) evaluate semularity function

(A) write x(t) in terms of singularity function

(B) Evaluate x_n

(C) Evaluate & Plot the spectrum for x(t) & c(t)

(D) Evaluate Bandwidth for x(t) & c(t) & s(t)

(E) Evaluate & plot spectrum s(t)

(f) Evaluate PSD (power spectral density) for each x(t) & c(t) & s(t)

(h) Evaluate total Power x(t), c(t), s(t)

(i) Evaluate & plot spectrum v(t)

(g) Design Low Pass filter to recover the message signal