Chapter 2: Memory and Storage

In this chapter you will learn:

- what the purpose of RAM and ROM is and how they differ
- what is meant by flash memory
- what is meant by virtual memory and why we might use it
- what is meant by secondary storage and how we can choose a suitable storage device
- how to calculate the size of a file

What is the purpose of RAM?

OCR specification reference:

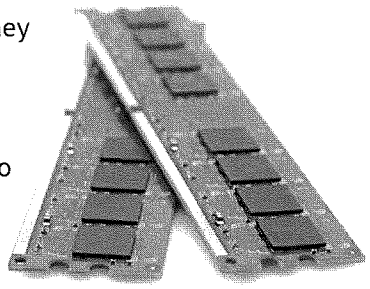
☑ the purpose of RAM in a computer system

RAM is short for random access memory. It is the place in a computer where all the programs and data that are currently in use are stored. These are stored in RAM when they are in use as this allows the computer to quickly access them. This is because RAM is quicker to read to and write from than any other storage in a computer, such as the **hard disk**.

RAM – the place in memory where all current programs and data in use are stored

Hard disk – a type of magnetic storage device inside a computer that is used to store data long-term

RAM is very useful as it allows quick access to the data and programs in use; however, the items in RAM only stay there as long as the computer is turned on. As soon as the computer is turned off, all the data and programs that are stored in RAM are lost – this means that RAM is an example of what we call volatile memory. In order to save the data and programs we want to use again, a computer needs a hard disk to save these items to. If we save these items to a hard disk they will not be lost when we shut our computer down.



RAM is given this name as any location in the memory can be directly accessed. A computer does not have to move sequentially through each memory location to find the data or program it needs; it can go straight to the memory location through the use of a highly organised and efficient system.

What is the purpose of ROM?

OCR specification reference:

☑ the purpose of ROM in a computer system

ROM is short for read-only memory. It is given this name as the computer only reads from this memory and doesn't write to it. ROM contains the programs that allow your computer to 'boot up'. The data and programs that are stored in ROM are not lost when the computer is turned off; they will still remain in the ROM.

ROM – the place in memory where the 'boot-up' programs are stored

ROM is often described as non-volatile memory, meaning it is permanent. This means that the contents of the ROM remain permanently in the memory, even when the computer loses power.

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What is the difference between RAM and ROM?

OCR specification reference:

☑ the difference between RAM and ROM

The differences between RAM and ROM are described below:

RAM	ROM
• Stores programs and data in currently in use • Can be written to and read from • Volatile • Larger in memory capacity • Contents lost when computer turned off	• Stores the programs needed to boot up the computer • Can only be read from • Non-volatile • Smaller in memory capacity • Contents not lost when computer turned off

What is flash memory?

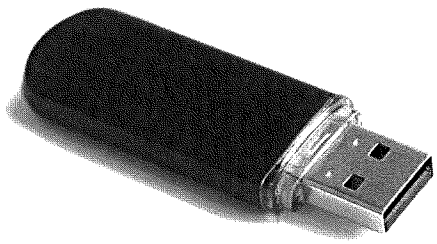
OCR specification reference:

☑ flash memory

Flash memory is a type of non-volatile memory. This means it will retain its contents even without any power. Flash memory is used to store data on a long-term basis. It is described as a **solid-state storage** device as it has no moving parts, unlike a hard disk.

Solid-state storage – a type of flash memory storage device used to store data long-term

Flash memory was invented by Dr Fujio Masuoka in the 1980s, who at the time worked for Toshiba. He called it flash memory because a colleague said the process of erasing data from the type of chip used for the storage device reminded him of the flash from a camera. Flash memory is made up of cells that contain storage transistors, which contain logic gates. Electrons and positive and negative charges are used to write and erase data to and from the flash memory.



As flash memory has no moving parts, it tends to be more robust than a hard disk, and is often smaller in size. It is also quicker to read from and write to as the computer does not need to wait for the device to warm up. This makes it a suitable choice for storage in lots of small devices. Flash memory does suffer from wear and tear, just like a hard disk. It can only be written to and read from a set number of times before it will fail. This is normally quite a large number, such as a million. Flash memory is quite expensive to manufacture. This may be one of the reasons it hasn't completely replaced the hard disk in many computers.

Flash memory can be found in devices such as:

- USB memory sticks
- SD cards
- Solid-state drives (SSD)

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What is virtual memory and when might we need it?

OCR specification reference:

☑ the need for virtual memory

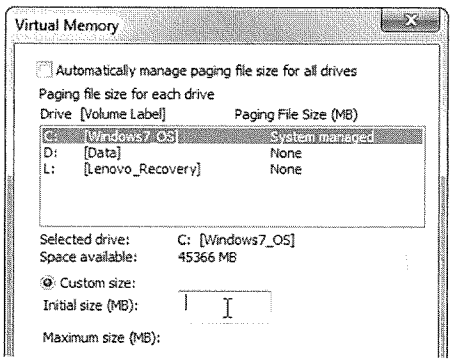
Virtual memory is a feature of an **operating system**. It is a way of allowing the hard disk in the computer to act as an extension of the RAM, by allowing sections (called pages) of data to be stored in the hard disk. In most operating systems, the user can specify an exact amount of virtual memory they want the operating system to use, as shown in the screenshot below.

Operating system – the software that supports a computer's basic functions

Paging – separating data into sections called pages and switching the storage of them between RAM and virtual memory depending on how often they are used

A computer will make use of this feature when it is running out of space in the RAM. The operating system will temporarily move pages of the data to be stored in the hard disk while it is not currently using them. When it needs these pages again it will switch them with some of the pages that are not currently in use the RAM, bringing the data back into the RAM and storing further pages in the hard disk. This process is known as **paging**.

If a computer did not have the ability to make use of the hard disk in this way, it would need to close certain files and applications to open others, as there would not be enough room in RAM for many applications and files to be open. If a computer system relied too heavily on the use of virtual memory the performance would be affected. This is because accessing data and programs from the hard disk, even when formatted to act as virtual memory, is much slower than accessing them from RAM.



What is secondary storage?

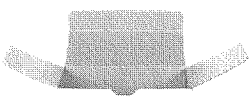
OCR specification reference:

☑ the need for secondary storage

☑ common types of storage:

- optical
- magnetic
- solid state

Secondary storage refers to any storage – either internal or external to a computer – that is not under the direct control of the CPU. An example of internal secondary storage would be the hard disk; an example of external storage (often referred to as offline storage) would be a CD or an external hard drive. Data that is directly under the control of the CPU is called primary storage. An example of this would be the RAM.



A computer system needs secondary storage to store data long-term. RAM is volatile memory, so its contents are lost when the computer is turned off. Secondary storage is needed to store the contents of RAM for when they are needed again at a later date.

There are three types of secondary storage; these are optical, magnetic and solid-state.

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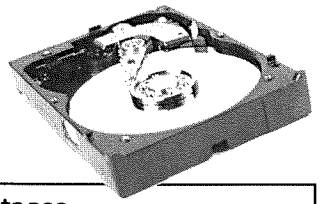
Optical storage

Optical storage uses a lens and a light beam to read and write data onto a disk. Examples of optical storage are CD, DVD and Blu-ray, which all vary in size. CDs typically can hold up to 700 MB of data, DVDs typically hold up to 4.7 GB of data and Blu-rays can hold up to 50 GB! The advantages and disadvantages of optical storage include:

Advantages	Disadvantages
• Disks are small and light making them very portable • Disks are cheap to manufacture • Disks are fairly durable, meaning that they are safe to store data on for long periods of time • Some formats, such as CD-R and DVD-R, mean that data cannot be overwritten	• The storage capacity of disks is relatively small compared to other storage devices • In some cases, such as Blu-ray, a special drive is required to read/write the data to and from a disk

Magnetic storage

Magnetic storage devices use magnets to record data on rotating metal plates. An example of a magnetic storage is a hard disk drive.



The advantages and disadvantages of magnetic storage include:

Advantages	Disadvantages
• Large storage capacity • Fast access to read and write data • Fairly inexpensive to manufacture	• Data can be lost or altered by magnetic field or mechanical problems • Can suffer wear and tear due to moving parts

Discussion point: Can you think of any other examples of magnetic storage? There's one that most people carry around with them and use on a daily basis; can you think what it is?

Solid-state storage

Solid-state storage uses flash memories to store data. Examples of solid-state storage are solid-state drives, SD cards and USB memory sticks.

The advantages and disadvantages of magnetic storage include:

Advantages	Disadvantages
• Faster boot-up as they do not need to 'warm up' due to having no moving parts • Can be made to be very compact in size • Large storage capacity • More robust than magnetic due to having no moving parts	• Expensive to manufacture • Have a limited numbers of times that data can be written to and read from

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How do we choose a suitable secondary storage device?

OCR specification reference:

☑ suitable storage devices and storage media for a given application, and the advantages and disadvantages of these, using characteristics:

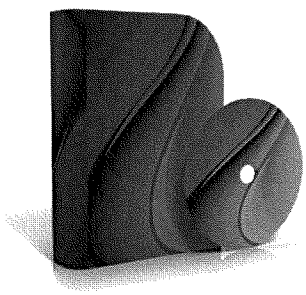
- capacity
- speed
- portability
- durability
- reliability
- cost

There are a number of elements that we may want to consider when choosing a suitable storage device for our data; these are:

Capacity	The amount of data we can store on the device
Speed	The rate at which we can transfer data. Measured in megabits per second (mbps)
Portability	Whether we need to move the data around and carry it with us
Durability	The number of read/write operations that can be performed before a device may fail
Reliability	How consistent the device is when storing data and the probability of it working when required
Cost	The cost of manufacture and sale for a device

Example 1 – Software Company

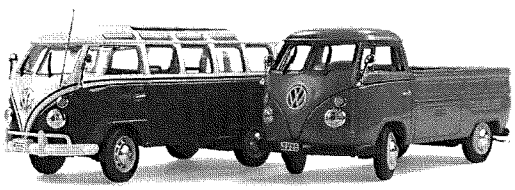
A software company would like to give away a free trial of its latest software with a well-known technology magazine. The company needs to choose a suitable storage device to distribute its free trial. The company will need to consider a device that is portable as it will need to be attached to the magazines; they will need to choose a device that is cheap to manufacture as it will need a large quantity of them to include in each magazine. They will also need to choose a device that will keep the data reliable. They are not likely to need a device that has a large capacity as the free trial software will be reasonably small.



Discussion point: What would be the most suitable storage device for the company to use and why?

Example 2 – Model Car Company

A model car company wants to make a new remote-control car. They want a user to also be able to input programs into the model car that will give it instructions on how to drive around certain tracks.



The user will make use of a keypad on the base of the car to do this. The instructions will need to be stored in a device in the car when input.

Discussion point: What would be the most suitable storage device for the company to use and why?

Discussion point: Can you think of any examples where you might want to use flash storage over a different type of secondary storage?

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How do we calculate the size of a file?

OCR specification reference:

- ☑ bit, nibble, byte, kilobyte, megabyte, gigabyte, terabyte, petabyte
- ☑ data capacity and calculation of data capacity requirements

When we store a file it takes up a certain amount of storage space. We call this the file size, and we call the amount of data a storage device can store its storage capacity. We may want to calculate the size of a file to see how big it will be to store. Most computers will do this for us, but it is useful for us to know how to do this as well.

To calculate the size of a file we need to know how data is measured. To measure data, we can use the following units:

Unit	Abbreviation	Capacity
Bit	b	1 bit
Nibble	-	4 bits
Byte	B	8 bits
Kilobyte	kB	1024 bytes
Megabyte	MB	1024 kB
Gigabyte	GB	1024 MB
Terabyte	TB	1024 GB
Petabyte	PB	1024 TB

Discussion point: What is the biggest unit of storage that exists?

Is storage this size actually needed?

To convert to a bigger unit we always divide. To convert to a smaller unit we always multiply. For example:

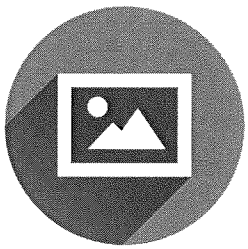
To convert 1 kilobyte to bits we multiply by 1024 and then by 8:

1 x 1024 x 8 = 8192 bits

To convert 3,600,000 bytes to megabytes we divide by 1024 and then divide by 1024 again:

3,600,000 ÷ 1024 ÷ 1024 = 3.44 Mb

Example



Charlie has an image that is 16-bit. It has a resolution of 100 pixels by 100 pixels. Charlie wants to calculate the size of the image file and he wants to write this in kB.

This is how Charlie can calculate the size of the file:

- *100 × 100 = 1000* *This means there are 1,000 pixels in the image.*
- *1000 × 16 = 16 000* *Each pixel in the image requires 16 bits of storage.*

This means the size of the file is 16,000 bits. Charlie wants to write this in KB.

- *16 000 / 8 = 2000* *This calculation will give Charlie the file size in bytes.*
- *2000 / 1024 = 1.96* *This calculation will give Charlie the file size in KB.*

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Chapter Summary

- RAM is the place in a computer where all the programs and data that are currently in use are stored. It is volatile memory.
- ROM contains the programs that allow your computer to 'boot up'. It is non-volatile memory.
- Flash memory is a type of non-volatile memory that is used to store data long-term.
- Secondary storage is any storage, either internal or external to a computer, that is not under the direct control of the CPU. There are three types: optical, magnetic and solid-state.
- There are several factors a user will need to consider when choosing a suitable storage device; these include capacity, speed, portability, durability, reliability and cost.

Practice Questions

1. Explain the difference between RAM and ROM. [2]
2. Describe what is meant by flash memory. [2]
3. Explain why a computer needs both primary and secondary storage. [2]
4. Explain two reasons why a computer needs virtual memory. [2]
5. A company is developing a camera drone as a product. They need to choose a suitable type of storage for all the footage the camera will record. Explain which storage type would be most suitable and why. [3]

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