

CHAPTER 1

1.1 Base-10: 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32
 Octal: 20 21 22 23 24 25 26 27 30 31 32 33 34 35 36 37 40
 Hex: 10 11 12 13 14 15 16 17 18 19 1A 1B 1C 1D 1E 1F 20
 Base-13 A B C 10 11 12 13 14 15 16 17 18 19 23 24 25 26

1.2 (a) 32,768 (b) 67,108,864 (c) 6,871,947,674

1.3 $(4310)_5 = 4 * 5^3 + 3 * 5^2 + 1 * 5^1 = 580_{10}$
 $(198)_{12} = 1 * 12^2 + 9 * 12^1 + 8 * 12^0 = 260_{10}$
 $(735)_8 = 7 * 8^2 + 3 * 8^1 + 5 * 8^0 = 477_{10}$
 $(525)_6 = 5 * 6^2 + 2 * 6^1 + 5 * 6^0 = 197_{10}$

1.4 14-bit binary: 11_1111_1111_1111
 Decimal: $2^{14} - 1 = 16,383_{10}$
 Hexadecimal: 3FFF₁₆

1.5 Let b = base

(a) $14/2 = (b + 4)/2 = 5$, so b = 6

(b) $54/4 = (5*b + 4)/4 = b + 3$, so $5 * b = 52 - 4$, and b = 8

(c) $(2 * b + 4) + (b + 7) = 4b$, so b = 11

1.6 $(x - 3)(x - 6) = x^2 - (6 + 3)x + 6*3 = x^2 - 11x + 22$

Therefore: $6 + 3 = b + 1$ so b = 8

Also, $6*3 = (18)_{10} = (22)_8$

1.7 68BE = 0110_1000_1011_1110 = 110_100_010_111_110 = (64276)₈

1.8 (a) Results of repeated division by 2 (quotients are followed by remainders):

$431_{10} = 215(1); 107(1); 53(1); 26(1); 13(0); 6(1) \quad 3(0) \quad 1(1)$
 Answer: 1111_1010₂ = FA₁₆

(b) Results of repeated division by 16:

$431_{10} = 26(15); 1(10)$ (Faster)
 Answer: FA = 1111_1010

1.9 (a) $10110.0101_2 = 16 + 4 + 2 + .25 + .0625 = 22.3125$

(b) $16.5_{16} = 16 + 6 + 5*(.0615) = 22.3125$

(c) $26.24_8 = 2 * 8 + 6 + 2/8 + 4/64 = 22.3125$

$$(d) FAFA.B_{16} = 15 \cdot 16^3 + 10 \cdot 16^2 + 15 \cdot 16 + 10 + 11/16 = 64,250.6875$$

$$(e) 1010.1010_2 = 8 + 2 + .5 + .125 = 10.625$$

1.10 (a) $1.10010_2 = 0001.1001_2 = 1.9_{16} = 1 + 9/16 = 1.563_{10}$

(b) $110.010_2 = 0110.0100_2 = 6.4_{16} = 6 + 4/16 = 6.25_{10}$

Reason: 110.010_2 is the same as 1.10010_2 shifted to the left by two places.

1.11

$$\begin{array}{r}
 1011.11 \\
 101 \overline{) 111011.0000} \\
 \underline{101} \\
 01001 \\
 \underline{101} \\
 1001 \\
 \underline{101} \\
 1000 \\
 \underline{101} \\
 0110
 \end{array}$$

The quotient is carried to two decimal places, giving 1011.11

Checking: $111011_2 / 101_2 = 59_{10} / 5_{10} \cong 1011.11_2 = 58.75_{10}$

1.12 (a) 10000 and 110111

$$\begin{array}{r}
 1011 \\
 +101 \\
 \hline
 10000 = 16_{10}
 \end{array}$$

$$\begin{array}{r}
 1011 \\
 \times 101 \\
 \hline
 1011 \\
 1011 \\
 1011 \\
 \hline
 110111 = 55_{10}
 \end{array}$$

(b) 62_h and 958_h

$$\begin{array}{r}
 2E_h \quad 0010_1110 \\
 +34_h \quad 0011_0100 \\
 \hline
 62_h \quad 0110_0010 = 98_{10}
 \end{array}$$

$$\begin{array}{r}
 2E_h \\
 \times 34_h \\
 \hline
 B^38 \\
 8^2A \\
 \hline
 9 \ 5 \ 8_h = 2392_{10}
 \end{array}$$

1.13 (a) Convert 27.315 to binary:

	Integer Quotient		Remainder	Coefficient
$27/2 =$	13	+	$\frac{1}{2}$	$a_0 = 1$
$13/2$	6	+	$\frac{1}{2}$	$a_1 = 1$
$6/2$	3	+	0	$a_2 = 0$
$3/2$	1	+	$\frac{1}{2}$	$a_3 = 1$
$\frac{1}{2}$	0	+	$\frac{1}{2}$	$a_4 = 1$

$$27_{10} = 11011_2$$

	Integer		Fraction	Coefficient
.315 x 2	= 0	+	.630	$a_{-1} = 0$
.630 x 2	= 1	+	.26	$a_{-2} = 1$
.26 x 2	= 0	+	.52	$a_{-3} = 0$
.52 x 2	= 1	+	.04	$a_{-4} = 1$

$$.315_{10} \cong .0101_2 = .25 + .0625 = .3125$$

$$27.315 \cong 11011.0101_2$$

(b) $2/3 \cong .666666667$

	Integer		Fraction	Coefficient
.6666_6666_67 x 2	= 1	+	.3333_3333_34	$a_{-1} = 1$
.333333334 x 2	= 0	+	.6666666668	$a_{-2} = 0$
.6666666668 x 2	= 1	+	.333333336	$a_{-3} = 1$
.333333336 x 2	= 0	+	.6666666672	$a_{-4} = 0$
.6666666672 x 2	= 1	+	.3333333344	$a_{-5} = 1$
.3333333344 x 2	= 0	+	.6666666688	$a_{-6} = 0$
.6666666688 x 2	= 1	+	.3333333376	$a_{-7} = 1$
.3333333376 x 2	= 0	+	.6666666752	$a_{-8} = 0$

$$.666666667_{10} \cong .10101010_2 = .5 + .125 + .0313 + .0078 = .6641_{10}$$

$$.10101010_2 = .1010_2 = .AA_{16} = 10/16 + 10/256 = .6641_{10} \text{ (Same as (b)).}$$

1.14 **(a)** 1000_0000 **(b)** 0000_0000 **(c)** 1101_1010
1s comp: 0111_1111 1s comp: 1111_1111 1s comp: 0010_0101
2s comp: 1000_0000 2s comp: 0000_0000 2s comp: 0010_0110

(d) 0111_0110 **(e)** 1000_0101 **(f)** 1111_1111
1s comp: 1000_1001 1s comp: 0111_1010 1s comp: 0000_0000
2s comp: 1000_1010 2s comp: 0111_1011 2s comp: 0000_0001

1.15 **(a)** 52,784,630 **(b)** 63,325,600
9s comp: 47,215,369 9s comp: 36,674,399
10s comp: 47,215,370 10s comp: 36,674,400

(c) 25,000,000 **(d)** 00,000,000
9s comp: 74,999,999 9s comp: 99,999,999
10s comp: 75,000,000 10s comp: 00,000,000

1.16 B2FA B2FA: 1011_0010_1111_1010
15s comp: 4D05 1s comp: 0100_1101_0000_0101
16s comp: 4D06 2s comp: 0100_1101_0000_0110 = 4D06

1.17 **(a)** 3409 → 03409 → 96590 (9s comp) → 96591 (10s comp)
06428 – 03409 = 06428 + 96591 = 03019

(b) 1800 → 01800 → 98199 (9s comp) → 98200 (10 comp)
125 – 1800 = 00125 + 98200 = 98325 (negative)
Magnitude: 1675
Result: 125 – 1800 = 1675

(c) $6152 \rightarrow 06152 \rightarrow 93847$ (9s comp) $\rightarrow 93848$ (10s comp)

$$2043 - 6152 = 02043 + 93848 = 95891 \text{ (Negative)}$$

Magnitude: 4109

$$\text{Result: } 2043 - 6152 = -4109$$

(d) $745 \rightarrow 00745 \rightarrow 99254$ (9s comp) $\rightarrow 99255$ (10s comp)

$$1631 - 745 = 01631 + 99255 = 0886 \text{ (Positive)}$$

$$\text{Result: } 1631 - 745 = 886$$

1.18 Note: Consider sign extension with 2s complement arithmetic.

(a) 10001

1s comp: 01110

2s comp: 01111

10011

Diff: 00010

(b) 100011

1s comp: 1011100 with sign extension

2s comp: 1011101

0100010

1111111 sign bit indicates that the result is negative

0000001 2s complement

-000001 result

(c) 101000

1s comp: 1010111

2s comp: 1011000

001001

Diff: 1100001 (negative)

0011111 (2s comp)

-011111 (diff is -31)

(d) 10101

1s comp: 1101010 with sign extension

2s comp: 1101011

110000

0011011 sign bit indicates that the result is positive

Check: $48 - 21 = 27$

1.19 $+9286 \rightarrow 009286$; $+801 \rightarrow 000801$; $-9286 \rightarrow 990714$; $-801 \rightarrow 999199$

(a) $(+9286) + (801) = 009286 + 000801 = 010087$

(b) $(+9286) + (-801) = 009286 + 999199 = 008485$

(c) $(-9286) + (+801) = 990714 + 000801 = 991515$

(d) $(-9286) + (-801) = 990714 + 999199 = 989913$

1.20 $+49 \rightarrow 0_110001$ (Needs leading zero indicate + value); $+29 \rightarrow 0_011101$ (Leading 0 indicates + value)

$-49 \rightarrow 1_001111$; $-29 \rightarrow 1_100011$

(a) $(+29) + (-49) = 0_011101 + 1_001111 = 1_101100$ (1 indicates negative value.)

Magnitude = 0_010100 ; Result $(+29) + (-49) = -20$

(b) $(-29) + (+49) = 1_100011 + 0_110001 = 0_010100$ (0 indicates positive value)

$(-29) + (+49) = +20$

(c) Must increase word size by 1 (sign extension) to accomodate overflow of values:

$(-29) + (-49) = 11_100011 + 11_001111 = 10_110010$ (1 indicates negative result)

Magnitude: $1_001110 = 78_{10}$

Result: $(-29) + (-49) = -78$

1.21 +9742 → 009742 → 990257 (9's comp) → 990258 (10s comp)
+641 → 000641 → 999358 (9's comp) → 999359 (10s comp)

(a) (+9742) + (+641) → 010383

(b) (+9742) + (-641) → 009742 + 999359 = 009102
Result: (+9742) + (-641) = 9102

(c) -9742 + (+641) = 990258 + 000641 = 990899 (negative)
Magnitude: 009101
Result: (-9742) + (641) = -9101

(d) (-9742) + (-641) = 990258 + 999359 = 989617 (Negative)
Magnitude: 10383
Result: (-9742) + (-641) = -10383

1.22 8,723
BCD: 1000_0111_0010_0011
ASCII: 0_011_1000_011_0111_011_0010_011_0001

1.23

1000	0100	0010	(842)
<u>0101</u>	<u>0011</u>	<u>0111</u>	(+537)
1101	0111	1001	
<u>0110</u>			
0001	0011	0111	0101 (1,379)

(a)	(b)
6 3 1 1 Decimal	6 4 2 1 Decimal
0 0 0 0 0	0 0 0 0 0
0 0 0 1 1	0 0 0 1 1
0 0 1 0 2	0 0 1 0 2
0 1 0 0 3	0 0 1 1 3
0 1 1 0 4 (or 0101)	0 1 0 0 4
0 1 1 1 5	0 1 0 1 5
1 0 0 0 6	1 0 0 0 6 (or 0110)
1 0 1 0 7 (or 1001)	1 0 0 1 7
1 0 1 1 8	1 0 1 0 8
1 1 0 0 9	1 0 1 1 9

1.25

(a) 5,137 ₁₀	BCD: 0101_0011_0111
(b)	Excess-3: 1000_0100_0110_1010
(c)	2421: 1011_0001_0011_0111
(d)	6311: 0111_0001_0100_1001

1.26 5,137 9s Comp: 4,862
2421 code: 0100_1110_1100_1000
1s comp: 1011_0001_0011_0111 same as (c) in 1.25

1.27 For a deck with 52 cards, we need 6 bits ($32 < 52 < 64$). Let the msb's select the suit (e.g., diamonds, hearts, clubs, spades are encoded respectively as 00, 01, 10, and 11. The remaining four bits select the "number" of the card. Example: 0001 (ace) through 1011 (9), plus 101 through 1100 (jack, queen, king). This a jack of spades might be coded as 11_1010. (Note: only 52 out of 64 patterns are used.)

1.28 G (dot) (space) B o o l e
01000111_11101111_01101000_01101110_00100000_11000100_11101111_11100101

1.29 Bill Gates

1.30 73 F4 E5 76 E5 4A EF 62 73

73: 0_111_0011 s
F4: 1_111_0100 t
E5: 1_110_0101 e
76: 0_111_0110 v
E5: 1_110_0101 e
4A: 0_100_1010 j
EF: 1_110_1111 o
62: 0_110_0010 b
73: 0_111_0011 s

1.31 $62 + 32 = 94$ printing characters

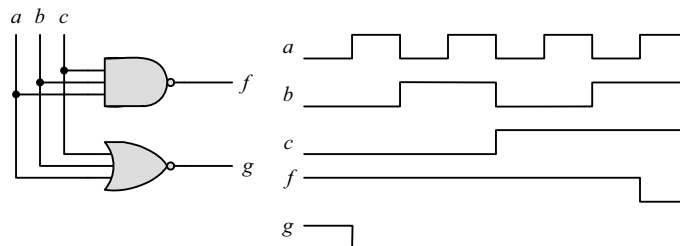
1.32 bit 6 from the right

1.33 (a) 897 (b) 564 (c) 871 (d) 2,199

1.34 ASCII for decimal digits with odd parity:

(0): 10110000 (1): 00110001 (2): 00110010 (3): 10110011
(4): 00110100 (5): 10110101 (6): 10110110 (7): 00110111
(8): 00111000 (9): 10111001

1.35 (a)



1.36

