

Exercise walk-through

Data storage ■ 3.3

eXercise

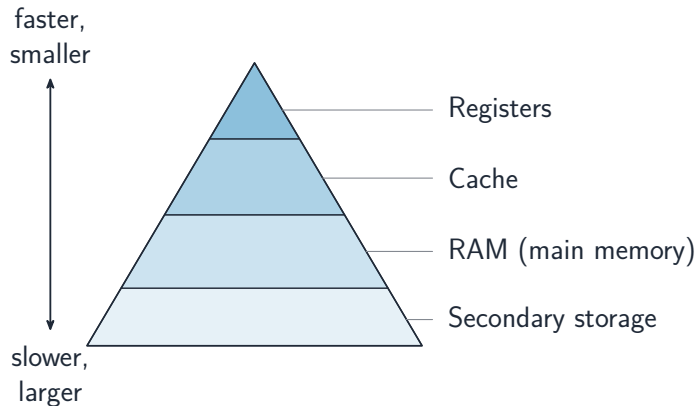
You must be able to

- compare RAM and ROM (volatile/non-volatile, read/write)
- describe magnetic, optical and solid-state secondary storage
- explain virtual memory

Method — Memory and storage

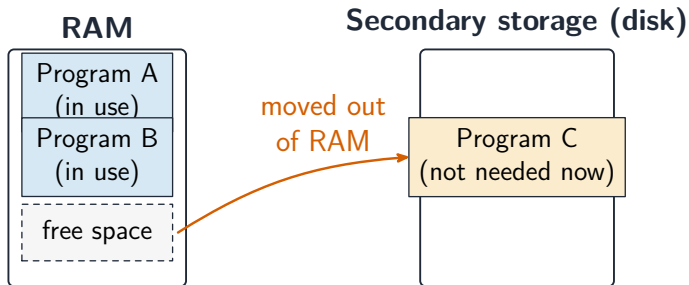
- **RAM:** volatile, read/write. **ROM:** non-volatile, read-only (start-up).

Method — Memory and storage



A memory hierarchy: registers, cache, RAM, secondary storage

Method — Memory and storage



This frees RAM, so more programs can run than RAM alone could hold — but it is slower, because the disk is much slower than RAM.

Virtual memory moves unused data to disk to free RAM

Method — Naming the storage, and choosing between types

Primary storage is directly addressable by the CPU. **RAM** 随机存取存储器 is volatile: it loses its contents when the power goes off, and it holds the programs, data and parts of the operating system currently in use. **ROM** 只读存储器 is non-volatile and holds the start-up instructions (the bootstrap or BIOS) that never change.

Secondary storage is non-volatile and not directly addressed by the CPU. The three technologies, with what each is best at:

Type	How it stores data	Good	Poor
magnetic 磁性 (hard disc drive)	magnetised sectors on spinning platters, read by a moving head	very large capacity, low cost per gigabyte	moving parts, so slower and easily damaged by knocks
optical 光学 (CD, DVD, Blu-ray)	pits and lands burned into a track, read by a laser	cheap, removable, good for distributing files	small capacity, slow, scratches easily
solid state 固体 (SSD)	electrons trapped in NAND flash cells	fast, silent, robust,	costs more per

Method — Naming the storage, and choosing between types

Virtual memory 虚拟内存 is space on secondary storage used as if it were RAM. When RAM is full, pages not in use are moved out to the virtual memory, freeing RAM for the current program; they are moved back when needed. It lets a computer run more (or larger) programs than RAM alone allows, but because secondary storage is much slower, heavy use of it slows the computer down.

Cloud storage 云存储 keeps data on remote servers reached over the internet. It gives access from any device and anywhere, automatic backup, and easy sharing; it needs an internet connection, may cost a subscription, and puts the security of the data in someone else's hands.

Practice 2.1 ■ 1 mark

State whether RAM is volatile or non-volatile.

Solution 2.1

Worked steps

volatile **B1**.

Practice 2.2 ■ 3 marks

Name the three types of secondary storage.

Solution 2.2

Method: Naming the storage, and choosing between types

Worked steps

magnetic; optical; solid state **B1** **B1** **B1**.

Practice 2.3 ■ 2 marks

Give one difference between RAM and ROM.

Solution 2.3

Worked steps

RAM is volatile and loses its contents when the power is off, while ROM is non-volatile and keeps them **B1**; RAM holds the programs and data in use, while ROM holds the start-up instructions **B1**.

Practice 2.4 ■ 2 marks

Describe how data is stored on an optical disc.

Solution 2.4

Method: Naming the storage, and choosing between types

Worked steps

A laser burns pits into the reflective layer along a spiral track, leaving lands between them **B1**; a laser then reads the disc, and the change between a pit and a land represents the binary data **B1**.

Practice 2.5 ■ 3 marks

Explain what virtual memory is and why it is used.

Solution 2.5

Method: Naming the storage, and choosing between types

Worked steps

Virtual memory is an area of secondary storage used as though it were RAM **B1**; when RAM is full, pages that are not currently needed are moved out to it **B1**, which allows more or larger programs to run than the RAM alone could hold **B1**.

Exam-style 3.1 ■ 1 mark

ROM is used to store:

- A** programs in use now
- B** the start-up instructions
- C** files permanently
- D** virtual memory

Solution 3.1

A programs in use now

B the start-up instructions 

C files permanently

D virtual memory

Worked steps

B. ROM stores the start-up (boot) instructions.

Exam-style 3.2 ■ 2 marks

A computer uses virtual memory.

- (a) Explain what virtual memory is.
- (b) State one disadvantage of using virtual memory.

Solution 3.2

Worked steps

- (a) part of secondary storage used as extra (pretend) RAM **M1**; unused data is moved there to free RAM, so more programs can run **A1**.
- (b) it is slower (secondary storage is slower than RAM) **B1**.

Exam-style 3.3 ■ 1 mark

State one difference between an SSD and an HDD.

Solution 3.3

Worked steps

-
- (a) The surface is divided into tracks and sectors on spinning platters **B1**; a read-write head magnetises tiny areas, and the direction of magnetisation represents a 1 or a 0 **B1**.
- (b) It uses NAND flash memory with no moving parts **B1**; electrons are trapped in or released from cells (control gates), and the state of each cell represents a 1 or a 0 **B1**.
- (c) Any three of: faster to read and write, so the laptop starts up and loads files quickly; no moving parts, so it survives being carried and knocked; silent; lighter; uses less power, so the battery lasts longer **B3**.
- (d) It costs more per gigabyte, so the same money buys less capacity (or: each cell has a limited number of write cycles) **B1**.
- (e) When the RAM is full, the operating system moves pages that are not currently in

Solution 3.3

Worked steps

use out to virtual memory on the drive **B1**; that frees RAM for the program the student is using **B1**; the pages are moved back when they are needed again **B1**; because the drive is much slower than RAM, the student notices the laptop slowing down and the drive working constantly if too many programs are open **B1**.

(f) Any two benefits **B2**: the work can be reached from any device and any place with internet; it is backed up automatically; it is easy to share with a teacher; the school does not have to buy and maintain the storage. One drawback **B1**: it needs an internet connection, or the data's security depends on the provider, or there may be a subscription cost.

Exam-style 3.3 ■ 2 marks

A school replaces the hard disc drives in its laptops with solid-state drives.

- (a) Describe how a magnetic hard disc drive stores data.
- (b) Describe how a solid-state drive stores data.
- (c) Give three benefits of the solid-state drives for laptops that students carry between classes.
- (d) Give one drawback of solid-state storage compared with a magnetic hard disc.
- (e) The laptops have 4 GB of RAM. Explain how virtual memory allows a student to open more programs than the RAM can hold, and describe what the student would notice if many programs were open.
- (f) The school also stores the students' work in cloud storage. Give two benefits and one drawback of this.

Solution 3.3

Method: Naming the storage, and choosing between types

Worked steps

- (a) The surface is divided into tracks and sectors on spinning platters **B1**; a read-write head magnetises tiny areas, and the direction of magnetisation represents a 1 or a 0 **B1**.
- (b) It uses NAND flash memory with no moving parts **B1**; electrons are trapped in or released from cells (control gates), and the state of each cell represents a 1 or a 0 **B1**.
- (c) Any three of: faster to read and write, so the laptop starts up and loads files quickly; no moving parts, so it survives being carried and knocked; silent; lighter; uses less power, so the battery lasts longer **B3**.

Solution 3.3

(d) It costs more per gigabyte, so the same money buys less capacity (or: each cell has a limited number of write cycles) **B1**.

(e) When the RAM is full, the operating system moves pages that are not currently in use out to virtual memory on the drive **B1**; that frees RAM for the program the student is using **B1**; the pages are moved back when they are needed again **B1**; because the drive is much slower than RAM, the student notices the laptop slowing down and the drive working constantly if too many programs are open **B1**.

(f) Any two benefits **B2**: the work can be reached from any device and any place with internet; it is backed up automatically; it is easy to share with a teacher; the school does not have to buy and maintain the storage. One drawback **B1**: it needs an internet connection, or the data's security depends on the provider, or there may be a subscription cost.