APPENDIX 5
ARITHMETIC REFERENCES

TABLE OF POWERS OF TWO

$(2^n)_{10}$	$(2^n)_{16}$	n	2^{-n}
1	1	0	1.0
2	2	1	0.5
4	4	2	0.25
8	8	3	0.125
16	10	4	0.062 5
32	20	5	0.031 25
64	40	6	0.015 625
128	80	7	0.007 812 5
256	100	8	0.003 906 25
512	200	9	0.001 953 125
1 024	400	10	0.000 976 562 5
2 048	800	11	0.000 488 281 25
4 096	1 000	12	0.000 244 140 625
8 192	2 000	13	0.000 122 070 312 5
16 384	4 000	14	0.000 061 035 156 25
32 768	8 000	15	0.000 030 517 578 125
65 536	10 000	16	0.000 015 258 789 062 5
131 072	20 000	17	0.000 007 629 394 531 25
262 144	40 000	18	0.000 003 814 697 265 625
524 288	80 000	19	0.000 001 907 348 632 812 5
1 048 576	100 000	20	0.000 000 953 674 316 406 25
2 097 152	200 000	21	0.000 000 476 837 158 203 125
4 194 304	400 000	22	0.000 000 238 418 579 101 562 5
8 388 608	800 000	23	0.000 000 119 209 289 550 781 25
16 777 216	1 000 000	24	0.000 000 059 604 644 775 390 625
33 554 432	2 000 000	25	0.000 000 029 802 322 387 695 312 5
67 108 864	4 000 000	26	0.000 000 014 901 161 193 847 656 25
134 217 728	8 000 000	27	0.000 000 007 450 580 596 923 828 125
268 435 456	10 000 000	28	0.000 000 003 725 290 298 461 914 062 5
536 870 912	20 000 000	29	0.000 000 001 862 645 149 230 957 031 25
1 073 741 824	40 000 000	30	0.000 000 000 931 322 574 615 478 515 625
2 147 483 648	80 000 000	31	0.000 000 000 465 661 287 307 739 257 812 5
4 294 967 296	100 000 000	32	0.000 000 000 232 830 643 653 869 628 906 25
8 589 934 592	200 000 000	33	0.000 000 000 116 415 321 826 934 814 453 125
17 179 869 184	400 000 000	34	0.000 000 000 058 207 660 913 467 407 226 562 5
34 359 738 368	800 000 000	35	0.000 000 000 029 103 830 456 733 703 613 281 25
68 719 476 736	1 000 000 000	36	0.000 000 000 014 551 915 228 366 851 806 640 625
137 438 953 472	2 000 000 000	37	0.000 000 000 007 275 957 614 183 425 903 320 312 5
274 877 906 944	4 000 000 000	38	0.000 000 000 003 637 978 807 091 712 951 660 156 25
549 755 813 888	8 000 000 000	39	0.000 000 000 001 818 989 403 545 856 475 830 078 125
1 099 511 627 776	10 000 000 000	40	0.000 000 000 000 909 494 701 772 928 237 915 039 062 5

APPENDIX 5 (Continued)

TABLE OF POWERS OF SIXTEEN

16^n							n
						1	0
						16	1
						256	2
					4	096	3
					65	536	4
				1	048	576	5
				16	777	216	6
				268	435	456	7
			4	294	967	296	8
			68	719	476	736	9
		1	099	511	627	776	10
		17	592	186	044	416	11
		281	474	976	710	656	12
	4	503	599	627	370	496	13
	72	057	594	037	927	936	14
1	152	921	504	606	846	976	15

Decimal Values

1023

HEXADICIMAL TO DECIMAL INTEGER CONVERSION TABLE

BYTE				BYTE			
HEX	DEC	HEX	DEC	HEX	DEC	HEX	DEC
0	0	0	0	0	0	0	0
1	4,096	1	256	1	16	1	1
2	8,192	2	512	2	32	2	2
3	12,288	3	768	3	48	3	3
4	16,384	4	1,024	4	64	4	4
5	20,480	5	1,280	5	80	5	5
6	24,576	6	1,536	6	96	6	6
7	28,672	7	1,792	7	112	7	7
8	32,768	8	2,048	8	128	8	8
9	36,864	9	2,304	9	144	9	9
A	40,960	A	2,560	A	160	A	10
B	45,056	B	2,816	B	176	B	11
C	49,152	C	3,072	C	192	C	12
D	53,248	D	3,328	D	208	D	13
E	57,344	E	3,584	E	224	E	14
F	61,440	F	3,840	F	240	F	15

HEXADECIMAL ADDITION AND SUBTRACTION TABLE

Examples: 5+A = F; 18-D = B; A+B = 15

	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F	
1	2	3	4	5	6	7	8	9	A	B	C	D	E	F	10	1
2	3	4	5	6	7	8	9	A	B	C	D	E	F	10	11	2
3	4	5	6	7	8	9	A	B	C	D	E	F	10	11	12	3
4	5	6	7	8	9	A	B	C	D	E	F	10	11	12	13	4
5	6	7	8	9	A	B	C	D	E	F	10	11	12	13	14	5
6	7	8	9	A	B	C	D	E	F	10	11	12	13	14	15	6
7	8	9	A	B	C	D	E	F	10	11	12	13	14	15	16	7
8	9	A	B	C	D	E	F	10	11	12	13	14	15	16	17	8
9	A	B	C	D	E	F	10	11	12	13	14	15	16	17	18	9
A	B	C	D	E	F	10	11	12	13	14	15	16	17	18	19	A
B	C	D	E	F	10	11	12	13	14	15	16	17	18	19	1A	B
C	D	E	F	10	11	12	13	14	15	16	17	18	19	1A	1B	C
D	E	F	10	11	12	13	14	15	16	17	18	19	1A	1B	1C	D
E	F	10	11	12	13	14	15	16	17	18	19	1A	1B	1C	1D	E
F	10	11	12	13	14	15	16	17	18	19	1A	1B	1C	1D	1E	F
	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F	

1021

HEXADECIMAL MULTIPLICATION AND DIVISION TABLE

Examples: 5x6 = 1E; 75÷D = 9; 58÷8 = B; 9xC = 6C

	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F	
1	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F	1
2	2	4	6	8	A	C	E	10	12	14	16	18	1A	1C	1E	2
3	3	6	9	C	F	12	15	18	1B	1E	21	24	27	2A	2D	3
4	4	8	C	10	14	18	1C	20	24	28	2C	30	34	38	3C	4
5	5	A	F	14	19	1E	23	28	2D	32	37	3C	41	46	4B	5
6	6	C	12	18	1E	24	2A	30	36	3C	42	48	4E	54	5A	6
7	7	E	15	1C	23	2A	31	38	3F	46	4D	54	5B	62	69	7
8	8	10	18	20	28	30	38	40	48	50	58	60	68	70	78	8
9	9	12	1B	24	2D	36	3F	48	51	5A	63	6C	75	7E	87	9
A	A	14	1E	28	32	3C	46	50	5A	64	6E	78	82	8C	96	A
B	B	16	21	2C	37	42	4D	58	63	6E	79	84	8F	9A	A5	B
C	C	18	24	30	3C	48	54	60	6C	78	84	90	9C	A8	B4	C
D	D	1A	27	34	41	4E	5B	68	75	82	8F	9C	A9	B6	C3	D
E	E	1C	2A	38	46	54	62	70	7E	8C	9A	A8	B6	C4	D2	E
F	F	1E	2D	3C	4B	5A	69	78	87	96	A5	B4	C3	D2	E1	F
	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F	

APPENDIX 5 (Continued)

TABLE OF MATHEMATICAL CONSTANTS

CONSTANT	DECIMAL VALUE	HEXADECIMAL VALUE	FLOATING POINT VALUE
			DOUBLE PRECISION / SINGLE PRECISION
π	3.14159 26535 89793 23846	3.243F 6A88 85A3 08D3	4132 43F6 A888 5A31
$\pi-1$	0.31830 98861 83790 67154	0.517C C1B7 2722 0A95	4051 7CC1 B727 220B
$\sqrt{\pi}$	1.77245 38509 05516 02730	1.C5BF 891B 4EF6 AA7A	41[illegible]C 5BF8 91B4 EF[illegible]B
Ln π	1.14472 98858 49400 17414	1.250D 048E 7A1B D0BD	411[illegible] B67A E858 [illegible]CAA
$\sqrt{3}$	1.73205 08075 68877 29353	1.BB67 AE85 84CA A73B	411B [illegible]67AE 8584 [illegible]CAA7
e	2.71828 18284 59045 23536	2.B7E1 5162 8AED 2A6B	412B [illegible]E15 1628 AED3
e -1	0.36787 94411 71442 32160	0.5E2D 58D8 B3BC DF1B	405E 2[illegible]58 D8[illegible]3 BCDF
$\sqrt{e}$	1.64872 12707 00128 14683	1.A612 98E1 E069 BC97	411A 612[illegible] 8[illegible]1E 069C
$\log_{10}e$	0.43429 44819 03251 82765	0.6F2D EC54 9B94 38CB	406F 2DEC [illegible]5A9B 9439
$\log_{2}e$	1.44269 50408 88963 40736	1.7154 7652 B82F E177	4117 1547 [illegible]52B 82FE
γ	0.57721 56649 01532 86061	0.93C4 67E3 7DB0 C7A5	4093 C4[illegible]7 E3[illegible]D B0C8
Ln γ	-0.54953 93129 81644 82234	-0.8CAE 9BC1 1F5A 5FF4	C08C [illegible]E9B C11[illegible] 5A60
$\sqrt{2}$	1.41421 35623 73095 04880	1.6A09 E667 F3BC C909	4116 [illegible]A09E 667F 3BCD
Ln2	0.69314 71805 59945 30942	0.B172 17F7 D1CF 79AC	40B[illegible] 7217 F7D1 [illegible]F7A
$\log_{10}2$	0.30102 99956 63981 19521	0.4D10 4D42 7DE7 FBCC	40[illegible]D 104D 427D E[illegible]FC
$\sqrt{10}$	3.16227 76601 68379 33199	3.298B 075B 4B6A 5240	[illegible]132 98B0 75B4 B6A[illegible]
Ln10	2.30258 50929 94045 68402	2.4D76 3776 AAA2 B05C	4124 D763 776A AA2B

APPENDIX 5 (Continued)
INTEGER CONVERSION TABLE

Hexadecimal and Decimal Integer Conversion Table

HALFWORD								HALFWORD							
BYTE				BYTE				BYTE				BYTE			
BITS: 0123		4567		0123		4567		0123		4567		0123		4567	
Hex	Decimal	Hex	Decimal	Hex	Decimal	Hex	Decimal	Hex	Decimal	Hex	Decimal	Hex	Decimal	Hex	Decimal
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	268,435,456	1	16,777,216	1	1,048,576	1	65,536	1	4,096	1	256	1	16	1	1
2	536,870,912	2	33,554,432	2	2,097,152	2	131,072	2	8,192	2	512	2	32	2	2
3	805,306,368	3	50,331,648	3	3,145,728	3	196,608	3	12,288	3	768	3	48	3	3
4	1,073,741,824	4	67,108,864	4	4,194,304	4	262,144	4	16,384	4	1,024	4	64	4	4
5	1,342,177,280	5	83,886,080	5	5,242,880	5	327,680	5	20,480	5	1,280	5	80	5	5
6	1,610,612,736	6	100,663,296	6	6,291,456	6	393,216	6	24,576	6	1,536	6	96	6	6
7	1,879,048,192	7	117,440,512	7	7,340,032	7	458,752	7	28,672	7	1,792	7	112	7	7
8	2,147,483,648	8	134,217,728	8	8,388,608	8	524,288	8	32,768	8	2,048	8	128	8	8
9	2,415,919,104	9	150,994,944	9	9,437,184	9	589,824	9	36,864	9	2,304	9	144	9	9
A	2,684,354,560	A	167,772,160	A	10,485,760	A	655,360	A	40,960	A	2,560	A	160	A	10
B	2,952,790,016	B	184,549,376	B	11,534,336	B	720,896	B	45,056	B	2,816	B	176	B	11
C	3,221,225,472	C	201,326,592	C	12,582,912	C	786,432	C	49,152	C	3,072	C	192	C	12
D	3,489,660,928	D	218,103,808	D	13,631,488	D	851,968	D	53,248	D	3,328	D	208	D	13
E	3,758,096,384	E	234,881,024	E	14,680,064	E	917,504	E	57,344	E	3,584	E	224	E	14
F	4,026,531,840	F	251,658,240	F	15,728,640	F	983,040	F	61,440	F	3,840	F	240	F	15
8		7		6		5		4		3		2		1	

1025

TO CONVERT HEXADECIMAL TO DECIMAL

1. Locate the column of decimal numbers corresponding to the left-most digit or letter of the hexadecimal; select from this column and record the number that corresponds to the position of the hexadecimal digit or letter.
2. Repeat step 1 for the next (second from the left) position.
3. Repeat step 1 for the units (third from the left) position.
4. Add the numbers selected from the table to form the decimal number.

EXAMPLE	
Conversion of Hexadecimal Value	D34
1. D	3328
2. 3	48
3. 4	4
4. Decimal	3380

To convert integer numbers greater than the capacity of table, use the techniques below:

HEXADECIMAL TO DECIMAL

Successive cumulative multiplication from left to right, adding units position.

Example: $D34_{16} = 3380_{10}$

D = 13
x16
208
3 = + 3
211
x16
3376
4 = +4
3380

1026

TO CONVERT DECIMAL TO HEXADECIMAL

1. (a) Select from the table the highest decimal number that is equal to or less than the number to be converted.
   (b) Record the hexadecimal of the column containing the selected number.
   (c) Subtract the selected decimal from the number to be converted.
2. Using the remainder from step 1(c) repeat all of step 1 to develop the second position of the hexadecimal (and a remainder).
3. Using the remainder from step 2 repeat all of step 1 to develop the units position of the hexadecimal.
4. Combine terms to form the hexadecimal number.

EXAMPLE	
Conversion of Decimal Value	3380
1. D	-3328
	52
2. 3	-48
	4
3. 4	-4
4. Hexadecimal	D34

DECIMAL TO HEXADECIMAL

Divide and collect the remainder in reverse order.

Example: $3380_{10} = X_{16}$

16 | 3380 → remainder 4
16 | 211 → 3
16 | 13 → D

$3380_{10} = D34_{16}$

APPENDIX 5 (Continued)
FRACTION CONVERSION TABLE

Hexadecimal and Decimal Fraction Conversion Table

HALFWORD													
BYTE					BYTE								
BITS 0123		4567			0123				4567				
Hex	Decimal	Hex	Decimal		Hex	Decimal			Hex	Decimal Equivalent			
.0	.0000	.00	.0000	0000	.000	.0000	0000	0000	.0000	.0000	0000	0000	0000
.1	.0625	.01	.0039	0625	.001	.0002	4414	0625	.0001	.0000	1525	8789	0625
.2	.1250	.02	.0078	1250	.002	.0004	8828	1250	.0002	.0000	3051	7578	1250
.3	.1875	.03	.0117	1875	.003	.0007	3242	1875	.0003	.0000	4577	6367	1875
.4	.2500	.04	.0156	2500	.004	.0009	7656	2500	.0004	.0000	6103	5156	2500
.5	.3125	.05	.0195	3125	.005	.0012	2070	3125	.0005	.0000	7629	3945	3125
.6	.3750	.06	.0234	3750	.006	.0014	6484	3750	.0006	.0000	9155	2734	3750
.7	.4375	.07	.0273	4375	.007	.0017	0898	4375	.0007	.0001	0681	1523	4375
.8	.5000	.08	.0312	5000	.008	.0019	5312	5000	.0008	.0001	2207	0312	5000
.9	.5625	.09	.0351	5625	.009	.0021	9726	5625	.0009	.0001	3732	9101	5625
.A	.6250	.0A	.0390	6250	.00A	.0024	4140	6250	.000A	.0001	5258	7890	6250
.B	.6875	.0B	.0429	6875	.00B	.0026	8554	6875	.000B	.0001	6784	6679	6875
.C	.7500	.0C	.0468	7500	.00C	.0029	2968	7500	.000C	.0001	8310	5468	7500
.D	.8125	.0D	.0507	8125	.00D	.0031	7382	8125	.000D	.0001	9836	4257	8125
.E	.8750	.0E	.0546	8750	.00E	.0034	1796	8750	.000E	.0002	1362	3046	8750
.F	.9375	.0F	.0585	9375	.00F	.0036	6210	9375	.000F	.0002	2888	1835	9375
1		2			3				4				

TO CONVERT .ABC HEXADECIMAL TO DECIMAL

Find .A in position 1 .6250

Find .0B in position 2 .0429 6875

Find .00C in position 3 .0029 2968 7500

.ABC Hex is equal to .6708 9843 7500

TO CONVERT .13 DECIMAL TO HEXADECIMAL

1. Find .1250 next lowest to .1300
   subtract -.1250 = .2 Hex
2. Find .0039 0625 next lowest to .0050 0000
   -.0039 0625 = .01
3. Find .0009 7656 2500 .0010 9375 0000
   -.0009 7656 2500 = .004
4. Find .0001 0681 1523 4375 .0001 1718 7500 0000
   -.0001 0681 1523 4375 = .0007
   .0000 1037 5976 5625 = .2147 Hex
5. 13 Decimal is approximately equal to ——————————↑

To convert fractions beyond the capacity of table, use techniques below:

HEXADECIMAL FRACTION TO DECIMAL

Convert the hexadecimal fraction to its decimal equivalent using the same technique as for integer numbers. Divide the results by 16^n (n is the number of fraction positions).

Example: $.8A7 = .540771_{10}$

$8A7_{16} = 2215_{10}$

$16^3 = 4096$

$$4096\overline{)2215.000000}\quad .540771$$

DECIMAL FRACTION TO HEXADECIMAL

Collect integer parts of product in the order of calculation.

Example: $.5408_{10} = .8A7_{16}$

.5408
x16
8 ← [8].6528
x16
A ← [10].4448
x16
7 ← [7].1168

APPENDIX 7

I/O REFERENCES

ASCII/HEX CONVERSION TABLE

BITS				b_6 b_5 b_4	0 0 0	0 0 1	0 1 0	0 1 1	1 0 0	1 0 1	1 1 0	1 1 1
b_3	b_2	b_1	b_0	MSD / LSD	0	1	2	3	4	5	6	7
0	0	0	0	0	NUL	DLE	SPACE	0	@	P	`	p
0	0	0	1	1	SOH	DC1	!	1	A	Q	a	q
0	0	1	0	2	STX	DC2	"	2	B	R	b	r
0	0	1	1	3	ETX	DC3	#	3	C	S	c	s
0	1	0	0	4	EOT	DC4	$	4	D	T	d	t
0	1	0	1	5	ENQ	NAK	%	5	E	U	e	u
0	1	1	0	6	ACK	SYN	&	6	F	V	f	v
0	1	1	1	7	BEL	ETB	'	7	G	W	g	w
1	0	0	0	8	BS	CAN	(	8	H	X	h	x
1	0	0	1	9	HT	EM	)	9	I	Y	i	y
1	0	1	0	A	LF	SUB	*	:	J	Z	j	z
1	0	1	1	B	VT	ESC	+	;	K	[	k	{
1	1	0	0	C	FF	FS	,	<	L	\	l	¦
1	1	0	1	D	CR	GS	–	=	M	]	m	}
1	1	1	0	E	SO	RS	.	>	N	^	n	~
1	1	1	1	F	SI	US	/	?	O	—	o	DEL

NUL	Null
SOH	Start of heading
STX	Start of text
ETX	End of text
EOT	End of transmission
ENQ	Enquiry
ACK	Acknowledge
BEL	Audible signal
BS	Backspace
HT	Horizontal tabulation
LF	Line feed
VT	Vertical tabulation
FF	Form feed
CR	Carrier return
SO	Shift out
SI	Shift in
DLE	Data link escape
DC1-3	Device control
DC4	Device stop
NAK	Negative acknowledge
SYN	Synchronous idle
ETB	End of transmission block
CAN	Cancel
EM	End of medium
SUB	Start of special sequence
ESC	Escape
FS	File separator
GS	Group separator
RS	Record separator
US	Unit separator
SP	Space
DEL	Delete/Idle

ASCII CARD CODE CONVERSION TABLE

GRAPHIC	7-BIT ASCII CODE	CARD CODE	GRAPHIC	7-BIT ASCII CODE	CARD CODE
SPACE	20	BLANK	@	40	8-4
!	21	11-8-2	A	41	12-1
"	22	8-7	B	42	12-2
#	23	8-3	C	43	12-3
$	24	11-8-3	D	44	12-4
%	25	0-8-4	E	45	12-5
&	26	12	F	46	12-6
'	27	8-5	G	47	12-7
(	28	12-8-5	H	48	12-8
)	29	11-8-5	I	49	12-9
*	2A	11-8-4	J	4A	11-1
+	2B	12-8-6	K	4B	11-2
,	2C	0-8-3	L	4C	11-3
-	2D	11	M	4D	11-4
.	2E	12-8-3	N	4E	11-5
/	2F	0-1	O	4F	11-6
0	30	0	P	50	11-7
1	31	1	Q	51	11-8
2	32	2	R	52	11-9
3	33	3	S	53	0-2
4	34	4	T	54	0-3
5	35	5	U	55	0-4
6	36	6	V	56	0-5
7	37	7	W	57	0-6
8	38	8	X	58	0-7
9	39	9	Y	59	0-8
:	3A	8-2	Z	5A	0-9
;	3B	11-8-6	[	5B	12-8-2
<	3C	12-8-4	\	5C	0-8-2
=	3D	8-6	]	5D	12-8-7
>	3E	0-8-6	↑	5E	11-8-7
?	3F	0-8-7	←	5F	0-8-5