GCSE COMPUTER SCIENCE

Number systems

Binary, denary and hexadecimal — and the method for getting between them, not just the answer.

128	64	32	16	8	4	2	1
1	0	1	1	0	1	0	1

128 + 32 + 16 + 4 + 1 = 181

so 10110101 in binary is 181 in denary, and B5 in hex

BINARY ADDITION — AND WHERE AN OVERFLOW COMES FROM

carry		1	1	1	1	1	1	
	0	1	0	1	1	0	1	0
+	0	0	1	1	0	1	1	0
	1	0	0	1	0	0	0	0

90 + 54 = 144

1 + 1 is 0 carry 1. · 1 + 1 + 1 is 1 carry 1.
A carry out of the eighth column is an **overflow error**: the answer no longer fits in a byte.

HEXADECIMAL — ONE DIGIT IS EXACTLY FOUR BITS

0 0000 0	**1** 0001 1	**2** 0010 2	**3** 0011 3	**4** 0100 4	**5** 0101 5	**6** 0110 6	**7** 0111 7
8 1000 8	**9** 1001 9	**A** 1010 10	**B** 1011 11	**C** 1100 12	**D** 1101 13	**E** 1110 14	**F** 1111 15

Denary to binary

Write the place values, then take the biggest one that fits and keep going down.

Put a 1 under every value you used and a 0 under every value you did not. Never skip a column.

Binary to denary

Add up the place values that carry a 1.

Eight bits reach 255, not 256 — because one of the 256 patterns is zero.

Binary to hex

Split the byte into two halves of four bits and convert each half on its own.

1101 1010 becomes D and A, so DA. Never convert the whole byte at once.

Why hex at all

It is shorter to write and read than binary, and each digit maps onto exactly four bits.

One byte is always two hex digits. That is the whole reason it is used.

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Logic gates

Six gates, their symbols and their truth tables. Q is the output.

AND

Both inputs must be 1.

Q = A · B

A	B	Q
0	0	0
0	1	0
1	0	0
1	1	1

An alarm that sounds only when the sensor triggers AND the system is armed.

OR

Either input will do.

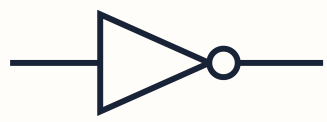
Q = A + B

A	B	Q
0	0	0
0	1	1
1	0	1
1	1	1

A light that comes on from the switch by the door OR the one at the top of the stairs.

NOT

Flips the input. One input only.



Q = NOT A

A	Q
0	1
1	0

A warning lamp wired to come on when a signal goes off.

NAND

AND, then inverted.

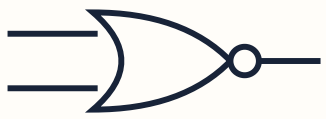
Q = NOT (A · B)

A	B	Q
0	0	1
0	1	1
1	0	1
1	1	0

Every other gate can be built out of NAND gates alone, which is why chips are full of them.

NOR

OR, then inverted.



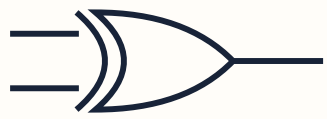
Q = NOT (A + B)

A	B	Q
0	0	1
0	1	0
1	0	0
1	1	0

Output only when nothing is on — the check that all inputs are clear.

XOR

One or the other, but not both.

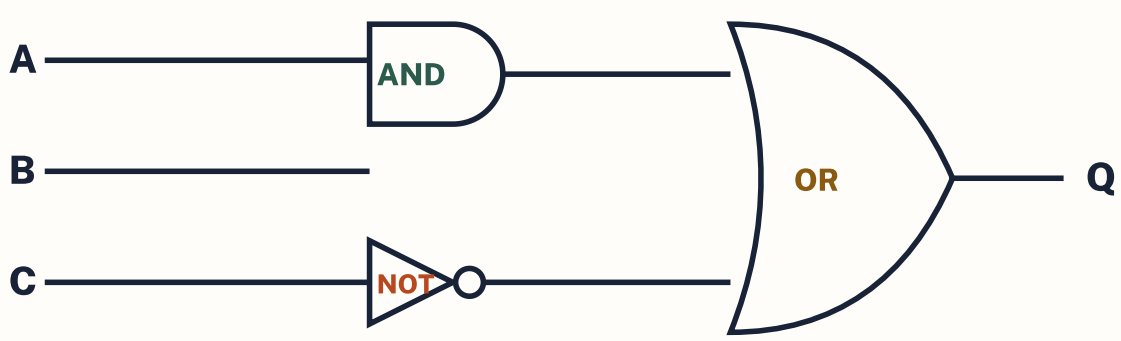


Q = A ⊕ B

A	B	Q
0	0	0
0	1	1
1	0	1
1	1	0

Spots difference. Two values compared bit by bit: 1 wherever they disagree.

TWO GATES IN A CIRCUIT — WHAT A QUESTION ACTUALLY GIVES YOU



Q = (A · B) + NOT C

A	B	C	A·B	NOT C	Q
0	0	0	0	1	1
0	1	0	0	1	1
1	1	0	1	1	1
1	1	1	1	0	1
0	1	1	0	0	0
1	0	1	0	0	0

Settled subject content. The selection, the wording and every drawing on this sheet are ours. NAND and NOR are the same shapes as AND and OR with a circle on the output — the circle is what inverts.

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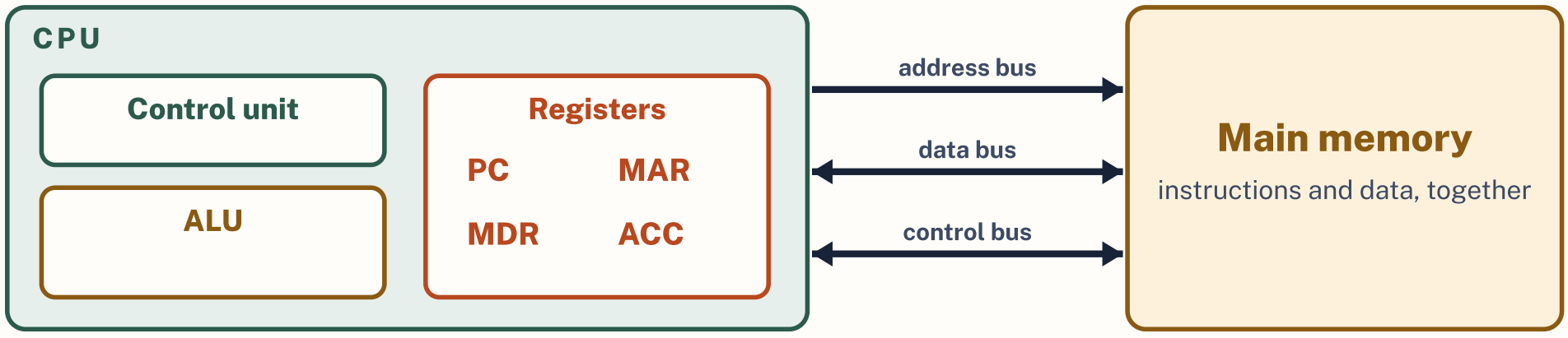
Inside the machine

One architecture and one loop. Everything a processor does is these three steps, over and over.



CU
Control unit
Decodes the instruction and tells every other part what to do.

ALU
Arithmetic logic unit
Does the sums and the comparisons. Nothing else calculates.

PC
Program counter
Holds the address of the next instruction. It increments every cycle.

MAR
Memory address register
Holds the address being read from or written to.

MDR
Memory data register
Holds the data that has just come back, or is about to go out.

ACC
Accumulator
Holds the result the ALU has just produced.

THE FETCH–DECODE–EXECUTE CYCLE

Fetch
The address in the PC goes to the MAR. That address is read from memory and the instruction arrives in the MDR. The PC increments.

Decode
The control unit works out what the instruction is and what it needs.

Execute
The instruction is carried out — a calculation in the ALU, a read or write to memory, or a jump.

WHAT MAKES THE LOOP RUN FASTER

Clock speed
Cycles per second, in gigahertz. 3 GHz is three billion fetch–decode–execute cycles every second.

Cores
Independent processors on one chip. Two cores can run two instructions at once — if the software is written to use both.

Cache
A small, very fast memory inside the CPU. The bigger it is, the less often the processor waits on main memory.

Clock speed, cores and cache size all change how fast this loop runs. None of them changes what the loop does.

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Sorting and searching

Four algorithms. You are asked to trace them by hand, so trace this one first.

One pass moves the largest value to the end. Repeat until a pass makes no swaps at all.

Looking for 31 in a sorted list: three checks, not nine.

Linear search

Start at the first item and check every one in turn.

Works on any list, sorted or not. Slow on a long list — worst case it checks all of them.

Binary search

Check the middle. Throw away the half that cannot contain it. Repeat.

Far faster — but the list must be sorted first, and sorting costs more than the search saves if you only look once.

Bubble sort

Compare each neighbouring pair and swap them if they are the wrong way round. Repeat until a pass makes no swaps.

Simple to write and slow to run. Easy to trace by hand, which is why it is the one you are asked to trace.

Merge sort

Split the list in half over and over until every piece is one item. Then merge the pieces back in order.

Much faster on a long list. Divide and conquer — the splitting is the easy half, the merging is where the work is.

Settled subject content. The selection, the wording and every drawing on this sheet are ours. Binary search halves the list every step, which is why it beats linear search on anything long — and why the list has to be sorted before you start.

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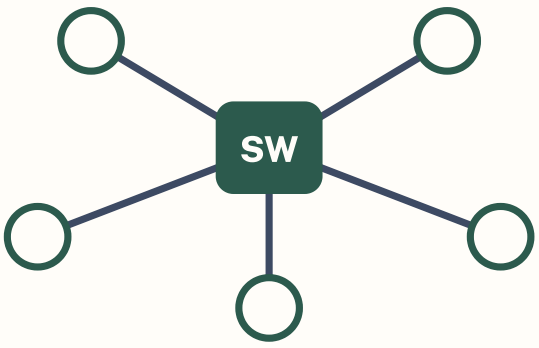
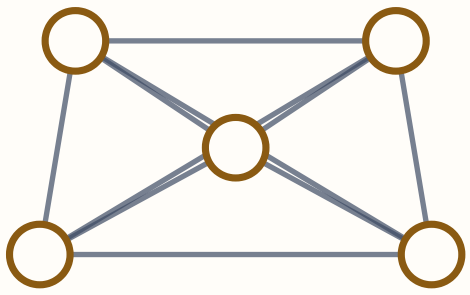
Networks

How machines are wired together, and the rules they use to talk once they are.



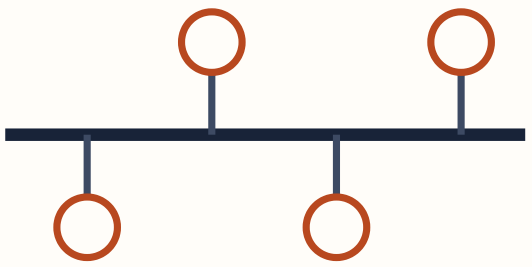
Star

Every device connects to a central switch. One cable fails and one device is off. The switch fails and everything is off.



Mesh

Devices connect to each other, often to several. No single point of failure, and it reroutes around a break. Expensive in cable.



Bus

Every device shares one backbone cable. Cheap and simple. Busy traffic collides, and a break in the backbone takes the whole network down.

KINDS OF NETWORK

LAN
Local area network

One site — a school, an office, a house. The organisation owns the cabling and the hardware.

WAN
Wide area network

Sites joined across distance, over infrastructure somebody else owns. The internet is the largest one.

Client–server
One machine serves many

Files and accounts live centrally. Easier to back up and control, and the server going down stops everyone.

Peer-to-peer
Every machine is equal

No server to buy or maintain. Files are scattered, so backing up and finding things is harder.

PROTOCOLS — AN AGREED SET OF RULES FOR ONE JOB EACH

TCP/IP
Splits data into packets, addresses them, and puts them back in order at the far end.

HTTP / HTTPS
Requests web pages. The S adds encryption, so anyone intercepting sees nothing usable.

SMTP
Sends email.

IMAP
Retrieves email, leaving it on the server so every device sees the same inbox.

FTP
Moves files between machines.

DHCP
Hands out IP addresses automatically when a device joins.

THE HARDWARE THAT JOINS THEM

NIC
Network interface card — gives a device its unique MAC address.

Switch
Sends a frame only to the port it is addressed to.

Router
Joins networks and chooses the path between them.

WAP
Wireless access point — the same job as a switch, over radio.