1.2 Unsigned binary numbers

Counting in binary

Humans have ten fingers so humans use a base ten number system. Ex: 452 means $4\times10^2 + 5\times10^1 + 2\times10^0$. Digital system valued signals (high, low) so digital systems use a base two number system. Ex: 1101 means $1\times2^3 + 1\times2^2 + 0\times2^1 + 1\times2^0$. A ten is called a ***decimal*** number (from Latin "decem" meaning ten), while a number in base two is called a ***binary*** number (fr meaning two together).

Base ten has ten symbols for a digit: 0, 1, ..., 9. When counting up and reaching 9, the digit resets to 0 and a 1 carries to the 008, 009, 010, 011, or 098, 099, 100, 101. Base two has only two symbols for a digit: 0 and 1. So counting up results in freq 000, 001, 010, 011, 100, 101, 110, 111. Each digit in a binary number is called a ***bit***, short for "binary digit".

PARTICIPATION ACTIVITY 1.2.1: Counting up in decimal and in binary.

Start ☐ 2x speed

-	0	0	
*	1	1	
* *	2	10	Reset, carry
* * *	3	11	
* * * *	4	100	Reset, carry and reset, carry
* * * * *	5	101	
* * * * * *	6	110	Reset, carry
* * * * * * *	7	111	
* * * * * * * *	8	1000	Reset, carry and reset, carry and reset, carr
* * * * * * * * *	9	1001	

* * * * * * * * * *	10	Reset digit to 0, carry 1	1010	Reset, carry
* * * * * * * * * * *	11		1011	
	...			
	98			
	99			
	100	Reset digit to 0, carry 1 to next digit which is 9 so reset to 0, carry 1 to next digit		

Note: This section only covers unsigned binary numbers. An ***unsigned binary*** number can only represent non-negative valu bit binary number being 0000 (0), 0001 (1), 0010 (2), ..., 1111 (15). In contrast, a signed binary number uses the leftmost bit whether a number is positive or negative.

PARTICIPATION ACTIVITY 1.2.2: Counting up in binary.

Type the next higher 3-digit binary number.

1) 000

Check Show answer

2) 001

Check Show answer

3) 010

Check Show answer

4) 011

Check Show answer

5) 111 (type a 4-bit answer)

Check Show answer

CHALLENGE ACTIVITY 1.2.1: Counting up with 3 bits.

Can you count from 000 to 111 in binary in 20 seconds?

Start

Decimal	Binary (3 bits)
0	000
1	001
2	010
3	011

4	100
5	101
6	110
7	111

6 7 8

1	2	3	4	5	6	7	8

Check Next

Converting from binary to decimal

Software and hardware developers benefit from being able to quickly convert between binary and decimal numbers.

Given a binary number, each digit's weight is summed to form a decimal number. Ex: 1101 = $1\times2^3 + 1\times2^2 + 0\times2^1 + 1\times2^0 = 8$

PARTICIPATION ACTIVITY 1.2.3: Binary to decimal tool.

Reset

0	0	0	0	0	0	0	0
2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
128	64	32	16	8	4	2	1

0 · 128 + **0** · 64 + **0** · 32 + **0** · 16 + **0** · 8 + **0** · 4 + **0** · 2 + **0** · 1 = 0

(decimal v

PARTICIPATION ACTIVITY 1.2.4: Converting from binary to decimal.

Convert from binary to decimal. Use the fewest decimal digits possible. Recall that four-bit binary digit weights are 8, 4, 2, and 1.

1) 0001

Check Show answer

2) 0010

Check Show answer

3) 0111

Check Show answer

4) 1001

Check Show answer

5) 1111

Check Show answer

Converting from decimal to binary

Given a decimal number, starting from the leftmost binary digit (greater than the decimal number), a 1 is placed in each dig resulting binary number doesn't exceed the decimal number.

PARTICIPATION ACTIVITY 1.2.5: Converting from decimal to four-bit binary.

Type a four-bit answer: 0101, not 101. Four-bit binary digit weights: 8, 4, 2, 1.

1) 3

Check Show answer

2) 4

Check Show answer

3) 5

Check Show answer

4) 13

Check Show answer

PARTICIPATION

ACTIVITY 1.2.6: Binary-to-decimal converter.

Edit either box

Binary ⇄ Decimal

Adding binary numbers

For decimal numbers, adding by hand starts at the right and adds each digit, possibly carrying a 1 to the digit on the left. Ac numbers is identical.

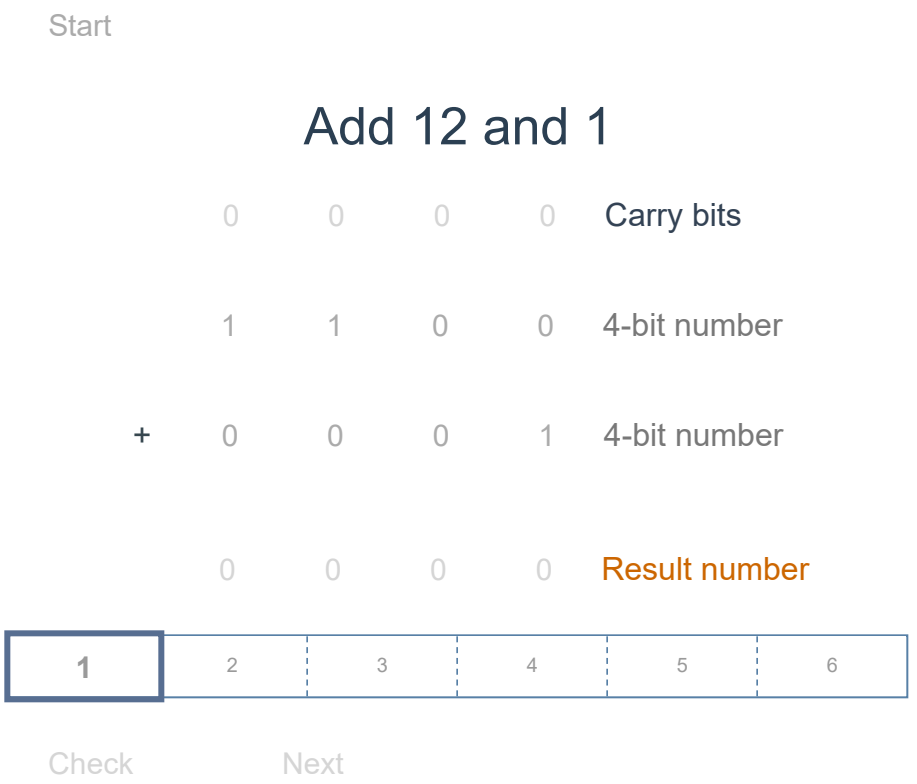
PARTICIPATION ACTIVITY 1.2.7: Adding in binary.

Start ☐ 2x speed

```
  1  1
  0  1  1  1
+ 0  1  1  0
  1  1  0  1
```

(So 7 + 6 = 13)

CHALLENGE ACTIVITY 1.2.2: Binary addition.



PARTICIPATION ACTIVITY 1.2.8: Adding binary numbers.

1) 0010
+ 0010

Check Show answer

2) 0110
+ 0010

Check Show answer

3) 0101
+ 0111

Check Show answer

4) 1111
+ 0001

Check Show answer

Overflow

Overflow occurs when the result of a binary operation is too large to fit in allowed number of bits. Ex: For four-bit numbers, 10000, which is too large for four bits. When adding two unsigned numbers, if the leftmost bit generates a carry bit, overflo

PARTICIPATION ACTIVITY 1.2.9: Overflow for unsigned numbers.

Indicate which operations yield overflow for four-bit binary numbers.

1) 0001 + 0010

- ○ Overflow

- No overflow

2) 0111 + 0111
   - Overflow
   - No overflow

3) 1000 + 0111
   - Overflow
   - No overflow

4) 1000 + 1000
   - Overflow
   - No overflow

5) 1100 + 0111
   - Overflow
   - No overflow

6) 1111 + 1111
   - Overflow
   - No overflow

7) In base 10, for 2 digit numbers:
   50 + 70
   - Overflow
   - No overflow

Provide feedback on this section