Grade 10 Computer Science

CBC NOTES | Terms 1, 2 and 3 - notes for 17 topics

IN EVERY TOPIC

- What you will learn, the key words and key terms explained.
- Clear notes under headings and subheadings, with labelled pictures and step-by-step procedures.
- Comparison tables, and advantages and disadvantages where methods are compared.
- Key points to remember, then structured questions to practise.
- All the answers and a glossary at the back.

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1.1 Evolution of Computers

WHAT YOU WILL LEARN

By the end of this topic you should be able to:

- identify early computing devices and how they relate to the evolution of electronic computers
- describe the principal technologies that defined the development of computers
- relate the principal technologies to their respective computer generation

KEY WORDS

abacus, Pascaline, Jacquard loom, Analytical Engine, vacuum tube, transistor, integrated circuit, microprocessor, generation, Moore's Law.

The phone in a parent's pocket is millions of times more powerful than the room-sized computers of the 1940s. It did not appear overnight. In this topic we trace the counting tools people used long before electricity, the technologies that made each new generation of computer smaller, faster and cheaper, and how to match each generation to the technology that defined it.

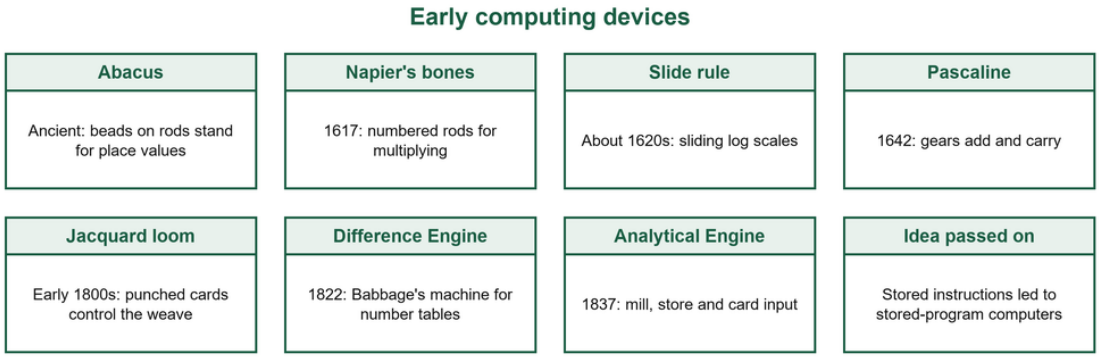
1. Early computing devices

> **Computing device**
> Any tool or machine that helps people count, calculate or process data.

Long before electronic computers, people built tools to make counting and calculating faster and more accurate. Each one solved a real problem of its time, and several of their ideas (moving parts that hold digits, rods that store tables, punched cards that hold instructions) were carried forward into modern computers.

Early computing devices and what they gave to modern computers

Device	Who / when	How it worked	Idea passed on
Abacus	Ancient traders, thousands of years ago	Beads slid along rods; each rod stands for a place value	Place value and a device that holds numbers
Napier's bones	John Napier, 1617	Numbered rods laid side by side to read off multiplication results	Storing tables so a machine can look results up
Slide rule	William Oughtred, about 1620s	Two sliding scales based on logarithms; multiply by adding lengths	Fast approximate calculation used by engineers until the 1970s
Pascaline	Blaise Pascal, 1642	Toothed gears added and subtracted; a full wheel carried 1 to the next	Automatic carrying, as in today's adders
Jacquard loom	Joseph Jacquard, early 1800s	Punched cards told the weaving machine which threads to lift	Instructions stored on cards: a stored program
Difference Engine	Charles Babbage, 1822	Gears worked out tables of numbers automatically	A machine that follows a fixed method by itself
Analytical Engine	Charles Babbage, 1837 (design)	Had a "mill" to calculate, a "store" for numbers and punched-card input	The plan of a general-purpose computer



Early computing devices, from the abacus to the Analytical Engine

REMEMBER

Ada Lovelace wrote a method (an algorithm) for the Analytical Engine to calculate a series of numbers, so she is called the first computer programmer. The Engine itself was never completed in Babbage's lifetime.

2. Why electronic computers replaced mechanical ones

Mechanical devices used gears, levers and rods. Moving parts are slow, wear out and jam. An electronic computer uses electrical signals switched on and off instead, so it has far fewer moving parts and can switch millions of times faster.

Electronic compared with mechanical devices

+ Advantages

- Much faster: signals switch in tiny fractions of a second
- More accurate: no slipping gears
- Can store a program and change it easily
- Can handle very large amounts of data

- Disadvantages

- Need a steady electricity supply
- Early ones were huge, hot and very expensive
- Need trained people to build, program and repair them

One of the first large electronic computers was ENIAC (Electronic Numerical Integrator and Computer), finished in 1945. It used about 18,000 vacuum tubes, filled a large room and needed special cooling. Only governments, armies and big universities could afford such machines.

3. The principal technologies

A principal technology is the main electronic part a generation of computers was built from. Each new technology did the same job as the one before (switching current on and off to represent 0 and 1) but in a smaller space, with less power and heat, and at a lower cost.

Vacuum tube (valve)

A glass tube with no air inside that switches or strengthens an electric current. Large, hot and short-lived.

Transistor

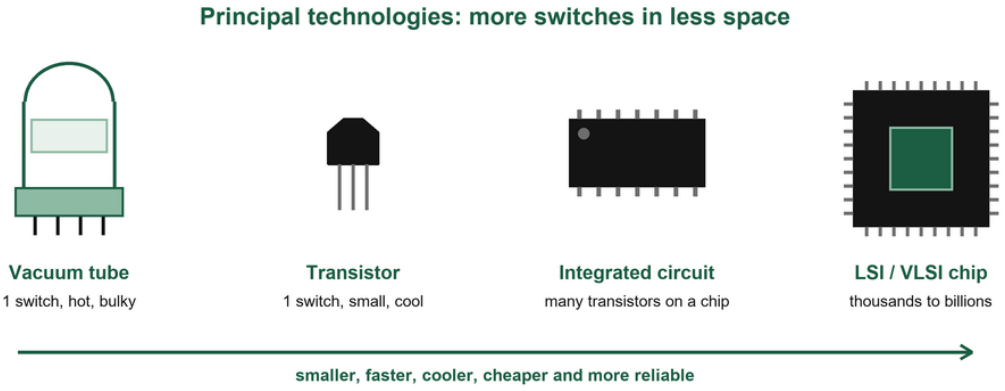
A small switch made from a semiconductor such as silicon. It does the job of a vacuum tube but is far smaller, cooler and more reliable.

Integrated circuit (IC)
Many transistors and other parts built together on one small chip of silicon.

Large scale integration (LSI)
Thousands of transistors on one chip. This made the first microprocessors possible.

Very large scale integration (VLSI)
Hundreds of thousands to millions (and today billions) of transistors on one chip.

Microprocessor
A whole central processing unit (CPU) built on a single chip, for example the Intel 4004 of 1971.



Each principal technology packs more switches into less space

MOORE'S OBSERVATION
In 1965 Gordon Moore noticed that the number of transistors on a chip was doubling about every two years. A chip with 2,000,000 transistors would have about 2 × 2,000,000 = 4,000,000 two years later. This steady growth is why computers keep getting smaller and cheaper.

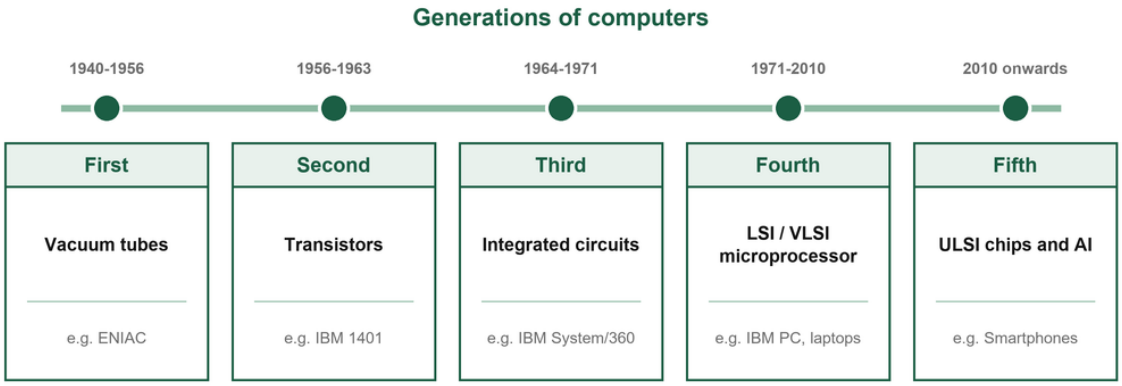
4. Generations of computers

Computers are grouped into generations by the principal technology they used. The dates are approximate because a new technology spread slowly from country to country.

The five generations of computers

Generation	Principal technology	Main features	Examples
First (about 1940-1956)	Vacuum tubes	Room-sized, very hot, used a lot of power; programmed in machine language (0s and 1s); punched-card input	ENIAC, UNIVAC I
Second (about 1956-1963)	Transistors	Smaller, faster, cooler and more reliable; assembly language and early high-level languages; magnetic storage	IBM 1401

Generation	Principal technology	Main features	Examples
Third (about 1964-1971)	Integrated circuits	Smaller and cheaper still; keyboards and monitors; an operating system ran several programs at once; languages such as FORTRAN and COBOL	IBM System/360
Fourth (about 1971-2010)	LSI and VLSI chips (microprocessor)	Personal computers on a desk; graphical user interface with windows, icons and a mouse; networks and the internet	IBM PC, Apple Macintosh, laptops
Fifth (about 2010 onwards)	Ultra large scale integration and artificial intelligence	Pocket-sized and connected; recognise speech and images; learn from data	Smartphones, voice assistants, AI systems



Generations of computers and their principal technologies

Matching a description to its generation

Description: "fills a room, uses vacuum tubes, programmed in 0s and 1s".
Clue: vacuum tubes are the principal technology of the first generation.
Answer: first generation.
Description: "fits in a pocket, understands spoken commands, connects to the internet".
Clue: speech recognition is artificial intelligence; a pocket device needs chips with billions of transistors.
Answer: fifth generation.

5. What the changes mean for us

Each generation brought the same five gains: smaller size, higher speed, lower power use, lower cost and greater reliability. That is how computers moved from a single government room to every school, office and pocket.

- Mobile money such as M-Pesa runs on fifth-generation phones and servers that handle millions of payments a day.
- KCSE and KJSEA results are processed by computers in hours instead of weeks.
- Farmers get weather and market prices by SMS or voice, without visiting a town office.

THINK ABOUT IT

Today's fastest computer will look slow in a few decades. Emerging technologies such as quantum computing may become the principal technology of a future generation.

KEY POINTS TO REMEMBER

- Early computing devices include the abacus, Napier's bones, the slide rule, the Pascaline, the Jacquard loom and Babbage's Difference and Analytical Engines.
- The Jacquard loom's punched cards and the Analytical Engine's mill and store led to the idea of a stored-program computer.
- The principal technologies were vacuum tubes, transistors, integrated circuits, LSI and VLSI chips.
- Generations: first = vacuum tubes, second = transistors, third = integrated circuits, fourth = LSI/VLSI microprocessors, fifth = ULSI chips and artificial intelligence.
- Each generation made computers smaller, faster, cheaper, cooler and more reliable.

ANSWER THESE

1. Name four computing devices that were used before electronic computers. (4 marks)

2. Explain how the Jacquard loom contributed to the development of computers. (2 marks)

3. State the principal technology of each of the five generations of computers. (5 marks)

4. Give three reasons why transistors replaced vacuum tubes. (3 marks)

5. Define a microprocessor and state the generation in which it was introduced. (2 marks)

6. A computer is described as "the size of a cupboard, built from integrated circuits, using a keyboard and monitor". Name its generation and give a reason. (2 marks)

7. State four features of fifth-generation computers. (4 marks)

8. A chip has 3,000,000 transistors. If the number doubles every two years, about how many will a chip have after four years? Show your working. (2 marks)

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1.2 Computer Architecture

WHAT YOU WILL LEARN

By the end of this topic you should be able to:

- describe the functional organisation and architecture of a von Neumann computer
- analyse the relationships among the functional elements of a von Neumann computer
- create a model of a computer architecture depicting the structural elements of a von Neumann computer
- use binary, octal and hexadecimal number systems to represent data in a von Neumann's digital computer

KEY WORDS

von Neumann architecture, Control Unit, Arithmetic and Logic Unit, stored-program concept, register, address bus, data bus, control bus, binary, octal, hexadecimal.

Every computer, from a school desktop to a bank's server, is organised in almost the same way. That plan was described by John von Neumann in 1945. In this topic we study the parts of a von Neumann computer, how they talk to each other over buses, the fetch-execute cycle, the two families of instruction sets (RISC and CISC) and the number systems a digital computer uses to hold data.

1. The von Neumann computer

> **Computer architecture**
> The design of a computer: its parts, what each part does and how the parts are connected.

> **Stored-program concept**
> Program instructions and the data they work on are kept together in the same memory, so a new program can be loaded without rewiring the machine.

A von Neumann computer has these functional elements:

Functional elements of a von Neumann computer

Element	What it does
Input	Brings data and instructions in, for example a keyboard, mouse or scanner.
Central Processing Unit (CPU)	Processes data. It has a Control Unit (CU) and an Arithmetic and Logic Unit (ALU), plus small fast stores called registers.
Control Unit (CU)	Fetches each instruction from memory, decodes it and sends control signals to the other parts.
Arithmetic and Logic Unit (ALU)	Does calculations (add, subtract) and comparisons (is 7 greater than 5?).
Memory (storage)	Holds the program's instructions and the data in one place.
Output	Gives out results, for example a monitor, printer or speaker.
Buses	Groups of wires that carry addresses, data and control signals between the parts.