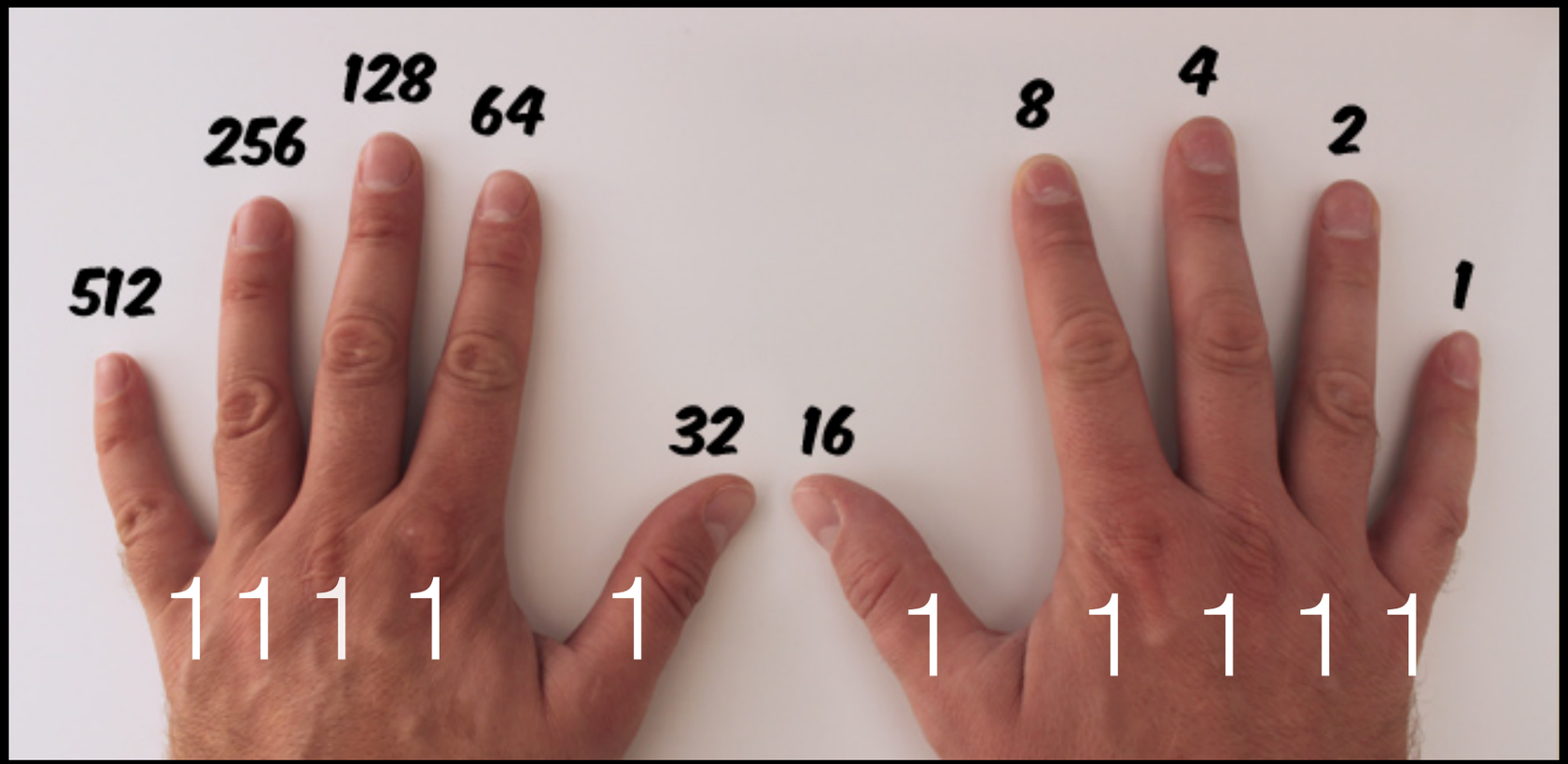

1111111111=
512+256+128+64+32+16+8+4+2+1=
1023

unit 1

Adding in Binary:

One of the Basic Operations of a CPU
&
A Useful Skill for a Computer Scientist

unit 1

- Naming things in computer science is an important skill since the computer only understands on/off also known as `0`/1 (***binary*** digits or ***bits***).

unit 1

- Recall the “Naming Game” where we used bits to uniquely name items—after more than a handful of items, it becomes difficult to keep track of the names!

Item	Computer Name (using three bits)
	0 0 0
	0 0 1
	0 1 0
	0 1 1
	1 0 0
	1 0 1
	1 1 0
	1 1 1

unit 1

- ***Binary addition*** is a strategy to help keep track of the uniqueness of computer names we assign to items.

unit 1

The Rules of Binary Addition

unit 1

The Rules of Binary Addition

$$0 + 0 = 0$$

The Rules of Binary Addition

$$0 + 0 = 0$$

$$0 + 1 = 1$$

The Rules of Binary Addition

$$0 + 0 = 0$$

$$0 + 1 = 1$$

$$1 + 0 = 1$$

unit 1

The Rules of Binary Addition

$$0 + 0 = 0$$

$$0 + 1 = 1$$

$$1 + 0 = 1$$

$$1 + 1 = 10$$

The Rules of Binary Addition

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

That last rule is strange!

Let's recall how we did regular addition in elementary school…

e.g.

Let's recall how we did regular addi mentary school…

Means "for example"

e.g.

Let's recall how we did regular addi mentary school…

Means "for example"

e.g.

238

\+ 5

———

Let's recall how we did regular addi mentary school…

Means "for example"

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238

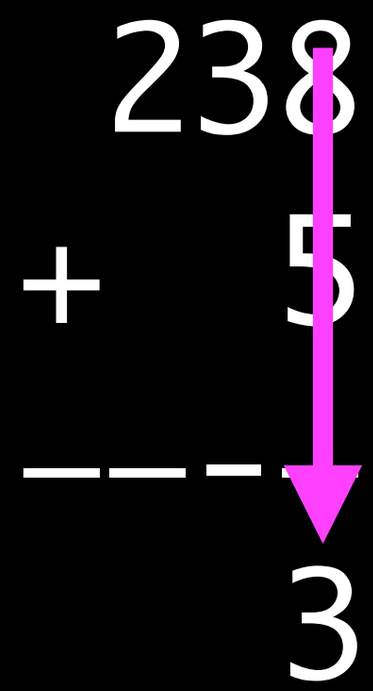
\+ 5

———

Let's recall how we did regular addit mentary school…

Means "for example"

e.g.



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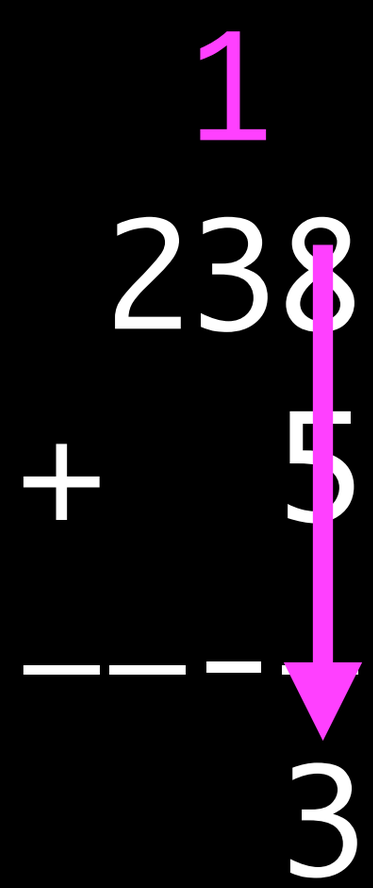
Means "for example"

e.g.



Let's recall how we did regular addit[illegible] mer[illegible]

e.g.

Means "for example"

This digit is "carried" to the next column

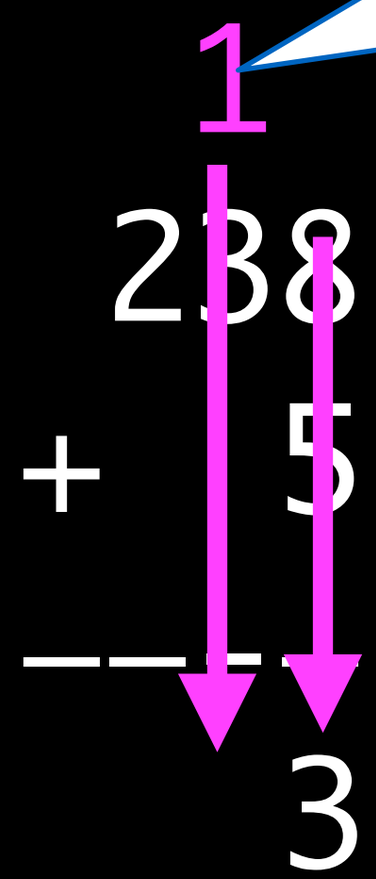
```
  1
  238
+   5
-----
  243
```

Let's recall how we did regular addit[illegible] mer[illegible]

e.g.

Means "for example"

This digit is "carried" to the next column



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e.g.

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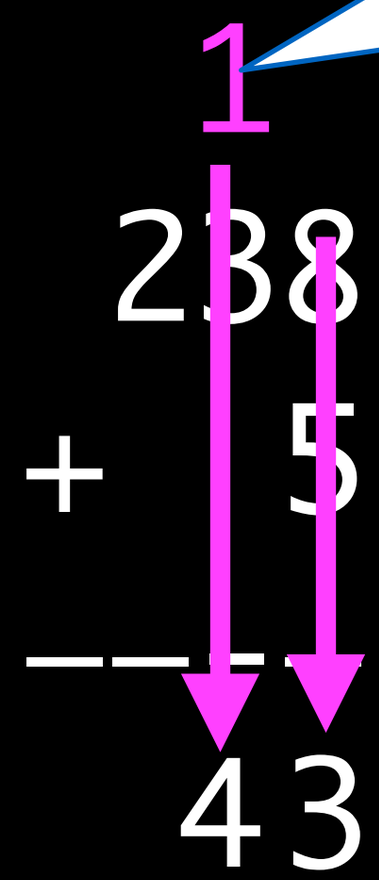
This digit is "carried" to the next column



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e.g.

Means "for example"

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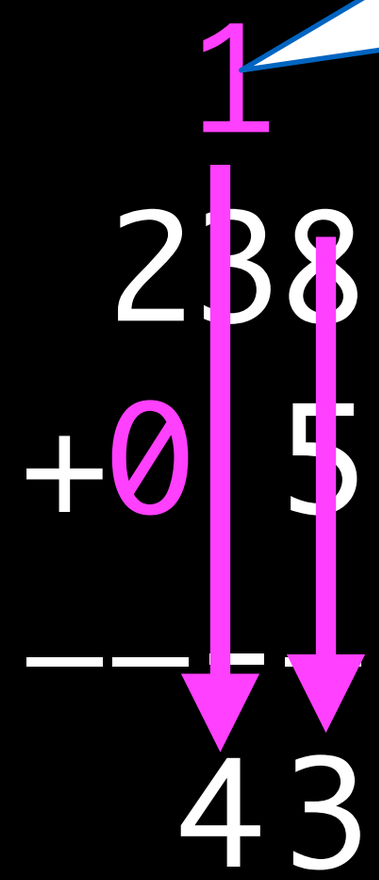

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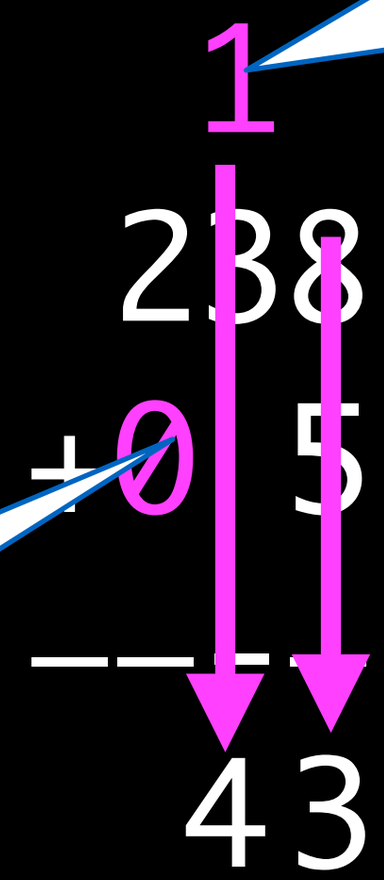

We "imagine" this digit

Let's recall how we did regular addit[illegible] mer[illegible]

e.g.

Means "for example"

This digit is "carried" to the next column

```
  1
  238
+ 05
-----
  43
```

We "imagine" this digit

Let's recall how we did regular addit[illegible] mer[illegible]

e.g.

Means "for example"

This digit is "carried" to the next column

```
  1
  238
+ 05
-----
  243
```

We "imagine" this digit

Let's see an example of binary addition.

e.g.

Let's see an example of binary addition.

Means "for example"

e.g.

Let's see an example of binary addition.

Means "for example"

e.g.

```
  101
+   1
----
```

Let's see an example of binary addition.

Means "for example"

e.g.

```
  101
+   1
-----
```

Let's see an example of binary addition.

Means "for example"

e.g.

```
  101
+   1
-----
```

0

Let's see an example of binary addition.

Means "for example"

e.g.

```
  1
 101
+  1
----
 110
```

Let's see an example of binary addition

e.g.

Means "for example"

This digit is "carried" to the next column

```
  1
 101
+  1
----
 110
```

Let's see an example of binary addition

e.g.

Means "for example"

This digit is "carried" to the next column

```
  1
 101
+ 11
----
 1000
```

Let's see an example of binary addition

e.g.

Means "for example"

This digit is "carried" to the next column

```
  1
 101
+  1
----
 110
```

Let's see an example of binary addition

e.g.

Means "for example"

This digit is "carried" to the next column

```
  1
 101
+ 01
-----
  110
```

Let's see an example of binary addition

e.g.

Means "for example"

This digit is "carried" to the next column

```
  1
 101
+ 01
-----
 110
```

We "imagine" this digit

Let's see an example of binary addition

e.g.

Means "for example"

This digit is "carried" to the next column

```
  1
 101
+ 01
----
 110
```

We "imagine" this digit

Let's see an example of binary addition

e.g.

Means "for example"

This digit is "carried" to the next column

```
  1
 101
+ 01
-----
 110
```

We "imagine" this digit

You try one:

You try one:

$$\begin{array}{r} 1101 \\ +\ \ 101 \\ \hline \end{array}$$

You try one:

$$\begin{array}{r} 1101 \\ +\ \ 101 \\ \hline 0 \end{array}$$

You try one:

$$\begin{array}{r} 1 \\ 1101 \\ +\ \ 101 \\ \hline 0 \end{array}$$

You try one:

```
   1
 1101
+ 101
------
  10
```

You try one:

```
   1
 1101
+ 101
------
 010
```

You try one:

```
  1  1
   1101
+   101
------
  010
```

You try one:

```
  1  1
   1101
+   101
------
  0010
```

You try one:

```
  1 1  1
    1101
+   101
------
  0010
```

You try one:

```
  1 1  1
  0 1101
+   101
-------
  0010
```

You try one:

```
  1 1  1
  0 1101
+   101
-------
  10010
```