CHAPTER 3

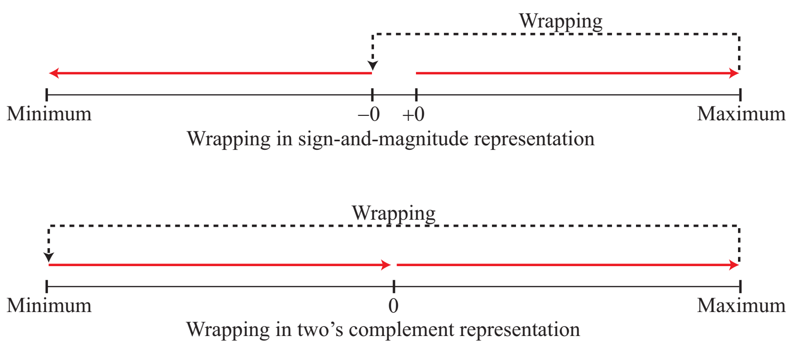
Data Storage

(Solutions to Odd-Numbered Problems)

Review Questions

1. We discussed five data types: number, text, audio, image, and video.
3. In the bitmap graphic method each pixel is represented by a bit pattern.
5. The three steps are sampling, quantization, and encoding.
7. In both representations, the upper half of the range represents the negative numbers. However, the wrapping is different as shown in Figure S3.7. In addition, there are two zeros in sign-and-magnitude but only one in two's complement.

Figure S3.7



9. In both systems, the leftmost bit represents the sign. If the leftmost bit is 0, the number is positive; if it is 1, the number is negative.

Multiple-Choice Questions

11. c 13. d 15. b 17. a 19. a 21. d
23. c 25. d 27. b

Exercises

29. $10^2 = 100$ if zero is allowed. $9^2 = 81$ if zero is not allowed.

31. $2^n = 8 \rightarrow n = 3$ or $\log_2 8 = 3$

33. $2^n = 900 \rightarrow n \approx 10$ or $\log_2 900 = 9.81 \rightarrow 10$. With $n = 10$ we can uniquely assign $2^{10} = 1024$ bit pattern. Then 1024 – 900 = 124 patterns are unassigned. These unassigned patterns are not sufficient for extra 300 employees. If the company hires 300 new employees, it is needed to increase the number of bits to 11.

35. 256 level can be represented by 8 bits because $2^8 = 256$. Therefore, the number of bits per seconds is

$$(8000 \text{ sample/ sec}) \times (8 \text{ bits / sample}) = 64{,}000 \text{ bits /seconds}$$

37.

a. $41 = 32 + 8 + 1 = (0000\ 0000\ 0010\ 1001)_2$

b. $411 = 256 + 128 + 16 + 8 + 2 + 1 = (0000\ 0001\ 1001\ 1011)_2$

c. $1234 = 1024 + 128 + 64 + 16 + 2 = (0000\ 0100\ 1101\ 0010)_2$

d. $342 = 256 + 64 + 16 + 4 + 2 = (0000\ 0001\ 0101\ 0110)_2$

39.

a. 102 =

Convert 102 to binary	0	0	0	0	0	0	0	0	0	1	1	0	0	1	1	0

b. –179 =

Convert 179 to binary	0	0	0	0	0	0	0	0	1	0	1	1	0	0	1	1
	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓
Apply two's complement operation	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**0**	**1**	**0**	**0**	**1**	**1**	**0**	1

c. 534 =

Convert 534 to binary	0	0	0	0	0	0	1	0	0	0	0	1	0	1	1	0

d. Overflow occurs because 62,056 is not in the range –32768, +32767

41.

a. 0111 0111 =

Leftmost bit is 0. The sign is +	0	1	1	1	0	1	1	1
Integer changed to decimal								119
Sign is added								+ 119

b. 1111 1100 =

Leftmost bit is 1. The sign is –	1	1	1	1	1	1	0	0
	↓	↓	↓	↓	↓	↓	↓	↓
Apply two's complement operation	**0**	**0**	**0**	**0**	**0**	**1**	0	0
Integer changed to decimal								4
Sign is added								–4

c. 0111 0100 =

Leftmost bit is 0. The sign is +	0	1	1	1	0	1	0	0
Integer changed to decimal								116
Sign is added								+ 116

d. 1100 1110 =

Leftmost bit is 1. The sign is –	1	1	0	0	1	1	1	0
	↓	↓	↓	↓	↓	↓	↓	↓
Apply two's complement operation	**0**	**0**	**1**	**1**	**0**	**0**	1	0
Integer changed to decimal								50
Sign is added								–50

43.

a. 01110111 → 10001001 → 01110111

b. 11111100 → 00000100 → 11111100

c. 01110100 → 10001100 → 01110100

d. 11001110 → 00110010 → 11001110

45. Answers are shown with space between the three parts for clarity

a. S = 1,
E = 0 + 127 = 127 = $(01111111)_2$,
M = 10001 (plus 18 zero added at the right to make the number of bits 23)
→ **1 01111111 10001000000000000000000**

b. S = 0,
E = 3 + 127 = 130 = $(10000010)_2$,
M = 111111 (plus 17 zero added at the right)
→ **0 10000010 11111100000000000000000**

c. S = 0
E = –4 + 127 = 123 = $(01111011)_2$,

M = 01110011 (plus 15 zero added at the right)
→ **0 01111011 01110011000000000000000**

d. S = 1
E = –5 + 127 = 122 = $(01111010)_2$,
M = 01101000 (plus 15 zero added at the right)
→ **1 01111010 01101000000000000000000**

47. Answers are shown with spaces between the three parts for clarity

a. 7.1875 = $(111.0011)_2 = 2^2 \times 1.110011$
S = 0
E = 2 + 127 = 129 = $(10000001)_2$
M = 110011 (plus 17 zero at the right)
→ **0 10000001 11001100000000000000000**

b. –12.640625 = $(–1100.101001)_2 = – 2^3 \times 1.100101001$
S = 1
E = 3 + 127 = 130 = $(10000010)_2$
M = 100101001 (plus 14 zero at the right)
→ **1 10000010 10010100100000000000000**

c. 11.40625 = $(1011.01101)_2 = 2^3 \times 1.01101101$
S = 0
E = 3 + 127 = 130 = $(10000010)_2$
M = 01101101 (plus 15 zero at the right)
→ **0 10000010 01101101000000000000000**

d. –0.375 = –0.011 = $– 2^{–2} \times 1.1$
S = 1
E = –2 + 127 =125 = $(01111101)_2$
M = 1 (plus 22 zero at the right)
→ **1 01111101 10000000000000000000000**

49.

a. 53 = 32 + 16 + 4 + 1 =

+	0	32	16	0	4	0	1		
↓	↓	↓	↓	↓	↓	↓	↓		
0	0	1	1	0	1	0	1	=	**0011 0101**

b. –107 = – (64 + 32 + 8 + 2 + 1) =

–	64	32	0	8	0	2	1		
↓	↓	↓	↓	↓	↓	↓	↓		
1	1	1	0	1	0	1	1	=	**1110 1011**

c. –5 = – (4+1) = 10000101

–	0	0	0	0	4	0	1		
↓	↓	↓	↓	↓	↓	↓	↓		
1	0	0	0	0	1	0	1	=	**1000 0101**

d. 154 creates overflow because 154 is not in the range –127 to +127

51.

a. $(01110111)_2$ =

Leftmost bit is 0. The sign is +	0	1	1	1	0	1	1	1
Integer changed to decimal								119
Sign is added								+119

b. $(11111100)_2$ =

Leftmost bit is 1. The sign is –	1	1	1	1	1	1	0	0
	↓	↓	↓	↓	↓	↓	↓	↓
Apply one's complement operation	**0**	**0**	**0**	**0**	**0**	**0**	1	1
Integer changed to decimal								3
Sign is added								–3

c. $(01110100)_2$ =

Leftmost bit is 0. The sign is +	0	1	1	1	0	1	0	0
Integer changed to decimal								116
Sign is added								+116

d. $(11001110)_2$ =

Leftmost bit is 1. The sign is –	1	1	0	0	1	1	1	0
	↓	↓	↓	↓	↓	↓	↓	↓
Apply one's complement operation	**0**	**0**	**1**	**1**	**0**	**0**	0	1
Integer changed to decimal								49
Sign is added								–49

53.

a. $(01110111)_2$

One's complement =	10001000	Two's complement =	10001001
	+1		
	10001001		

b. $(11111100)_2$

One's complement =	00000011	Two's complement =	00000100
	+1		
	00000100		

c. $(01110100)_2$

One's complement =	10001011 +1 10001100	Two's complement =	10001100

d. $(11001110)_2$

One's complement =	00110001 +1 00110010	Two's complement =	00110010

55.

a. +234 → 234
b. +560 → Overflow because 560 is not in the range –499 to 499
c. –125 → 874
d. –111 → 888

57.

a. +234 → 234
b. +560 → Overflow because 560 is not in the range –500 to 499
c. –125 → 874 + 1 = 875
d. –111 → 888 + 1 = 889

59.

a. $(+B14)_{16} \rightarrow (B14)_{16}$
b. $(+FE1)_{16} \rightarrow$ Overflow because it is not in the range $(-7FF)_{16}$ to $(7FF)_{16}$
c. $(-1A)_{16} = (-01A)_{16} \rightarrow (FE5)_{16}$
d. $(-1E2)_{16} \rightarrow (E1D)_{16}$

61.

a. $(+B14)_{16} \rightarrow (B14)_{16}$
b. $(+FE1)_{16} \rightarrow$ Overflow because it is not in the range $(-800)_{16}$ to $(7FF)_{16}$
c. $(-1A)_{16} = (-01A)_{16} \rightarrow (FE5 +1)_{16} = (FE6)_{16}$
d. $(-1E2)_{16} \rightarrow (E1D +1)_{16} = (E1E)_{16}$