

Digital Media

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What we will Cover

- Base₂
 - Addition
 - Subtraction

Binary Addition

Binary Addition

- Binary Addition Rules: 4 rules!

A	B	A + B
0	0	0
0	1	1
1	0	1
1	1	10

2 in decimal

Binary Addition

- Add individual bits!
- Follow the 4 rules of addition!
- Carry “1” if applicable!

A	B	A + B
0	0	0
0	1	1
1	0	1
1	1	10

$$\begin{array}{r} 10101 \\ + 11001 \\ \hline \end{array}$$

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$$1 + 1 = 10$$

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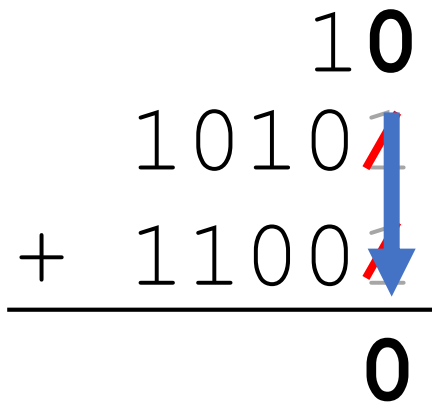
$$\begin{array}{r} 10 \\ 1010\cancel{1} \\ + 1100\cancel{1} \\ \hline \end{array}$$



$$1 + 1 = 10$$

Binary Addition

- Add individual bits!
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0	0	0
0	1	1
1	0	1
1	1	10

$$\begin{array}{r} 10 \\ 1010 \\ + 1100 \\ \hline 0 \end{array}$$


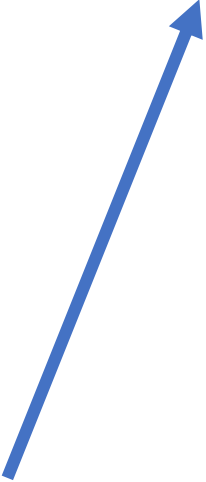

$$1 + 1 = 10$$

Binary Addition

- Add individual bits!
- Follow the 4 rules of addition!
- Carry “1” if applicable!

$$\begin{array}{r} 1 \\ 101\cancel{0}\cancel{1} \\ + 110\cancel{0}\cancel{1} \\ \hline 0 \end{array}$$

$$0 + 0 = 0$$



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0	0	0
0	1	1
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$$\begin{array}{r} 0 \\ 1 \\ 101\cancel{0}\cancel{1} \\ + 110\cancel{0}\cancel{1} \\ \hline 0 \end{array}$$

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Binary Addition

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$$\begin{array}{r} 01 \\ 1 \\ 101\cancel{0}\cancel{1} \\ + 110\cancel{0}\cancel{1} \\ \hline 0 \end{array}$$

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0	0	0
0	1	1
1	0	1
1	1	10


$$0 + 1 = 1$$

Binary Addition

- Add individual bits!
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- Carry “1” if applicable!

$$\begin{array}{r} \cancel{0} \\ \cancel{1} \\ 101\cancel{0}\cancel{1} \\ + 110\cancel{0}\cancel{1} \\ \hline 10 \end{array}$$

A	B	A + B
0	0	0
0	1	1
1	0	1
1	1	10


$$0 + 1 = 1$$

Binary Addition

- Add individual bits!
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$$\begin{array}{r} \cancel{0} \\ \cancel{1} \\ 10\mathbf{1} \cancel{0} \cancel{1} \\ + 11\mathbf{0} \cancel{0} \cancel{1} \\ \hline 10 \end{array}$$

A	B	A + B
0	0	0
0	1	1
1	0	1
1	1	10


$$1 + 0 = 1$$

Binary Addition

- Add individual bits!
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$$\begin{array}{r} \cancel{0} \\ \cancel{1} \\ 10\cancel{1}\cancel{0}\cancel{1} \\ + 11\cancel{0}\cancel{0}\cancel{1} \\ \hline 110 \end{array}$$

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0	0	0
0	1	1
1	0	1
1	1	10


$$1 + 0 = 1$$

Binary Addition

- Add individual bits!
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$$\begin{array}{r} \cancel{0} \\ \cancel{1} \\ 1\mathbf{0} \cancel{1} \cancel{0} \cancel{1} \\ + 1\mathbf{1} \cancel{0} \cancel{0} \cancel{1} \\ \hline 110 \end{array}$$

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Binary Addition

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A	B	A + B
0	0	0
0	1	1
1	0	1
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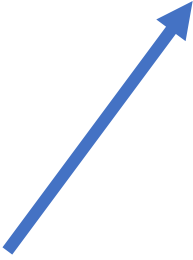

$$0 + 1 = 1$$

Binary Addition

- Add individual bits!
- Follow the 4 rules of addition!
- Carry “1” if applicable!

$$\begin{array}{r} \cancel{0} \\ \cancel{1} \\ 1 \cancel{0} \cancel{1} \cancel{0} \cancel{1} \\ + 1 \cancel{1} \cancel{0} \cancel{0} \cancel{1} \\ \hline 1110 \end{array}$$

A	B	A + B
0	0	0
0	1	1
1	0	1
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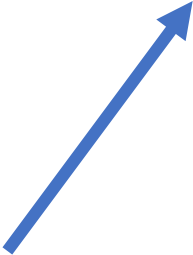

$$1 + 1 = 10$$

Binary Addition

- Add individual bits!
- Follow the 4 rules of addition!
- Carry “1” if applicable!

$$\begin{array}{r} \cancel{0} \\ 10 \cancel{1} \\ \cancel{1} \cancel{0} \cancel{1} \cancel{0} \cancel{1} \\ + \cancel{1} \cancel{1} \cancel{0} \cancel{0} \cancel{1} \\ \hline 1110 \end{array}$$

A	B	A + B
0	0	0
0	1	1
1	0	1
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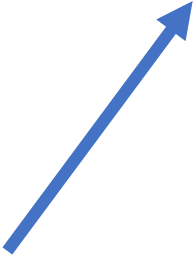

$$1 + 1 = 10$$

Binary Addition

- Add individual bits!
- Follow the 4 rules of addition!
- Carry “1” if applicable!


$$\begin{array}{r} \cancel{0} \\ 10 \cancel{1} \\ + \cancel{1} \cancel{0} \cancel{1} \cancel{0} \cancel{0} \cancel{1} \\ \hline 101110 \end{array}$$

A	B	A + B
0	0	0
0	1	1
1	0	1
1	1	10


$$1 + 1 = 10$$

Binary Addition

- Confirm the binary addition! (Optional)
 - Convert Base_2 to Base_{10}

Base_2		Base_{10}
$\begin{array}{r} 10101 \\ + 11001 \\ \hline 101110 \end{array}$		$\begin{array}{r} 21 \\ + 25 \\ \hline 46 \end{array}$

Binary Addition – 3 Values

- Add individual bits!
- Follow the 4 rules of addition!
- Carry “1” if applicable!

A	B	A + B
0	0	0
0	1	1
1	0	1
1	1	10

$$\begin{array}{r} 1 \ 1 \ 1 \\ 1 \ 1 \ 1 \\ 1 \ 0 \ 1 \\ \hline \end{array}$$

Binary Addition – 3 Values

- Add individual bits!
- Follow the 4 rules of addition!
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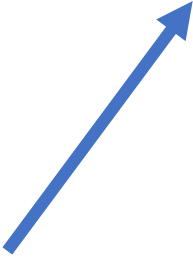
A	B	A + B
0	0	0
0	1	1
1	0	1
1	1	10

$$\begin{array}{r} 1 \ 1 \ 1 \\ 1 \ 1 \ \mathbf{1} \\ 1 \ 0 \ \mathbf{1} \\ \hline \end{array}$$

Binary Addition – 3 Values

- Add individual bits!
- **Follow the 4 rules of addition!**
- Carry “1” if applicable!

A	B	A + B
0	0	0
0	1	1
1	0	1
1	1	10


$$1 + 1 = 10$$

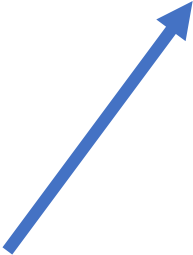
$$\begin{array}{r} 1 \quad 1 \quad 1 \\ 1 \quad 1 \quad 1 \\ 1 \quad 0 \quad 1 \\ \hline \end{array}$$

Binary Addition – 3 Values

- Add individual bits!
- Follow the 4 rules of addition!
- **Carry “1” if applicable!**

A	B	A + B
0	0	0
0	1	1
1	0	1
1	1	10

$$\begin{array}{r} 10 \\ 111 \\ 11\cancel{1} \\ 10\cancel{1} \\ \hline \end{array}$$


$$1 + 1 = 10$$

Binary Addition – 3 Values

- Add individual bits!
- Follow the 4 rules of addition!
- Carry “1” if applicable!

A	B	A + B
0	0	0
0	1	1
1	0	1
1	1	10

$0 + 1 = 1$

$$\begin{array}{r} 10 \\ 111 \\ 11\cancel{1} \\ 10\cancel{1} \\ \hline \end{array}$$

Binary Addition – 3 Values

- Add individual bits!
- Follow the 4 rules of addition!
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A	B	A + B
0	0	0
0	1	1
1	0	1
1	1	10

$0 + 1 = 1$

$$\begin{array}{r} 1 \cancel{0} \\ 1 1 \cancel{1} \\ 1 1 \cancel{1} \\ 1 0 \cancel{1} \\ \hline 1 \end{array}$$

Binary Addition – 3 Values

- Add individual bits!
- Follow the 4 rules of addition!
- Carry “1” if applicable!

A	B	A + B
0	0	0
0	1	1
1	0	1
1	1	10


$$1 + 0 = 1$$

$$\begin{array}{r} 1\cancel{0} \\ 11\cancel{1} \\ 1\mathbf{1}\cancel{1} \\ 1\mathbf{0}\cancel{1} \\ \hline 1 \end{array}$$

Binary Addition – 3 Values

- Add individual bits!
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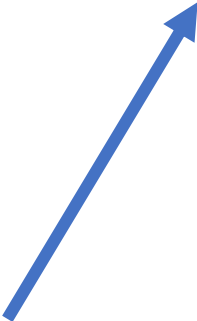

$$1 + 0 = 1$$

$$\begin{array}{r} 1 \\ 1 \cancel{0} \\ 1 1 \cancel{1} \\ 1 \cancel{1} \cancel{1} \\ 1 \cancel{0} \cancel{1} \\ \hline 1 \end{array}$$

Binary Addition – 3 Values

- Add individual bits!
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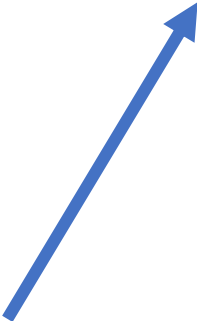

$$1 + 1 = 10$$

$$\begin{array}{r} 1 \\ 1 1 \\ 1 1 \\ 1 1 \\ \hline 1 \end{array}$$

Binary Addition – 3 Values

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A	B	A + B
0	0	0
0	1	1
1	0	1
1	1	10


$$1 + 1 = 10$$

$$\begin{array}{r} 0 \\ 1 \\ \mathbf{1} \cancel{1} \cancel{0} \\ 1 \cancel{1} \cancel{1} \\ 1 \cancel{1} \cancel{1} \\ 1 \cancel{0} \cancel{1} \\ \hline 1 \end{array}$$

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0	1	1
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1	1	10


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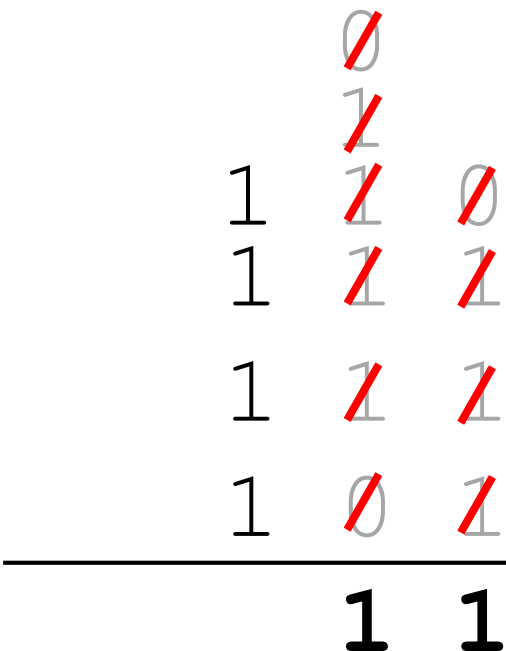
$$\begin{array}{r} 0 \\ 1 \\ 1\cancel{1}\cancel{0} \\ 1\cancel{1}\cancel{1} \\ 1\cancel{1}\cancel{1} \\ 1\cancel{0}\cancel{1} \\ \hline 1 \end{array}$$

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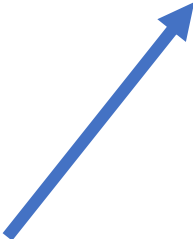

$$0 + 1 = 1$$

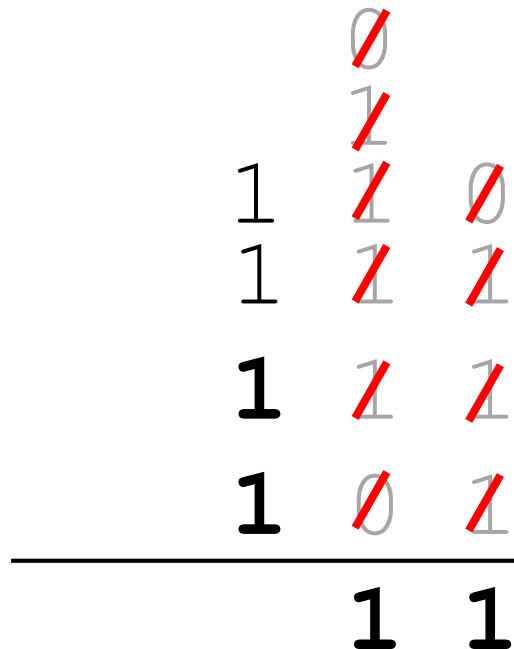

$$\begin{array}{r} \cancel{0} \\ \cancel{1} \\ 1111 \\ 1111 \\ 1111 \\ 1 \cancel{0} \\ \hline 11 \end{array}$$

Binary Addition – 3 Values

- Add individual bits!
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- Carry “1” if applicable!

A	B	A + B
0	0	0
0	1	1
1	0	1
1	1	10


$$1 + 1 = 10$$


$$\begin{array}{r} 0 \\ 1 \\ 11 \\ 11 \\ \mathbf{1}11 \\ \mathbf{1}01 \\ \hline 10100 \end{array}$$

Binary Addition – 3 Values

- Add individual bits!
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- Carry “1” if applicable!

A	B	A + B
0	0	0
0	1	1
1	0	1
1	1	10

$$\begin{array}{r} 00 \\ 1111 \\ 111 \\ 101 \\ \hline 11 \end{array}$$

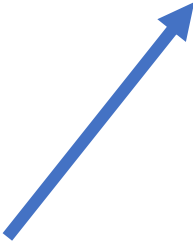
$1 + 1 = 10$

Binary Addition – 3 Values

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A	B	A + B
0	0	0
0	1	1
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1	1	10

$$\begin{array}{r} 0\cancel{0} \\ 0\cancel{1} \\ 1\mathbf{1}\cancel{1}\cancel{0} \\ \mathbf{1}\cancel{1}\cancel{1} \\ \cancel{1}\cancel{1}\cancel{1} \\ \cancel{1}\cancel{0}\cancel{1} \\ \hline \mathbf{1}\mathbf{1} \end{array}$$

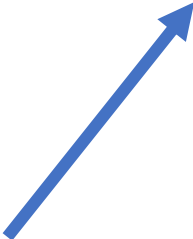

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Binary Addition – 3 Values

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$$\begin{array}{r} 0 \\ 10 \\ 1\cancel{1}\cancel{1}\cancel{0} \\ \cancel{1}\cancel{1}\cancel{1} \\ \cancel{1}\cancel{1}\cancel{1} \\ \cancel{1}\cancel{0}\cancel{1} \\ \hline 11 \end{array}$$

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$$\begin{array}{r} 0 \\ 0 \cancel{0} \\ 0 \cancel{1} \\ 1 \cancel{1} \cancel{1} \cancel{0} \\ 1 \cancel{1} \cancel{1} \cancel{1} \\ \cancel{1} \cancel{1} \cancel{1} \\ \cancel{1} \cancel{1} \cancel{1} \\ \cancel{1} \cancel{0} \cancel{1} \\ \hline 1 1 \end{array}$$

A	B	A + B
0	0	0
0	1	1
1	0	1
1	1	10


$$0 + 0 = 0$$

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Binary Addition – 3 Values

- Add individual bits!
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$$\begin{array}{r} \cancel{0} \\ \cancel{0} \cancel{0} \\ 1 \cancel{0} \cancel{1} \\ 1 \cancel{1} \cancel{1} \cancel{0} \\ \cancel{1} \cancel{1} \cancel{1} \\ \cancel{1} \cancel{1} \cancel{1} \\ \cancel{1} \cancel{1} \cancel{1} \\ \cancel{1} \cancel{0} \cancel{1} \\ \hline 0 1 1 \end{array}$$

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0	0	0
0	1	1
1	0	1
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$$0 + 0 = 0$$

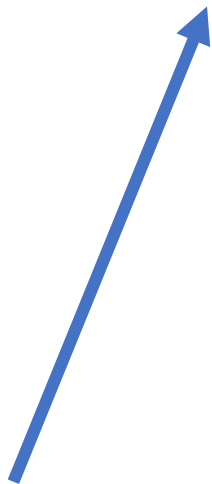
$$0 + 0 = 0$$

Binary Addition – 3 Values

- Add individual bits!
- Follow the 4 rules of addition!
- Carry “1” if applicable!

$$\begin{array}{r} \cancel{0} \\ \cancel{0} \cancel{0} \\ 1 \cancel{0} \cancel{1} \\ 1 \cancel{1} \cancel{1} \cancel{0} \\ \cancel{1} \cancel{1} \cancel{1} \\ \cancel{1} \cancel{1} \cancel{1} \\ \cancel{1} \cancel{0} \cancel{1} \\ \hline 0 1 1 \end{array}$$

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$$1 + 1 = 10$$

Binary Addition – 3 Values

- Add individual bits!
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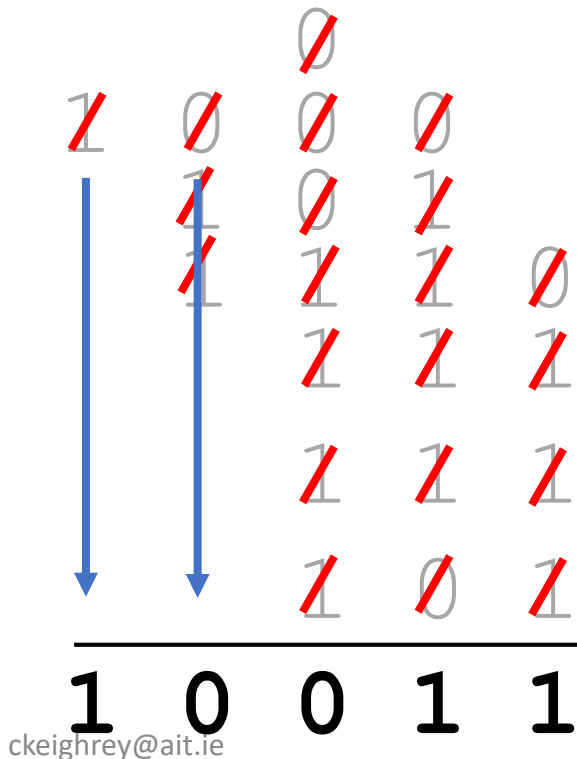
$$\begin{array}{rcccc} & & 0 & & \\ 1 & 0 & 0 & 0 & \\ & 1 & 0 & 1 & \\ & 1 & 1 & 1 & 0 \\ & & 1 & 1 & 1 \\ & & 1 & 1 & 1 \\ & & 1 & 0 & 1 \\ \hline & & 0 & 1 & 1 \end{array}$$

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Binary Addition – 3 Values

- Add individual bits!
- Follow the 4 rules of addition!
- Carry “1” if applicable!



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0	1	1
1	0	1
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$1 + 1 = 10$

Binary Subtraction

Binary Subtraction

- Binary Addition Rules: 4 rules!

A	B	A - B
0	0	0
0	1	1*
1	0	1
1	1	0

Binary Subtraction

- Binary Addition Rules: 4 rules!

A	B	A - B
0	0	0
0	1	1*
1	0	1
1	1	0

Borrow from the
next more
significant bit

Binary Subtraction

- Subtract individual bits!
- Follow 4 rules!
- Remember to borrow from the next most significant bit!

A	B	A - B
0	0	0
0	1	1*
1	0	1
1	1	0

$$\begin{array}{r} 1\ 1\ 0\ 1 \\ - 1\ 0\ 1\ 1 \\ \hline \end{array}$$

Binary Subtraction

- Subtract individual bits!
- Follow 4 rules!
- Remember to borrow from the next most significant bit!

A	B	A - B
0	0	0
0	1	1*
1	0	1
1	1	0

$$\begin{array}{r} 1101 \\ - 1011 \\ \hline \end{array}$$

Binary Subtraction

- Subtract individual bits!
- **Follow 4 rules!**
- Remember to borrow from the next most significant bit!

A	B	A - B
0	0	0
0	1	1*
1	0	1
1	1	0

$$\begin{array}{r} 1\ 1\ 0\ \mathbf{1} \\ - 1\ 0\ 1\ \mathbf{1} \\ \hline \end{array}$$

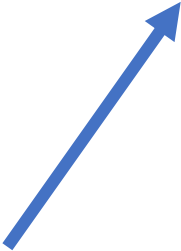

$$1 - 1 = 0$$

Binary Subtraction

- Subtract individual bits!
- Follow 4 rules!
- **Remember to borrow from the next most significant bit!**

A	B	A - B
0	0	0
0	1	1*
1	0	1
1	1	0

$$\begin{array}{r} 110\cancel{1} \\ - 101\cancel{1} \\ \hline 0 \end{array}$$

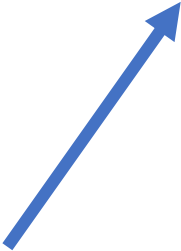

$$0 - 1 = 1^*$$

Binary Subtraction

- Subtract individual bits!
- Follow 4 rules!
- Remember to borrow from the next most significant bit!

A	B	A - B
0	0	0
0	1	1*
1	0	1
1	1	0

$$\begin{array}{r} 0 0 \\ 1 \cancel{1} \cancel{0} \cancel{1} \\ - 1 1 \cancel{1} \\ \hline 1 0 \end{array}$$



$$10 - 1 = 1^*$$
$$(2 - 1 = 1)$$

Binary Subtraction

- Subtract individual bits!
- Follow 4 rules!
- Remember to borrow from the next most significant bit!

$$\begin{array}{r} 0 \cancel{1} 0 \\ 1 \cancel{1} \cancel{0} \cancel{1} \\ - 1 \cancel{1} \cancel{1} \\ \hline 1 0 \end{array}$$

$$0 - 0 = 0$$



A	B	A - B
0	0	0
0	1	1*
1	0	1
1	1	0

Binary Subtraction

- Subtract individual bits!
- Follow 4 rules!
- Remember to borrow from the next most significant bit!

A	B	A - B
0	0	0
0	1	1*
1	0	1
1	1	0

$$\begin{array}{r} \cancel{0} \cancel{1} \cancel{0} \\ \mathbf{1} \cancel{1} \cancel{0} \cancel{1} \\ - \mathbf{1} \cancel{0} \cancel{1} \cancel{1} \\ \hline \mathbf{0} \mathbf{1} \mathbf{0} \end{array}$$


$$1 - 1 = 0$$

Binary Subtraction

- Subtract individual bits!
- Follow 4 rules!
- Remember to borrow from the next most significant bit!

A	B	A - B
0	0	0
0	1	1*
1	0	1
1	1	0

$$\begin{array}{r} \cancel{0} \cancel{1} \cancel{0} \\ \cancel{1} \cancel{1} \cancel{0} \cancel{1} \\ - \cancel{1} \cancel{0} \cancel{1} \cancel{1} \\ \hline 0 0 0 \end{array}$$


$$1 - 1 = 0$$

Questions

