1702EC401 – Signals and Systems				
Academic Year :	**2018-2019**	**Question Bank**	Programme:	B.E – ECE
Year / Semester:	*II / IV*		Course Coordinator:	R.KEERTHIKA

PART – A (2 Mark Questions With Key)				
S. No	**Questions**	**Mark**	**COs**	**BTL**
	UNIT III			
1	**Why CT signals are represented by samples?** ¾ A CT signal can not be processed in the digital processor or computer. ¾ To enable the digital transmission of CT signals.	2	3	K1
2	**What is meant by sampling?** A sampling is a process by which a CT signal is converted into a sequence of discrete samples with each sample representing the amplitude of the signal at the particular instant of time.	2	3	K1
3	**State Sampling theorem.** A band limited signal of finite energy, which has no frequency components higher than the W hertz, is completely described by specifying the values of the signal at the instant of timeseparated by 1/2W seconds and A band limited signal of finite energy, which has no frequency components higher than the Whertz, is completely recovered from the knowledge of its samples taken at the rate of 2Wsamples per second.	2	3	K1
4	**What is meant by aliasing?** When the high frequency interferes with low frequency and appears as Low then the phenomenon is called aliasing.	2	3	K1
5	**What are the effects aliasing?** Since the high frequency interferes with low frequency then the distortion is generated. The data is lost and it cannot be recovered.	2	3	K1

6	**How the aliasing process is eliminated.** **i**). Sampling rate fs 2W. ii). strictly band limit the signal to 'W'. This can be obtained by using the Low pass filer before the sampling process. It is also called as ant aliasing filter.	2	3	K1
7	**Define Nyquist rate. and Nyquist interval.** ¾ When the sampling rate becomes exactly equal to '2W'samples/sec, for a given bandwidth of W hertz,then it is called Nyquist rate. ¾ Nyquist interval is the time interval between any two adjacent samples. Nyquist rate = 2W Hz¾ Nyquist interval = 1/2W seconds.	2	3	K1
8	**Define sampling of band pass signals.** A band pass signal x(t) whose maximum bandwidth is '2W' can be completely represented into and recovered from its samples, if it is sampled at the minimum rate of twice the band width.	2	3	K1
9	**Define Z transform.** The Z transform of a discrete time signal x[n] is denoted by X(z) and it is given as X(z)= x[n] z-n.and the value n range from - to + . Here 'z' is the complex variable. This Z transform is also called as bilateral or two sided Z transform.	2	3	K1
10	**What are the two types of Z transform?** (i) Unilateral Z transforms (ii) Bilateral Z transforms	2	3	K1
11	**Define unilateral Z transform.** The unilateral Z transform of signal x[n] is given as X(z)= x[n] z-n The unilateral and bilateral Z transforms are same for causal signals.	2	3	K2
12	**What is region of Convergence?** The region of convergence or ROC is specified for Z transform, where it Converges.	2	3	K1
13	**What are the Properties of ROC?** The ROC of a finite duration sequence includes the entire z- plane, except z= 0 and |z|= 1.	2	3	K1

	ROC does not contain any poles. ROC is the ring in the z-plane cantered about origin. ROC of causal sequence (right handed sequence) is of the form $\lvert z \rvert > r$. v. ROC of left handed sequence is of the form $\lvert z \rvert < r$. ROC of two sided sequence is the concentric ring in the z plane.			
14	**What is the time shifting property of Z transform?**	2	3	K1
	x[n] <--->X(Z) then x[n-k] <--->Z-k X[Z].			
15	**What is the differentiation property in Z domain?**	2	3	K2
	x[n] <--->X(Z) then nx[n]<---> -z d/dz{X[Z].}.			

PART – B (12 Mark Questions with Key)

S. No	Questions	Mark	CO	BTL
1	**State and prove the properties of Convolution.**	**12**	**3**	**K2**

4.5 Properties of Convolution

Let us consider two signals $x_1(t)$ and $x_2(t)$. The convolution of two signals $x_1(t)$ and $x_2(t)$ is given by the equation

$$x_1(t) * x_2(t) = \int_{-\infty}^{\infty} x_1(\tau)\, x_2(t-\tau)\, d\tau \qquad (4.46$$

1. Commutative property:

Convolution obeys commutative property. That is

$$x_1(t) * x_2(t) = x_2(t) * x_1(t) \qquad (4.4$$

proof

We have

$$x_1(t) * x_2(t) = \int_{-\infty}^{\infty} x_1(\tau)\, x_2(t-\tau)d\tau$$

$$\text{Let } t - \tau = p$$
$$\text{then } \quad -d\tau = dp$$

Substituting these values in Eq. (4.48) we get

$$x_1(t) * x_2(t) = -\int_{\infty}^{-\infty} x_2(p)\, x_1(t-p)dp$$
$$= \int_{-\infty}^{\infty} x_2(p) x_1(t-p)dp$$
$$= x_2(t) * x_1(t)$$
$$\Rightarrow \quad \boxed{x_1(t) * x_2(t) = x_2(t) * x_1(t)}$$

2. Distributive property:

$$x_1(t) * [x_2(t) + x_3(t)] = x_1(t) * x_2(t) + x_1(t) * x_3(t)$$

3. Associative property:

$$x_1(t) * [x_2(t) * x_3(t)] = [x_1(t) * x_2(t)] * x_3(t)$$

4. Shift property:

$$\text{If } \quad x_1(t) * x_2(t) = z(t)$$

then

$$x_1(t) * x_2(t-T) = z(t-T)$$

Proof

$$x_1(t) * x_2(t-T) = \int_{-\infty}^{\infty} x_1(\tau)\, x_2(t-T-\tau)d\tau$$
$$= z(t-T)$$

Similarly

$$x_1(t-T) * x_2(t) = z(t-T) \quad (4.54)$$

and $$x_1(t-T_1) * x_2(t-T_2) = z(t-T_1-T_2) \quad (4.55)$$

5. Convolution with an impulse:

Convolution of a signal $x(t)$ with a unit impulse is the signal $x(t)$ itself.

That is

$$x(t) * \delta(t) = x(t) \quad (4.56)$$

Proof

$$x(t) * \delta(t) = \int_{-\infty}^{\infty} x(\tau)\delta(t-\tau)d\tau$$

$\delta(t-\tau) = 1$ for $t = \tau$ $= 0$ otherwise

$$= x(t)$$

6. Convolution with shifted impulse

Convolution of a signal $x(t)$ with shifted impulse $\delta(t-t_0)$ is equal to $x(t-t_0)$. That is

$$x(t) * \delta(t-t_0) = x(t-t_0) \quad (4.57)$$

Proof

$$x(t) * \delta(t-t_0) = \int_{-\infty}^{\infty} x(\tau)\delta(t-\tau-t_0)\, d\tau$$

$$= x(\tau)\,|_{\tau=t-t_0} = x(t-t_0)$$

7. Convolution with unit step

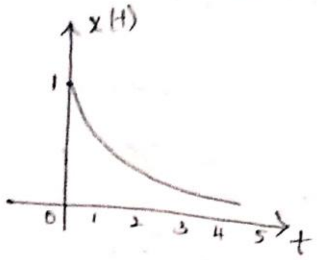
Convolution of a signal $x(t)$ with unit step signal $u(t)$ is given by

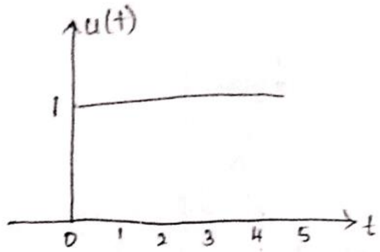
$$x(t) * u(t) = \int_{-\infty}^{t} x(\tau)\, d\tau \quad (4.58)$$

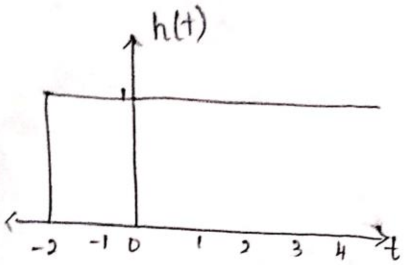
	Proof $$x(t) * u(t) = \int_{-\infty}^{\infty} x(\tau)u(t-\tau)d\tau$$ $$= \int_{-\infty}^{t} x(\tau)d\tau \quad \boxed{u(t-\tau) = 1 \text{ for } \tau < t = 0 \text{ for } \tau > t}$$ **8. Convolution with shifted unit step** Convolution of a signal $x(t)$ with shifted unit step signal is given by $$x(t) * u(t-t_0) = \int_{-\infty}^{t-t_0} x(\tau)d\tau \quad (4.59)$$ **9. Width property:** Let the duration $x_1(t)$ and $x_2(t)$ are T_1 and T_2 respectively. Then the duration of the signal obtained by convolving $x_1(t)$ and $x_2(t)$ is $T_1 + T_2$.			
2	**Find the convolution of the following signals x(t) =e^{-2t} u(t) & h(t) = u(t+2)**	**12**	**3**	**K2**

Solution:

$x(t) = e^{-2t}u(t)$ $\quad$ $h(t) = u(t+2)$



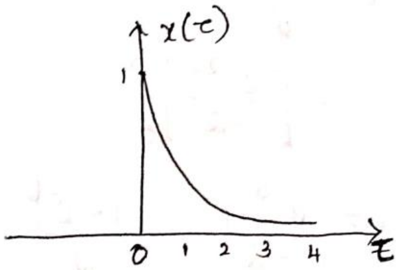


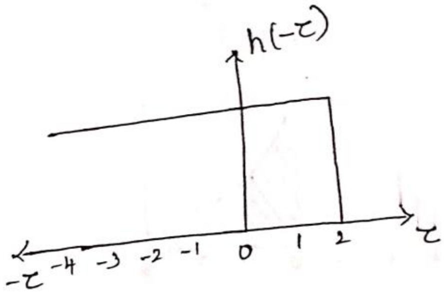


put $t = 0$

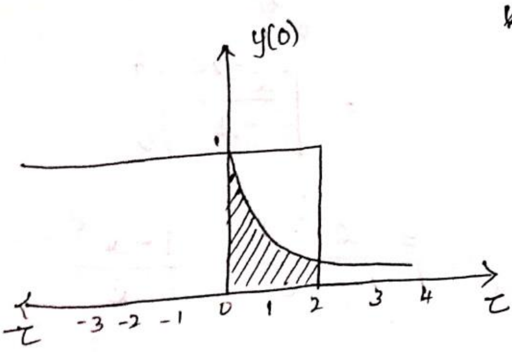
$$y(t) = \int_{-\infty}^{\infty} x(\tau)\, h(t-\tau)\, d\tau$$

$$y(0) = \int_{-\infty}^{\infty} x(\tau)\, h(-\tau)\, d\tau$$





$$y(0) = \int_{-\infty}^{\infty} e^{-2\tau}u(\tau)\, u(-\tau+2)\, d\tau$$



$u(-\tau+2) = 1$

$$= \int_{0}^{2} e^{-2\tau}\, d\tau$$

$$= \left[\frac{e^{-2\tau}}{-2}\right]_0^2$$

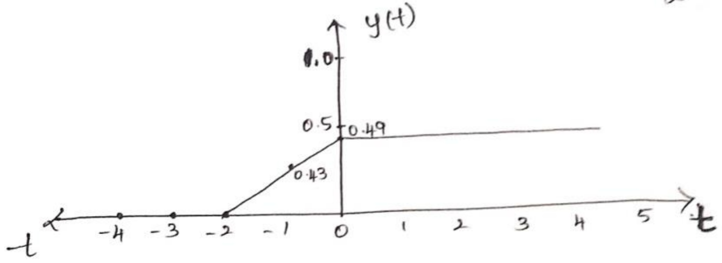
$$= \frac{e^{-4}-1}{-2} \Rightarrow \frac{1-e^{-4}}{2}$$

$$y(t) = \begin{cases} 0, & t \le -2 \\ \frac{1-e^{-2}}{2}, & t = -1 \\ \frac{1-e^{-2(t+2)}}{2}, & t \ge 0 \end{cases}$$

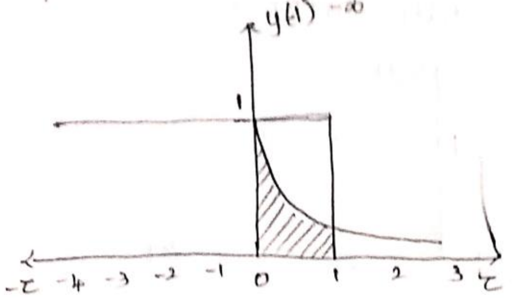
$\frac{1-e^{-2}}{2} = 0.43$

$\frac{1-e^{-4}}{2} = 0.49$

$\frac{1-e^{-6}}{2} = 0.49$

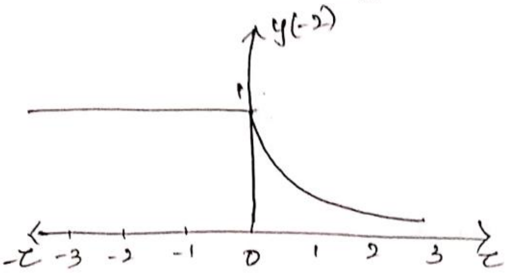


put $t = -1 \Rightarrow \int_{-\infty}^{\infty} x(\tau)\, h(-1-\tau)$



$$y(-1) = \int_0^1 e^{-2\tau} d\tau = \left[\frac{e^{-2\tau}}{-2}\right]_0^1 = \frac{e^{-2}-1}{-2} = \frac{1-e^{-2}}{2}$$

put $t = -2 \Rightarrow \int_{-\infty}^{\infty} x(\tau)\, h(-2-\tau)$

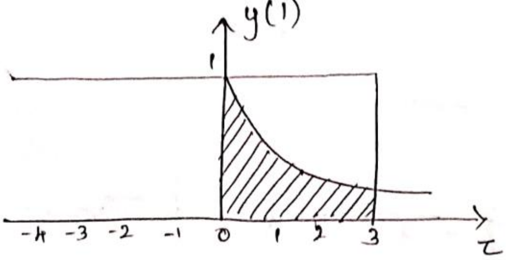


$y(-2) = 0$

$y(-3) = 0$

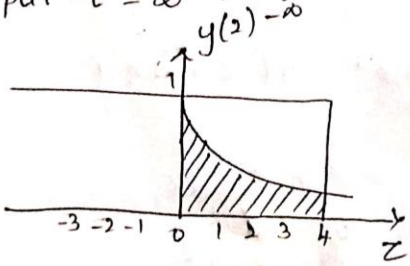
$y(-4) = 0$

put $t = 1 \Rightarrow \int_{-\infty}^{\infty} x(\tau)\, h(1-\tau)$



$$y(+1) = \int_0^3 e^{-2\tau} d\tau = \left[\frac{e^{-2\tau}}{-2}\right]_0^3 = \frac{e^{-6}-1}{-2} = \frac{1-e^{-6}}{2}$$

put $t = 2 \Rightarrow \int_{-\infty}^{\infty} x(\tau)\, h(2-\tau)$



$$y(2) = \int_0^4 e^{-2\tau} d\tau = \left[\frac{e^{-2\tau}}{-2}\right]_0^4 = \frac{e^{-8}-1}{-2} = \frac{1-e^{-8}}{2}$$

3	**Using Laplace transform, solve the following differential equations.** **$d^3y(t)/dt^3 + 7d^2y(t)/dt^2 + 16dy(t)/dt + 12y(t) = x(t)$ if $dy(0^-)/dt = 0$, $d^2y(0^-)/dt^2 = 0$, $y(0^-) = 0$ & $x(t) = \delta(t)$**	**12**	**3**	**K2**

(ii) $\frac{d^3y(t)}{dt^3}+7\frac{d^2y(t)}{dt^2}+16\frac{dy(t)}{dt}+12y(t)=x(t)$

Applying Laplace transform on both sides we get

$$[s^3Y(s)-s^2y(0^-)-s\frac{dy(0^-)}{dt^2}-\frac{d^2y(0^-)}{dt^2}]+7[s^2Y(s)-sy(0^-)-\frac{dy(0^-)}{dt}]$$
$$+16[sY(s)-y(0^-)]+12Y(s)=X(s) \quad (6.73)$$

Given

$$y(0^-)=0$$
$$\frac{dy(0^-)}{dt}=0 \quad \text{and} \quad \frac{d^2y(0^-)}{dt^2}=0$$

Substituting these values in Eq. (6.73), we get

$$s^3Y(s)+7s^2Y(s)+16sY(s)+12Y(s)=X(s)$$
$$Y(s)[s^3+7s^2+16s+12]=X(s)$$
$$\frac{Y(s)}{X(s)}=\frac{1}{s^3+7s^2+16s+12}$$

For $x(t)=\delta(t); X(s)=1$. Therefore

$$Y(s)=\frac{1}{s^3+7s^2+16s+12}$$
$$=\frac{1}{(s+3)(s+2)^2}$$
$$=\frac{A}{s+2}+\frac{B}{(s+2)^2}+\frac{C}{s+3}$$

-3	1	7	16	12
	0	-3	-12	-12
	1	4	4	0

$$\Rightarrow s^3+7s^2+6s+12$$
$$=(s+3)(s^2+4s+4)$$
$$=(s+3)(s+2)^2$$

$$A=\frac{1}{1!}\frac{d}{ds}\left[(s+2)^2\frac{1}{(s+3)(s+2)^2}\right]\Bigg|_{s=-2}$$
$$=\frac{d}{ds}\left[\frac{1}{s+3}\right]\Bigg|_{s=-2}$$
$$=\frac{-1}{(s+3)^2}\Bigg|_{s=-2}=-1$$
$$B=(s+2)^2\frac{1}{(s+3)(s+2)^2}\Bigg|_{s=-2}=1$$
$$C=(s+3)\frac{1}{(s+3)(s+2)^2}\Bigg|_{s=-3}=1$$
$$Y(s)=\frac{-1}{s+2}+\frac{1}{(s+2)^2}+\frac{1}{s+3}$$
$$\Rightarrow \quad y(t)=-e^{-2t}u(t)+te^{-2t}u(t)+e^{-3t}u(t)$$

4	**Find the impulse & step response of the system $H(s)=10/(s^2+6s+10)$**	**6**	**3**	**K2**

$$H(s) = \frac{10}{s^2+6s+10}$$

$$\frac{Y(s)}{X(s)} = \frac{10}{s^2+6s+10}$$

For an impulse $x(t) = \delta(t); X(s) = 1$

$$\Rightarrow \quad Y(s) = \frac{10}{s^2+6s+10}$$

$$= \frac{10}{(s+3)^2+1^2}$$

Taking inverse Laplace transform we get

$$y(t) = 10e^{-3t}\sin t\,u(t)$$

(ii) For a unit step input

$$x(t) = u(t)$$

$$X(s) = \frac{1}{s}$$

$$H(s) = \frac{Y(s)}{X(s)} = \frac{10}{s^2+6s+10}$$

$$Y(s) = \frac{10}{s(s^2+6s+10)}$$

$$= \frac{A}{s} + \frac{Bs+C}{s^2+6s+10}$$

$$\Rightarrow \quad \frac{10}{s(s^2+6s+10)} = \frac{A(s^2+6s+10)+s(Bs+C)}{s(s^2+6s+10)}$$

$$(A+B)s^2 + (6A+C)s + 10A = 10$$

Comparing the coefficient of s^2, s and constant we get

$$A+B=0\,;\ 6A+C=0$$

$$10A = 10$$

$$A = 1$$

$$B = -1$$

$$C = -6$$

$$Y(s) = \frac{1}{s} + \frac{-s-6}{s^2+6s+10}$$

$$= \frac{1}{s} - \frac{(s+6)}{s^2+6s+10}$$

$$= \frac{1}{s} - \frac{s+6}{(s+3)^2+1}$$

$$= \frac{1}{s} - \left\{\frac{s+3}{(s+3)^2+1} + \frac{3}{(s+3)^2+1}\right\}$$

Taking inverse Laplace transform we get

$$y(t) = u(t) - \left\{e^{-3t}\cos t\,u(t) + 3e^{-3t}\sin t\,u(t)\right\}$$

$$= \left[1 - e^{-3t}\{\cos t + 3\sin t\}\right]u(t)$$

5	**Forthe transfer function H(S) = (s+10)/ (s^2 + 3s+2) find the response due to input x(t)=**	**6**	**3**	**K2**

sin(2t) u(t)

Solution:

Given

$$x(t) = \sin(2t)u(t)$$

$$x(t) = \frac{2}{s^2+4}$$

$$H(s) = \frac{Y(s)}{X(s)} = \frac{s+10}{(s^2+3s+2)}$$

$$\Rightarrow \quad Y(s) = \frac{s+10}{(s+1)(s+2)} \cdot \frac{2}{s^2+4}$$

$$= \frac{2(s+10)}{(s+1)(s+2)(s^2+4)}$$

$$= \frac{A}{s+1} + \frac{B}{s+2} + \frac{Cs+D}{s^2+4}$$

$$\Rightarrow \quad 2(s+10) = A(s+2)(s^2+4) + B(s+1)(s^2+4) + (Cs+D)(s+1)(s+2)$$

$$= A(s^3+2s^2+4s+8) + B(s^3+s^2+4s+4) + C(s^3+3s^2+2s) + D(s^2+3s+2)$$

$$= (A+B+C)s^3 + (2A+B+3C+D)s^2 + (4A+4B+2C+3D)s + 8A+4B+2D$$

$$A+B+C=0\,;2A+B+3C+D=0;\quad 4A+4B+2C+3D=2$$

$$8A+4B+2D=20$$

Solving for A, B, C and D we get

$$A = \frac{18}{5}; B=-2; C=\frac{-8}{5}; D=\frac{-2}{5}$$

$$Y(s) = \frac{18}{5(s+1)} - \frac{2}{s+2} - \left(\frac{\frac{8}{5}s+\frac{2}{5}}{s^2+4}\right)$$

$$= \frac{18}{5(s+1)} - \frac{2}{s+2} - \frac{8}{5}\frac{s}{s^2+4} - \frac{2}{5}\frac{1}{s^2+4}$$

$$= \frac{18}{5(s+1)} - \frac{2}{s+2} - \frac{8}{5}\left(\frac{s}{s^2+4}\right) - \frac{1}{5}\left(\frac{2}{s^2+4}\right)$$

$$y(t) = \frac{18}{5}e^{-t} - 2e^{-t} - \frac{8}{5}\cos 2t - \frac{1}{5}\sin 2t$$

6 i	**Plot the pole – zero diagram of the following transfer functions H(S)=(s+2)/(s^2+2s+2) , H(S)=(s+3)/s(s^2+4)(s+2)(s+1)**	6	3	K2

(i) Given the transfer function

$$H(s) = \frac{s+2}{s^2+2s+2}$$

The zeros can be obtained by equating the numerator polynomial to zero

$$s+2=0$$
$$s=-2$$

The poles can be obtained by equating the denominator polynomial to zero

$$s^2+2s+2=0$$
$$s_{1,2} = \frac{-2 \pm \sqrt{4-8}}{2} = -1 \pm j$$

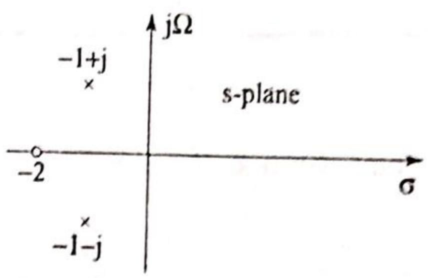
The poles are at $-1 \pm j$ and the zero is at -2. The pole-zero diagram is shown in Fig. 6.18.

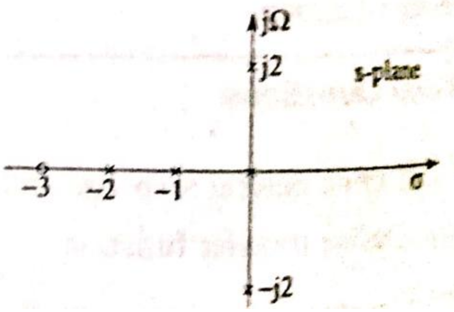
(ii) Given

$$H(s) = \frac{s+3}{s(s^2+4)(s+2)(s+1)}$$

The zero is at $s=-3$ and the poles are at $s=0; s=\pm j2; s=-2; s=-1$

The pole-zero diagram is shown in Fig.6.19.





6 ii	**For a system with transfer function H(S)= (s+5)/(s^2+5s+6) find the zero state response if the input x(t)=e^{-3t} u(t).**			

Solution: Given

$$H(s) = \frac{s+5}{s^2+5s+6}$$
$$\frac{Y(s)}{X(s)} = \frac{s+5}{(s+2)(s+3)}$$

For

$$x(t) = e^{-3t}u(t) \quad X(s) = \frac{1}{s+3}.$$

$$\Rightarrow \quad Y(s) = \frac{s+5}{(s+2)(s+3)^2}$$
$$= \frac{A}{s+2} + \frac{B}{s+3} + \frac{C}{(s+3)^2}$$
$$A = (s+2)\frac{s+5}{(s+2)(s+3)^2}\Bigg|_{s=-2} = \frac{-2+5}{(-2+3)^2} = 3$$
$$B = \frac{1}{1!}\frac{d}{ds}\left[(s+3)^2\frac{s+5}{(s+2)(s+3)^2}\right]\Bigg|_{s=-3}$$
$$= \frac{(s+2)-(s+5)}{(s+2)^2}\Bigg|_{s=-3}$$
$$= \frac{-3}{(-3+2)^2} = -3$$
$$C = (s+3)^2\frac{s+5}{(s+2)(s+3)^2}\Bigg|_{s=-3} = -2$$
$$Y(s) = \frac{3}{s+2} - \frac{3}{s+3} - \frac{2}{(s+3)^2}$$

Taking inverse Laplace transform, we have

$$y(t) = 3e^{-2t}u(t) - 3e^{-3t}u(t) - 2te^{-3t}u(t)$$

	Part C (20 Mark Questions with Key)			
1	**Using Laplace transform, solve the following differential equations.** **$d^2y(t)/dt^2 + 3dy(t)/dt + 2y(t) = dx(t)/dt$ if $y(0^-)$, $dy(0)/dt = 1$ & $x(t) = e^{-t}u(t)$**	20	3	K2

Taking Laplace transform on both sides we get

$$\left[s^2Y(s) - sy(0^-) - \frac{dy}{dt}(0^-)\right] + 3[sY(s) - y(0^-)]$$

$$+2Y(s) = sX(s) - x(0^-)$$

$$y(0^-) = 2; \frac{dy(0^-)}{dt} = 1$$

$$(s^2Y(s) - 2s - 1) + 3[sY(s) - 2] + 2Y(s) = sX(s)$$

$$Y(s)[s^2 + 3s + 2] = 2s + 7 + sX(s)$$

Given $x(t) = e^{-t}u(t)$

$$X(s) = \frac{1}{s+1}$$

$$\Rightarrow Y(s)[s^2 + 3s + 2] = 2s + 7 + \frac{s}{s+1}$$ $2s^2$

$$Y(s) = \frac{2s+7}{s^2+3s+2} + \frac{s}{(s+1)(s^2+3s+2)}$$

$$= \frac{(2s+7)(s+1)+s}{(s+1)(s^2+3s+2)}$$

$$= \frac{2s^2+10s+7}{(s+1)(s^2+3s+2)}$$

$$= \frac{2s^2+10s+7}{(s+1)^2(s+2)}$$

$$= \frac{A}{s+1} + \frac{B}{(s+1)^2} + \frac{C}{s+2}$$

$$A = \frac{1}{1!}\frac{d}{ds}\left[(s+1)^2\frac{2s^2+10s+7}{(s+1)^2(s+2)}\right]\Bigg|_{s=-1}$$

$$= \frac{(s+2)(4s+10) - (2s^2+10s+7)}{(s+2)^2}\Bigg|_{s=-1}$$

$$= 7$$

$$B = (s+1)^2\frac{2s^2+10s+7}{(s+1)^2(s+2)}\Bigg|_{s=-1} = -1$$

$$C = (s+2)\frac{2s^2+10s+7}{(s+1)^2(s+2)}\Bigg|_{s=-2} = -5$$

$$Y(s) = \frac{7}{s+1} - \frac{1}{(s+1)^2} - \frac{5}{s+2}$$

Taking inverse Laplace transform on both sides, we get

$$y(t) = 7e^{-t}u(t) - te^{-t}u(t) - 5e^{-2t}u(t)$$

2	**Find the convolution of the following signals x(t) and h(t)** **X(t) =1 when 0<t<2 and h(t)=1 when 0<t<3**	20	3	K2

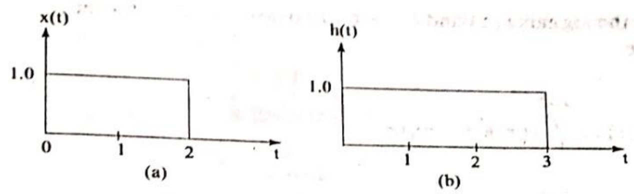


Fig. 4.12

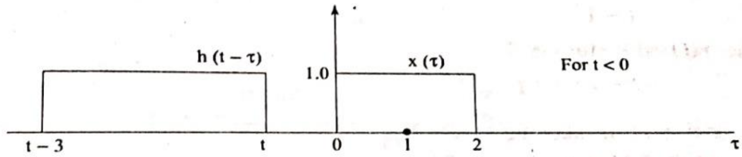


Fig. 4.13

As shown in Fig. 4.13 the signals $x(\tau)$ and $h(t-\tau)$ does not overlap for $t < 0$. Therefore the product $x(\tau)\ h(t-\tau)$ is zero.

That is

$$y(t) = \int_{-\infty}^{\infty} x(\tau)\ h(t-\tau) = 0 \quad \text{for} \quad t < 0$$

Now shift the signal $h(t-\tau)$ right until the right edge of the signal $h(t-\tau)$ intersects left edge of $x(\tau)$.

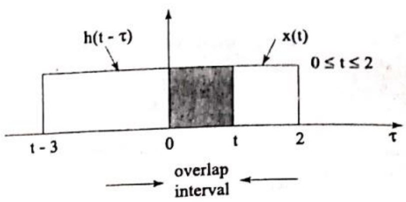


Fig. 4.14

In the interval $0 \le t < 2$

$$y(t) = \int_0^t dt = t$$

In the interval $2 \le t < 3$

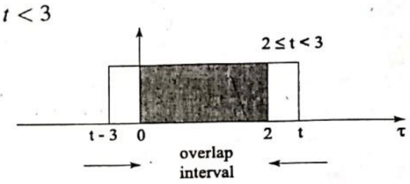


Fig. 4.15

$$y(t) = \int_0^2 d\tau = 2$$

In the interval $3 \le t < 5$

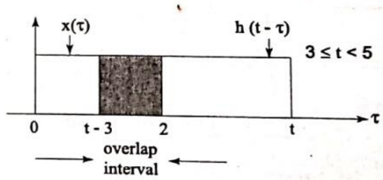


Fig. 4.16

$$y(t) = \int_{t-3}^{2} d\tau = 2 - (t-3)$$

$$= 5 - t$$

For $t \ge 5$

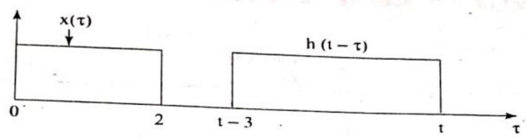


Fig. 4.17

The signals $x(\tau)$ and $h(t-\tau)$ does not overlap. Therefore $y(t) = 0$

$$\begin{aligned} y(t) &= 0 \text{ for } t < 0 \\ &= t \text{ for } 1 \le t < 2 \\ &= 2 \text{ for } 2 \le t < 3 \\ &= 5 - t \text{ for } 3 \le t < 5 \\ &= 0 \text{ for } t \ge 5 \end{aligned}$$

The sketch of $y(t)$ is shown in Fig. 4.18.