



BAHAGIAN PEPERIKSAAN DAN PENILAIAN
JABATAN PENDIDIKAN POLITEKNIK
KEMENTERIAN PENDIDIKAN TINGGI

JABATAN KEJURUTERAAN ELEKTRIK

PEPERIKSAAN AKHIR
SESI DISEMBER 2016

DEE 6122: SIGNAL AND SYSTEM

TARIKH : 05 APRIL 2017
MASA : 2.30PM – 4.30PM (2 JAM)

Kertas ini mengandungi **LAPAN (8)** halaman bercetak.

Bahagian A: Struktur (4 soalan)
Bahagian B: Esei (2 soalan)

Dokumen sokongan yang disertakan : Formula

JANGAN BUKA KERTAS SOALAN INI SEHINGGA DIARAHKAN

(CLO yang tertera hanya sebagai rujukan)

SECTION A : 60 MARKS

BAHAGIAN A : 60 MARKAH

INSTRUCTION:

This section consists of **FOUR (4)** structure questions. Answer **ALL** questions.

ARAHAN :

Bahagian ini mengandungi **EMPAT (4)** soalan berstruktur. Jawab **SEMUA** soalan.

QUESTION 1

SOALAN 1

CLO1
C1

(a) Identify the difference between even and odd signals.

Kenal pasti perbezaan di antara isyarat genap dan ganjil.

[3 marks]

[3 markah]

CLO1
C2

(b) Describe the signal of Unit Step Function $u(t)$ and Unit Impulse Function, $\delta(t)$.

Gambarkan isyarat Unit Step Function, $u(t)$ dan Unit Impulse Function, $\delta(t)$

[5 marks]

[5 markah]

CLO1
C3

(c) Sketch $x(t) = u(1-t)$ and $x(t) = [u(t)-u(t-1)]$ for the continuous time signal shown in **Figure A1(c)**

*Lakar $x(t) = u(1-t)$ dan $x(t) = [u(t)-u(t-1)]$ untuk isyarat masa berterusan $x(t)$ pada **Rajah A1(c)***

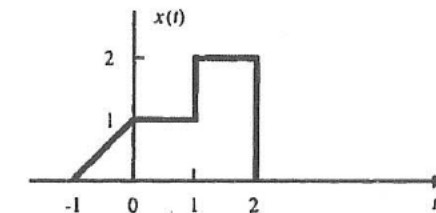


Figure A1(c) / Rajah A1(c)

[7 marks]

[7 markah]

QUESTION 2

SOALAN 2

CLO1
C1

(a) Define the convolution of two continuous time signals $x(t)$ and $h(t)$ denoted by

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

Takrifkan konvolusi dua isyarat masa berterusan $x(t)$ dan $h(t)$ bagi persamaan

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

[3 marks]

[3 markah]

CLO1
C2

(b) Express the input-output relationship for a block diagram of LTI system shown in Figure A2(b).

Nyatakan hubungan data masukan dan keluaran bagi gambar rajah blok sistem LTI seperti dalam Rajah A2(b).

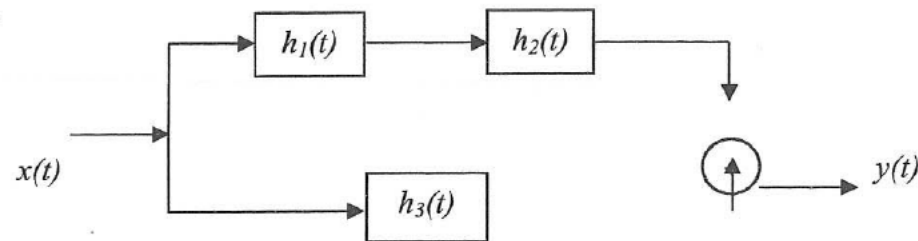


Figure A2(b) / Rajah A2(b)

[5 marks]

[5 markah]

CLO1
C3

(c) Sketch the output of $y[n] = x[n] * h[n]$ with reference to the Figure A2(c) where

$$x[n] = -\delta[n] + 2\delta[n-1] + \delta[n-2]$$

$$h[n] = \delta[n] + \delta[n-2]$$

Lakarkan keluaran bagi $y[n] = x[n] * h[n]$ dengan merujuk kepada Rajah A2(c) di mana

$$x[n] = -\delta[n] + 2\delta[n-1] + \delta[n-2]$$

$$h[n] = \delta[n] + \delta[n-2]$$

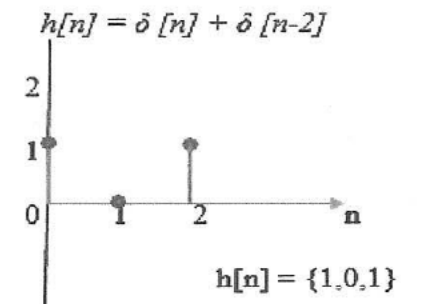
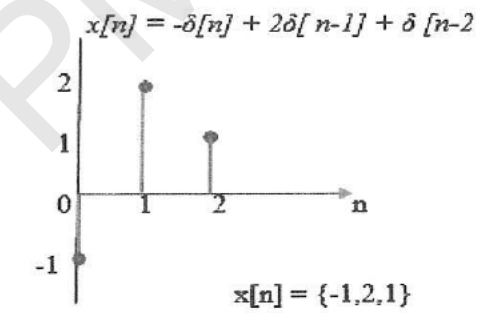


Figure A2(c) / Rajah A2(c)

[7 marks]

[7 markah]

QUESTION 3

SOALAN 3

- CLO2
C1 (a) Identify the Region of Convergence (ROC) in Linear Time Invariant (LTI) System
Kenalpasti "Region of Convergence" (ROC) dalam sistem "Linear Time Invariant" (LTI)

[3 marks]

[3 markah]

- CLO2
C2 (b) Compute the inverse of the following Laplace Transform using partial fraction method

$$X(s) = \frac{s+3}{s(s+1)}$$

Kirakan Jelmaan Laplace Songsang bagi persamaan berikut menggunakan kaedah pecahan separa

$$X(s) = \frac{s+3}{s(s+1)}$$

[5 marks]

[5 markah]

- CLO2
C3 (c) Complete the Laplace Transform $X(s)$ and sketch the pole zero with the ROC for the following signal $x(t)$

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

Lengkapkan Jelmaan Laplace $X(s)$ dan lakarkan kutub sifar dengan ROC bagi isyarat $x(t)$ berikut :

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

[7 marks]

[7 markah]

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QUESTION 4

SOALAN 4

- CLO2
C2 (a) Express the following signal to the complex exponential Fourier Series representation by using Euler's formula.

$$x(t) = \cos \omega_0 t$$

Ungkapkan isyarat berikut kepada kompleks eksponen Siri Fourier dengan menggunakan formula Euler's.

$$x(t) = \cos \omega_0 t$$

[3 marks]

[3 markah]

- CLO2
C3 (b) Interpret the complex exponential Fourier Series for the following signal

$$X(t) = \cos 6t + \sin 4t \quad \text{where } \omega_0 = 2$$

Terangkan eksponen kompleks Siri Fourier bagi isyarat berikut

$$X(t) = \cos 6t + \sin 4t \quad \text{where } \omega_0 = 2$$

[5 marks]

[5 markah]

- CLO2
C4 (c) Referring to **Figure A4(c)**, determine the complex exponential Fourier Series of $x(t)$
*Merujuk kepada **Rajah A4(c)**, Tentukan kompleks eksponen Siri Fourier bagi $x(t)$*

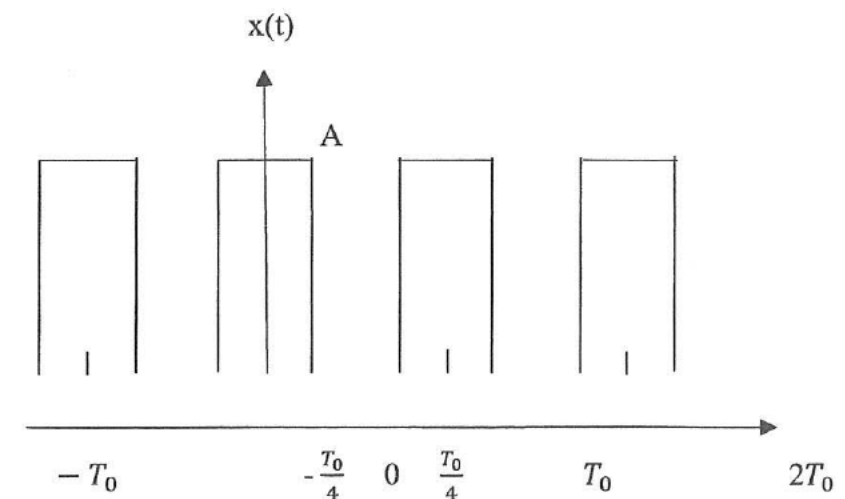


Figure A4(c) /Rajah A 4(c)

T

[7 marks]

[7 markah]

SECTION B : 40 MARKS

BAHAGIAN B : 40 MARKAH

INSTRUCTION:

This section consists of TWO (2) essay questions. Answer ALL questions.

ARAHAN:

Bahagian ini mengandungi DUA (2) soalan esei. Jawab SEMUA soalan.

QUESTION 1

SOALAN 1

Calculate the $h(t)$ for causal LTI system and sketch the ROC for $H(z)$ on the poles-zeros diagram for the following equation.

(Hint: Apply linearity and time delay properties to get the system function $H(z)$ which is the equal to $Y(z)/X(z)$).

$$y[n] - 3y[n-1] + 2y[n-2] = x[n].$$

Kirakan $h(t)$ untuk sistem causal LTI dengan menunjukkan ROC Rajah kutub-sifar bagi $H(z)$ untuk persamaan berikut.

(Gunakan ciri Linearity dan Time delay untuk mendapatkan fungsi sistem $H(z)$ yang bersamaan dengan $Y(z)/X(z)$.)

$$y[n] - 3y[n-1] + 2y[n-2] = x[n].$$

[20 marks]

[20 markah]

CLO2
C3

QUESTION 2

SOALAN 2

CLO3
C4

Discrete Fourier Transform (DFT) is a mathematic operation to change the N-sample discrete signal to the same frequency samples and is defined as,

$$X(k) = \sum_{n=0}^{N-1} x[n]e^{-j2\pi nk/N}$$

Draw the real and imaginary diagram of the sequence $x[n] = \{1,2,3,4\}$ after being transformed using the above definition.

Jelmaan Diskrit Fourier (DFT) adalah operasi matematik untuk mengubah isyarat diskrit N-sample kepada sampel yang mempunyai frekuensi yang sama dan didefinisikan sebagai,

$$X(k) = \sum_{n=0}^{N-1} x[n]e^{-j2\pi nk/N}$$

Lukiskan rajah komponen real dan imaginary bagi jujukan $x[n] = \{1,2,3,4\}$ yang telah dijelmakan menggunakan definisi di atas.

[20 marks]

[20 markah]

SOALAN TAMAT

Energy and Power of Signal

$$E_x = \int_{-T/2}^{T/2} x(t)x^*(t)dt = \int_{-T/2}^{T/2} |x(t)|^2 dt$$

$$P_x = \frac{1}{T} \int_{-T/2}^{T/2} x(t)x^*(t)dt = \frac{1}{T} \int_{-T/2}^{T/2} |x(t)|^2 dt = \frac{1}{T} E_x$$

Trigonometric of Signal in terms of Complex Exponential of Signal

$$x(t) = \cos \omega_1 t = \frac{e^{j\omega_1 t} + e^{-j\omega_1 t}}{2}$$

$$x(t) = \sin \omega_1 t = \frac{e^{j\omega_1 t} - e^{-j\omega_1 t}}{2j}$$

Complex Exponential Fourier Series

$$f(t) = \sum_{n=-\infty}^{\infty} C_n e^{jn\omega t} \quad C_n = \frac{1}{T} \int_0^T f(t) e^{-jn\omega t} dt$$

$$\int \cos at dt = \frac{1}{a} \sin at$$

$$\int \sin at dt = -\frac{1}{a} \cos at$$

$$\int t \cos at dt = \frac{1}{a^2} \cos at + \frac{1}{a} t \sin at$$

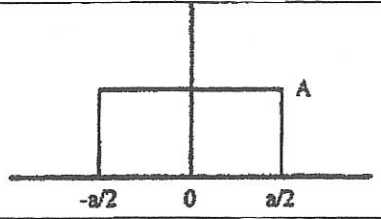
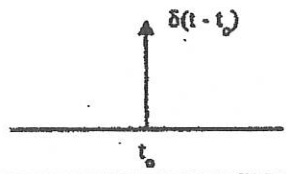
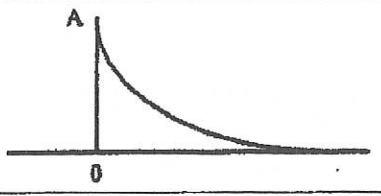
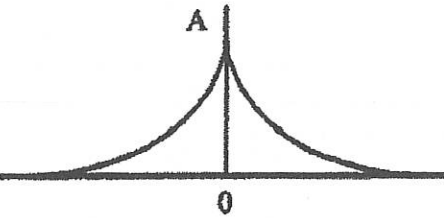
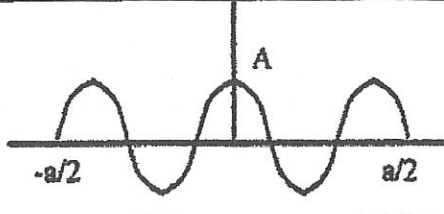
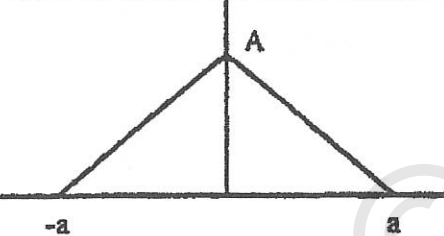
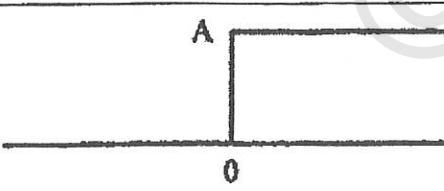
$$\int t \sin at dt = \frac{1}{a^2} \sin at - \frac{1}{a} t \cos at$$

$$\int e^{-at} dt = \frac{e^{-at}}{-a}$$

Properties Of Fourier Transform

Theorem	Jika $F[f(t)] = F(\omega)$, maka:
Definition	$F(\omega) = \int_{-\infty}^{\infty} f(t) e^{-j\omega t} dt$ $f(t) = \frac{1}{2\pi} \int_{-\infty}^{\infty} F(\omega) e^{j\omega t} d\omega$
Linearity	$F[af_1(t) + bf_2(t)] = aF_1(\omega) + bF_2(\omega)$
Symmetry	$F(\omega) = 2 \int_0^{\infty} f(t) \cos \omega t dt \quad : f(t) \text{ even}$ $F(\omega) = -2j \int_0^{\infty} f(t) \sin \omega t dt \quad : f(t) \text{ odd}$
Time Shifting	$F[f(t-a)] = F(\omega) e^{-j\omega a}$
Time Scaling	$F[f(at)] = \frac{1}{ a } F\left(\frac{\omega}{a}\right)$
Magnitude Scaling	$F[af(t)] = aF(\omega)$
Frequency Shifting (or Amplitude Modulation)	$F[f(t) e^{j\omega_0 t}] = F(\omega - \omega_0)$ $F[f(t) \cos \omega_0 t] = \frac{1}{2} [F(\omega - \omega_0) + F(\omega + \omega_0)]$ $F[f(t) \sin \omega_0 t] = \frac{1}{2j} [F(\omega - \omega_0) - F(\omega + \omega_0)]$
Time differentiation	$F\left[\frac{d^n}{dt^n} f(t)\right] = (j\omega)^n F(\omega)$
Convolution in t	$F^{-1}[F_1(\omega) F_2(\omega)] = \int_{-\infty}^{\infty} f_1(\tau) f_2(t - \tau) d\tau$
Convolution in ω	$F[f_1(t) f_2(t)] = \frac{1}{2\pi} \int_{-\infty}^{\infty} F_1(\lambda) F_2(\omega - \lambda) d\lambda$
Reversal	$F[f(-t)] = F^*(\omega) = F(-\omega)$
Duality	$F(t) = 2\pi f(-\omega)$
Time Coefficient	$F[t^n f(t)] = (j)^n \frac{d^n F(\omega)}{d\omega^n}$

Fourier Transform Pair

<p>Pulse</p> $f(t) = A u\left(t + \frac{a}{2}\right) - A u\left(t - \frac{a}{2}\right)$		$A a \operatorname{sinc}\left(\frac{\omega a}{2}\right)$
<p>Impulse</p> $\delta(t - t_0)$		$e^{-j\omega t_0}$
<p>Decaying exponential</p> $A e^{-at} u(t)$		$\frac{A}{a + j\omega}$
<p>Symmetric decaying exponential</p> $A e^{-a t }$		$\frac{2 a A}{a^2 + \omega^2}$
<p>Tone burst (gated cosine)</p> $A f(t) \cos \omega_0 t$		$\frac{A a}{2} [\operatorname{sinc}(\omega - \omega_0) + \operatorname{sinc}(\omega + \omega_0)]$
<p>Sawtooth</p>		$A a \operatorname{sinc}^2\left(\frac{\omega a}{2}\right)$
<p>Step input</p> $A u(t)$		$A \left[\pi \delta(\omega) + \frac{1}{j\omega} \right]$

Fourier Transform Pairs

$f(t)$	$F(\omega)$
$\delta(t)$	1
1	$2\pi\delta(\omega)$
$u(t)$	$\pi\delta(\omega) + \frac{1}{j\omega}$
$u(t + \tau) - u(t - \tau)$	$2 \frac{\sin \omega \tau}{\omega}$
$ t $	$\frac{-2}{\omega^2}$
$\operatorname{sgn}(t)$	$\frac{2}{j\omega}$
$e^{-at} u(t)$	$\frac{1}{a + j\omega}$
$e^{at} u(-t)$	$\frac{1}{a - j\omega}$
$t^n e^{-at} u(t)$	$\frac{n!}{(a + j\omega)^{n+1}}$
$e^{-a t }$	$\frac{2a}{a^2 + \omega^2}$
$e^{j\omega_0 t}$	$2\pi\delta(\omega - \omega_0)$
$\sin \omega_0 t$	$j\pi[\delta(\omega + \omega_0) - \delta(\omega - \omega_0)]$
$\cos \omega_0 t$	$\pi[\delta(\omega + \omega_0) + \delta(\omega - \omega_0)]$
$\sin(\omega t + \theta)$	$\frac{s \sin \theta + \omega \cos \theta}{s^2 + \omega^2}$
$\cos(\omega t + \theta)$	$\frac{s \cos \theta - \omega \sin \theta}{s^2 + \omega^2}$
$e^{-at} \sin \omega_0 t u(t)$	$\frac{\omega_0}{(a + j\omega)^2 + \omega_0^2}$
$e^{-at} \cos \omega_0 t u(t)$	$\frac{a + j\omega}{(a + j\omega)^2 + \omega_0^2}$

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	$\frac{df}{dt}$	$sF(s) - f(0^-)$
	$\frac{d^2 f}{dt^2}$	$s^2 F(s) - sf(0^-) - f'(0^-)$
	$\frac{d^3 f}{dt^3}$	$s^3 F(s) - s^2 f(0^-) - sf'(0^-) - f''(0^-)$
	$\frac{d^n f}{dt^n}$	$s^n F(s) - s^{n-1} f(0^-) - s^{n-2} f'(0^-) - \dots - f^{(n-1)}(0^-)$
Time integration	$\int_0^t f(t) dt$	$\frac{1}{s} F(s)$
Frequency differentiation	$tf(t)$	$-\frac{d}{ds} F(s)$
Frequency integration	$\frac{f(t)}{t}$	$\int_s^\infty F(s) ds$
Time periodicity	$f(t) = f(t+nT)$	$\frac{F_1(s)}{1 - e^{-sT}}$
Initial value	$f(0^+)$	$\lim_{s \rightarrow \infty} sF(s)$
Final value	$f(\infty)$	$\lim_{s \rightarrow 0} sF(s)$
Convolution	$f_1(t) * f_2(t)$	$F_1(s)F_2(s)$

Laplace Transform Pairs

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

*Defined for $t \geq 0$, $f(t) = 0$ for $t < 0$

Z-Transform Pairs

$x(t)$	$X(s)$	$X(z)$
1. $\delta(t) = \begin{cases} 1 & t=0, \\ 0 & t=kT, k \neq 0 \end{cases}$	1	1
2. $\delta(t - kT) = \begin{cases} 1 & t=kT, \\ 0 & t \neq kT \end{cases}$	e^{-kTs}	z^{-k}
3. $u(t)$, unit step	$1/s$	$\frac{z}{z-1}$
4. t	$1/s^2$	$\frac{Tz}{(z-1)^2}$
5. t^2	$2/s^3$	$\frac{T^2 z(z+1)}{(z-1)^3}$
6. e^{-at}	$\frac{1}{s+a}$	$\frac{z}{z-e^{-aT}}$
7. $1 - e^{-at}$	$\frac{a}{s(s+a)}$	$\frac{(1-e^{-aT})z}{(z-1)(z-e^{-aT})}$
8. te^{-at}	$\frac{1}{(s+a)^2}$	$\frac{Tze^{-aT}}{(z-e^{-aT})^2}$
9. $t^2 e^{-at}$	$\frac{2}{(s+a)^3}$	$\frac{T^2 e^{-aT} z(z+e^{-aT})}{(z-e^{-aT})^3}$
10. $be^{-bt} - ae^{-at}$	$\frac{(b-a)s}{(s+a)(s+b)}$	$\frac{z[z(b-a) - (be^{-aT} - ae^{-bT})]}{(z-e^{-aT})(z-e^{-bT})}$
11. $\sin \omega t$	$\frac{\omega}{s^2 + \omega^2}$	$\frac{z \sin \omega T}{z^2 - 2z \cos \omega T + 1}$
12. $\cos \omega t$	$\frac{s}{s^2 + \omega^2}$	$\frac{z(z - \cos \omega T)}{z^2 - 2z \cos \omega T + 1}$
13. $e^{-at} \sin \omega t$	$\frac{\omega}{(s+a)^2 + \omega^2}$	$\frac{(ze^{-aT} \sin \omega T)}{z^2 - 2ze^{-aT} \cos \omega T + e^{-2aT}}$
14. $e^{-at} \cos \omega t$	$\frac{s+a}{(s+a)^2 + \omega^2}$	$\frac{z - ze^{-aT} \cos \omega T}{z^2 - 2ze^{-aT} \cos \omega T + e^{-2aT}}$
15. $1 - e^{-at} \left(\cos bt + \frac{a}{b} \sin bt \right)$	$\frac{a^2 + b^2}{s[(s+a)^2 + b^2]}$	$\frac{z(Az+B)}{(z-1)z^2 - 2e^{-aT}(\cos bT)z + e^{-2aT}}$ $A = 1 - e^{-aT} \cos bT - \frac{a}{b} e^{-aT} \sin bT$ $B = e^{-2aT} + \frac{a}{b} e^{-aT} \sin bT - e^{-aT} \cos bT$

Properties of the Fourier Transform

Property	Sequence	Fourier transform
	$x[n]$	$X(\Omega)$
	$x_1[n]$	$X_1(\Omega)$
	$x_2[n]$	$X_2(\Omega)$
Periodicity	$x[n]$	$X(\Omega + 2\pi) = X(\Omega)$
Linearity	$a_1 x_1[n] + a_2 x_2[n]$	$a_1 X_1(\Omega) + a_2 X_2(\Omega)$
Time shifting	$x[n - n_0]$	$e^{-j\Omega n_0} X(\Omega)$
Frequency shifting	$e^{j\Omega_0 n} x[n]$	$X(\Omega - \Omega_0)$
Conjugation	$x^*[n]$	$X^*(-\Omega)$
Time reversal	$x[-n]$	$X(-\Omega)$
Time scaling	$x_{(m)}[n] = \begin{cases} x[n/m] & \text{if } n = km \\ 0 & \text{if } n \neq km \end{cases}$	$X(m\Omega)$
Frequency differentiation	$nx[n]$	$j \frac{dX(\Omega)}{d\Omega}$
First difference	$x[n] - x[n-1]$	$(1 - e^{-j\Omega}) X(\Omega)$
Accumulation	$\sum_{k=-\infty}^n x[k]$	$\pi X(\Omega) \delta(\Omega) + \frac{1}{1 - e^{-j\Omega}} X(\Omega)$ $ \Omega \leq \pi$
Convolution	$x_1[n] * x_2[n]$	$X_1(\Omega) X_2(\Omega)$
Multiplication	$x_1[n] x_2[n]$	$\frac{1}{2\pi} X_1(\Omega) \otimes X_2(\Omega)$
Real sequence	$x[n] = x_d[n] + x_a[n]$	$X(\Omega) = A(\Omega) + jB(\Omega)$ $X(-\Omega) = X^*(\Omega)$ $\text{Re}\{X(\Omega)\} = A(\Omega)$ $j \text{Im}\{X(\Omega)\} = jB(\Omega)$
Even component	$x_d[n]$	
Odd component	$x_a[n]$	
Parseval's relations		$\sum_{n=-\infty}^{\infty} x_1[n] x_2^*[n] = \frac{1}{2\pi} \int_{-\pi}^{\pi} X_1(\Omega) X_2^*(-\Omega) d\Omega$ $\sum_{n=-\infty}^{\infty} x[n] ^2 = \frac{1}{2\pi} \int_{-\pi}^{\pi} X(\Omega) ^2 d\Omega$

Common Fourier Transform Pairs

$x[n]$	$X(\Omega)$
$\delta[n]$	1
$\delta[n - n_0]$	$e^{-j\Omega n_0}$
$x[n] = 1$	$2\pi\delta(\Omega), \Omega \leq \pi$
$e^{j\Omega_0 n}$	$2\pi\delta(\Omega - \Omega_0), \Omega , \Omega_0 \leq \pi$
$\cos \Omega_0 n$	$\pi[\delta(\Omega - \Omega_0) + \delta(\Omega + \Omega_0)], \Omega , \Omega_0 \leq \pi$
$\sin \Omega_0 n$	$-j\pi[\delta(\Omega - \Omega_0) - \delta(\Omega + \Omega_0)], \Omega , \Omega_0 \leq \pi$
$u[n]$	$\pi\delta(\Omega) + \frac{1}{1 - e^{-j\Omega}}, \Omega \leq \pi$
$-u[-n - 1]$	$-\pi\delta(\Omega) + \frac{1}{1 - e^{-j\Omega}}, \Omega \leq \pi$
$a^n u[n], a < 1$	$\frac{1}{1 - ae^{-j\Omega}}$
$-a^n u[-n - 1], a > 1$	$\frac{1}{1 - ae^{-j\Omega}}$
$(n + 1)a^n u[n], a < 1$	$\frac{1}{(1 - ae^{-j\Omega})^2}$
$a^m, a < 1$	$\frac{1 - a^2}{1 - 2a \cos \Omega + a^2}$
$x[n] = \begin{cases} 1 & n \leq N_1 \\ 0 & n > N_1 \end{cases}$	$\frac{\sin[\Omega(N_1 + \frac{1}{2})]}{\sin(\Omega/2)}$
$\frac{\sin Wn}{\pi n}, 0 < W < \pi$	$X(\Omega) = \begin{cases} 1 & 0 \leq \Omega \leq W \\ 0 & W < \Omega \leq \pi \end{cases}$
$\sum_{k=-\infty}^{\infty} \delta[n - kN_0]$	$\Omega_0 \sum_{k=-\infty}^{\infty} \delta(\Omega - k\Omega_0), \Omega_0 = \frac{2\pi}{N_0}$