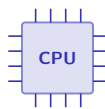


Hardware

AS Computer Science • Topic 3

A-Level Computer Science



Hardware

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

Hardware

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

Hardware

Components and embedded systems

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
- – one task; hard to update (**firmware** 固件)



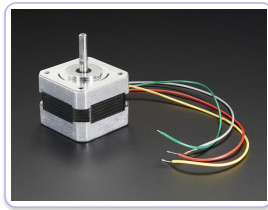
2

Storage devices

Input and output devices



keyboard



Motor actuator



monitor

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

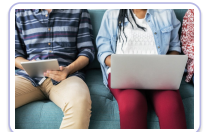
Input devices you should know



mouse — optical movement

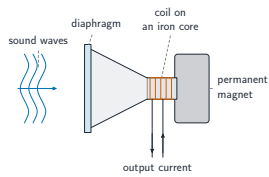


scanner — reflected light



touchscreen — input and output

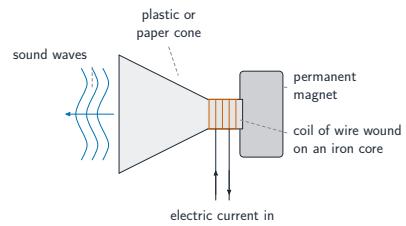
Microphone and loudspeaker



microphone 麦克风: sound → signal

A microphone signal is digitised by an **ADC** 模数转换器.

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.

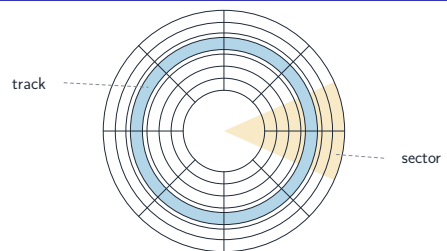
Magnetic hard disk

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

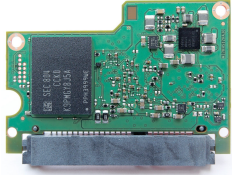


Tracks, sectors and the head



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

Solid-state and optical



SSD 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; the reflected laser reads the transitions.

3 Memory

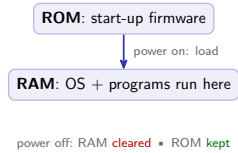
Buffers

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



RAM against ROM

RAM
volatile — lost at
power off
read *and* write
holds running pro-
grams & data

ROM
non-volatile — kept at
power off
read-only
holds start-up instruc-
tions

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

Hardware
└ Memory

Memory variants

SRAM 静态 RAM

flip-flops; fast, costly –
CPU **cache** 高速缓存

DRAM 动态 RAM

capacitors, must **refresh** 刷新;
dense – main memory

PROM / EPROM / EEPROM

write-once / UV-erase /
electrically-erase (flash)

4 Monitoring and control

Hardware
└ Monitoring and control

Monitoring vs control

```

graph TD
    A[Sensors send signals to the processor] --> B[An ADC converts the signals to digital]
    B --> C[Processor compares the data with stored values]
    C --> D[Monitoring]
    C --> E[Control]
    D --> F[If a reading is out of range, show a warning or alarm]
    F --> G[No action is taken – the system only watches]
    E --> H[If a reading is out of range, send signals to actuators (motor, valve)]
    H --> I[The actuators change the environment]
    I -- feedback loop --> A
          
```

Both read **sensors** 传感器:

- **monitoring** 监控: reports data, **no action**
- **control** 控制系统: **acts** via **actuators** 执行器 in a **feedback** 反馈 loop

Hardware
└ Monitoring and control

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

Hardware
└ Logic

Logic gates

NOT

AND

OR

NAND

NOR

XOR

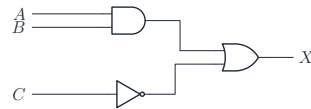
A **logic gate** 逻辑门 does one **Boolean** 布尔 operation; inputs/outputs are 0 or 1. Know the symbol, function and **truth table** 真值表 of each.

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

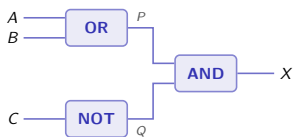


A **logic circuit** 逻辑电路 wires gates to do a Boolean expression – here

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

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.

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