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1 Binary arithmetic

1.1 Tell if the following computations can be performed using 8-bit unsigned numbers – you don't need to give the result, just state if it is possible or not. If calculation is not possible state reason why.

a) 27 + 55 → Possible
b) 13 – 19 → Result is signed number → Impossible
c) 39 – 16 → Possible
d) 359 – 219 → 359 and 219 can't be represented in 8-bit → Impossible
e) 192 + 71 = 263 → Can't be presented in 8-bit → Impossible
f) 42 + 33 → Possible

1.2 Convert the following hexadecimal numbers to decimal.

a) $0x19 = 1 \cdot 16^1 + 9 \cdot 16^0 = 25$
b) $0x100 = 1 \cdot 16^2 = 256$
c) $0xBEEF = 11 \cdot 16^3 + 14 \cdot 16^2 + 14 \cdot 16^1 + 15 \cdot 16^0 = 48879$
d) $0xACE = 10 \cdot 16^2 + 12 \cdot 16^1 + 14 \cdot 16^0 = 2766$
e) $0x2022 = 2 \cdot 16^3 + 2 \cdot 16^1 + 2 \cdot 16^0 = 8226$
f) $0xAC0DE5 = 10 \cdot 16^5 + 12 \cdot 16^4 + 13 \cdot 16^2 + 14 \cdot 16^1 + 5 \cdot 16^0 = 11275749$

1.3 Convert following base-10 numbers to binary and calculate using 2-complement arithmetic. Remember: $P - Q = P + (-Q)$. Use enough bits so that no overflow occurs. State the minimum number of bits needed for each assignment.

a) 67 – 5

```
  1 1000 1111
+  0100 0011
   1111 1010
  ----------
   0011 1110
```

→ Minimum number of bits: 8

b) 123 + 998 – 754 = 1121 – 754

```
  1 1000 0000 0011
+  0100 0110 0001
   1101 0000 1101
  ---------------
   0001 0110 1111
```

→ Minimum number of bits: 12

c) 45 – 124

```
  0 0001 1111
+  0010 1101
   1000 0011
  ----------
   1011 0001
```

→ Minimum number of bits: 8

d) -78 – 23

$$\begin{array}{r} 1\ 1100\ 0001 \\ +\ \ 1011\ 0010 \\ \hline 1110\ 1000 \\ \hline 1001\ 0001 \end{array}$$

→ Minimum number of bits: 8

1.4 Assume that following numbers are all signed 16-bit numbers that have been written with hexadecimal digits.

A = 0xABBA = 1010 1011 1011 1010 → -A = 0101 0100 0100 0110
B = 0x0ACE = 0000 1010 1100 1110 → -B = 1111 0101 0011 0010
C = 0x1974 = 0001 1001 0111 0100 → -C = 1110 0110 1000 1100
Calculate the following and indicate if an overflow occurred in the calculation:

a) A + B

$$\begin{array}{rr} & 0\ 0001\ 0111\ 1111\ 110 \\ A & \ \ 1010\ 1011\ 1011\ 1010 \\ B & +\ \ 0000\ 1010\ 1100\ 1110 \\ \hline & 1011\ 0110\ 1000\ 1000 \end{array}$$

→ No overflow occured

b) C – A

$$\begin{array}{rr} & 0\ 0010\ 0000\ 1000\ 100 \\ C & \ \ 0001\ 1001\ 0111\ 0100 \\ -A & +\ \ 0101\ 0100\ 0100\ 0110 \\ \hline & 0110\ 1101\ 1011\ 1010 \end{array}$$

→ No overflow occured

c) B + C

$$\begin{array}{rr} & 0\ 0011\ 0111\ 1111\ 100 \\ B & \ \ 0000\ 1010\ 1100\ 1110 \\ C & +\ \ 0001\ 1001\ 0111\ 0100 \\ \hline & 0010\ 0100\ 0100\ 0010 \end{array}$$

→ No overflow occured

d) A – C

$$\begin{array}{rl} & 1\ 1101\ 1111\ 0111\ 000 \\ A & 1010\ 1011\ 1011\ 1010 \\ -C \quad + & \underline{1110\ 0110\ 1000\ 1100} \\ & 1\ 1001\ 0010\ 0100\ 0110 \end{array}$$

→ No overflow occured