Arithmetic: addition

Unsigned binary addition follows the same rules as ordinary arithmetic
Example: 4-bit UB

carry	0	1	1	1		decimal
		0	0	1	1	3
		0	1	1	1	7
result		1	0	1	0	10

Two's complement addition also follows the same rules as UB
Example: 4-bit 2C

carry	1	1	1	1		
		1	0	1	1	-5
		0	1	1	1	7
result		0	0	1	0	2

Note that the carry from the high-order bit may be ignored.

How do we subtract?

Negate the number to be subtracted and add
a - b = a + (-b)

Arithmetic: overflow

Assumption: we have enough bits to represent a value.
However, a computer must work with a finite number of bits.
What happens if the result doesn't fit in the available bits?

> **This is called overflow.**
> **Result of an operation is greater than the max possible value**
> **or less than the min value.**

In UB:

carry	1	1	1	1		decimal
		1	0	1	1	11
		0	1	1	1	7
result		0	0	1	0	2

What should the result be?
Overflow occurs in UB when there is a carry out of the msb. (Value is too large for N bits.)
What about 2C?
In our example of 2C addition, there was a carry out of the msb, but the result was correct!

carry	1	1	1	1		
		1	0	1	1	-5
		0	1	1	1	7
result		0	0	1	0	2

In fact, whenever we add a positive and a negative number, overflow won't occur,
because the result will be less than the magnitude of the larger value.
When does overflow occur in 2C?

carry	1	0	1	1		
		1	0	1	1	-5
		1	0	0	1	-7

result	0	1	0	0	4

When the signs of the values are the same, and the sign of the result is different.
Another way of detecting this is by the fact that the carry in to the msb is different from the carry out.

Arithmetic: multiplication

UB multiplication also follows the same rules as ordinary arithmetic

carry	0	1	1	1	0	0		decimal
				0	1	0	1	5
				0	1	1	1	7
				0	1	0	1	
			0	1	0	1		
		0	1	0	1			
	0	0	0	0				
result	0	1	0	0	0	1	1	35

Notice that the operations can be carried out using just add and shift
How many bits are needed?

2C multiplication: sign bit must be extended to get proper answer

carry	2	2	2	1	1	0	0		
	1	1	1	1	1	1	0	1	-3
					0	1	1	1	7
	1	1	1	1	1	1	0	1	
	1	1	1	1	1	0	1		
	1	1	1	1	0	1			
	0	0	0	0	0				
result	1	1	1	0	1	0	1	1	-21

How do we carry a 2 in binary?