**[IT CookBook] 기초 신호 및 시스템**
**: 개념과 원리가 한눈에 보이는 200여 개의 풍부한 예제**

# [연습문제 답안 이용 안내]

# Chapter 07 라플라스 변환

## [Quick Review]

[1] *Ans)* 많은

[2] *Ans)* ×

[3] *Ans)* 우편향

[4] *Ans)* 인과

[5] *Ans)* ○

[6] *Ans)* ○

[7] *Ans)* 안정한

[8] *Ans)* 6

[9] *Ans)* 실수

[10] *Ans)* ×

[11] *Ans)* ○

[12] *Ans)* ×

[13] *Ans)* 임펄스 응답, 미분방정식

[14] *Ans)* 분모

[15] *Ans)* 곱

[16] *Ans)* ○

[17] *Ans)* 영점

[18] *Ans)* ○

[19] *Ans)* 극, 좌반면

[20] *Ans)* $s = j\omega$

# [기초 문제]

**7.1** *Ans)*

(a) $X(s)=\dfrac{1}{s+a}(1-e^{-(s+a)})$

(b) $X(s)=\dfrac{2}{s^3}$

(c) $X(s)=\dfrac{s^2-\omega_0^2}{(s^2+\omega_0^2)^2}$

(d) $X(s)=\dfrac{1}{s}e^{-s}+\dfrac{1}{s+1}e^{-(s+1)}$

**7.2** *Ans)*

(a) $X(s)=\dfrac{s+1}{s^2}$

(b) $X(s)=-\dfrac{s-1}{s^2}$

(c) $X(s)=\dfrac{s+1}{s^2}e^{-s}$

(d) $X(s)=\dfrac{e^{-s}}{s^2}$

**7.3** *Ans)*

(a) $Y(s)=\dfrac{2(s+6)}{s^2+6s+8}$

(b) $Y(s)=\dfrac{s^2+6s+7}{(s^2+3s+2)^2}$

(c) $Y(s)=\dfrac{s(s+3)}{s^2+3s+2}$

(d) $Y(s)=\dfrac{s+3}{s(s^2+3s+2)}$

**7.4** *Ans)*

(a) $y(t)=tu(t)$

(b) $y(t)=u(t)+u(t-4)$

(c) $y(t)=u(t)-e^{-t}u(t)$

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

**7.5** *Ans)*

(a) $x(t) = (-3e^{-2t} + 7e^{-4t})u(t)$

(b) $x(t) = (\frac{5}{2}t - \frac{5}{4} + \frac{5}{4}e^{-2t})u(t)$

(c) $x(t) = (-e^{-2t} + t^2e^{-t} - te^{-t} + e^{-t})u(t)$

(d) $x(t) = (e^{-2(t-2)} + e^{-3(t-2)})u(t-2)$

7.6 *Ans)*

(a) $x(0) = \lim_{s\to\infty} sX(s) = 1$

$x(\infty) = \lim_{s\to 0} sX(s) = 0$

$x(t) = (-e^{-t} + 2e^{-2t})u(t) \quad \to \quad x(0) = 1, \quad x(\infty) = 0$

(b) $x(0) = \lim_{s\to\infty} sX(s) = 1$

$x(\infty) = \lim_{s\to 0} sX(s) = 2$

$x(t) = (2 - e^{-2t})u(t) \quad \to \quad x(0) = 1, \quad x(\infty) = 2$

(c) $x(0) = \lim_{s\to\infty} sX(s) = 0$

$x(\infty) = \lim_{s\to 0} sX(s) = 2$

$x(t) = (2 - 2e^{-t} - te^{-t})u(t) \quad \to \quad x(0) = 0, \quad x(\infty) = 2$

(d) $x(0) = \lim_{s\to\infty} sX(s) = 0$

$x(\infty) = \lim_{s\to 0} sX(s) = 1$

$x(t) = (1 - e^{-t}\cos t)u(t) \quad \to \quad x(0) = 0, \quad x(\infty) = 0$

7.7 *Ans)*

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

(b) $y(t) = (2 + 6t)e^{-2t}u(t)$

7.8 *Ans)*

(a) 전달함수 : $H(s) = \frac{2}{(s+1)(s+4)}$

임펄스 응답 : 은 전달 함수를 라플라스 역변환하여 얻을 수 있다.

$h(t) = (\frac{2}{3}e^{-t} - \frac{2}{3}e^{-4t})u(t)$

계단 응답 : $y(t) = (\frac{1}{2} - \frac{2}{3}e^{-t} + \frac{1}{6}e^{-4t})u(t)$

(b) 전달함수 : $H(s)=\dfrac{2(s+3)}{(s+1)(s+4)}$

임펄스 응답 : $h(t)=(\frac{4}{3}e^{-t}+\frac{2}{3}e^{-4t})u(t)$

계단 응답 : $y(t)=(\frac{3}{2}-\frac{4}{3}e^{-t}-\frac{1}{6}e^{-4t})u(t)$

(c) 전달함수 : $H(s)=\dfrac{2}{(s+1)(s^2+2s+2)}$

임펄스 응답 : $h(t)=2(e^{-t}-e^{-t}\cos t)u(t)$

계단 응답 : $y(t)=(1-2e^{-t}+e^{-t}\cos(t+\frac{\pi}{4}))u(t)$

7.9 *Ans)*

(a) 전달함수 : $H(s)=-\dfrac{2s+1}{s+1}$

임펄스 응답 : $h(t)=-2\delta(t)+e^{-t}u(t)$

(b) 전달함수 : $H(s)==\dfrac{s^2+4s+5}{(s+1)(s+2)}$

임펄스 응답 : $h(t)=\delta(t)+2e^{-t}u(t)-e^{-2t}u(t)$

(c) 전달함수 : $H(s)=\dfrac{-s^2+s+3}{s(s+3)}$

임펄스 응답 : $h(t)=-\delta(t)+(1+3e^{-3t})u(t)$

7.10 *Ans)*

(a) 안정
(b) 불안정
(c) 임계 안정(불안정)
(d) 불안정
(e) 안정
(f) 안정

# [응용 문제]

7.11 *Ans)*

(a) (i) $x(t)=tu(t)-(t-1)u(t-1)-u(t-1)$

(ii) $X(s)=-\frac{1}{s}e^{-s}+\frac{1}{s^2}(1-e^{-s})$

(iii) $X(s)=\mathcal{L}\{tu(t)-(t-1)u(t-1)-u(t-1)\}=\frac{1}{s^2}(1-e^{-s})-\frac{1}{s}e^{-s}$

(b) (i) $x(t)=\sin t\,u(t)+\sin(t-\pi)u(t-\pi)$

(ii) $X(s)=\frac{1}{s^2+1}(1+e^{-\pi s})$

(iii) $X(s)=\mathcal{L}\{\sin t\,u(t)+\sin(t-\pi)u(t-\pi)\}=\frac{1}{s^2+1}(1+e^{-\pi s})$

(c) (i) $x(t)=tu(t)-(t-1)u(t-1)-u(t-1)+e^{-1}e^{-(t-1)}u(t-1)$

(ii) $X(s)=-\frac{1}{s}e^{-s}+\frac{1}{s^2}(1-e^{-s})+\frac{1}{s+1}e^{-(s+1)}$

(iii) $X(s)=\mathcal{L}\{tu(t)-(t-1)u(t-1)-u(t-1)+e^{-1}e^{-(t-1)}u(t-1)\}$

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

(d) (i) $x(t)=\frac{2}{5}tu(t)-\frac{2}{5}(t-5)u(t-5)-3u(t-5)+u(t-10)$

(ii) $X(s)=\frac{1}{s}(e^{-10s}-3e^{-5s})+\frac{2}{5}\frac{1}{s^2}(1-e^{-5s})$

(iii) $X(s)=\mathcal{L}\{\frac{2}{5}tu(t)-\frac{2}{5}(t-5)u(t-5)-3u(t-5)+u(t-10)\}$

$$=\frac{2}{5}\frac{1}{s^2}(1-e^{-5s})+\frac{1}{s}(e^{-10s}-3e^{-5s})$$

7.12 *Ans)*

(a) $X(s)=3\frac{1-s}{s^2}e^{-2s}$

(b) $X(s)=\frac{3}{s^2}(e^{-s}-e^{-3s})+\frac{3}{s}(e^{-s}-3e^{-3s})$

(c) $X(s)=\frac{1}{s+1}e^{-\tau s}$

(d) $X(s)=\frac{s+3}{(s+2)^2}e^{-(s+2)}$

7.13

(a) *Ans)* $x(t)=\hat{x}(t)+\hat{x}(t-T)+\hat{x}(t-2T)+\cdots+\hat{x}(t-nT)+\cdots$

$$\therefore\ X(s)=\frac{1}{1-e^{-Ts}}\hat{X}(s)$$

(b) *Ans)* (a) $X(s)=\dfrac{3}{s(1-e^{-4s})}(e^{-s}+e^{-3s}-e^{-4s}-1)$

(b) $X(s)=\dfrac{1}{s^2(1+e^{-s})}-\dfrac{e^{-s}}{s(1-e^{-2s})}$

7.14 *Ans)*

(1) RL 회로

(a) $L\dfrac{di(t)}{dt}+Ri(t)=v(t)$

(b) $h(t)=\dfrac{1}{L}e^{-\frac{R}{L}t}u(t)$

(c) $H(\omega)=\dfrac{1}{R+j\omega L}$

(d) $H(s)=\dfrac{1}{Ls+R}$

(2) RC 회로

(a) $R\dfrac{di(t)}{dt}+\dfrac{1}{C}i(t)=\dfrac{dv(t)}{dt}$

(b) $h(t)=\dfrac{1}{R}\delta(t)-\dfrac{1}{R^2C}e^{-\frac{1}{RC}t}u(t)$

(c) $H(\omega)=\dfrac{j\omega C}{1+j\omega RC}$

(d) $H(s)=\dfrac{Cs}{RCs+1}$

7.15 *Ans)* $y(t)=(4-4e^{-2t}+16e^{-3t})u(t)$