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Fund. of Comp. Systems
HW 1
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1.

(a) Binary

10011100

$2^7 + 2^4 + 2^3 + 2^2 = 156$

01111000

$2^6 + 2^5 + 2^4 + 2^3 = 120$

(b) One's complement

10011100 -> 01100011

$-(2^6 + 2^5 + 2^1 + 2^0) = -99$

01111000 -> 01111000

$2^6 + 2^5 + 2^4 + 2^3 = 120$

(c) Two's complement

10011100

$-2^7 + 2^4 + 2^3 + 2^2 = -100$

01111000

$2^6 + 2^5 + 2^4 + 2^3 = 120$

The number 01111000 is the same in for each because it has no leading 1.

2.

(a) Given 12 bits in two's complement, the most positive number one could represent is

011111111111 base 2 = 2047 base 10.

The most negative number is

100000000000 base 2 = -2048 base 10.

(b) Assuming a word represented an address in memory, the PDP-8 could address 2^{12} = 4096 different locations. There are a few ways to arrive at this answer. One way is by the fact that there are 2 possibilities for the position of each bit and thus 2^{12} possibilities for the ordered bits. Another is to see that there are 2047 numbers greater than 0 that can be represented, 2048 numbers less than zero and zero (2047+2048+1=4096).

3. DEAD

(a) Binary D = 1101, E = 1110, A = 1010, so DEAD = 1101111010101101

(b) Octal

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1 101 111 010 101 101
1 5   7   2   5   5   -> 157255
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(c) Decimal 13*16^3 + 14*16^2 + 10*16^1 + 13*16^0 = 57,005

(d) Binary-Coded Decimal 0101 0111 0000 0000 0101
5 7 0 0 5 -> 57005

4. 2 + -7 = -5

(a) Signed-magnitude numbers
We represent our numbers in 4 bit binary with a sign bit as the 4th.
2 -> 0010, -7 -> 1111, -5 -> 1101
To do the addition, because the signs differ we subtract the smaller.

$$\begin{array}{r} 111 \\ -\underline{010} \\ 101 \end{array}$$

We then return it with the sign of the larger number: 1101.

(b) One's complement
2 -> 0010, -7 -> 1000, -5 -> 1010
Addition is done as we would with unsigned binary.

$$\begin{array}{r} 0010 \\ +\underline{1000} \\ 1010 \end{array}$$

(c) Two's complement
2 -> 0010, -7 -> 1001, -5 -> 1011
Again, addition is done in the usual way.

$$\begin{array}{r} 0010 \\ +\underline{1001} \\ 1011 \end{array}$$

5. BCD Addition

$$\begin{array}{rr} 1 & 0001 \\ 42 & 0100\ 0010 \\ +\underline{49} & +\underline{0100\ 1001} \\ 91 & 1001\ 0001 \end{array}$$

6.

(a) $XY\overline{Z} + X\overline{Y}Z + \overline{X}YZ$
(b) $(X + Y)(Y + Z)(X + \overline{Z})$

X	Y	Z	a	b
0	0	0	0+0+0 = 0	(0)(0)(1) = 0
0	0	1	0+0+0 = 0	(0)(1)(0) = 0
0	1	0	0+0+0 = 0	(1)(1)(1) = 1
0	1	1	0+0+1 = 1	(1)(1)(0) = 0

1	0	0	0+0+0 = 0	(1)(0)(1) = 0
1	0	1	0+1+0 = 1	(1)(1)(1) = 1
1	1	0	1+0+0 = 1	(1)(1)(1) = 1
1	1	1	0+0+0 = 0	(1)(1)(1) = 1