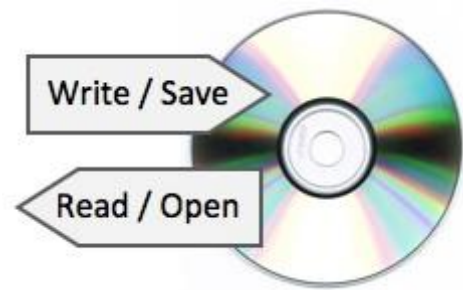# What is Data Storage?

When we talk about 'storing' data, we mean putting the data in a known place. We can later come back to that place and get our data back again.

'**Writing**' data or '**saving**' data are other ways of saying 'storing' data.

'**Reading**' data, '**retrieving**' data or '**opening**' a file are ways of saying that we are getting our data back from its storage location.

Backing Storage vs Main Memory

Main memory (sometimes known as **internal memory** or **primary storage**) is another name for **RAM** (and **ROM**).

Main memory is usually used to **store data temporarily**. In the case of RAM, it is **volatile** (this means that when power is switched off all of the data in the memory disappears).

Main memory is used to store data whilst it is being **processed by the CPU**. Data can be put into memory, and read back from it, **very quickly**.

Memory is fast to access, but only holds data temporarily...

Backing Storage

Backing storage (sometimes known as **secondary storage**) is the name for all other **data storage devices** in a computer: hard-drive, etc.

Backing storage is usually **non-volatile**, so it is generally used to **store data for a long time**.

Backing storage devices are slower to access, but can hold data permanently...

Storage Media & Devices

The device that actually holds the data is known as the **storage medium**('media' is the plural).

The device that saves data onto the storage medium, or reads data from it, is known as the **storage device**.

Sometimes the storage medium is a **fixed** (permanent) part of the storage device, e.g. the magnetic coated discs built into a hard drive

Sometimes the storage medium is **removable** from the device, e.g. a CD-ROM can be taken out of a CD drive.

Accessing Stored Data

We refer to a collection of data stored in a computer system as a 'file'. Files are often organised into 'folders'.

Whenever you click 'Save' in an application, burn files to a CD-R, copymusic onto your MP3 player, or drag and drop a file onto memory stick, you are using storage devices - devices that can store and retrieve data.
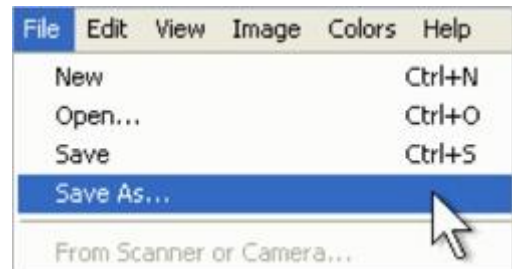
Serial / Sequential Access

A serial (or sequential) access storage device is one that stores files **one-by-one** in a sequence.

A non-computer serial access device that will be familiar to you is a VHS videotape. Because video is stored on a long piece of tape, when TV shows are recorded onto the tape, they go on **one-by-one**, in **order**...
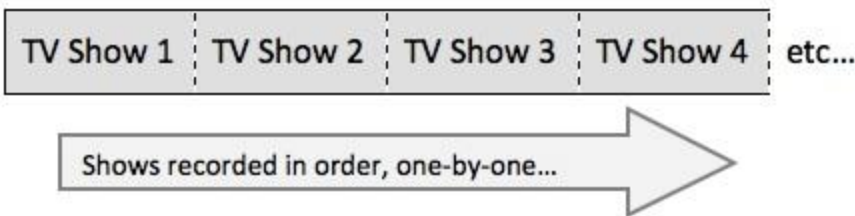
If you want to watch a show that you recorded earlier, you have to **rewind / fast-forward** through all other shows until you find it.

The shows are only accessible in the **same order** that you recorded them. This type of one-by-one storage and access is called **serial access**.

Systems that store things on tape (video, music, computer data, etc.) are always serial access

Direct / Random Access

A direct (or 'random') access storage device is one that stores files so that they can be **instantly accessed** - there is no need to search through other files to get to the one you want.

An example of a direct access device would be a DVD movie. Unlike the VHS videotape movie, you can **jump** to any scene on a DVD.

All parts of the DVD are **directly** accessible. This type of file storage is called **direct access**.
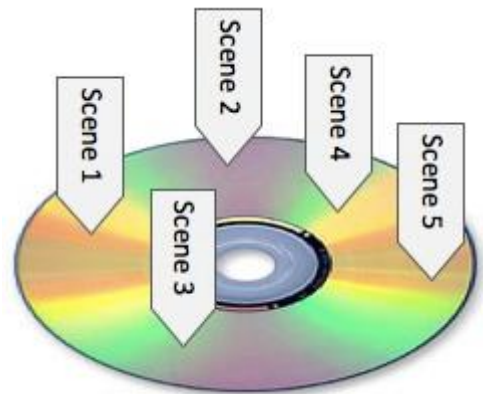
Data Storage Capacity

Solid-State Storage Devices

Some storage media can only store a very limited amount of data, whilst others can store vast amounts...

Floppy disc	1.44MB
Zip disc	750MB
CD-ROM	800MB
Jaz Drive	2GB = 2,000MB
DVD	4.7GB = 4,700MB
USB memory stick	16GB = 16,000MB
Backup tape	800GB = 800,000MB
Hard drive	1TB = 1,000,000MB

Small data capacity

Huge data capacity

*Data storage capacity is measured in **bytes** (B).*

*A **thousand** bytes is known as a **kilobyte** (kB)*

1,000B = 1kB

*A **million** bytes is known as a**megabyte** (MB)*

1,000,000B = 1MB

*A **thousand million** bytes is called a **gigabyte** (GB)*

1,000,000,000B = 1GB

*A **million million** bytes is called a terabyte (TB)*

1,000,000,000,000B = 1TB

Even a very basic storage devices like a floppy disc can storage over a megabyte of data - that's over 1 million letters or numbers!

And modern hard drives can store a terabyte of data or more - that's more words than you could type even if you started now, and typed until your old age!

1 Hard-Drive = **750,000 Floppy Discs!**

Data Access Speeds

Some storage devices can access data very quickly, whilst others are extremely slow...

* Note: Modern back-up tapes have very fast access speeds, but only to save/read data sequentially (they are serial access devices). Tapes are very slow if you want to read files out of order, since the tape has to be rewound and fast-forwarded.

Floppy disc drive	*Very slow access speeds*
Zip disc drive	
CD-ROM drive	
Jaz Drive	
DVD drive	
USB memory stick	
Backup tape drive*	
Hard drive	*Very fast access speeds*

*Access speeds are measured in**bytes per second** (Bps).*

*Slow devices have speeds measured in thousands of Bps (**kBps**).*

Magnetic Storage Devices / Media

Why Magnetic?

Magnetic storage media and devices store data in the form of tiny**magnetised dots**. These dots are created, read and erased using magnetic fields created by very tiny **electromagnets**.

In the case of magnetic tape the dots are arranged along the length of a**long plastic strip** which has been coated with a magnetisable layer (audio and video tapes use a similar technology).
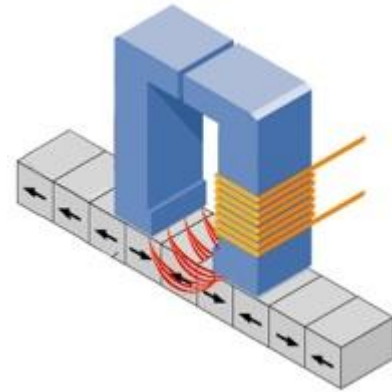
In the case of magnetic **discs** (e.g. floppy disc or hard-drive), the dots are arranged in **circles** on the surface of a **plastic, metal or glass** disc that has a magnetisable coating.

Hard Drives

Hard-drives have a **very large storage capacity** (up to 1TB). They can be used to store vast amounts of data. Hard-drives are **random access**devices and can be used to store all types of films, including **huge files**such as movies. Data **access speeds** are **very fast**.

Data is stored inside a hard-drive on rotating metal or glass discs (called 'platters').

Fixed Hard Drive

A hard-drive **built into the case** of a computer is known as 'fixed'. Almost every computer has a fixed hard-drive.

Fixed hard-drives act as the **main backing storage device** for almost all computers since they provide almost instant access to files (**random access** and **high access speeds**).

Portable Hard Drive

A portable hard-drive is one that is placed into a **small case** along with some electronics that allow the hard-drive to be accessed using a **USB** or similar connection.

Portable hard-drives allow very **large amounts of data** to be **transported**from computer to computer.

Many portable music players (such as the iPod classic) contain tiny hard-drives. These miniature devices are just not much bigger than a stamp, but can still store over 100MB of data!

Magnetic Tape

Magnetic tape is a **large capacity**, **serial access** medium. Because it is a serial access medium, accessing individual files on a tape is **slow**.

Tapes are used where **large amounts of data** need to be stored, but where quick access to individual files is not required. A typical use is for **data back-up** (lots of data, but rarely only accessed in an emergency)

Tapes are also used and in some **batch-processing** applications (e.g. to hold the list of data that will be processed).

Removeable Media Magnetic Discs

Floppy Disc
A **removable**, **portable**, **cheap**, **low-capacity** (1.44MB) storage medium. Floppy discs are **random access** devices used for transfer **small amounts of data** between computers, or to back-up small files, etc. Access times are **slow**.

Almost every PC used to have a floppy disc drive. These are **obsolete** now, having been replaced by higher capacity technology such as CD-ROMs, DVDs and USB memory sticks.

Zip Disc
A **removable** and **portable** storage medium, similar in appearance to a floppy disk, but with a much **higher capacity** (100MB, 250MB or 750MB).

Zip discs are **random access** devices which were used for data back-up or moving **large files** between computers.

Another **obsolete** storage device, zip discs were a popular replacement for floppy discs for a few years, but they never caught on fully before being superseded by cheaper media like CD-ROMs and CD-Rs

Jaz Disc

A **removable** and **portable** storage medium based on hard-drive technology, with a **large capacity** (1GB or 2GB).

Jaz discs are **random access** devices which were used for data **back-up** or moving **large files** between computers.

Discs were **expensive** to buy and **not very reliable**.

Like the Zip disc, this system never really caught on and was superseded by far cheaper and more reliable and cheaper technology.

Optical Storage Devices / Media

Why 'Optical'?

Optical storage devices save data as patterns of **dots** that can be read using **light**. A **laser beam** is the usual light source.

The data on the storage medium is read by bouncing the laser beam off the surface of the medium. If the beam hits a dot it is **reflected** back differently to how it would be if there were no dot. This difference can be detected, so the data can be read.

Dots can be created using the laser beam (for media that is **writable** such as CD-Rs). The beam is used in a high-power mode to actually mark the surface of the medium, making a dot. This process is known as '**burning**' data onto a disc.

This is a magnified view of the dots on the surface of a CD.
The different patterns of dots correspond to the data stored on the disc.

Read-Only Optical Discs

Read-only optical discs have data written onto them when they are**manufactured**. This

data **cannot be changed**.

CD-ROM
Compact Disc - Read-Only Memory (CD-ROM) discs can hold around**800MB** of data. The data cannot be altered (non-volatile), so cannot be accidently deleted. CD-ROMs are **random-access** devices.

CD-ROMs are used to **distribute** all sorts of data: **software** (e.g. office applications or games), **music**, electronic **books** (e.g. an encyclopaedia with sound and video.)

DVD-ROM
Digital Versatile Disc - Read-Only Memory (DVD-ROM) discs can hold around **4.7GB** of data (a dual-layer DVD can hold twice that). DVD-ROMs are **random-access** devices.

DVD-ROMs are used in the same way as CD-ROMs (see above) but, since they can hold more data, they are also used to store high-quality **video**.

High Capacity Optical Discs

Blu-Ray

Blu-Ray disks are a recent replacement for DVDs. A Blu-Ray disc can hold **25 - 50GB** of data (a dual-layer Blu-Ray disc can hold twice that). Blu-Ray discs are **random-access** devices.

Blu-Ray discs are used in the same way as DVD-ROMs (see above) but, since they can hold more data, they are also used to store very high-quality, **high-definition (HD) video**.

*The 'Blu' part of Blu-Ray refers to the fact that the laser used to read the disc uses **blue** light instead of red light. Blue light has a **shorter wave-length** than red light (used with CDs and DVDs).*

*Using a blue laser allows more data to be placed closer together on a Blu-Ray disc, than on a DVD or CD, so Blu-Ray has a much **higher storage capacity** than these older discs.*

HD DVD

High-density DVD (HD-DVD) discs can hold around **15GB** of data (a dual-layer HD-DVD can hold twice that). HD-DVDs are **random-access** devices.

HD-DVD discs are used in the same way as DVD-ROMs (see above) but, since they can hold more data, they are also used to store very high-quality, **high-definition (HD) video**.

The HD-DVD format was launched at the same time as Blu-Ray. For about a year they competed to be the 'next DVD'. For various reasons, Blu-Ray won the fight, and the HD-DVD format has been abandoned.

Recordable Optical Discs

Recordable optical discs can have **data written** onto them ('**burnt**') by a computer user using a special disc drive (a disc '**burner**').

CD-R and DVD-R

CD-Recordable (CD-R) and DVD-recordable (DVD-R) discs can have **data burnt** onto them, but **not erased**. You can keep adding data **until the disc is full**, but you cannot remove any data or re-use a full disc.

CD-RW and DVD-RW

CD-ReWritable (CD-RW) and DVD-ReWritable (DVD-RW) discs, unlike CD-Rs and DVD-Rs, can have **data burnt** onto them and **also erased** so that the discs can be **re-used**.

*When CD-Rs and DVD-Rs are burnt, the laser makes **permanent** marks on the silver-coloured metal layer. This is why these discs cannot be erased.*

When CD-RWs and DVD-RWs are burnt the laser makes marks on the metal layer, but in a way that can be undone. So these discs can be erased.

DVD-RAM

DVD-Random Access Memory (DVD-RAM) discs are a type of **re-writable**DVD. They often come in a floppy-disc style **case** (to protect the disc).

DVD-RAM discs have a similar capacity to a normal DVD, holding **4.7GB** of data. DVD-RAM discs are **random-access** devices.

DVD-RAM discs are used in many**camcorders** (video recording cameras).

The discs are much higher quality than normal DVD-RWs and can reliably store data for up to 30 years. This means that they are often used for video and data **back-up** and **archiving**.

'Solid-State'?

The term 'solid-state' essentially means 'no moving parts'.

Solid-state storage devices are based on **electronic circuits** with **no moving parts** (no reels of tape, no spinning discs, no laser beams, etc.)

Solid-state storage devices store data using a special type of **memory**called **flash memory**...

Flash Memory

Flash memory is a type of Electronically-Erasable Programmable Read-Only Memory (**EEPROM**). Flash memory is **non-volatile** (like ROM) but the data stored in it can also be **erased** or **changed** (like RAM).

Flash memory can be found in many data storage devices...

You might wonder why, since flash memory is non-volatile, normal computers don't use it instead of RAM. If they did we would have computers that you could turn off, turn back on again and no data would be lost – it would be great!

*The reason is **speed** – saving data to flash memory is very slow compared to saving it to RAM. If a computer were to use flash memory as a replacement for RAM it would run very **slowly**.*

*However some portable computers are starting to use flash memory (in the form of **solid-state 'discs'** as a replacement for **hard-drives**. No moving parts mean less to go wrong and longer battery life.*

USB Memory Sticks

Memory sticks (or 'thumb-drives') have made many other forms of portable storage almost obsolete (why burn a CD or DVD when you can more easily copy your files onto a memory stick?).

Memory sticks are **non-volatile**, **random-access** storage devices.

Each of these small devices has some **flash memory** connected to a **USB interface**. Plug it into your computer and it appears as a drive. You can then add files, erase files, etc. You can use it to **move any type of file**between computers.

Flash memory used to be very expensive, but in recent years it has become much **cheaper** and you can now buy a 16GB memory stick for just a few dollars.

Memory Cards

Many of our digital devices (**cameras**, **mobile phones**, **MP3 players**, etc.) require **compact**, **non-volatile** data storage. Flash memory cards provide this and come in a variety of shapes and sizes.

One of the most common formats used by digital cameras is the SD Card. The cards store the digital images taken by the camera.

Mobile phones contain a Subscriber Identity Module (**SIM**) card that contains the phone's number, the phonebook numbers, text messages, etc.

Many phones also have extra memory cards to store music, video, photos, etc. (e.g Tiny Micro-SD cards).

Smart Cards

Many credit cards (e.g. '**chip-and-pin**' cards), door entry cards, satellite TV cards, etc. have replaced the very limited storage of the magnetic strip (the dark strip on the back of older cards) with **flash memory**. This is more **reliable** and has a much **larger storage capacity**.

Cards with flash memory are called **smart cards**.

Backing Up Data

What is a Backup?

A backup simply means making **one or more copies** of your data.

For example, if you have a folder of photos stored on the hard-drive of your laptop, you might back them up by copying them to a CD-R.

*Note: If you move the photos from the hard-drive to a CD-R, you do **not** have a back-up – you still only have **one copy** of the photos, but now they are on a CD instead of the hard-drive.*

*You only have a backup if you have a **second copy** of your data.*

Why Backup Your Data?

If you delete a file by accident, your computer breaks, your laptop is stolen, or your business burns to the ground, having a backup copy means that you have not lost your precious data. You can recover your lost files and continue working.

Most businesses use computers to store very important data (customer records, financial information, designs for products, etc.) If this data is lost, the business could possibly have to close. Backing-up business data is essential.

How Are Backups Created?

Personal backups of the data on your hard-drive can be made by…

- Burning files to a **CD-R**
- Copying files to an **external hard-drive**
- Copying the files to **another computer** on a network

Businesses backup essential data by…

- Making copies of data **very regularly**
- Using large-capacity media such as **magnetic tape**
- Keeping **old copies** of backups, just in case
- **Automating** the system so that nobody forgets to do it!
- Keeping backup media **off-site** (in case of fire or theft)