

Chapter 2

7. (a) $110011.11 = 1 \times 2^5 + 1 \times 2^4 + 1 \times 2^3 + 1 \times 2^0 + 1 \times 2^{-1} + 1 \times 2^{-2}$
 $= 32 + 16 + 2 + 1 + 0.5 + 0.25 = 51.75$
 (b) $101010.01 = 1 \times 2^5 + 1 \times 2^3 + 1 \times 2^1 + 1 \times 2^{-2} = 32 + 8 + 2 + 0.25$
 $= 42.25$
 (c) $1000001.111 = 1 \times 2^6 + 1 \times 2^0 + 1 \times 2^{-1} + 1 \times 2^{-2} + 1 \times 2^{-3}$
 $= 64 + 1 + 0.5 + 0.25 + 0.125 = 65.875$
 (d) $1111000.101 = 1 \times 2^6 + 1 \times 2^5 + 1 \times 2^4 + 1 \times 2^3 + 1 \times 2^{-1} + 1 \times 2^{-3}$
 $= 64 + 32 + 16 + 8 + 0.5 + 0.125 = 120.625$
 (e) $1011100.10101 = 1 \times 2^6 + 1 \times 2^4 + 1 \times 2^3 + 1 \times 2^2 + 1 \times 2^{-1} + 1 \times 2^{-3} + 1 \times 2^{-5}$
 $= 64 + 16 + 8 + 4 + 0.5 + 0.125 + 0.03125$
 $= 92.65625$
 (f) $1110001.0001 = 1 \times 2^6 + 1 \times 2^5 + 1 \times 2^4 + 1 \times 2^0 + 1 \times 2^{-4}$
 $= 64 + 32 + 16 + 1 + 0.0625 = 113.0625$
 (g) $1011010.1010 = 1 \times 2^6 + 1 \times 2^4 + 1 \times 2^3 + 1 \times 2^2 + 1 \times 2^{-1} + 1 \times 2^{-3}$
 $= 64 + 16 + 8 + 2 + 0.5 + 0.125 = 90.625$
 (h) $1111111.11111 = 1 \times 2^6 + 1 \times 2^5 + 1 \times 2^4 + 1 \times 2^3 + 1 \times 2^2 + 1 \times 2^1 + 1 \times 2^{-1} + 1 \times 2^{-2} + 1 \times 2^{-3} + 1 \times 2^{-4} + 1 \times 2^{-5}$
 $= 64 + 32 + 16 + 8 + 4 + 2 + 1 + 0.5 + 0.25 + 0.125 + 0.0625 + 0.03125$
 $= 127.96875$

9. (a) $(2^4 - 1) < 17 < (2^5 - 1)$; 5 bits
 (b) $(2^5 - 1) < 35 < (2^6 - 1)$; 6 bits
 (c) $(2^5 - 1) < 49 < (2^6 - 1)$; 6 bits
 (d) $(2^6 - 1) < 68 < (2^7 - 1)$; 7 bits
 (e) $(2^6 - 1) < 81 < (2^7 - 1)$; 7 bits
 (f) $(2^6 - 1) < 114 < (2^7 - 1)$; 7 bits
 (g) $(2^7 - 1) < 132 < (2^8 - 1)$; 8 bits
 (h) $(2^7 - 1) < 205 < (2^8 - 1)$; 8 bits

14. (a) $0.98 \times 2 = 1.96$ 1 (MSB)
 $0.96 \times 2 = 1.92$ 1
 $0.92 \times 2 = 1.84$ 1
 $0.84 \times 2 = 1.68$ 1
 $0.68 \times 2 = 1.36$ 1
 $0.36 \times 2 = 0.72$ 0
 continue if more accuracy is desired
 0.111110
 (b) $0.347 \times 2 = 0.694$ 0 (MSB)
 $0.694 \times 2 = 1.388$ 1
 $0.388 \times 2 = 0.776$ 0
 $0.776 \times 2 = 1.552$ 1
 $0.552 \times 2 = 1.104$ 1
 $0.104 \times 2 = 0.208$ 0
 $0.208 \times 2 = 0.416$ 0
 continue if more accuracy is desired
 0.0101100

(c) $0.9028 \times 2 = 1.8056$ 1 (MSB)
 $0.8056 \times 2 = 1.6112$ 1
 $0.6112 \times 2 = 1.2224$ 1
 $0.2224 \times 2 = 0.4448$ 0
 $0.4448 \times 2 = 0.8896$ 0
 $0.8896 \times 2 = 1.7792$ 1
 $0.7792 \times 2 = 1.5584$ 1
 continue if more accuracy is desired
 0.1110011

16. (a) $\begin{array}{r} 11 \\ -01 \\ \hline 10 \end{array}$ (b) $\begin{array}{r} 101 \\ -100 \\ \hline 001 \end{array}$ (c) $\begin{array}{r} 110 \\ -101 \\ \hline 001 \end{array}$
 (d) $\begin{array}{r} 1110 \\ -0011 \\ \hline 1011 \end{array}$ (e) $\begin{array}{r} 1100 \\ -1001 \\ \hline 0011 \end{array}$ (f) $\begin{array}{r} 11010 \\ -10111 \\ \hline 00011 \end{array}$

17. (a) $\begin{array}{r} 11 \\ \times 11 \\ \hline 11 \\ 11 \\ \hline 1001 \end{array}$ (b) $\begin{array}{r} 100 \\ \times 10 \\ \hline 000 \\ 100 \\ \hline 1000 \end{array}$ (c) $\begin{array}{r} 111 \\ \times 101 \\ \hline 111 \\ 000 \\ 1001 \\ \hline 100011 \end{array}$ (d) $\begin{array}{r} 1001 \\ \times 110 \\ \hline 0000 \\ 1001 \\ 1001 \\ \hline 10110 \end{array}$
 (e) $\begin{array}{r} 1101 \\ \times 1101 \\ \hline 1101 \\ 0000 \\ 1101 \\ 1101 \\ \hline 10101001 \end{array}$ (f) $\begin{array}{r} 1110 \\ \times 1101 \\ \hline 1110 \\ 0000 \\ 1110 \\ 1110 \\ \hline 10110110 \end{array}$

20. Zero is represented by all 0's only in 2's complement.

22. Take the 1's complement and add 1:

(a) $01 + 1 = 10$ (b) $000 + 1 = 001$
 (c) $0110 + 1 = 0111$ (d) $0010 + 1 = 0011$
 (e) $00011 + 1 = 00100$ (f) $01100 + 1 = 01101$
 (g) $01001111 + 1 = 01010000$ (h) $11000010 + 1 = 11000011$

25. (a) Magnitude of 12 = 1100
 $+12 = 00001100$ (b) Magnitude of 68 = 1000100
 $-68 = 10111100$
 (c) Magnitude of $101_{10} = 1100101$
 $+101_{10} = 01100101$ (d) Magnitude of 125 = 1111101
 $-125 = 10000011$

28. (a) $10011001 = -(1100111) = -103$
 (b) $01110100 = +(1110100) = +116$
 (c) $10111111 = -(1000001) = -65$

30. (a) $11000000101001001110001000000000$
 Sign = 1
 Exponent = $10000001 = 129 - 127 = 2$
 Mantissa = $1.01001001110001 \times 2^2 = 101.001001110001$
 $-101.001001110001 = -5.15258789$

- (b) $01100110010000111110100100000000$
 Sign = 0
 Exponent = $11001100 = 204 - 127 = 77$
 Mantissa = 1.100001111101001
 $1.100001111101001 \times 2^{77}$

34. (a)
$$\begin{array}{r} 00110011 \\ - 00010000 \\ \hline \end{array}$$
 (b)
$$\begin{array}{r} 00110011 \\ + 11110000 \\ \hline 00100011 \end{array}$$
 (c)
$$\begin{array}{r} 01100101 \\ - 11101000 \\ \hline \end{array}$$

$$\begin{array}{r} 01100101 \\ + 00011000 \\ \hline 01111101 \end{array}$$

39. (a) $23_{16} = 2 \times 16^1 + 3 \times 16^0 = 32 + 3 = 35$
 (b) $92_{16} = 9 \times 16^1 + 2 \times 16^0 = 144 + 2 = 146$
 (c) $1A_{16} = 1 \times 16^1 + 10 \times 16^0 = 16 + 10 = 26$
 (d) $8D_{16} = 8 \times 16^1 + 13 \times 16^0 = 128 + 13 = 141$
 (e) $F3_{16} = 15 \times 16^1 + 3 \times 16^0 = 240 + 3 = 243$
 (f) $EB_{16} = 14 \times 16^1 + 11 \times 16^0 = 224 + 11 = 235$
 (g) $5C2_{16} = 5 \times 16^2 + 12 \times 16^1 + 2 \times 16^0 = 1280 + 192 + 2 = 1474$
 (h) $700_{16} = 7 \times 16^2 = 1792$

42. (a) $51_{16} - 40_{16} = 11_{16}$
 (b) $C8_{16} - 3A_{16} = 8E_{16}$
 (c) $FD_{16} - 88_{16} = 75_{16}$

49. (a) $104 = 0001\ 0000\ 0100$
 (b) $128 = 0001\ 0010\ 1000$
 (c) $132 = 0001\ 0011\ 0010$
 (d) $150 = 0001\ 0101\ 0000$
 (e) $186 = 0001\ 1000\ 0110$
 (f) $210 = 0010\ 0001\ 0000$
 (g) $359 = 0011\ 0101\ 1001$
 (h) $547 = 0101\ 0100\ 0111$
 (i) $1051 = 0001\ 0000\ 0101\ 0001$

52. (a)
$$\begin{array}{r} 0010 \\ + 0001 \\ \hline 0011 \end{array}$$
 (b)
$$\begin{array}{r} 0101 \\ + 0011 \\ \hline 1000 \end{array}$$
 (c)
$$\begin{array}{r} 0111 \\ + 0010 \\ \hline 1001 \end{array}$$

 (d)
$$\begin{array}{r} 1000 \\ + 0001 \\ \hline 1001 \end{array}$$
 (e)
$$\begin{array}{r} 00011000 \\ + 00010001 \\ \hline 00101001 \end{array}$$
 (f)
$$\begin{array}{r} 01100100 \\ + 00110011 \\ \hline 10010111 \end{array}$$

 (g)
$$\begin{array}{r} 01000000 \\ + 01000111 \\ \hline 10000111 \end{array}$$
 (h)
$$\begin{array}{r} 10000101 \\ + 00010011 \\ \hline 10011000 \end{array}$$

56. (a) $1+1+0+1+1$ Binary
 $1\ 0\ 1\ 1\ 0$ Gray
 (b) $1+0+0+1+0+1+0$ Binary
 $1\ 1\ 0\ 1\ 1\ 1\ 1$ Gray
 (c) $1+1+1+1+0+1+1+1+0+1+1+0$ Binary
 $1\ 0\ 0\ 0\ 1\ 1\ 0\ 0\ 1\ 1\ 0\ 0\ 1$ Gray

57. (a) $1\ 0\ 1\ 0$ Gray
 $1\ 1\ 0\ 0$ Binary
 (b) $0\ 0\ 0\ 1\ 0$ Gray
 $0\ 0\ 0\ 1\ 1$ Binary
 (c) $1\ 1\ 0\ 0\ 0\ 0\ 1\ 0\ 0\ 0\ 1$ Gray
 $1\ 0\ 0\ 0\ 0\ 0\ 1\ 1\ 1\ 1\ 0$ Binary

60. (a) $1\ 10100100$ (b) $0\ 00001001$ (c) $1\ 11111110$