CHAPTER 3

Data Storage

(Solutions to Review Questions and Problems)

Review Questions

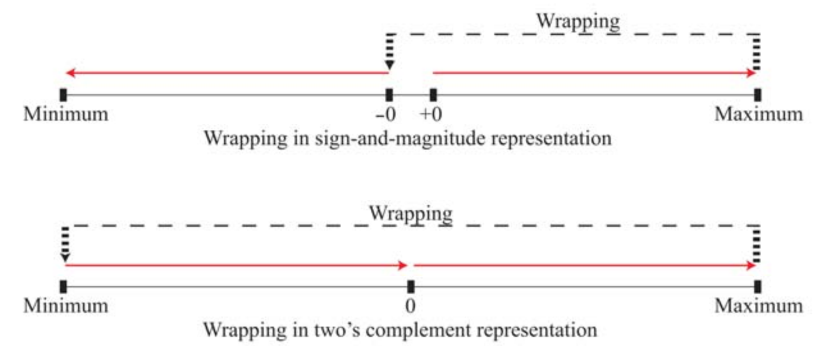
Q3-1. We discussed five data types: numbers, text, audio, images, and video.

Q3-3. In the bitmap graphic method each pixel is represented by a bit pattern.

Q3-5. The three steps are sampling, quantization, and encoding.

Q3-7. In both representations, the upper half of the range represents the negative numbers. However, the wrapping is different as shown in Figure Q3.7. In addition, there are two zeros in sign-and-magnitude but only one in two's complement.

Figure Q3.7 *Wrapping for two number representations*



Q3-9. 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.

Problems

P3-1. $2^5 = 32$ patterns.

P3-3.

a. If zero is allowed, (10^2 for numbers) × (26^3 for letters) = 1757600.
b. If zero is not allowed, (9^2 for numbers) × (26^3 for letters) = 1423656.

P3-5. $2^n = 7 \rightarrow n \approx 3$ or $\log_2 7 = 2.81 \rightarrow 3$.

P3-7. $2^4 - 10 = 6$ are wasted.

P3-9.

a. $23 = 16 + 4 + 2 + 1 = (0000\ 1011)_2$
b. $121 = 64 + 32 + 16 + 8 + 1 = (0111\ 1001)_2$
c. $34 = 32 + 2 = (0010\ 0010)_2$.
d. Overflow occurs because 342 > 255.

P3-11.

a. The number −12 =

Convert 12 to binary	0	0	0	0	1	1	0	0
	↓	↓	↓	↓	↓	↓	↓	↓
Apply two's complement operation	**1**	**1**	**1**	**1**	**0**	1	0	0

b. Overflow occurs because −145 is not in the range −128 to +127.

c. The number 56 =

Convert 56 to binary	0	0	1	1	1	0	0	0

d. Overflow occurs because 142 is not in the range −128 to +127.

P3-13.

a. 0110 1011 = 64 + 32 + 8 + 2 +1 = 107.
b. 1001 0100 = 128 + 16 + 4 = 148.
c. 0000 0110 = 4 + 2 = 6.
d. 0101 0000 = 64 + 16 = 80.

P3-15. We change the sign of the number by applying the two's complement operation.

a. 01110111 → 10001001

b. 11111100 → 00000100

c. 01110111 → 10001001

d. 11001110 → 00110010

P3-17.

a.

1.10001	$= 2^0 \times 1.10001$

b.

$2^3 \times 111.1111$	$= 2^5 \times 1.111111$

c.

$2^{-2} \times 101.110011$	$= 2^0 \times 1.01001100$

d.

$2^{-5} \times 101101.00000110011000$	$= 2^0 \times 1.01101000000110011000$

P3-19. Answers are shown with spaces between the three parts for clarity:

a. S = 1
E = 0 + 1023 = 1023 = $(01111111111)_2$,
M = 10001 (plus 47 zero added at the right)
→ **1 01111111111 1000100000000000000000000000000000000000000000000000**

b. S = 0
E = 3 + 1023 = 1026 = $(10000000010)_2$
M = 111111 (plus 46 zero added at the right)
→**010000000010 1111110000000000000000000000000000000000000000000000**

c. S = 0
E = –4 + 1023 = 1019 = $(01111111011)_2$

M = 01110011 (plus 44 zero added at the right)

→ **0 01111111011 0111001100000000000000000000000000000000000000000000**

d. S = 1

E = −5 + 1023 = $(01111111010)_2$

M = 01101000 (plus 44 zero added at the right)

→ **1 01111111010 0110100000000000000000000000000000000000000000000000**

P3-21.

a. $(01110111)_2$ =

0	1	1	1	0	1	1	1		
↓	↓	↓	↓	↓	↓	↓	↓		
+	64	32	16	0	4	2	1	→	**+119**

b. $(11111100)_2$ =

1	1	1	1	1	1	0	0		
↓	↓	↓	↓	↓	↓	↓	↓		
−	64	32	16	8	4	2	1	→	**−124**

c. $(01110100)_2$ =

0	1	1	1	0	1	0	0		
↓	↓	↓	↓	↓	↓	↓	↓		
+	64	32	16	0	4	0	0	→	**+116**

d. $(11001110)_2$ =

1	1	0	0	1	1	1	0		
↓	↓	↓	↓	↓	↓	↓	↓		
−	64	0	0	8	4	2	0	→	**−78**

P3-23.

a. $(53)_{16}$ =

Convert 53 to binary	0	1	0	1	0	0	1	1

b. $(-107)_{16}$ =

Convert 107 to binary	0	1	1	0	1	0	1	1
	↓	↓	↓	↓	↓	↓	↓	↓
Apply one's complement operation	**1**	**0**	**0**	**1**	**0**	**1**	**0**	**0**

c. $(-5)_{16}$ =

Convert 5 to binary	0	0	0	0	0	1	0	1
	↓	↓	↓	↓	↓	↓	↓	↓
Apply one's complement operation	**1**	**1**	**1**	**1**	**1**	**0**	**1**	**0**

d. $(154)_{16}$ = Overflow because 154 is not in the range of −127 to 127

P3-25.

a. 01110111 → 10001000 → 01110111
b. 11111100 → 00000011 → 11111100
c. 01110100 → 10001011 → 01110100
d. 11001110 → 00110001 → 11001110

P3-27.

a. With 3 digits we can express $10^3 = 1000$ integers, 500 for positives and 500 negatives. Then we can represent numbers in the range of −499 to 499.

b. The first digit determine the sign of the number. The number is positive if the first digit is 0 to 4 and negative if the first digit is 5 to 9.

c. We have two zeros, one positive and one negative.

d. +0 = 000 and −0 = 999.

P3-29.

a. With 3 digits we can represent $10^3 = 1000$ integers, 500 for zero and positives and 500 for negatives. Then we can represent numbers in the range of −500 to 499.

b. The first digit determine the sign of the number. The number is zero or positive if the first digit is 0 to 4 and negative if the first digit is 5 to 9.

c. No, there is only one representation for zero (0 = 000).

d. NA.

P3-31.

a. With 3 digits we can represent $16^3 = 4096$ integers, 2048 for positives and 2048 for negatives. Then we can represent numbers in the range of $(-7FF)_{16}$ to $(7FF)_{16}$.

b. The fifteen's complement of a positive number is itself. To find the fifteen complement of negative numbers, we subtract each digit from 15.

c. We have two zeros, a positive zero and a negative zero.

d. $+0 = (000)_{16}$ and $-0 = (EEE)_{16}$.

P3-33.

a. With 3 digits we can represent $16^3 = 4096$ integers, 2048 for zero and positives and 2048 for negatives. Then we can represent numbers in the range of $(-800)_{16}$ to $(7FF)_{16}$.

b. If the number is positive, the complement of the number is itself. If the number is negative we find the fifteen's complement and add 1 to it.

c. No, there is only one zero, $(000)_{16}$.

d. NA.