Universiti Malaysia PAHANG

Engineering • Technology • Creativity

FACULTY OF ELECTRICAL & ELECTRONICS ENGINEERING

FINAL EXAMINATION

COURSE	:	SIGNALS AND NETWORKS
COURSE CODE	:	BEE2143
LECTURER	:	FARADILA NAIM NURUL WAHIDAH ARSHAD ZUWAIRIE IBRAHIM
DATE	:	15 JUNE 2015
DURATION	:	3 HOURS
SESSION/SEMESTER	:	SESSION 2014/2015 SEMESTER II
PROGRAMME CODE	:	BEE/BEP

INSTRUCTIONS TO CANDIDATE:

1. This question paper consists of **FOUR (4)** questions. Answer **ALL** questions.
2. All answers to a new question should start on new page.
3. All the calculation answer and assumptions must be clearly stated.
4. Candidates are not allowed to bring any material other than those allowed by the invigilator into the examination room.

EXAMINATION REQUIREMENTS:

1. **APPENDIX I** – Table of Formula
2. Semilog Graph Paper

DO NOT TURN THIS PAGE UNTIL YOU ARE TOLD TO DO SO

This examination paper consists of **TWELVES (12)** printed pages including front page.

QUESTION 1

Given a periodic signal $x(t)$ in Figure 1.

(i) Find the expression of $x(t)$ using complex exponential Fourier series up to 5^{th} harmonic.

[15 Marks]

[CO1, PO1, C2]

(ii) Plot the magnitude spectrum of $x(t)$.

[2 Marks]

[CO1, PO1, C2]

(iii) Based on your answer in (ii), if $y(t)$ is shown in Figure 2, plot the magnitude spectrum (magnitude versus frequency) of $y(t)$. Briefly explain your answer.

[3 Marks]

[CO1, PO1, C3]

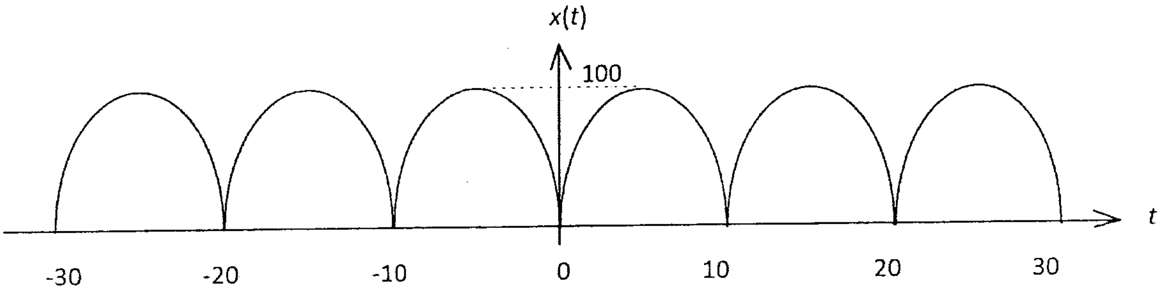


Figure 1

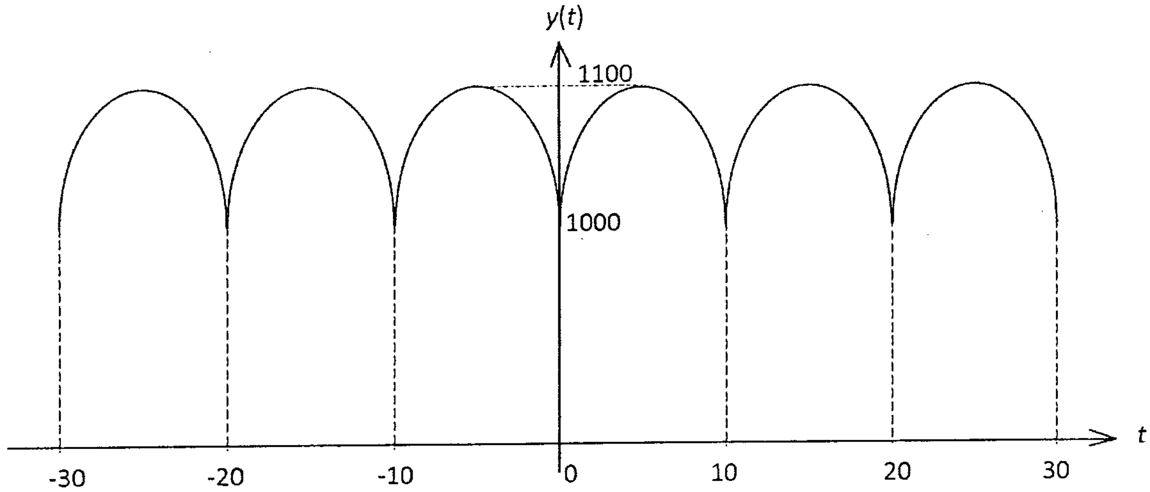


Figure 2

QUESTION 2

(a) A band-limited signal $x(t)$ with its magnitude spectra is shown in Figure 3. Signal $x(t)$ is the input to the modulation system in Figure 4. Let $m(t) = \cos(50t)$.

(i) Plot the magnitude spectra of filtered signal $w(t)$, modulated signal $z(t)$, and demodulated signal $y(t)$.

(ii) If your final spectrum, $y(t)$ must be reconstructed to match the input $x(t)$, $y(t)$ must be filtered. Design the required filter.

[9 Marks]

[CO2, PO1, C3]

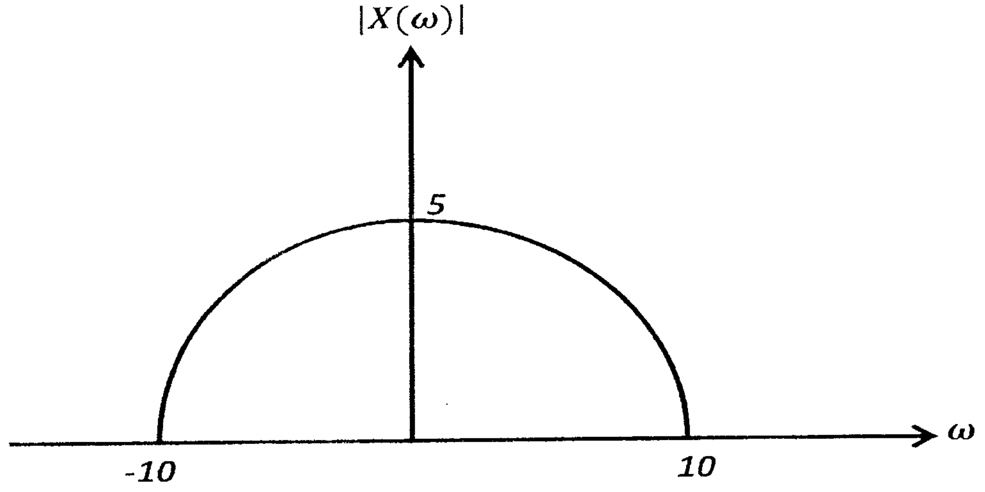


Figure 3

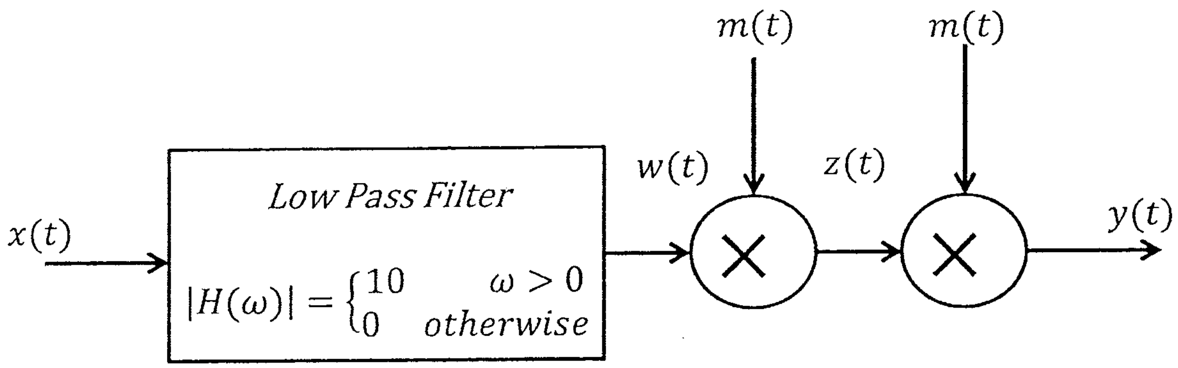


Figure 4

(b) Given an LTI (linear time invariant) system in Figure 5. Using Fourier Transform, find the solution *y(t)* for the given system.

[16 Marks]

[CO2, PO1, C3]

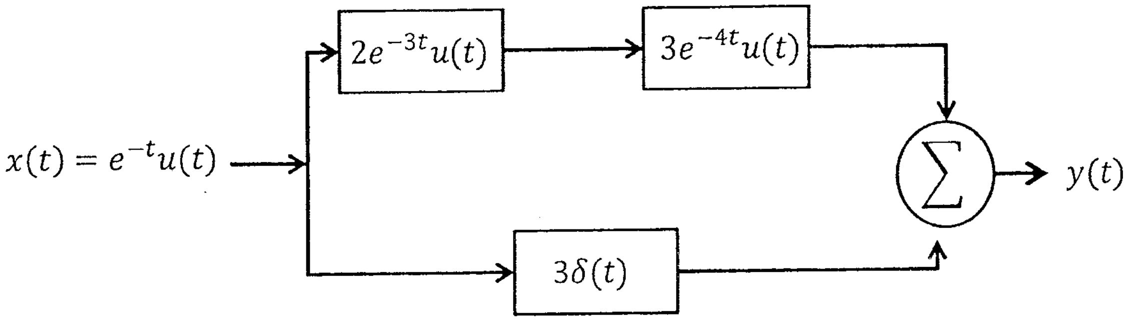


Figure 5

QUESTION 3

(a) Find the Laplace transform of the given signal in Figure 6.

[8 Marks]
[CO2, PO1, C3]

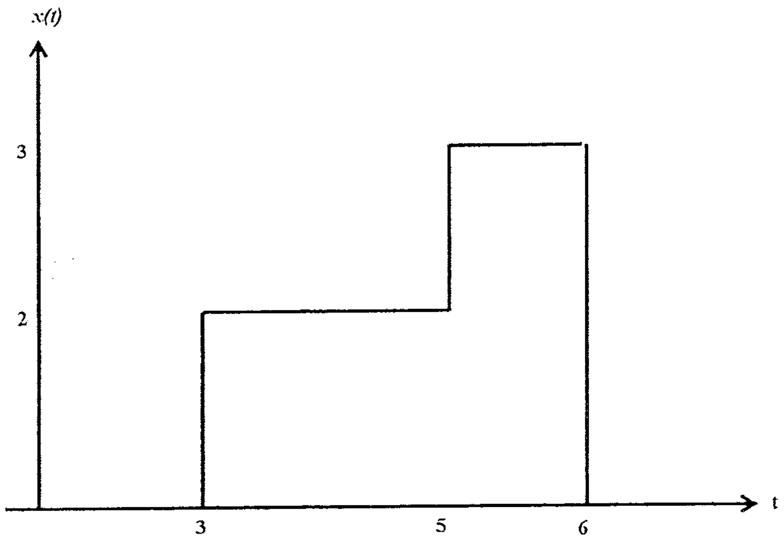


Figure 6

(b) Find the Inverse Laplace transform, *f(t)* of the given signal, *F(s)*.

$$F(s) = \frac{s+2}{s^2 - 4s + 20}$$

[8 Marks]
[CO2, PO1, C3]

(c) The circuit shown in Figure 7, the switch K moves from position A to B at a time $t = 0$. Determine $i_0(t)$ for $t > 0$.

[9 Marks]
[CO2, PO1, C3]

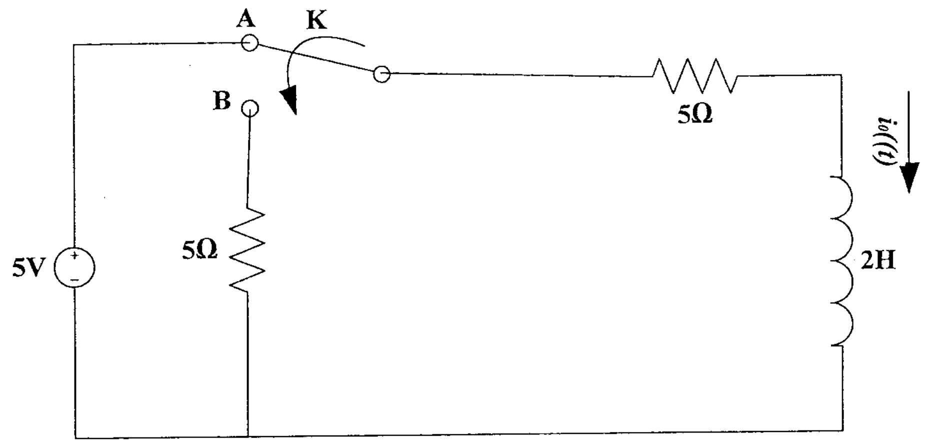


Figure 7

QUESTION 4

(a) Given a transfer function H(w),

$$H(s) = \frac{90s}{3s^2 + 90s + 600}$$

(i) Identify the type of filter for H(s)

(ii) Draw the magnitude and phase Bode plot for H(s).

(iii) Find the ω_0, center frequency of the filter.

[16 Marks]

[CO3, PO2, C3]

(b) Determine the transfer function from the magnitude Bode plot in Figure 8.

[6 Marks]

[CO3, PO2, C4]

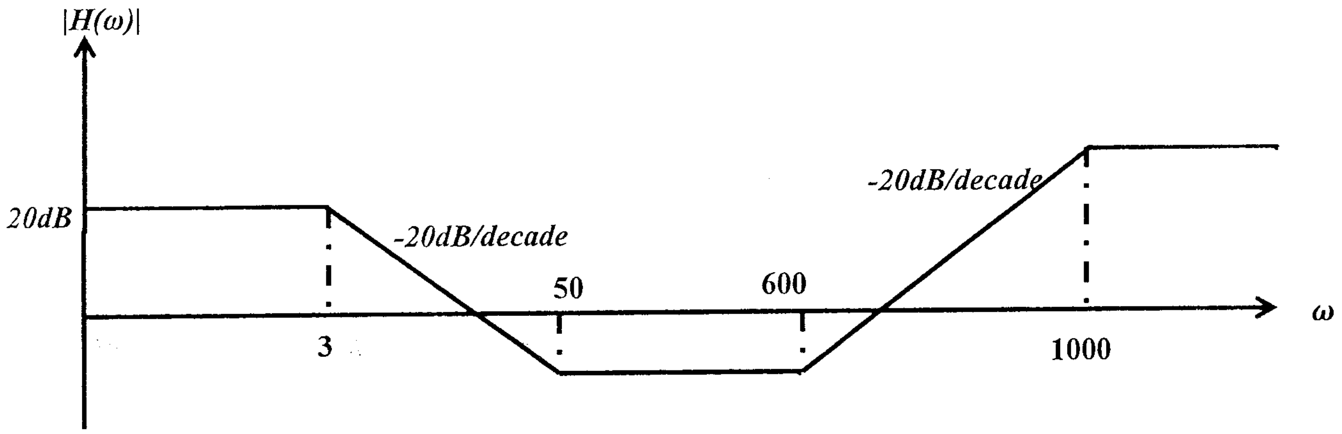


Figure 8

(c) Circuit in Figure 9 is a passive RLC filter.

(i) Find the transfer function H(s) in RLC terms.

(ii) Given that the value R = 3kΩ, L = 2kH and C = 1mF, determine the type of filter for the given circuit.

[8 Marks]

[CO3, PO2, C4]

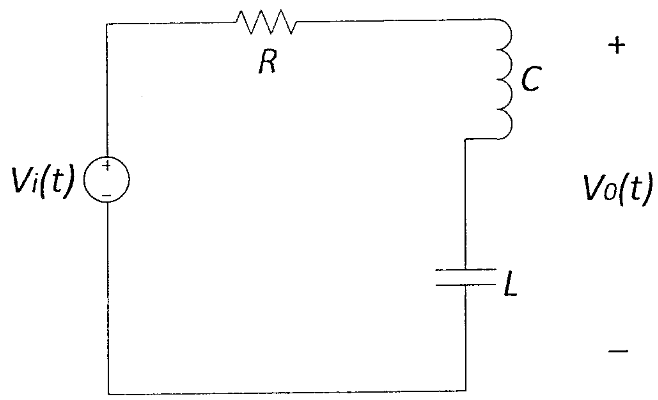


Figure 9

END OF QUESTION PAPER

APPENDIX I – Table of Formulas

MATHEMATICAL FORMULAS

Trigonometric identities

$\sin(-x) = -\sin x$
$\cos(-x) = \cos x$
$\pm\cos x = \sin(x \pm 90°)$
$\mp\sin x = \cos(x \pm 90°)$
$-\cos x = \cos(x \pm 180°)$

$e^{\pm jx} = \cos x \pm j\sin x$

$$\cos x = \frac{e^{jx} + e^{-jx}}{2}$$

$$\sin x = \frac{e^{jx} - e^{-jx}}{j2}$$

$\cos n\pi = (-1)^n$
$\sin n\pi = 0$
$\cos 2n\pi = 1$
$\sin 2n\pi = 0$

Complex numbers

$\frac{1}{j} = -j \quad , \quad j^2 = -1$

$z = x + jy = r\angle\phi = re^{j\phi}$

where $r\angle\phi = \sqrt{x^2 + y^2}\angle\tan^{-1}\frac{y}{x}$

Integrals

$$\int \sin ax dx = -\frac{1}{a}\cos ax$$

$$\int \cos ax dx = \frac{1}{a}\sin ax$$

$$\int x\sin ax dx = \frac{1}{a^2}\sin ax - \frac{x}{a}\cos ax$$

$$\int x\cos ax dx = \frac{1}{a^2}\cos ax + \frac{x}{a}\sin ax$$

$$\int e^{ax} dx = \frac{e^{ax}}{a}$$

$$\int xe^{ax} dx = \frac{e^{ax}}{a^2}(ax - 1)$$

$$\int x^2 e^{ax} dx = \frac{e^{ax}}{a^3}(a^2x^2 - 2ax + 2)$$

$$\int e^{ax}\sin bx\, dx = \frac{e^{ax}}{a^2 + b^2}(a\sin bx - b\cos bx)$$

$$\int e^{ax}\cos bx\, dx = \frac{e^{ax}}{a^2 + b^2}(a\cos bx + b\sin bx)$$

$$\int \frac{dx}{a^2 + x^2} = \frac{1}{a}\tan^{-1}\frac{x}{a}$$

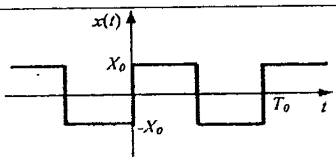
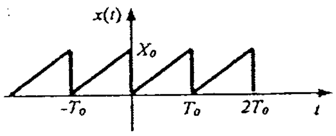
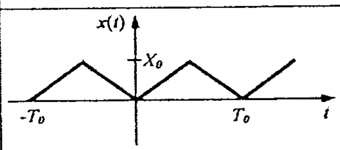
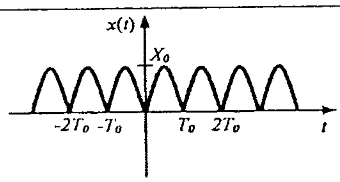
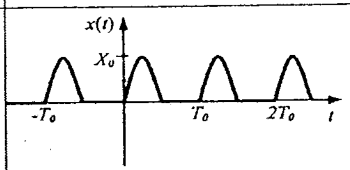
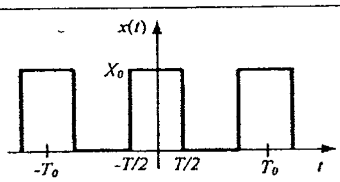
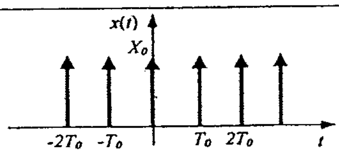
$$\int \frac{dx}{(a^2 + x^2)^2} = \frac{1}{2a^2}\left(\frac{x}{x^2 + a^2} + \frac{1}{a}\tan^{-1}\frac{x}{a}\right)$$

FOURIER SERIES

Exponential form

$$f(t) = c_0 + \sum_{\substack{n=-\infty \\ n\neq 0}}^{\infty} c_n e^{jn\omega_0 t} \quad \text{where } c_0 = a_0, c_n = \frac{1}{T}\int_0^T f(t)e^{-jn\omega_0 t}\,dt\,,\ c_n = \frac{a_n - jb_n}{2}$$

Fourier Coefficients Table

Name	Waveform	C_0	$C_n, n \neq 0$	Comments
1.Square Wave		0	$-j\frac{2X_0}{\pi n}$	$C_n = 0$, n even
2. Sawtooth		$\frac{X_0}{2}$	$j\frac{X_0}{2\pi n}$	
3. Triangular Wave		$\frac{X_0}{2}$	$\frac{-2X_0}{(\pi n)^2}$	$C_n = 0$, n even
4. Full-wave rectified.		$\frac{2X_0}{\pi}$	$\frac{-2X_0}{\pi(4n^2-1)}$	
5. Half-wave rectified		$\frac{X_0}{\pi}$	$\frac{-X_0}{\pi(n^2-1)}$	$C_n = 0$, n odd, except for $C_1 = -j\frac{X_0}{4}$, and $C_{-1} = j\frac{X_0}{4}$
6. Square Wave		$\frac{TX_0}{T_0}$	$\frac{TX_0}{T_0}\text{sinc}\frac{Tn\omega_0}{2}$	$\frac{Tn\omega_0}{2} = \frac{\pi T n}{T_0}$
7. Impulse train		$\frac{X_0}{T_0}$	$\frac{X_0}{T_0}$	

FOURIER TRANSFORM

Properties of the Fourier Transform

Property	$F(t)$	$F(\omega)$
Linearity	$a_1 f_1(t) + a_2 f_2(t)$	$a_1 F_1(\omega) + a_2 F_2(\omega)$
Scaling	$f(at)$	$\frac{1}{\lvert a \rvert} F\left(\frac{\omega}{a}\right)$
Time shift	$f(t-a)$	$e^{-j\omega a} F(\omega)$
Frequency shift	$e^{j\omega_0 t} f(t)$	$F(\omega - \omega_0)$
Modulation	$\cos(\omega_0 t) f(t)$	$\frac{1}{2}[F(\omega+\omega_0) + F(\omega-\omega_0)]$
Time differentiation	$\frac{df}{dt}$ $\frac{d^n f}{dt^n}$	$j\omega F(\omega)$ $(j\omega)^n F(\omega)$
Time integration	$\int_{-\infty}^{t} f(t)dt$	$\frac{F(\omega)}{j\omega} + \pi F(0)\delta(\omega)$
Duality	$F(t)$	$2\pi f(-\omega)$

Fourier Transform Pairs

$f(t)$	$F(\omega)$	$f(t)$	$F(\omega)$
$\delta(t)$	1	$e^{-a\lvert t \rvert}$	$\frac{2a}{a^2+\omega^2}$
1	$2\pi\delta(\omega)$	$e^{j\omega_0 t}$	$2\pi\delta(\omega-\omega_0)$
$u(t)$	$\pi\delta(\omega) + \frac{1}{j\omega}$	$\sin \omega_0 t$	$j\pi[\delta(\omega+\omega_0) - \delta(\omega-\omega$
$u(t+\tau) - u(t-\tau)$	$2\frac{\sin \omega\tau}{\omega}$	$\cos \omega_0 t$	$\pi[\delta(\omega+\omega_0) + \delta(\omega-\omega_0$
$\lvert t \rvert$	$-\frac{2}{\omega^2}$	$\mathrm{sgn}(t)$	$\frac{2}{j\omega}$
$e^{at}u(-t)$	$\frac{1}{a-j\omega}$	$rect(t/\tau)$	$\tau \operatorname{sinc}\left(\frac{\omega\tau}{2}\right)$
$e^{-at}u(t)$	$\frac{1}{a+j\omega}$	$tri(t/\tau)$	$\tau \operatorname{sinc}^2\left(\frac{\omega\tau}{2}\right)$
$t^n e^{-at}u(t)$	$\frac{n!}{(a+j\omega)^{n+1}}$	$e^{-at} \sin \omega_0 t\, u(t)$	$\frac{\omega_0}{(a+j\omega)^2 + \omega_0^2}$
		$e^{-at} \cos \omega_0 t\, u(t)$	$\frac{a+j\omega}{(a+j\omega)^2 + \omega_0^2}$

LAPLACE TRANSFORM

Definition of Laplace Transform

$$F(s) = \mathcal{L}\{f(t)\} = \int_0^\infty f(t)e^{-st}\,dt$$

Properties of the Laplace transform

Property	$f(t)$	$F(s)$
Linearity	$a_1 f_1(t) + a_2 f_2(t)$	$a_1 F_1(s) + a_2 F_2(s)$
Scaling	$f(at)$	$\frac{1}{a}F\left(\frac{s}{a}\right)$
Time shift	$f(t-a)u(t-a)$	$e^{-as}F(s)$
Frequency shift	$e^{-at}f(t)$	$F(s+a)$
Time differentiation	$\frac{df}{dt}$ $\frac{d^2 f}{dt^2}$ $\frac{d^n f}{dt^n}$	$sF(s) - f(0^-)$ $s^2F(s) - sf(0^-) - f'(0^-)$ $s^nF(s) - s^{n-1}f(0^-) - s^{n-2}f'(0^-) - \ldots - f^{(n-1)}(0^-)$
Time integration	$\int_0^t f(t)dt$	$\frac{1}{s}F(s)$
Frequency differentiation	$t^n f(t)$	$(-1)^n \frac{d^nF(s)}{d\omega^n}$
Frequency integration	$\frac{f(t)}{t}$	$\int_s^\infty F(s)ds$
Time periodicity	$f(t) = f(t+nT)$	$\frac{F_1(s)}{1-e^{-sT}} = \frac{1}{1-e^{-sT}}$
Initial value	$f(0)$	$\lim_{s\to\infty} sF(s)$
Final value	$f(\infty)$	$\lim_{s\to 0} sF(s)$

Laplace transform pairs

$f(t)$	$F(s)$
$\delta(t)$	1
$u(t)$	$\frac{1}{s}$
e^{-at}	$\frac{1}{s+a}$
t^n	$\frac{n!}{s^{n+1}}$
$t^n e^{-at}$	$\frac{n!}{(s+a)^{n+1}}$
$\sin \omega t$	$\frac{\omega}{s^2+\omega^2}$
$\cos \omega t$	$\frac{s}{s^2+\omega^2}$
$\sin(\omega t+\theta)$	$\frac{s\sin\theta + \omega\cos\theta}{s^2+\omega^2}$
$\cos(\omega t+\theta)$	$\frac{s\cos\theta - \omega\sin\theta}{s^2+\omega^2}$
$e^{-at}\sin \omega t$	$\frac{\omega}{(s+a)^2+\omega^2}$
$e^{-at}\cos \omega t$	$\frac{s+a}{(s+a)^2+\omega^2}$

s-domain equivalents

$$I_L(s) = \frac{V_L(s)}{sL} + \frac{i_L(0^-)}{s}$$

or

$$V_L(s) = sLI_L(s) - Li_L(0^-)$$

$$V_C(s) = \frac{1}{sC}I_C(s) + \frac{v_C(0^-)}{s}$$

or

$$I_C(s) = sCV_C(s) - Cv_C(0^-)$$