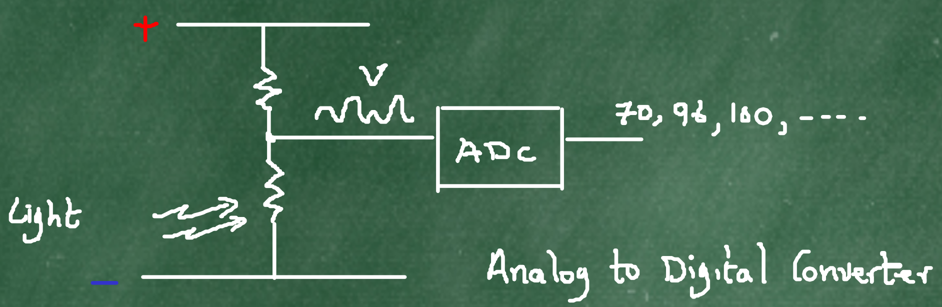
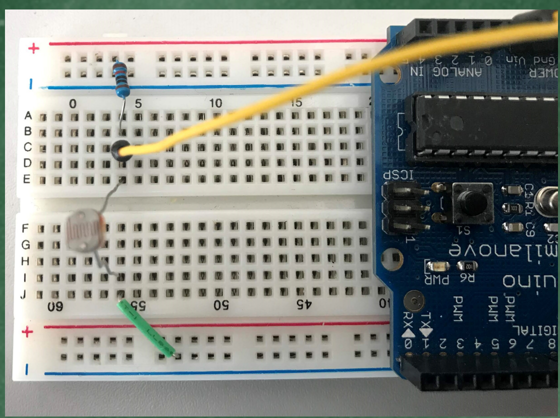
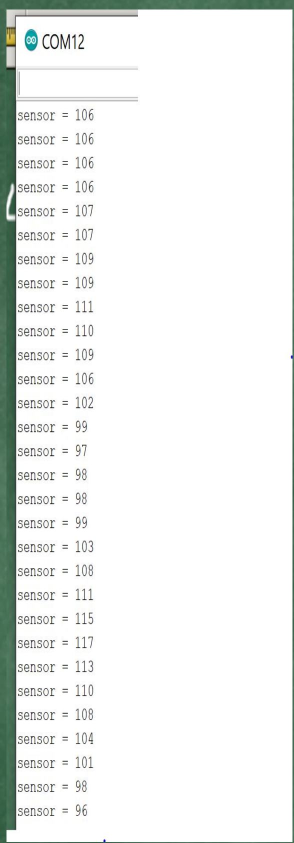
Example of modelling real Phenomena as numbers:

Light → Voltage → number

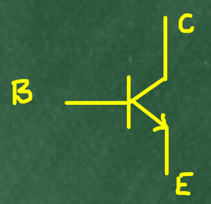





COM12

sensor = 106
sensor = 106
sensor = 106
sensor = 106
sensor = 107
sensor = 107
sensor = 109
sensor = 109
sensor = 111
sensor = 110
sensor = 109
sensor = 106
sensor = 102
sensor = 99
sensor = 97
sensor = 98
sensor = 98
sensor = 99
sensor = 103
sensor = 108
sensor = 111
sensor = 115
sensor = 117
sensor = 113
sensor = 110
sensor = 108
sensor = 104
sensor = 101
sensor = 98
sensor = 96

Exploring the transistor

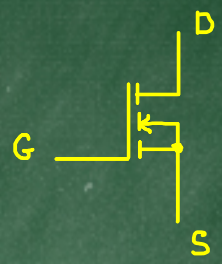


Bipolar Junction Transistor

B – Base

C – Collector

E – Emitter



MOSFET

G – Gate

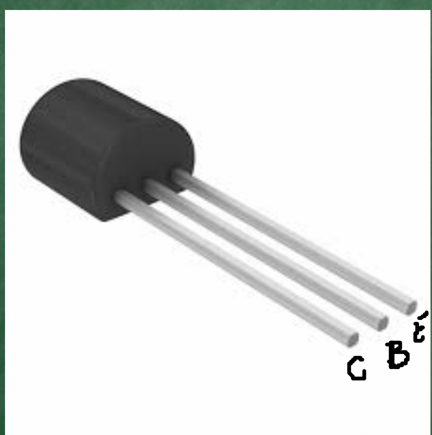
D – Drain

S – Source

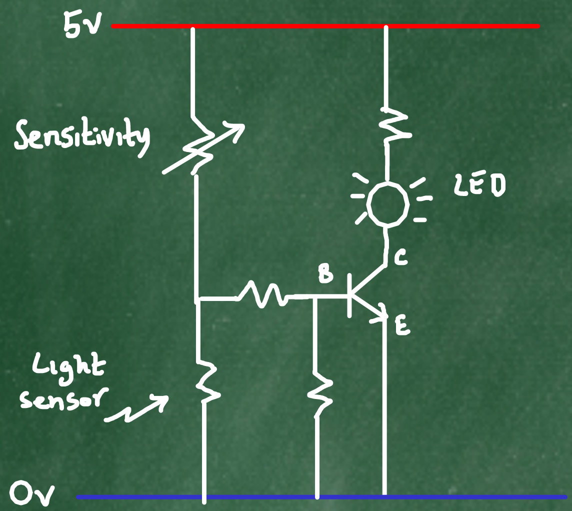
A Current flowing on the Base will open the channel between the Collector and Emitter.

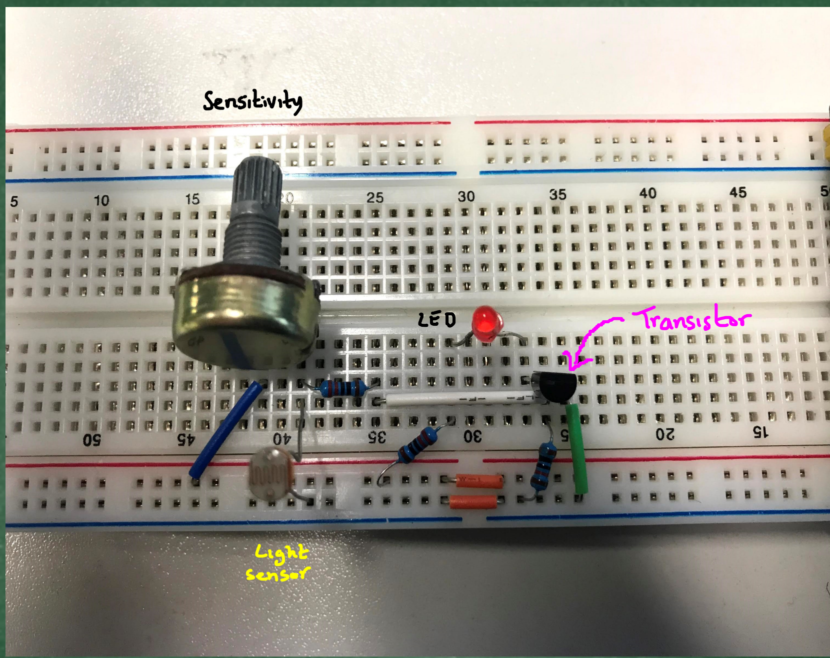
A Voltage on the Gate will open the channel between the Drain and the Source.

Both devices can act like an amplifier or like a Switch.



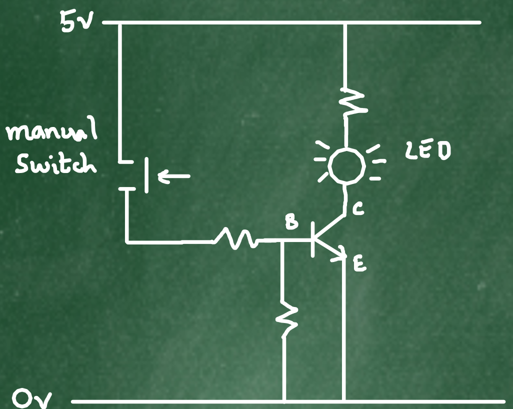
The transistor as an amplifier:

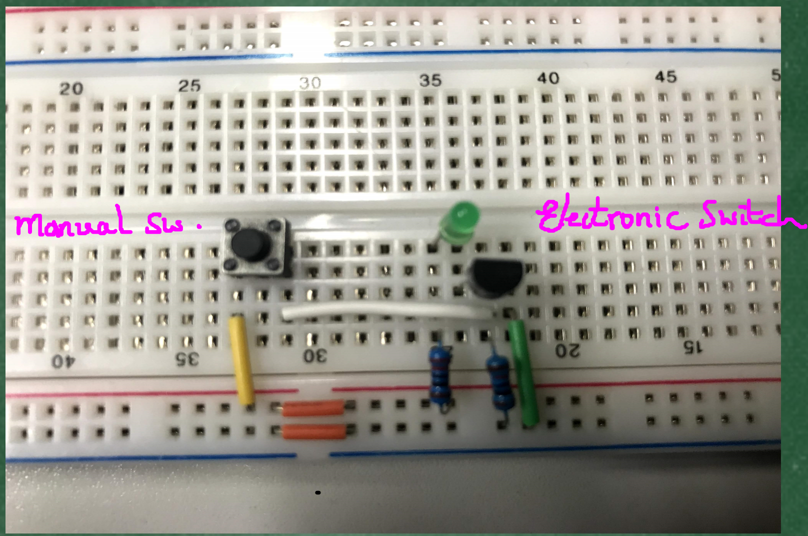




In Digital Electronics we are only Interested in having transistors act like switches.

In this mode, sufficient current/voltage to placed on the Base / Gate (respectively) to turn the transistor on fully.





In this example, a human operates the manual switch, however, it is the current flowing through that switch, when closed, that causes the transistor (i.e., the electronic switch) to turn on the LED.

Of course, the manual switch could equally be replaced by any number of electronic switches (transistors).

Because transistors naturally represent 2 states: on/off, Binary numbers can be used to represent these states directly.

Moreover, since numbers can be used to model information, regardless of the base of those numbers, Binary numbers are a good candidate for modelling information at the hardware level.

Moving Between Bases

$Base_{10} \rightarrow Base_2$?

Example

Convert $25_{10} \longrightarrow$ Binary

method: continually divide by 2 and read the remainders in reverse order.

2	25	
2	12	1
2	6	0
2	3	0
2	1	1
	0	1

Ans: 11001

Each digit in a binary number is called a bit (binary digit)

Typically more digits are needed in a smaller base to represent the same information in a large base.

However, we need a smaller number of <u>distinct</u> symbols.

— Trade-off.

Convert back to decimal.

method: starting with the least significant bit (LSB), multiply each bit by successive powers of 2, starting with 2^0 and then add all partial results together.

Thus,

$$1\,1\,0\,0\,1$$

$$\begin{aligned}
1 \times 2^0 &= 1 \\
0 \times 2^1 &= 0 \\
0 \times 2^2 &= 0 \\
1 \times 2^3 &= 8 \\
1 \times 2^4 &= 16 \\
\hline
& 25_{10}
\end{aligned}$$

These methods will work for converting decimal to any base and back. Simply use that base as divisor when going from decimal to that base and use powers of that base when converting back to decimal.

Some Examples

Convert $94_{10} \rightarrow \text{Base}_4$

4	94	
4	23	2
4	5	3
4	1	1
	0	1

Ans: 1132_4

Convert Back

1 1 3 2

$2 \times 4^0 = 2$

$3 \times 4^1 = 12$

$1 \times 4^2 = 16$

$1 \times 4^3 = 64$

94_{10}

Convert $109_{10} \rightarrow$ Base 16, i.e., to Hex.

16	109	
16	6	13 = D
	0	6

Ans: 6D

note.

10 = A
11 = B
12 = C
13 = D
14 = E
15 = F

Convert Back

6 D

$D \times 16^0 = 13$

$6 \times 16^1 = 96$

109_{10}.

Convert: $FACE_{16} \rightarrow$ Decimal

$$
\begin{array}{ccccccc}
F & & A & & C & & E \\
\downarrow & & \downarrow & & \downarrow & & \downarrow \\
F\times 16^3 & + & A\times 16^2 & + & C\times 16^1 & + & E\times 16^0
\end{array}
$$

$= 15 \times 256 + 10 \times 64 + 12 \times 16 + 14 \times 1$

$= 61440 + 2560 + 192 + 14 = 64,206_{10}$

See Past examination papers for more questions.