Table 2-1: Basic properties of the sine and cosine functions.

Property	Equation
Equivalence	$\sin\theta = \cos(\theta - \pi/2)$ or $\cos(\theta) = \sin(\theta + \pi/2)$
Periodicity	$\cos(\theta + 2\pi k) = \cos\theta$, when k is an integer
Evenness of cosine	$\cos(-\theta) = \cos\theta$
Oddness of sine	$\sin(-\theta) = -\sin\theta$
Zeros of sine	$\sin(\pi k) = 0$, when k is an integer
Ones of cosine	$\cos(2\pi k) = 1$ when k is an integer.
Minus ones of cosine	$\cos[2\pi(k + \frac{1}{2})] = -1$, when k is an integer.

Table 2-2: Some basic trigonometric identities.

Number	Equation
1	$\sin^2\theta + \cos^2\theta = 1$
2	$\cos 2\theta = \cos^2\theta - \sin^2\theta$
3	$\sin 2\theta = 2\sin\theta\cos\theta$
4	$\sin(\alpha \pm \beta) = \sin\alpha\cos\beta \pm \cos\alpha\sin\beta$
5	$\cos(\alpha \pm \beta) = \cos\alpha\cos\beta \mp \sin\alpha\sin\beta$

Table 2-3: Phasor Addition Example

Z	=	X	+	jY	Magnitude	Phase	Ph/pi	Ph(deg)
Z1		0.5814		1.597	1.7	1.222	0.389	70.00
Z2		-1.785		-0.6498	1.9	-2.793	-0.889	-160.00
Z3		-1.204		0.9476	1.532	2.475	0.788	141.79

Table 3-1: Complex amplitudes for the periodic signal that approximates the vowel "ah". The a_k coefficients are given for positive indices k, but the values for negative k are the conjugates, $a_{-k} = a_k^*$.

k	f_k (Hz)	a_k	**Mag**	**Phase**
1	100	0	0	0
2	200	$386 + j6101$	6 113	1.508
3	300	0	0	0
4	400	$-4433 + j14024$	14 708	1.877
5	500	$24000 - j4498$	24 418	-0.185
6	600	0	0	0
⋮	⋮	⋮	⋮	⋮
15	1500	0	0	0
16	1600	$828 - j6760$	6 811	-1.449
17	1700	$2362 + j0$	2 362	0

Middle-C	D	E	F	G	A	B	C
262 Hz	294	330	349	392	440	494	523

Table 7-1: Filter coefficients of 24-point FIR bandpass.

$$
\begin{aligned}
b_0 &= -0.0108 = b_{23} \\
b_1 &= 0.0037 = b_{22} \\
b_2 &= -0.0052 = b_{21} \\
b_3 &= 0.0300 = b_{20} \\
b_4 &= 0.0000 = b_{19} \\
b_5 &= -0.0526 = b_{18} \\
b_6 &= 0.0164 = b_{17} \\
b_7 &= -0.0219 = b_{16} \\
b_8 &= 0.1275 = b_{15} \\
b_9 &= 0.0000 = b_{14} \\
b_{10} &= -0.3236 = b_{13} \\
b_{11} &= 0.2330 = b_{12}
\end{aligned}
$$

Table 8-1: Summary of important z-transform properties and pairs.

SHORT TABLE OF z-TRANSFORMS			
	$x[n]$	$\overset{z}{\longleftrightarrow}$	$X(z)$
1.	$ax_1[n] + bx_2[n]$	$\overset{z}{\longleftrightarrow}$	$aX_1(z) + bX_2(z)$
2.	$x[n - n_0]$	$\overset{z}{\longleftrightarrow}$	$z^{-n_0}X(z)$
3.	$y[n] = x[n] * h[n]$	$\overset{z}{\longleftrightarrow}$	$Y(z) = H(z)X(z)$
4.	$\delta[n]$	$\overset{z}{\longleftrightarrow}$	1
5.	$\delta[n - n_0]$	$\overset{z}{\longleftrightarrow}$	z^{-n_0}
6.	$a^n u[n]$	$\overset{z}{\longleftrightarrow}$	$\dfrac{1}{1 - az^{-1}}$

Table 10-1: Values of $|H(j\omega)|$ for several values of ω.

ω	$\lvert H(j\omega)\rvert$
0	1
2	$2/\sqrt{8} = 0.707$
20	$2/\sqrt{404} \approx 0.0995$
∞	0

Table 11-1: Symmetries of the Fourier Transform

$x(t)$	$X(j\omega)$
Real, Even	Real, Even
Real, Odd	Imaginary, Odd
Imaginary, Even	Imaginary, Even
Imaginary, Odd	Real, Odd

Table 11-2: Basic Fourier transform pairs.

Table of Fourier Transform Pairs	
Time-Domain: $x(t)$	***Frequency-Domain:*** $X(j\omega)$
$e^{-at}u(t) \quad (a > 0)$	$\dfrac{1}{a + j\omega}$
$e^{bt}u(-t) \quad (b > 0)$	$\dfrac{1}{b - j\omega}$
$u(t + \frac{1}{2}T) - u(t - \frac{1}{2}T)$	$\dfrac{\sin(\omega T/2)}{\omega/2}$
$\dfrac{\sin(\omega_b t)}{\pi t}$	$[u(\omega + \omega_b) - u(\omega - \omega_b)]$
$\delta(t)$	1
$\delta(t - t_d)$	$e^{-j\omega t_d}$
$u(t)$	$\pi\delta(\omega) + \dfrac{1}{j\omega}$
1	$2\pi\delta(\omega)$
$e^{j\omega_0 t}$	$2\pi\delta(\omega - \omega_0)$
$A\cos(\omega_0 t + \phi)$	$\pi A e^{j\phi}\delta(\omega - \omega_0) + \pi A e^{-j\phi}\delta(\omega + \omega_0)$
$\cos(\omega_0 t)$	$\pi\delta(\omega - \omega_0) + \pi\delta(\omega + \omega_0)$
$\sin(\omega_0 t)$	$-j\pi\delta(\omega - \omega_0) + j\pi\delta(\omega + \omega_0)$
$\displaystyle\sum_{k=-\infty}^{\infty} a_k e^{jk\omega_0 t}$	$\displaystyle\sum_{k=-\infty}^{\infty} 2\pi a_k \delta(\omega - k\omega_0)$
$\displaystyle\sum_{n=-\infty}^{\infty} \delta(t - nT)$	$\dfrac{2\pi}{T}\displaystyle\sum_{k=-\infty}^{\infty} \delta(\omega - \dfrac{2\pi}{T}k)$

Table 11-3: Basic Fourier transform properties.

Table of Fourier Transform Properties		
Property Name	***Time-Domain: $x(t)$***	***Frequency-Domain: $X(j\omega)$***
Linearity	$ax_1(t) + bx_2(t)$	$aX_1(j\omega) + bX_2(j\omega)$
Conjugation	$x^*(t)$	$X^*(-j\omega)$
Time-Reversal	$x(-t)$	$X(-j\omega)$
Scaling	$x(at)$	$\frac{1}{\lvert a\rvert}X(j(\omega/a))$
Delay	$x(t-t_d)$	$e^{-j\omega t_d}X(j\omega)$
Modulation	$x(t)e^{j\omega_0 t}$	$X(j(\omega-\omega_0))$
Modulation	$x(t)\cos(\omega_0 t)$	$\frac{1}{2}X(j(\omega-\omega_0)) + \frac{1}{2}X(j(\omega+\omega_0))$
Differentiation	$\dfrac{d^k x(t)}{dt^k}$	$(j\omega)^k X(j\omega)$
Convolution	$x(t) * h(t)$	$X(j\omega)H(j\omega)$
Multiplication	$x(t)p(t)$	$\frac{1}{2\pi}X(j\omega) * P(j\omega)$

Table 13-1: Types of Fourier transforms.

	Discrete-time	Continuous-time
Discrete Frequency	DFT, $X[k]$	Fourier Series $\{a_k\}$
Continuous Frequency	DTFT, $X(e^{j\hat{\omega}})$	CTFT, $X(j\omega)$

Table 13-2: Number of operations for radix–2 FFT when N is a power of two. Notice how much smaller $\mu_c(N)$ is than $4N^2$.

N	$\mu_c(N)$	$\alpha_c(N)$	$\mu_r(N)$	$\alpha_r(N)$	$4N^2$
2	0	2	0	4	16
4	4	8	16	16	64
8	16	24	64	48	256
16	48	64	192	128	1024
32	128	160	512	320	4096
64	320	384	1280	768	16384
128	768	896	3072	1792	65536
256	1792	2048	7168	4096	262144
⋮	⋮	⋮	⋮	⋮	⋮

Table C-1: Laboratory material on *SP-First* CD-ROM.

Lab	*Subject*	*Cross-Reference*
Lab #1	Introduction to Matlab	Ch. **??**
Lab #2a	Introduction to Complex Exponentials—Multipath	Ch. **??**
Lab #2b	Introduction to Complex Exponentials—Direction Finding	Ch. **??**
Lab #3	AM and FM Sinusoidal Signals	Ch. **??**
Lab #4	Synthesis of Sinusoidal Signals	Ch. **??**
Lab #5	FM Synthesis for Musical Instruments	Ch. **??**
Lab #6	Digital Images: A/D and D/A	Ch. **??**
Lab #7	Sampling, Convolution, and FIR Filtering	Ch. **??**
Lab #8	Frequency Response: Bandpass & Nulling Filters	Ch. **??**
Lab #9	Encoding and Decoding Touch-Tone Signals	Ch. **??** and **??**
Lab #10	Octave Band Filtering	Ch. **??**
Lab #11	PeZ—The z, n, and $\hat{\omega}$ Domains	Ch. **??**
Lab #12	Two Convolution GUIs	Ch. 9
Lab #13	Numerical Evaluation of Fourier Series	Ch. 10
Lab #14a	Design with Fourier Series—Power Supply	Ch. 12
Lab #14b	Design with Fourier Series—Distortion	Ch. 12
Lab #15	Fourier Series	Ch. 12
Lab #16	AM Communication System	Ch. 12
Lab #17	Digital Communication: FSK Modem (Encoding)	Ch. 13
Lab #18	Digital Communication: FSK Modem (Decoding)	Ch. 13
Lab #19	The Fast Fourier Transform	Ch. 13
Lab #20	Extracting Frequencies of Musical Tones	Ch. **??**

Table C-2: Extended DTMF encoding table for Touch Tone dialing. When any key is pressed the tones of the corresponding column and row are generated and summed. Keys A–D (in the fourth column) are not implemented on commercial and household telephone sets, but are used in some military and other signaling applications.

FREQS	1209 Hz	1336 Hz	1477 Hz	1633 Hz
697 Hz	**1**	**2**	**3**	**A**
770 Hz	**4**	**5**	**6**	**B**
852 Hz	**7**	**8**	**9**	**C**
941 Hz	*	**0**	#	**D**