EX.

CHARACTER	CODE	BINARY
'P'	80	01010000
'a'	97	01100001
't'	116	01110100

THUS THE TEXT "Pat" WOULD BE REPRESENTED INTERNALLY AS

01010000 01100001 01110100

WHY BINARY? ANSWER: RELIABILITY.

ELECTRICAL SYSTEMS OPERATE BEST IN A BISTABLE ENVIRONMENT, IN WHICH THERE ARE 2 (RATHER THAN 10) STABLE ENERGY STATES SEPARATED BY A HUGE ENERGY BARRIER.

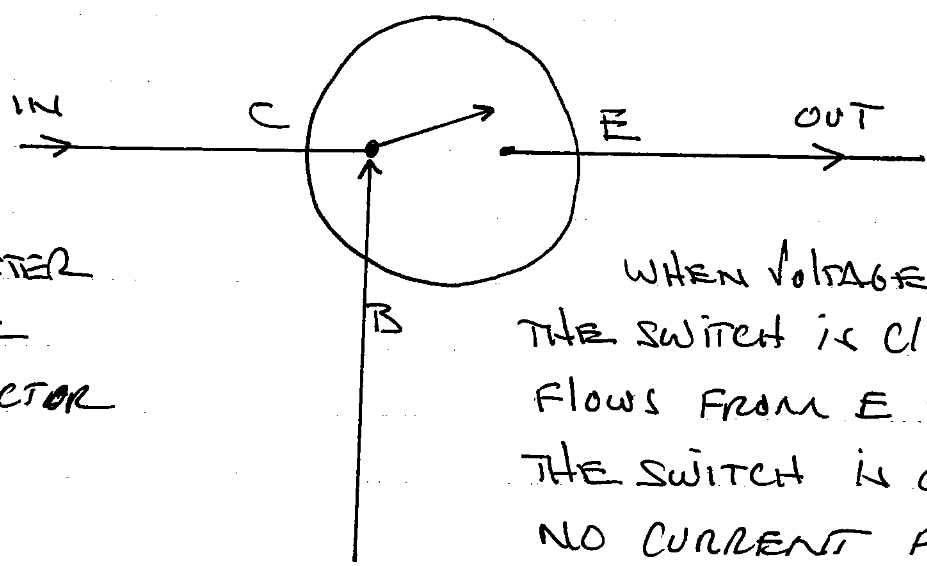
- ON - OFF
- HIGH - LOW
- POSITIVE - NEGATIVE

A BINARY COMPUTER CAN BE CONSTRUCTED FROM ANY ELECTRONIC DEVICE MEETING THESE CRITERIA:

1.) THE DEVICE HAS TWO STABLE ENERGY STATES (REPRESENTING 0 AND 1)
2.) THE STATES ARE SEPARATED BY A RELATIVELY HUGE ENERGY BARRIER
3.) ONE CAN DETERMINE WHICH STATE THE DEVICE WITHOUT LOOSING INFORMATION.
4.) ONE CAN CHANGE THE STATE OF THE DEVICE BY APPLYING A SUFFICIENT AMOUNT OF ENERGY.

TODAY THE MOST COMMONLY USED DEVICE WHICH SATISFIES THESE CRITERIA IS THE <u>TRANSISTOR</u>.

FOR THESE PURPOSES, THE TRANSISTOR IS AN ELECTRONICALLY CONTROLLED ELECTRIC SWITCH.



E: EMITTER
B: BASE
C: COLLECTOR

WHEN VOLTAGE IS HIGH AT B THE SWITCH IS CLOSED AND CURRENT FLOWS FROM E TO C. OTHERWISE THE SWITCH IS OPEN AND NO CURRENT FLOWS.

TYPICALLY A TRANSISTER CAN SWITCH STATES IN ABOUT 1 TO 10 NANO SECONDS (BILLIONTHS OF A SECOND). COMPUTER CHIPS CONTAIN ON THE ORDER OF TENS OF MILLIONS OF TRANSISTORS.

TRANSISTORS AND THE ELECTRICAL CONDUCTING PATHS WHICH CONNECT THEM ARE PRINTED PHOTOGRAPHICALLY ON A WAFER OF SILICON, WHICH IS THEN SLICED INTO A NUMBER OF CHIPS.

TRANSISTORS CAN BE COMBINED TO FORM LOGIC GATES, WHICH ARE THE FUNDAMENTAL BUILDING BLOCKS OF A BINARY COMPUTER.

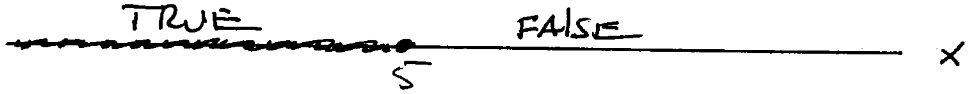
LOGIC / BOOLEAN ALGEBRA

A BOOLEAN EXPRESSION (OR LOGICAL EXPRESSION) IS ANY EXPRESSION OR STATEMENT WHICH CAN BE EVALUATED AS EITHER TRUE OR FALSE

EX.
- IT IS RAINING TODAY
- $1 < 2$
- $3 \geq 10$
- $2.5 \neq 13$
- $0 = 1$

LOGICAL EXPRESSIONS SOMETIMES CONTAIN VARIABLES, SO THAT THE VALUE OF THE EXPRESSION DEPENDS ON THE VALUE OF THE VARIABLE.

EX. $x \le 5$



LOGICAL EXPRESSIONS CAN BE COMBINED USING LOGICAL OPERATORS TO FORM COMPOUND EXPRESSIONS

OPERATORS: AND, OR, NOT

LET a AND b BE LOGICAL EXPRESSIONS. THE TRUTH TABLE FOR AND IS:

a	b	a AND b
F	F	F
F	T	F
T	F	F
T	T	T

(ALSO CONJUNCTION)

EX. $(1 < 2)$ AND $(3 \ge 10)$ is FALSE.

EX. $(2 < x)$ AND $(x \le 5)$

THE TRUTH TABLE FOR <u>OR</u> IS

a	b	a OR b
F	F	F
F	T	T
T	F	T
T	T	T

(DISJUNCTION)

<u>EX.</u> TODAY IS SUNNY OR TODAY IS THURSDAY

<u>EX.</u> $x \leq 6$ OR $x \geq 10$

THUS "a OR b" MEANS EITHER a, OR b, OR POSSIBLY BOTH ARE TRUE.

THERE IS ANOTHER MEANING OF THE WORD "OR" IN THE ENGLISH LANGUAGE. IN COMPUTER SCIENCE WE CALL THIS <u>EXCLUSIVE OR</u> AND DENOTE IT XOR. ITS TRUTH TABLE IS:

a	b	a XOR b
F	F	F
F	T	T
T	F	T
T	T	F

THUS "a XOR b" MEANS EITHER a, OR b, BUT NOT BOTH ARE TRUE.

<u>EX.</u> "YOUR MONEY OR YOUR LIFE." WHICH OR DO YOU HOPE IS BEING USED?

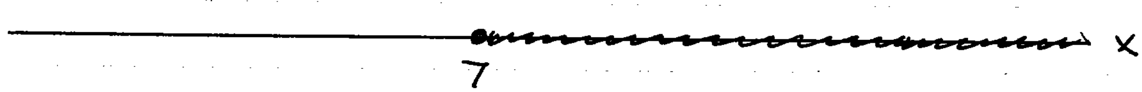
IN ENGLISH WE USE THE WORD "OR" TO MEAN BOTH <u>OR</u> AND <u>XOR</u>, AND USE CONTEXT TO TELL THE DIFFERENCE.

THE TRUTH TABLE FOR NOT IS

a	NOT a
F	T
T	F

(NEGATION)

<u>EX</u> NOT $x < 7$ MEANS $x \geq 7$



<u>NOTE</u>: NOT IS A <u>UNARY OPERATOR</u>, SINCE IT TAKES JUST ONE OPERAND, WHILE AND, OR (AND XOR) ARE <u>BINARY OPERATORS</u> (TWO OPERANDS.)

THERE ARE SEVERAL ALTERNATIVE NOTATIONS FOR THE OPERATORS AND, OR, NOT :

a AND b $\approx$ $a \wedge b$ $\approx$ $a \cdot b$
a OR b $\approx$ $a \vee b$ $\approx$ $a + b$
NOT a $\approx$ $\neg a$ $\approx$ $\overline{a}$

THE LAST COLUMN $(\cdot, +, {}^{-})$ IS PROBABLY MOST TYPICAL IN COMPUTER SCIENCE. ITS ALSO TYPICAL TO WRITE 1 FOR TRUE, AND 0 FOR FALSE.

OBSERVE THAT IF a, b, c ARE LOGICAL EXPRESSIONS, THEN

$$a \text{ AND } (b \text{ OR } c)$$

AND

$$(a \text{ AND } b) \text{ OR } c$$

HAVE DIFFERENT MEANINGS.

a	b	c	$a \cdot b$	$(a \cdot b)+c$	$b+c$	$a \cdot (b+c)$
0	0	0	0	0	0	0
0	0	1	0	1	1	0
0	1	0	0	0	1	0
0	1	1	0	1	1	0
1	0	0	0	0	0	0
1	0	1	0	1	1	1
1	1	0	1	1	1	1
1	1	1	1	1	1	1

THUS WE CANNOT WRITE

a AND b OR c

AND EXPECT TO BE UNDERSTOOD.

EXERCISE

SHOW THAT

(1) $a \cdot (b+c) \equiv (a \cdot b) + (a \cdot c)$

(2) $a + (b \cdot c) \equiv (a+b) \cdot (a+c)$.

HERE THE EQUIVALENCE $\equiv$ MEANS THAT THE LEFT AND RIGHT SIDES HAVE THE SAME TRUTH TABLES.

LOGIC GATES

A LOGIC GATE IS A DEVICE WHICH OPERATES ON A COLLECTION OF BINARY INPUTS TO PRODUCE A SINGLE BINARY OUTPUT.

THERE ARE THREE BASIC GATES CORRESPONDING TO THE LOGICAL OPERATORS AND, OR, NOT.