

You are expected to solve homework problems individually. If needed, you may seek help from your friends. However, do not copy. Show all steps with your solutions for full credit. Use additional papers if needed. Make sure you write your name on first page.

Name: Key**/ 50**

1. (10 points) Complete the following table:

Base10	Base2	Base16
243	11110011	F3
172	10101100	AC
241	11110001	F1
145	10010001	91
226	11100010	E2
36	00100100	24
195	11000011	C3
49	00110001	31
79	01001111	4F
123	01111011	7B

2. (5 points) The following decimal numbers are to be stored in a 6-bit 2's complement format. Show how they are stored

a) +14

Positive numbers are just converted to binary = 001110

b) -20

+20 = 010100
Complement every bit = 101011
Add 1 = 1

-20 is stored as 10110 0

c) +37

Cannot be stored, the range of 6 bit number is $-32 \leq n \leq 31$. Converting 37 to binary would give 100101, but that represents a negative number.

d) +25

Positive numbers are just converted to binary = 011001

e) -45

Cannot be stored, the range of 6 bit number is $-32 \leq n \leq 31$

3. (5 points) What is this number?

10110012 = ?₁₀

Answer: depends on the representation!

- a. Unsigned: 1011001₂ = 89₁₀
- b. Signed-magnitude: 1011001₂ = -25₁₀
- c. Two's complement: 1011001₂ = -39₁₀

4. (5 points) What are the overflow detection rules?

Overflow occurs when the value affects the sign bit:

- ✚ Adding two positives yields a negative
- ✚ Adding two negatives gives a positive
- ✚ No overflow when adding a positive and a negative number

5. (5 points) The following 6-bit 2's complement numbers were found in a computer. What decimal number do they represent?

a) 010000

Because it begins with 0, it is positive = 16

b) 011001

Because it begins with 0, it is positive = 16 + 8 + 1 = 25

c) 101011

Because it begins with 1, it is negative = $-32 + 8 + 2 + 1 = -21$

d) 100100

Because it begins with 1, it is negative = $-32 + 4 = -28$

e) 100000

Because it begins with 1, it is negative = -32

6. (10 points) Each of the following pairs of signed (2's complement) numbers are stored in computer (6 bits). Compute the sum as it is stored in a 6-bit computer word. Show the decimal equivalents of each operand and the sum. Indicate if there is overflow.

a)	001010		+ 10
	010100	+	+ 20
	<hr/>		
	011110		+30

b)	111110		- 2
	001100	+	+ 12
	<hr/>		
	001010		+ 10

c)	001010		+ 10
	011000		+ 24
	<hr/>		
	100010		+ 34

Looks like -30; should be +34; overflow
Sum of two positive numbers looks negative

d)	101001		- 23
	110001		- 15
	<hr/>		
	011010		- 38

Looks like +26; should be -38; overflow; sum of two negative numbers looks positive

e)
$$\begin{array}{r} 101010 \\ 100110 \\ \hline 010000 \end{array} \quad \begin{array}{r} -22 \\ + -26 \\ \hline -48 \end{array}$$

010000 \rightarrow Looks like +16; should be -48; overflow
sum of two negative numbers looks positive

7. (10 points) For each of the following pairs of signed integers (2's complement), subtract the second from the first. Indicate overflow where appropriate

a)
$$\begin{array}{r} 111010 \\ 000111 \end{array}$$

111010 \rightarrow Because it begins with 1, it is negative = $-32 + 16 + 8 + 2 = -6$

000111 \rightarrow Because it begins with 0, it is positive = $4 + 2 + 1 = 7$

2's complement of the subtrahend \rightarrow 111001

$$111010 + 111001 = 110011$$

Check = $-6 - (+7) = -6 - 7 = -13$

b)
$$\begin{array}{r} 100100 \\ 011000 \end{array}$$

100100 \rightarrow Because it begins with 1, it is negative = $-32 + 4 = -28$

011000 \rightarrow Because it begins with 0, it is positive = $16 + 8 = 24$

2's complement of the subtrahend \rightarrow 101000

$$100100 + 101000 = 001100$$

Check = $-28 - 24 = -52$

Positive number \rightarrow overflow

c)
$$\begin{array}{r} 010001 \\ 011000 \end{array}$$

010001 \rightarrow Because it begins with 0, it is positive = $16 + 1 = 17$

011000 \rightarrow Because it begins with 0, it is positive = $16 + 8 = 24$

2's complement of the subtrahend \rightarrow 101000

101000 \longrightarrow Because it begins with 1, it is negative = $-32 + 8 = -24$

$$010001 + 101000 = 111001$$

$$\text{Check} = 17 + (-24) = -7$$


d) 010000
100100

010000 \longrightarrow Because it begins with 0, it is positive = 16

2's complement of the subtrahend \longrightarrow 011100

011100 \longrightarrow Because it begins with 0, it is positive = $16 + 8 + 4 = 28$

$$010000 + 011100 = 101100$$

 Negative number \longrightarrow overflow