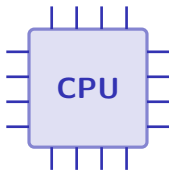


Hardware

AS Computer Science ■ Topic 3

A-Level Computer Science



What we will cover

- 1 Components & embedded systems
- 2 Storage devices
- 3 Memory: RAM, ROM & variants
- 4 Monitoring & control
- 5 Logic gates & circuits
- 6 Recap



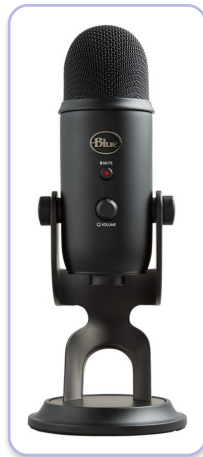
1

Components and embedded systems

The four building blocks



primary memory 主存储器
(RAM/ROM) is fast and direct;
secondary storage 辅助存储器 is large
and keeps data without power.



Microphone photo

Embedded systems

An **embedded system** 嵌入式系统 is a computer built **into another device** for one fixed job (washing machine, car engine, thermostat).

- + small, cheap, reliable, low power
- – locked to its one task; **firmware** 固件 updates may need special tools
- – often not repairable, and security is sometimes weak



A 3D printer builds an object layer by layer



- **FDM** melts plastic filament through a moving nozzle
- **stereolithography** cures liquid resin with a UV laser
- either way the object grows one thin **layer** at a time

Used for prototypes, custom parts and medical models – anything where one item is wanted, not a thousand.

2

Storage devices

Input and output devices



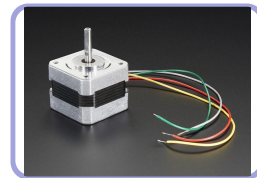
keyboard
input



monitor
output



laser printer
output



motor (actuator)
output

Laser printer 激光打印机: a charged **drum** 感光鼓 attracts **toner** 墨粉, which heat then fuses onto the paper.

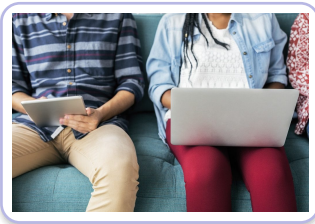
Input devices you should know



mouse – optical movement



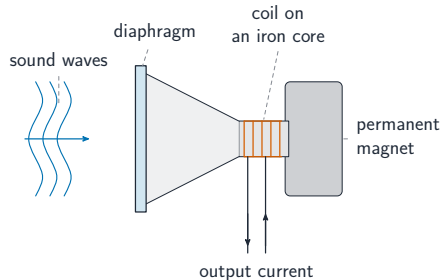
scanner – reflected light



touchscreen – input *and* output

A **touchscreen** 触摸屏 is both: **resistive** presses two conductive layers together (works with any object, less accurate); **capacitive** senses the change your finger makes to a charge grid (sharper, but needs skin or a special stylus).

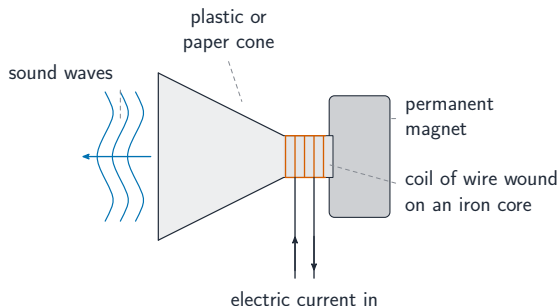
Microphone and loudspeaker



microphone 麦克风: *sound* → *signal*

A **diaphragm** 振膜 vibrates, changing a **capacitor** 电容器's charge or a coil's position; an **analogue-to-digital converter** 模数转换器 (ADC) digitises the signal. A loudspeaker runs the same parts backwards.

Inside the loudspeaker



A current in the coil sits in the magnet's field, so it is pushed in and out – the cone moves with it and pushes the air.

A current in the coil moves it in the magnet's field, the cone pushes the air, and you hear it. A microphone is the same parts run **backwards**.

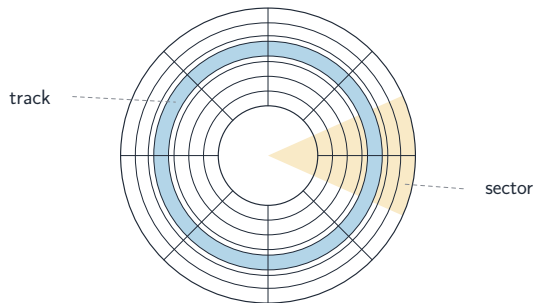
Magnetic hard disk

A **hard disk** 硬盘 stores bits as magnetised regions on spinning platters.

- a **read/write head** flies just above the surface
- data sits in concentric **tracks**, split into sectors
- cheap per GB, but mechanical – slower, and shock can crash the head



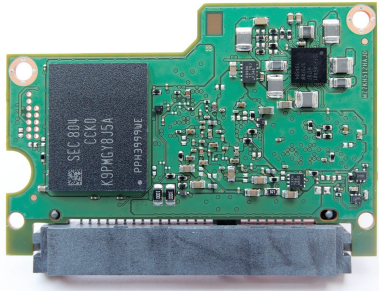
Tracks, sectors and the head



Access time is dominated by **seek** (moving the head to the track) and **latency** (waiting for the sector to arrive).

Data sits in concentric **tracks** divided into **sectors**; the head moves in and out while the platter spins, so access time is seek time plus rotational delay.

Solid-state and optical



solid-state drive 固态硬盘: *flash, no moving parts*

SSD: faster, tougher, lower power – but dearer per GB and cells wear out.

An optical disc



Pits and lands along a spiral track; a weak laser reads the reflections. The same drive **writes** with a stronger beam that burns the marks – CD, DVD and Blu-ray differ only in laser wavelength, and so in how small a pit can be.

Virtual reality headset

A **virtual reality** 虚拟现实 (VR) headset has two small displays (one per eye) and motion sensors (**accelerometer** 加速度计).

3

Memory

Buffers

A **buffer** 缓冲 holds data temporarily between devices of **different speeds**. The CPU writes to a printer buffer quickly, then works on; the printer prints from it at its own pace.



RAM and ROM

RAM 随机存取存储器

volatile 易失性, read/write
– running programs

ROM 只读存储器

non-volatile 非易失性,
read-only – firmware

ROM: start-up firmware

power on: load

RAM: OS + programs run here

power off: RAM **cleared** ▪ ROM **kept**

RAM against ROM

RAM

volatile — lost at power off
read *and* write
holds running programs & data

ROM

non-volatile — kept at power off
read-only
holds start-up instructions

RAM is **volatile** working memory that the processor writes to; ROM holds what must survive a power cut, such as the bootstrap.

RAM 随机存储器 is volatile working memory that loses everything at power-off;
ROM 只读存储器 is non-volatile and holds the start-up code.

Memory variants

SRAM 静态 RAM
transistors 晶体管 in
flip-flops; fast, costly –
CPU **cache** 高速缓存

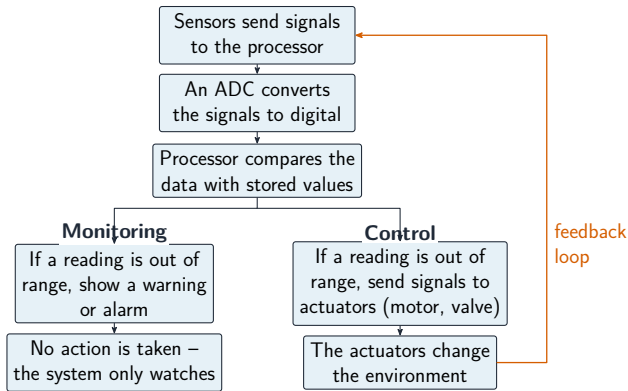
DRAM 动态 RAM
capacitors, must be **re-
freshed** 刷新 thousands of times
a second; dense – main memory

ROM you can program later
PROM – written once, fuses burned
EPROM – UV light erases the whole
chip
EEPROM – erased electrically, a byte at
a time, in circuit (flash is its descendant)

4

Monitoring and control

Monitoring vs control



Both read **sensors** 传感器:

- **monitoring** 监控: collects and reports, **takes no action** – a weather station logging readings
- **control** 控制系统: **acts** via **actuators** 执行器 in a **feedback** 反馈 loop

A sensor in a control system



A **thermistor** 热敏电阻: its resistance falls as it warms, so a potential divider turns temperature into a voltage the ADC can read.

5

Logic

Logic gates



NOT



AND



OR



NAND



NOR



XOR

A **logic gate** 逻辑门 does one **Boolean** 布尔 operation; inputs/outputs are 0 or 1. Know the symbol, function and **truth table** 真值表 of each.

Truth tables

A	B	AND	OR	NAND	NOR	XOR
0	0	0	0	1	1	0
0	1	0	1	1	0	1
1	0	0	1	1	0	1
1	1	1	1	0	0	0

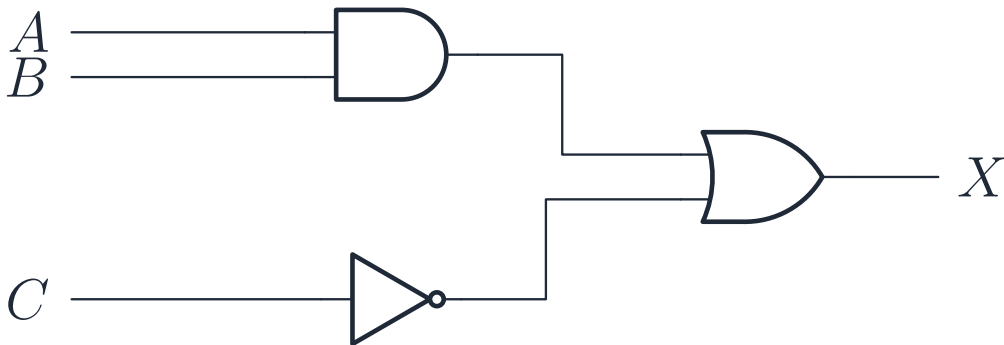
NOT: $0 \rightarrow 1, 1 \rightarrow 0$. **AND:** all 1. **OR:** any 1. **XOR:** inputs differ.

Logic circuits

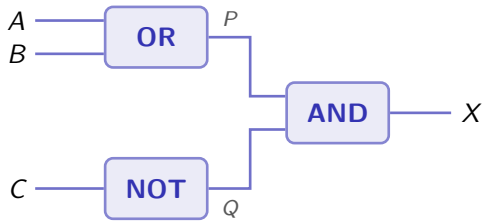
A **logic circuit** 逻辑电路 wires gates to do a Boolean expression – here

$$X = (A \text{ AND } B) \text{ OR } (\text{NOT } C).$$

Move freely between statement $\leftrightarrow$ expression $\leftrightarrow$ table $\leftrightarrow$ circuit.



Worked example: from circuit to truth table



$$P = A \text{ OR } B, \quad Q = \text{NOT } C$$
$$X = P \text{ AND } Q$$

A	B	C	P	Q	X
0	0	0	0	1	0
0	0	1	0	0	0
0	1	0	1	1	1
0	1	1	1	0	0
1	0	0	1	1	1
1	0	1	1	0	0
1	1	0	1	1	1
1	1	1	1	0	0

Work **gate by gate**: add a column for every intermediate signal, then combine.

From a problem statement

Turn the English into a Boolean expression first: "A and B" $\rightarrow$ A AND B; "A or B or both" $\rightarrow$ A OR B; "exactly one of A and B" $\rightarrow$ A XOR B; "neither A nor B" $\rightarrow$ A NOR B; "not both" $\rightarrow$ A NAND B.

Worked example. A machine's alarm X sounds when the guard is open ($A = 1$) **and** either the motor is running ($B = 1$) or the temperature is high ($C = 1$).

Worked example – English into Boolean

An alarm X sounds when the guard is open ($A = 1$) and either the motor runs ($B = 1$) or the temperature is high ($C = 1$). Write the expression and give the rows where $X = 1$.

- One clause at a time: “either B or C ” is $B + C$, and “ A and that” is $X = A \cdot (B + C)$.
- $X = 1$ needs $A = 1$ and at least one of B , C :
(1, 0, 1), (1, 1, 0) and (1, 1, 1) – three rows of eight.
- $A = 0$ can never sound the alarm, whatever B and C do.

Bracket the OR before ANDing it. $X = A \cdot B + C$ is a different circuit – one that sounds on a high temperature with the guard shut.

Exam tips

- Distinguish **RAM (volatile, read/write)** from **ROM (non-volatile, holds the bootstrap)**; SRAM (cache, faster) from DRAM (main memory, needs refreshing).
- For a **logic circuit**, build the Boolean expression gate by gate, then a truth table covering **every** input combination.
- Learn the symbol, expression and truth table for each gate (AND, OR, NOT, NAND, NOR, XOR).
- Explain a **buffer** (a temporary store bridging two different speeds) and the role of an interrupt.

6

Recap

Topic 3 – key takeaways

1

Components

input, output, primary memory,
secondary storage

2

Storage

HDD magnetic; SSD flash; optical
laser

3

Memory

RAM volatile; ROM non-volatile;
SRAM vs DRAM

4

Logic

six gates; build circuits from
expressions

Check yourself

- 1 Is RAM volatile or non-volatile?
- 2 Which memory is used for CPU cache?
- 3 A gate that outputs 1 only when inputs differ?
- 4 Monitoring or control: which acts on the data?



Answers 1. volatile 2. SRAM 3. XOR 4. control