1. Give the 1's complement of each binary number	ber:	er:	nary numł	ch bin	each	of	lement	compl	1's	e the	Give	1.
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a.	00011010	b. 11110111	c.	10001101

Give using three methods, the 2's complement of each of the binary numbers:

a 01010	h 11100	c 10001	d 10101 01
a. 01010	D. 11100	C. 10001	0.10101.01

### Solution:

1's complement (00011010) =11100101; 1's complement (11110111) =00001000;

1's complement (10001101) =01110010

2's complement (01010) = 100000 - 01010 = 10110;

2's complement (01010) = 1's complement (01010) + 1 = 10101 + 1 = 10110

2's complement (11100) = 100000 - 11100 = 00100;

2's complement (11100) = 1's complement (11100) + 1 = 00011 + 1 = 00100

2's complement (10001) = 100000 - 10001 = 01111;

2's complement (10001) = 1's complement (10001) + 1 = 01110 + 1 = 01111

- 2's complement (10101,01) = 100000,00 10101,01 = 01010,11;
- 2's complement (10101,01) = 1's complement (10101,01) + 0,01 = 01010,10 + 0,01 = 01010,11
- 2. Give the decimal value of the signed binary number 10010101, expressed in 8-bit sign-magnitude representation.

Give the decimal value of the signed binary numbers 010101 and 110101 expressed in 6-bit two's complement representation.

# Solution :

- 8-bit sign-magnitude representation of the signed binary number 10010101 = -21;
- 6-bit 2's complement signed representation of the signed binary number 010101 = +21;
- 6-bit 2's complement signed representation of the signed binary number 110101
  - = -(110101) = 2's complement (110101) = -(001011) = -11
- 3. Assume numbers are represented in 8-bit twos complement representation. Show the calculation of the following:
  - a. 6 + 13 b. -6 + 13 c. 6 13 d. -6 13 s.

Solution :

+6	00000110	-6	11111010	+6	00000110	-6	11111010
+13	00001101	+13	00001101	-13	11110011	-13	11110011
+19	00010011	+7	00000111	-7	11111001	-19	11101101

4. Give the value of the following number in 8-bit 1's complement representation; 8-bit 2's complement signed representation and 8-bit sign-magnitude representation.

a. -32 b. +128 c. -128 d. +127

Give the decimal value of the signed number  $(B7)_{16}$  expressed in 8-bit two's complement representation.

## Solution :

Number	8-bit sign-magnitude representation	8-bit 2's complement signed representation
-32	10100000	11100000
+128	No representation	No representation
-128	No representation	1000000

 $(B7)_{16} = 10110111 = -(10110111) = -two's complement (10110111) = -(01001001) = -73$ 

5. Add the following using 2's complement representation in 8-bit register. Also check overflow/underflow.

a. 15-6b. 16-24c. -5-9d. 125+58e. -62-89Perform, in signed binary using 2's complement notation, the operation:  $0011 \times 1011$ , check the<br/>result by performing the operation in decimal. Conclusion.

#### Solution:

In decimal:  $3 \times (-5) = -(3 \times 5) = -15$ 

Conclusion: Multiplication is performed between absolute values, the result is final if the operands have the same sign. If the operands have different signs, the result is complemented by 2.

- 6. Give the value of the following number in 8-bit 1's complement representation; 8-bit 2's
  - complement signed representation and 8-bit sign-magnitude representation.
  - a. +88 b. -88 c. -127 d. +127

### Solution :

Number	+88	-88	-127	+127
8-bit 1's complement representation of	01011000	10100111	1000000	01111111
8-bit 2's complement signed representation of	01011000	10101000	10000001	01111111
8-bit sign-magnitude representation of	01011000	11011000	11111111	01111111

7. Add the following using 2's complement representation in 8-bit register. Also check overflow/underflow.

b. +45+(-65) b. -27+(-101) c. +27+101 d. -103+(-69)

#### Solution:

Detecting Overflow/Underflow

Carry Bit	Sign Bit	Status
0	0	No Overflow/Underflow
1	1	
0	1	Overflow
1	0	Underflow

2's Complement Representation         +45+(-65)         sent 45 in binary $\rightarrow$ 00101101         sent -65 by 2's complement $\rightarrow$ 11101100 $0$ 0       0		-127 - 1000 0000 m -127 - 1000 0001 -128 - 1000 0000	1000 1000 inary val	ues incre	-1 -1 1111 1111 -2 -1 1111 1111 1111 -3 -1111 1110 case by 1	+2 0000 0010 +1 0000 0001 0 0000 0001 0 0000 000	g the ca	arry bit)	$\begin{array}{c} +122 \\ +126 \\ +126 \\ +125 \\ +127 \\ +127 \\ -9111 \\ 1191 \\ -9111 \\ 1191 \\ -9111 \\ 1191 \\ -9111 \\ $	
$\begin{array}{rrrr} +45+(-65) \\ \text{sent 45 in binary} \\ \text{sent -65 by 2's complement} \\ \begin{array}{rrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrrr$				2's Com	plement	Represer	ntation			
sent 45 in binary sent -65 by 2's complement $\rightarrow$ 11101100 $\begin{array}{c c c c c c c c c c c c c c c c c c c $	+	45+(–65	)							
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	rese	ent 45 in	binary			$\rightarrow$ 001(	01101			
$\begin{array}{ c c c c c c c c c c c c c c c c c c c$	rese	ent –65	by 2's co	mpleme	nt		→ 111	01100		
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$		0	1	1	1	1	1	1		
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$		0	0	1	0	1	1	0	1	45
1       1       1       0       1       1       0       0       -20         into Sign-Bit       = 0       0       out of Sign-Bit       = 0       0       0       0       -20         fore, no overflow       -27+(-101)       oresent $\rightarrow$ 11100101       0       1       -27         oresent       -101 by 2's complement $\rightarrow$ 10011011       1       -27         1       0       0       1       1       0       1       -27         1       0       0       1       1       0       1       -27         1       0       0       1       1       0       1       -27         1       0       0       1       1       0       1       -27         1       0       0       1       1       0       1       -27         1       0       0       1       1       0       1       -27         1       0       0       1       1       0       -128          = 1       refore, no everflow       +27+101       -10       1       101         prestor.       0       0		1	0	1	1	1	1	1	1	-65
into Sign-Bit = 0 out of Sign-Bit = 0 fore, no overflow -27+(-101) present -27 by 2's complement $\rightarrow$ 10011011 $\frac{1}{1}$ $\frac{1}{1}$		1	1	1	0	1	1	0	0	-20
$\begin{array}{ c c c c c c c c c c c c c c c c c c c$	b. – Repro	·27+(-10 esent -27 esent -10	)1) by 2's co 1 by 2's	ompleme complem	nt ent	→ → 10011	11100 011	101		
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$\begin{array}{c ccccccccccccccccccccccccccccccccccc$		1	1	1	0	0	1	0	1	-27
$\frac{1}{10000000000000000000000000000000000$		1	0	0	1	1	0	1	1	-101
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	arry arry <mark>her</mark> o	out of Sign-l out of Sign efore, no o	Bit n-Bit verflow	= 1 = 1						
1       0       0       0       0       0       0       0       128         rry into Sign-Bit       = 1         rry out of Sign-Bit       = 0         erefore, overflow $-103+(-69)$ present $-103$ by 2's complement $\rightarrow$ 10011001         present $-69$ by 2's complement $\rightarrow$ 10111011         1       0       1       1       1         1       0       1       1       0       1 $-103$ 1       0       1       1       0       1 $-69$ 0       1       0       1       0 $-172$ rry into Sign-Bit       = 0       = 0 $-772$ $-772$ rry out of Sign-Bit       = 1 $-772$ $-772$ $-772$	C. + Repr Repr	27+101 resent 27 resent 101	in binary in binary 1 0	$\begin{array}{c} \rightarrow 00\\ \gamma \rightarrow 01\\ \hline 1\\ 0 \end{array}$	0011011 100101 1 1	1	1 0	<u>1</u> 1	1 1	27
1       0       1       1       1       1       1       1         1       0       0       1       1       0       0       1       -103         1       0       1       1       1       0       1       -103         1       0       1       1       1       0       1       1       -69         0       1       0       1       0       1       0       -472         rry into Sign-Bit       = 0       = 0	C. + Repr Repr	27+101 resent 27 resent 101 0 0 1	in binary in binary 1 0 1 0	$\begin{array}{c} \rightarrow 00\\ y \rightarrow 01\\ \hline 1\\ 0\\ 1\\ 0 \end{array}$	0011011 100101 1 1 0 0	1 1 0 0	1 0 1 0	1 1 0 0	1 1 1 0	27 101 <del>128</del>
1     0     0     1     1     0     0     1     -103       1     0     1     1     1     0     1     1     -69       0     1     0     1     0     1     0     -472       rry into Sign-Bit     = 0       rry out of Sign-Bit     = 1	C. + Repr Repr O Carr Carr Carr Carr Repr Repr	27+101 resent 27 resent 101 0 0 1 y into Sign- y out of Sig efore, over ·103+(-6 esent -10	in binary in binary 0 1 0 Bit (n-Bit cflow 59) 03 by 2's	$\begin{array}{c} \rightarrow 00\\ y \rightarrow 01\\ \hline 1\\ 0\\ = 1\\ = 0\\ \hline s \text{ complements} \end{array}$	0011011 100101 1 1 0 0 0	1 0 0 → 100	1 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	1 / 1 0 / 0 0 / 1 0 / 1 11011	1 1 0	27 101 <del>128</del>
1     0     1     1     1     0     1     1     -69       0     1     0     1     0     1     0     -69       rry into Sign-Bit     = 0       rry out of Sign-Bit     = 1	C. + Repr Repr 0 Carry Carry Ther d Repr Repr	27+101 resent 27 resent 101 1 0 0 1 y into Sign- y out of Sig efore, over ·103+(-6 esent -10 esent -60	in binary in binary 1 0 1 0 Bit (n-Bit rflow 59) 03 by 2's 9 by 2's	$\begin{array}{c} \rightarrow 00\\ y \rightarrow 01\\ \hline 1\\ 0\\ 1\\ 0\\ = 1\\ = 0\\ \hline s \text{ complem}\\ \hline 1\\ \hline 1\\ \end{array}$	0011011 100101 1 1 0 0 0 0 0 0 0	1 0 0 → 100	1 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	1   1   0   0   0   0   0   0   0   0	1 1 0	27 101 <del>128</del>
0         1         0         1         0         -172           rry into Sign-Bit         = 0           rry out of Sign-Bit         = 1           perfore underflow	C. + Repr Repr Carr Carr Carr Carr Carr Repr Repr Repr	27+101 resent 27 resent 101 1 0 0 1 y into Sign- y out of Sig efore, over ·103+(-6 esent -11 esent -6 0 1	in binary in binary 1 0 1 <b>Bit</b> (n-Bit (n-Bit (flow) 59) 03 by 2's 9 by 2's 1 0	$\begin{array}{c} \rightarrow 00\\ y \rightarrow 01\\ \hline 1\\ 0\\ 1\\ 0\\ = 1\\ = 0\\ s \text{ complem}\\ \hline 1\\ 0\\ \hline 0\\ \end{array}$	0011011 100101 1 1 0 0 0 0 0 0	1 1 0 0 → 100	1 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	1 1 0 0 1 1 1 1 1 0 0	1 1 0	27 101 <del>128</del> -103
rry out of Sign-Bit = 1	C. + Repr Repr Carry Carry Carry Carry Carry Carry Carry Carry Carry Carry Carry Carry Carry Carry 1	27+101 resent 27 resent 101 1 0 0 1 y into Sign- y out of Sig efore, over ·103+(-6 esent -11 esent -69 0 1 1	in binary in binary 1 0 1 <b>Bit</b> (n-Bit (n-Bit)	$\begin{array}{c} \rightarrow 00\\ y \rightarrow 01\\ \hline 1\\ 0\\ = 1\\ = 0\\ s \text{ complem}\\ \hline 1\\ 0\\ 1\\ 0\\ 1\\ 0\\ 1\\ 0\\ 1\\ 0\\ 0\\ 0\\ 1\\ 0\\ 0\\ 0\\ 0\\ 0\\ 0\\ 0\\ 0\\ 0\\ 0\\ 0\\ 0\\ 0\\$	0011011 100101 1 1 0 0 0 0 1 1 1 1 1 1	1 0 0 0 → 100	1 0 1 0 0 0 0 0 0 0 0 0 0	1 1 0 0 1 1 1 0 1 0 1 0	1 1 0 0	27 101 128 -103 -69
profere underflow	C. + Repr Repr O Carry Carry Carry Carry Carry Carry Repr 1	27+101 resent 27 resent 101 1 0 0 1 y into Sign- y out of Sig efore, over ·103+(-6 esent -10 esent -60 1 1 1 0 0 0	in binary in binary 1 0 1 1 0 8 8 8 8 7 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9	$\begin{array}{c} \rightarrow 00\\ y \rightarrow 01\\ \hline 1\\ 0\\ 1\\ 0\\ = 1\\ = 0\\ s \text{ complem}\\ \hline 1\\ 0\\ 1\\ 0\\ 1\\ 0\\ - 0\\ \end{array}$	0011011 100101 1 1 0 0 0 0 1 1 1 1 1 1 1 1 1	1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	1 0 1 0 0 0 0 0 0 1 0 0 0 1	1 0 0 0 1 1 0 1 0 1 0	1 1 0 1 1 1 1 1 1 1 0	27 101 128
ereiore, undernow	Carry Carry Carry Carry Carry Carry Carry Repr 1	27+101 resent 27 resent 101 1 0 0 1 y into Sign- y out of Sig efore, over ·103+(-6 esent -10 esent -60 1 1 1 0 y into Sign- y out of Sig	in binary in binary in binary 1 0 1 <b>Bit</b> (n-Bit (n-Bit 59) 03 by 2's 9 by 2's 1 0 0 1 - Bit (n-Bit (n-Bit) 1	$\begin{array}{c} \rightarrow 00\\ y \rightarrow 01\\ \hline 1\\ 0\\ 1\\ 0\\ = 1\\ = 0\\ s \text{ complem}\\ \hline 1\\ 0\\ 1\\ 0\\ = 0\\ = 1\\ \end{array}$	0011011 100101 1 1 0 0 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1	1 0 0 0 0 0 0 0 0 0 0 0 0 0	1 0 1 0 0 0 0 0 1 0 0 1 0 0 1	1 0 0 0 1 1 0 1 0 1 0 0	1 1 0 1 1 1 1 1 1 1 0	27 101 128 -103 -69 -172