Number Systems

Review

PEMDAS

- Parentheses
- Exponents (Square root, Squares etc)
- Multiplication
- Division
- Addition
- Subtraction

Review

$(15 \div 3 + 4) - (3^2 - 7 \times 2)$

Option 1: $(15 \div 7) – (2 \times 2)$

Option 2: $(5 + 4) – (9 – 14)$

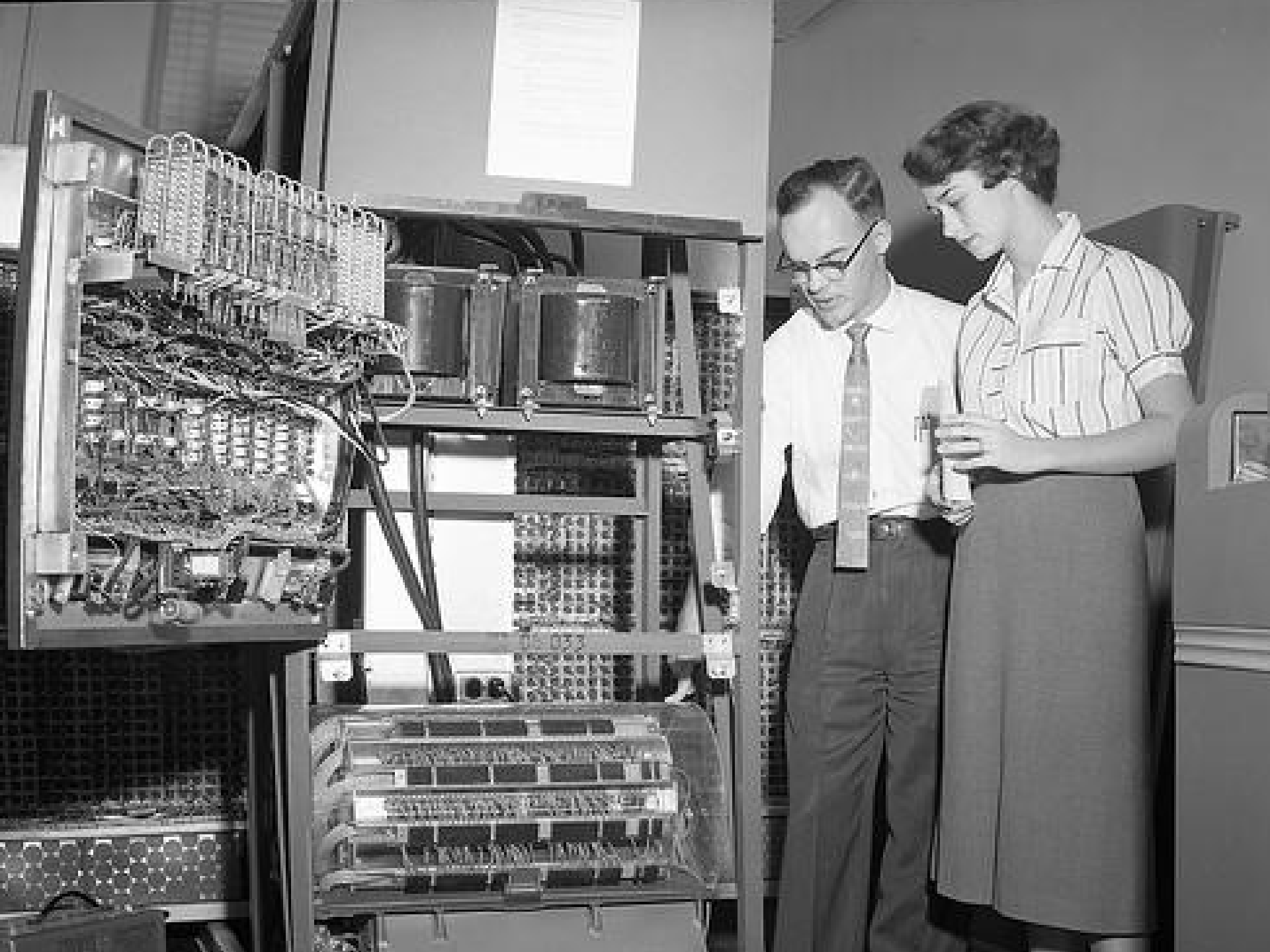
Option 3: $(15 \div 7) – (6 – 14)$

Option 4: $(5 + 4) – (2 \times 2)$

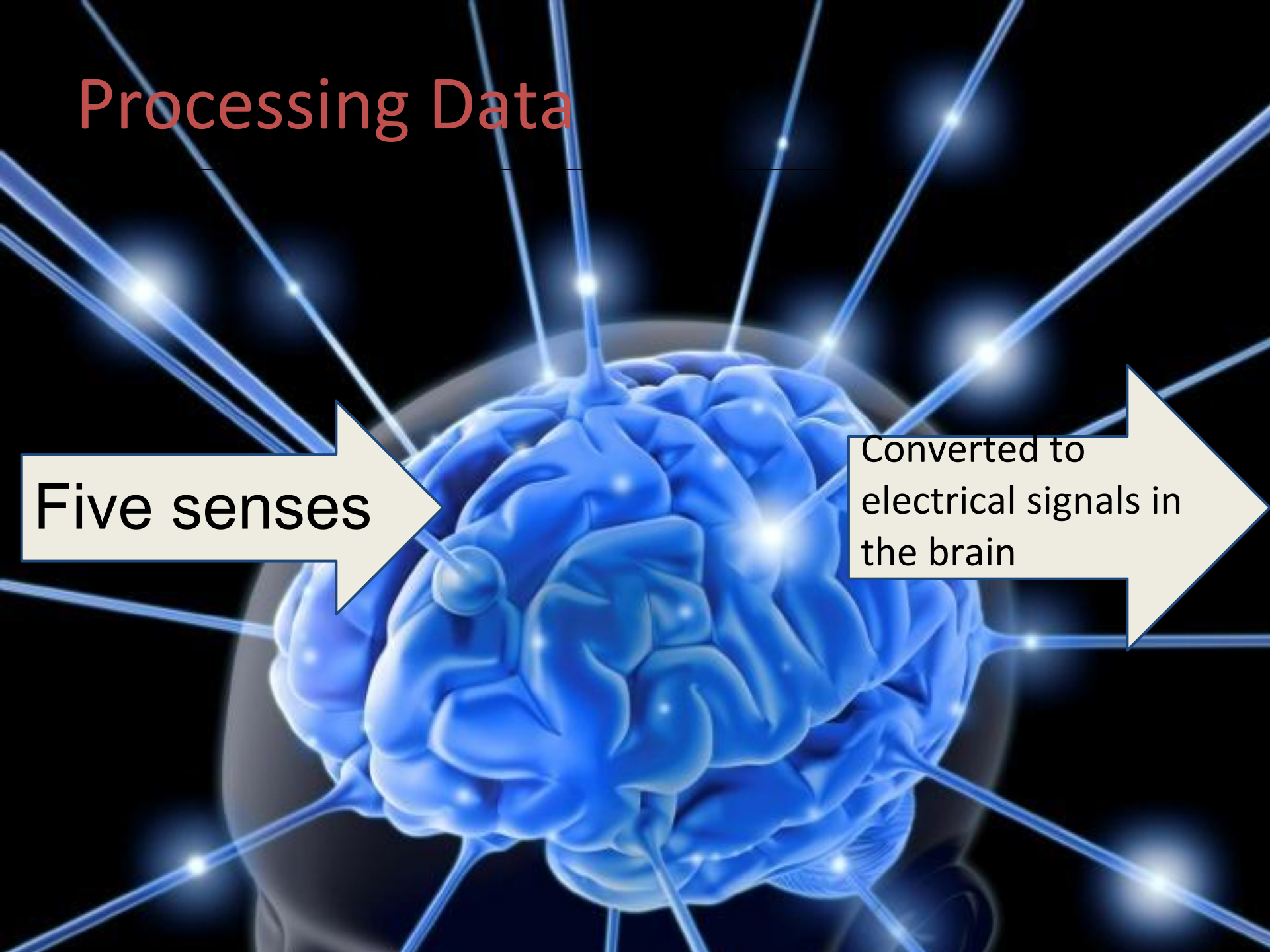
Review

111 x 111

```
    111
  x 111
-------
    111
   111x
  111xx
-------
  12321
```

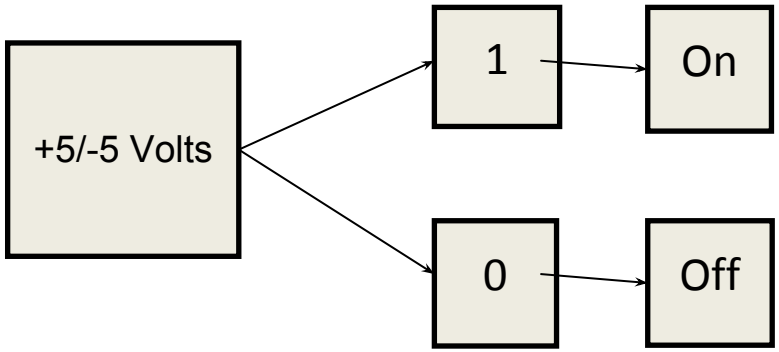


Processing Data

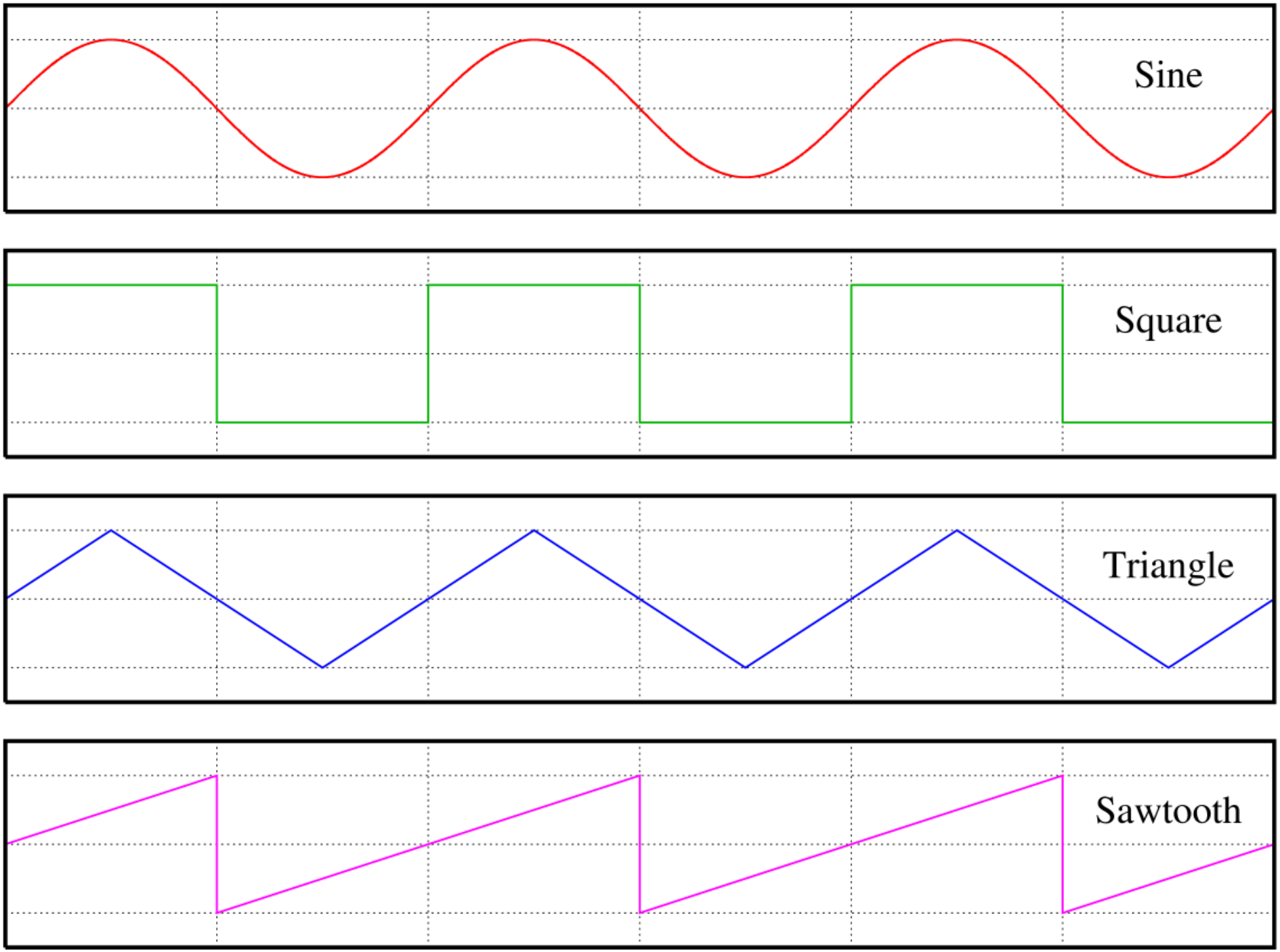


How do machines process data

Machines interpret electrical signals as 1s and 0s – **b**inary dig**its** or **bits**



Data in computers are represented by bits


Sine
Square
Triangle
Sawtooth

Numbers

Natural Numbers

Integers

Negative Numbers

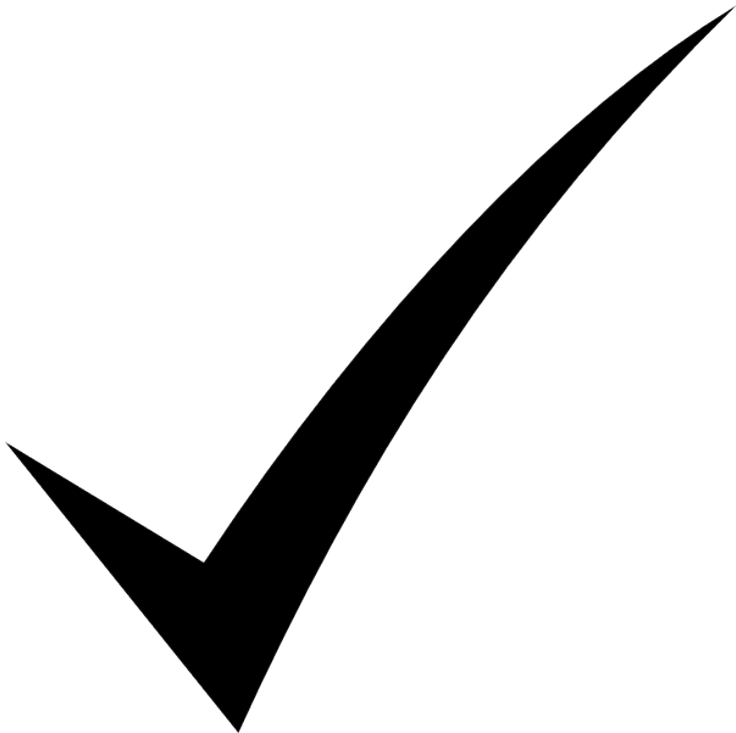
Rational Numbers

Irrational Numbers

But what is a **number**?

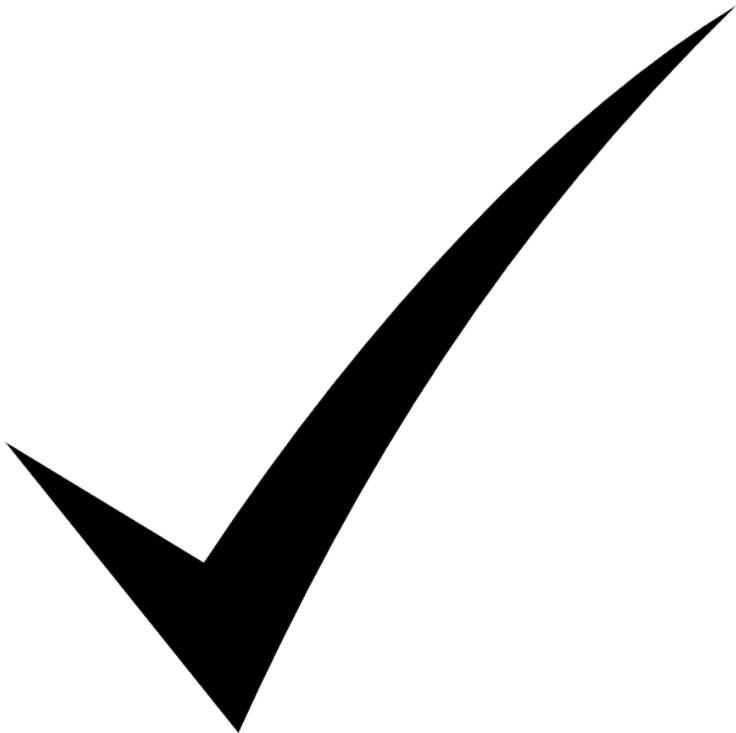
$$1 + 1 = 2$$

1 + 1 = 2



1 + 1 = 10

1 + 1 = 10



Numbers

Numbers are written using positional notation

Arranging and encoding numbers in succession

Every number system has a base

Numbers

Base dictates the value of position

Numbers

11

Decimal number system

943_{10}

$10^4\ 10^3\ 10^2\ 10^1\ 10^0$

9 4 3

$10^2 \times 9 + 10^1 \times 4 + 10^0 \times 3$

$= 100 \times 9 + 10 \times 4 + 1 \times 3$

$= 900 + 40 + 3 = 943_{10}$

Binary number system

$$111_2$$

$$2^4 \quad 2^3 \quad 2^2 \quad 2^1 \quad 2^0$$

$$1 \quad 1 \quad 1$$

$$2^2 \times 1 + 2^1 \times 1 + 2^0 \times 1$$

$$= 4 \times 1 + 2 \times 1 + 1 \times 1$$

$$= 4 + 2 + 1 = 7_{10}$$

Converted a binary number to a decimal number

We can have other number systems!

Octal – Base 8

Hexadecimal – Base 16

Convert from Binary to Decimal

1011_2

2^4	2^3	2^2	2^1	2^0
	8	**4**	**2**	**1**
	1	0	1	1

$8 + 0 + 2 + 1 = 11_{10}$

Convert from Binary to Decimal

11110001_2

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

$128 + 64 + 32 + 16 + 0 + 0 + 0 + 1 = 241_{10}$

Your turn

Convert **101011**$_2$ to a decimal number

Please show all steps!

To aid you:

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

Convert from Decimal to Binary

93_{10}

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

Verify

$$64 \times 1 + 16 \times 1 + 8 \times 1 + 4 \times 1 + 1 \times 1 = 93$$

Your turn

Convert $\mathbf{56}_{10}$ to a binary number

Please show all steps!

To aid you:

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

Binary Addition

- Informal rules..

$$1 + 0 = 1_2$$

$$0 + 1 = 1_2$$

$$1 + 1 = 10_2$$

$$1 + 1 + 1 = 11_2$$

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

Binary Addition

$$\begin{array}{rccccc} & 1 & 0 & {}^{1}1 & 1 & 0 \\ + & 1 & 0 & 1 & 1 & 1 \\ \hline 1 & 0 & 1 & 1 & 0 & 1 \end{array}$$

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

$$\begin{array}{rccccc} & & & {}^{10}1 & {}^{1}1 & 1 \\ & & & 1 & 1 & 1 \\ + & & & 1 & 1 & 1 \\ \hline 1 & 0 & 1 & 0 & 1 \end{array}$$

Your turn

Add $\mathbf{101}_2 + \mathbf{111}_2 + \mathbf{011}_2$

Please show all steps!

To aid you:

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

Binary Multiplication

$$
\begin{array}{rcccc}
 & & & 1 & 1 \\
\times & & & 1 & 1 \\
\hline
 & & {}^{1}0 & 1 & 1 \\
 & & 1 & 1 & \times \\
\hline
1 & 0 & 0 & 1 &
\end{array}
$$

Your turn

Multiply $\mathbf{111}_2$ x $\mathbf{111}_2$

Please show all steps!

To aid you:

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