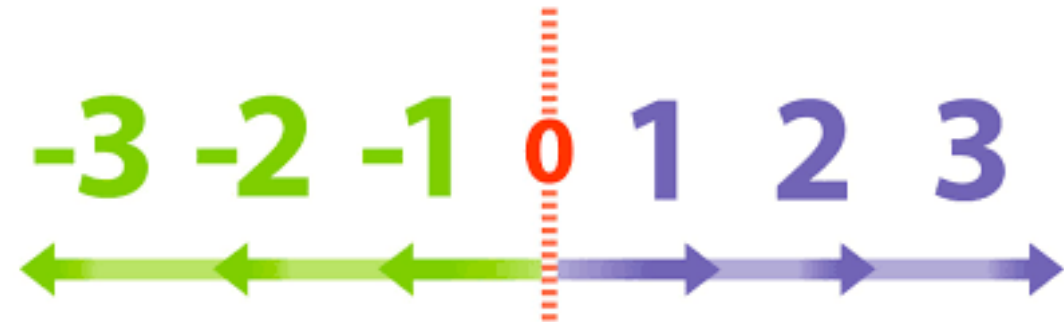


Learning Intention

To develop knowledge by
understanding that binary numbers
can be changed to represent
positive and negative numbers

To secure understanding by
explaining how negative numbers
are created using different
methods

To achieve excellence by
Applying knowledge to perform
conversions and subtractions using
two's complement.



Signed number

*An integer which has either a negative
or positive sign indicator*

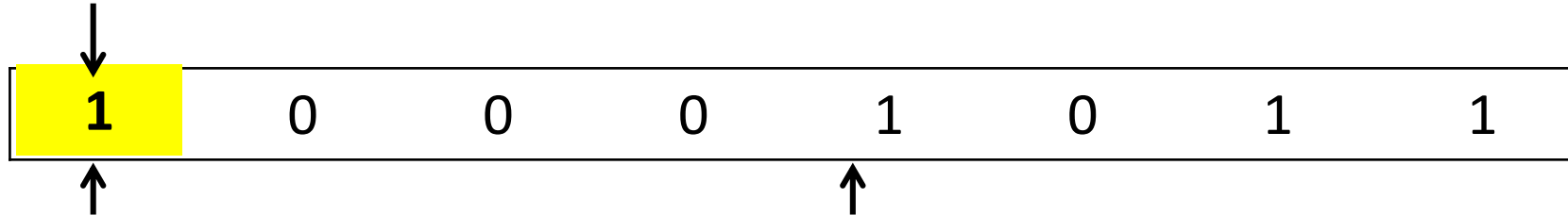
Sign and magnitude

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One method of using the **MSB** for signed numbers is called **sign and magnitude**

Most significant bit
MSB



Also known as **Sign bit**

Rest of the number is the **magnitude**

In this method:

1 on the MSB indicates a **negative number** so **1** 0 0 0 0 0 1 = - 1

0 on the MSB indicates a **positive number** so **0** 0 0 0 0 0 1 = + 1

The largest possible number is **+127** (or 01111111).

The smallest possible number is **-127** (or 11111111)

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Two's complement

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Another method of representing **signed** numbers is called **Two's complement**

Again it uses the MSB to determine positive or negative

0 = positive
1 = negative

The rules:

Positive numbers

Remain the same as normal binary
e.g 4 = 0 1 0 0 (up to 0 1 1 1 for 4 bit)

127 = 0 1 1 1 1 1 1 1 (*0 on the msb = positive 127*)

Negative numbers are different and follow this method:

1. Find the **positive version** of the binary number
2. **Invert** (flip) all digits so 1s become 0s and vice versa
3. **Add 1** to it

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Two's compliment: Negative numbers

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Example: find -5

Step 1: Write the positive version

$$\begin{array}{cccc} 8 & 4 & 2 & 1 \\ 0 & 1 & 0 & 1 \end{array} = +5$$

Step 2: flip all bits

$$\begin{array}{cccc} 1 & 0 & 1 & 0 \end{array}$$

Step 3: Add 1 to it

$$\begin{array}{cccc} 1 & 0 & 1 & 0 \\ & & & 1 \\ \hline 1 & 0 & 1 & 1 \end{array}$$

← Normal binary addition rules

- 5 using two's complement is

$$\begin{array}{cccc} -8 & 4 & 2 & 1 \\ 1 & 0 & 1 & 1 \end{array} = -5$$
$$(-8 + 2 + 1)$$

To secure understanding by explaining how negative numbers are created using different methods

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0 = positive
1 = negative

Two's compliment: Negative numbers

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Example: find -4

Step 1: Write the positive version

8	4	2	1
0	1	0	0

= + 4

Step 2: flip all bits

1	0	1	1
---	---	---	---

Step 3: Add 1 to it

1	0	1	1
	1	1	1
<hr/>			
1	1	0	0

← Normal binary addition rules

- 5 using two's complement is

-8	4	2	1
1	1	0	0

= - 4
(-8 + 4)

To secure understanding by explaining how negative numbers are created using different methods

To achieve excellence by Applying knowledge to perform conversions and subtractions using two's complement.

0 = positive
1 = negative

Two's complement: Negative numbers

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Example: 8 bit number

Step 1: Write the positive version

128	64	32	16	8	4	2	1	
0	0	1	1	0	1	0	1	= + 53

Step 2: flip all bits

1	1	0	0	1	0	1	0
---	---	---	---	---	---	---	---

0 = positive
1 = negative

Step 3: Add 1 to it

1	1	0	0	1	0	1	0	
							1	Normal binary addition rules
1	1	0	0	1	0	1	1	

- 53 using two's complement is

-128	64	32	16	8	4	2	1	
1	1	0	0	1	0	1	1	= - 53
(-128 + 64 + 8 + 2 + 1)								

To secure understanding by explaining how negative numbers are created using different methods

To achieve excellence by Applying knowledge to perform conversions and subtractions using two's complement.

Binary subtraction

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Binary subtraction works by

- taking the **Two's complement** of the second number
- and adding it to the first

Example: $7 - 5 = 2$

Positive
binary
versions:

7
8 4 2 1
0 1 1 1

5
8 4 2 1
0 1 0 1

Two's
complement
of 2nd
number:

1 0 1 1

Add them
together in
usual way:

Last bit
overflows and
is ignored

0 1 1 1
1 0 1 1
✗ 1 1 1
0 0 1 0

= 2

Reminder: Two's complement of 5

-8 4 2 1

1 0 1 1 = -5

(-8 + 2 + 1)

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complement.

Tasks 1 and 2

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Task 1 – *What is meant by a signed number?*

- Draw a diagram showing an 8 bit number
- Label the Most significant bit

Task 2

Sign and Magnitude

- Explain how sign and magnitude is used to represent negative and positive numbers – use an example/diagram

Two's complement

- Explain what Two's complement is and the method used to make negative numbers – use an example/diagram

Subtraction

- Write down the method of how to subtract binary numbers

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Task 3

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Task 3 – Complete worksheets in your books

Must show working out

- Task 1 sign and magnitude
- Task 2 Two's compliment
- Task 3 Binary subtraction

Excellence

Create a revision guide detailing all methods of binary conversions, addition, subtraction, shifts

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