3 Storage devices and media

In this chapter you will learn about:

★ storage devices:
- magnetic (hard disk drive (HDD) and magnetic tape drive)
- optical (CD, DVD and Blu-ray read/write devices)
- solid state (solid-state drive (SSD), pen drive and flash drive)

★ storage media:
- magnetic media (magnetic disks and magnetic tape)
- optical (CD, DVD and Blu-ray discs)
- solid state (including SD, XD and CFast).

Secondary storage includes all non-volatile devices that are not part of primary memory. They allow data to be stored as long as required by the user. This type of storage is much larger than RAM and ROM (primary memory), but data access time is considerably longer. All applications, the operating system, device drivers and general files (for example, documents, photos and music) are stored in secondary storage. There are three different categories of secondary storage which are based on technology that uses the following media:

- magnetic
- optical
- solid state.

It is very important to distinguish between the terms **storage media** and **storage device**. Media is the hardware on which the data is actually stored (for example, a CD or a DVD); whereas the storage device is the hardware used to read from or write to the media (for example, a CD/DVD reader or writer).

3.1 Magnetic media and magnetic storage devices

Using the properties of magnetism is one of the oldest known methods for the electronic storage of data; its roots go back to the nineteenth century.

Today, magnetic media rely on the property that an iron oxide coating can be magnetised to represent a binary 1-value and demagnetised to represent a binary 0-value. Because each magnetised area is very small, this allows a huge amount of data to be stored. One of the big advantages of this technology is that the magnetic state of the iron oxide is permanent unless it is written over again. The two most common devices that use these magnetic properties to store data are magnetic tape drives and hard disk drives (HDD).

3.1.1 Magnetic tape drives

A **magnetic tape** is a very thin strip of plastic which is coated in a magnetic layer (iron oxide). They are read from or written to by a read/write head in a magnetic tape storage device. The data is stored as a magnetised area (which represents a 1) or demagnetised area (which represents a 0). Data is read from the tape using serial access (in other words, data can only be read in the same order that it was written). This type of storage is useless in real-time or online applications (due to the very slow data access speeds) and is best suited to offline or batch processing. However, due to their vast storage capacity, magnetic tapes are still used on large industrial or university computers.

▲ **Figure 3.1** Magnetic tape drive

Uses of magnetic tape

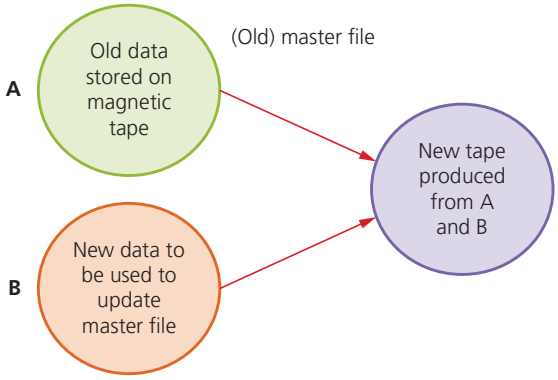
- Use in applications where batch processing is used (for example, clearing bank cheques, utility billing (gas, electricity, water), and producing pay slips). In these applications there is no need for any specific processing order and speed of data access is not essential).
- Used as a backup media where vast amounts of data need to be stored.
- Used in long-term archiving of data; magnetic tapes have huge data storage capacities and are known to be very stable, which makes them ideal for long-term storage.

Advantages of magnetic tapes

- They are generally less expensive (per byte) than the equivalent hard disk drive.
- It is a very robust technology (they do not deteriorate much over time and remain stable).
- They have a huge data storage capacity.
- The **data transfer rate** is actually fast (this should not be confused with data access time which is very slow for magnetic tapes).

Disadvantages of magnetic tape

- Very slow **data access times** (they use serial access, which means all the previous data needs to be read until the required data is found) - whilst magnetic tape data access time is slow, the data transfer rate is still high.
- When updating, another tape is needed to store the final updated version; this requires the use of a master tape (the original tape) and a transaction tape (which contains all the changes to be made) to produce a new master tape. This is clearly a slow way of updating data, and can also introduce errors, which is why magnetic tapes are no longer a common method of storing data).
- They are affected by magnetic fields; a strong magnet (for example, one found in a loudspeaker) can corrupt data stored on the tape.



▲ **Figure 3.2** Updating a magnetic tape

Advice

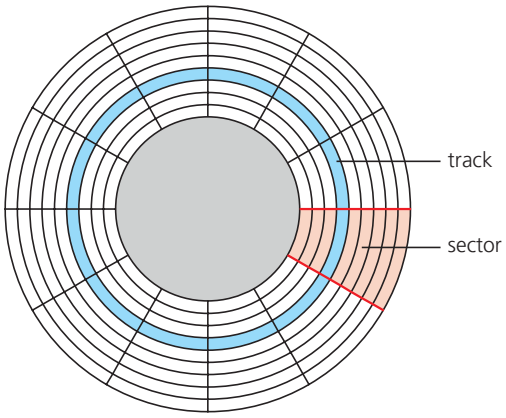
Data transfer rate is the rate at which data can be sent from a storage device to a computer (or vice versa). **Data access time** is the time it takes to locate specific data stored on the storage media.

3.1.2 Hard disk drives (HDD)

Hard disk drives (HDD) are still one of the most common methods used to store data on a computer. Data is stored in a digital format on the magnetic surfaces of the hard disks (or platters, as they are usually called). A hard disk drive will very often have more than one platter depending on its capacity. A number of read/write heads can access all of the platter surfaces in the disk drive (normally each platter will have two surfaces where the data is stored). These read/write heads can move very quickly – typically they can move from the centre of the disk to the edge of the disk (and back again) 50 times a second. Data on an HDD can be read using direct access – this means, unlike magnetic tape, earlier data does not have to be read first before the required data is found. We will now look in more detail at how HDD works:

▲ **Figure 3.3** Hard disk drive – the hard disk (platter) is the media and the hard disk drive (HDD) is the storage device

- Actuators are used to move the read/write heads (voice coils are used as the actuators; these are similar to the electromagnets used in speakers – hence their name).
- A read/write arm swings the read/write head back and forth across the platter; the platter is rotating at up to 10 000 rpm (revolutions per minute).
- Each read/write head contains a tiny magnet which allows the data on the platter to be read.
- Platters are made from glass, ceramic or aluminium which are coated in iron oxide.
- There are two read/write heads per platter (one for the top surface and one for the bottom surface).
- Data is stored in concentric, circular tracks; each track is broken up into sectors (see Figure 3.4).
- A map of the sectors is stored on the HDD and is known as a file allocation table (FAT); when the computer wants to store new data, it looks at the FAT map to find out which sectors are free and then moves the read/write heads to the correct location – this greatly speeds up the writing process.



▲ **Figure 3.4** Hard disk platter (showing tracks and sectors)

While hard disk drives have much faster data access times than magnetic tape, there are still small delays. Many applications require the read/write heads to constantly seek the correct blocks of data; this means a large number of head movements. The effects of **latency** then become very significant. (Latency is defined as the time it takes for a specific block of data on a data track to rotate around to the read/write head). Users will sometimes notice the effect of latency, especially if many different applications are open, when they see messages such as: 'Please wait' or, at its worst, 'not responding'. HDDs can be either fixed or portable.

Uses of fixed hard disk drives

- To store the operating system, systems software and working data/files.
- Storing applications software.
- Used in real-time systems (for example, robots, control of a chemical plant) and in online systems (for example, booking airline tickets, automatic stock control (using EPOS)).
- Used in file servers for computer networks.

Advantages of fixed hard disk drives

- They have a very fast data transfer rate and fast access times to data.
- They have very large memory capacities.

Disadvantages of fixed hard disk drives

- They can be fairly easily damaged (for example, if the correct shut-down procedure on a computer has not been correctly carried out, it is possible to sustain a head crash).
- They have many moving parts which can affect their overall reliability.
- Their read/write operation can be quite noisy when compared to solid-state drives.

3.1.3 Portable hard disk drives

Portable hard disk drives are essentially HDDs external to the computer and can be connected to the computer using one of the USB ports. In this way, they can be used as a backup device or another way of transferring files between computers.

Uses of portable hard disk drives

- They can be used as backup systems to prevent loss of data.
- They can be used to transfer data/files/software between computers.

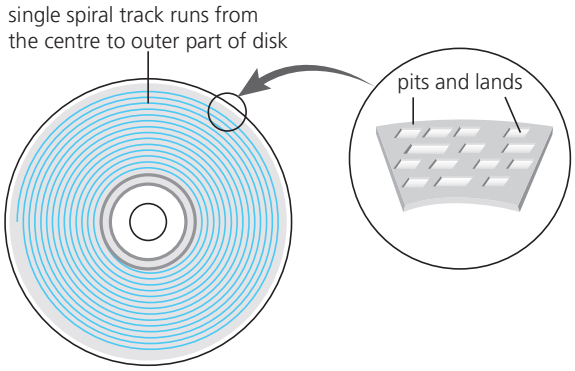
Advantages of portable hard disk drives

- The data access time and data transfer rate are very fast.
- They have a large memory capacity.
- They can be used as a method of transferring information between computers.

Disadvantages of portable hard disk drives

- As with fixed disk drives, they can be easily damaged if the user accidentally drops it or does not correctly shut down the drive after use.
- Data transfer rate is not as fast as for fixed hard drives.

3.2 Optical media and optical storage devices



▲ **Figure 3.5** Optical media

3.2.1 CD/DVD optical disks

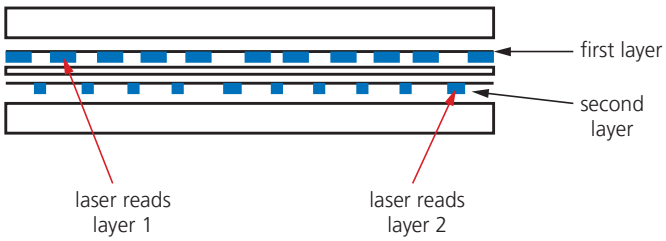
CDs and DVDS are described as **optical media** and are read from or written to by **optical storage devices**. Optical storage devices can be built in to a computer or connected externally via a USB cable. They rely on the optical properties of laser light, which is used to read data and to write data on the surface of the disk.

CDs and DVDs can be designated as: 'R' (write once only), 'RW' (can be written to or read from many times) or 'ROM' (read-only).

Both CDs and DVDs use a thin layer of metal alloy or a light-sensitive organic dye coating to store the data. As can be seen from the diagram in Figure 3.5, both systems use a single, spiral track, which runs from the centre of the disk to the edge. When the disk spins, an optical head in the drive unit moves to the start of the track. The laser beam then follows the spiral track from the centre outwards. The read/write head does not actually touch the CD or DVD surface. As with an HDD, a CD/DVD is divided into sectors, allowing direct access of data. Also, as in the case of HDD, the outer part of the disk runs faster than the inner part of the disk.

The data is stored in **pits** and **lands** on the spiral track (lands are the gaps between pits). A red laser is used to read and write the data. The depth of these pits is only about 20 per cent of the wavelength of the laser light used to read the disc. This means the wavelength of the reflected laser light is slightly different to the original laser light, causing **destructive interference**. This allows the pits and lands to be read and then be converted into binary data.

DVD technology is slightly different to that used in CDs. One of the main differences is the potential for **dual-layering** which considerably increases the storage capacity. Basically, this means that there are two individual recording layers. Two layers of a standard DVD are joined together with a transparent (polycarbonate) spacer, and a very thin reflector is also sandwiched between the two layers. Reading and writing of the second layer is done by a red laser focusing at a fraction of a millimetre difference compared to the first layer.



▲ **Figure 3.6** Dual-layering in a DVD

Standard, single-layer DVDs still have a larger storage capacity than CDs because the 'pit' size and track width are both smaller. This means that more data can be stored on the DVD surface. DVDs use lasers with a wavelength of 650 nanometres; CDs use lasers with a wavelength of 780 nanometres. The shorter the wavelength of the laser light, the greater the storage capacity of the medium.

Uses of CD-R and DVD-R

- Home recordings of music (CD-R) and films (DVD-R).
- Used to store data to be kept for later use or to be transferred to another computer.

Advantages of CD-R and DVD-R

- Cheaper medium than RW disks.
- Once burned (and finalised) they behave like a ROM.

Disadvantages of CD-R and DVD-R

- Can only be recorded once; if an error occurs then the disk has to be thrown away.
- Not all CD/DVD players can read CD-R/DVD-R.

Uses of CD-RW/DVD-RW

- Used to record television programmes which can be recorded over, time and time again (although increasingly replaced by HDD recording systems).
- Used in CCTV systems.
- Can be used as a backup device for files and data.

Advantages of CD-RW/DVD-RW

- Can be written over many times.
- Can use different file formats each time it is used.
- Not as wasteful as R format because the files/data can be added at a later stage (with CD-R/DVD-R it is only possible to do a write operation at the time and you cannot come back a few days later to add more files).

Disadvantages of CD-RW/DVD-RW

- Can be relatively expensive media.
- Possible to accidentally overwrite data.

Uses of CD-ROM/DVD-ROM

- These optical disks are read-only memory (ROM) which means they cannot be written over and can only be read. They are a permanent method of data storage.
- CD-ROM is used to store music files and to store software, computer games and reference software (such as an encyclopaedia).
- DVD-ROM has much larger storage and is used to store films; but now it is increasingly used to store computer data and the evermore sophisticated games.
- CD-ROMs and DVD-ROMs are used in applications where there is a real need to prevent the deletion or overwriting of important data.

Advantages of CD-ROM/DVD-ROM

- They are less expensive than hard disk drive systems.

Disadvantages of CD-ROM/DVD-ROM

- The data transfer rate/data access time is slower than for hard disks.

It should also be noted that there is another type of DVD, called DVD-RAM. It is constructed and operates differently to the other DVD formats and has been used as RAM in computers and camcorders. The format is now quite old.

3.2.2 Blu-ray discs

Blu-ray discs are another example of optical storage media. However, they are fundamentally different to DVDs in their construction and in the way they carry out read/write operations. Blu-ray discs are read from or written to using a Blu-ray optical storage device.

Note: it is probably worth mentioning why they are called Blu-ray rather than Blue-ray; the simple reason is it was impossible to copyright the word 'Blue' and hence the use of the word 'Blu'.

The main differences between DVD and Blu-ray are:

- A blue laser, rather than a red laser, is used to carry out Blu-ray read and write operations; the wavelength of blue light is only 405 nanometres (compared to 650 nm for red light).
- Using blue laser light means that the **pits** and **lands** can be much smaller; consequently, Blu-ray can store up to five times more data than normal DVD.
- Single-layer Blu-ray discs use a 1.2 mm thick polycarbonate disk; however, dual-layer Blu-ray and normal DVDs both use a sandwich of two 0.6 mm thick disks (i.e. 1.2 mm thick).
- Blu-ray disks automatically come with a secure encryption system which helps to prevent piracy and copyright infringement.
- The data transfer rate for a DVD is 10 Mbps and for a Blu-ray disc it is 36 Mbps (this equates to 1.5 hours to store 25 GB of data).

▲ **Figure 3.7** Blu-ray disc

Because Blu-ray discs can come in single-layer or dual-layer format it is probably also worth comparing the differences in capacity and interactivity of the two technologies.

Comparison of the capacity and interactivity of DVDs and Blu-ray discs

- A standard single-layer DVD has a storage capacity of 4.7 GB (enough to store a two-hour standard definition movie).
- A single-layer Blu-ray disc has a storage capacity of 27 GB (enough to store a two-hour high definition movie or 13 hours of standard definition movies).
- A dual-layer Blu-ray disc has a storage capacity of 50 GB (enough to store 4.5 hours of high definition movies or 20 hours of standard definition movies).
- Blu-ray devices allow greater interactivity than DVD devices. For example with Blu-ray, it is possible to:
  - record high definition television programmes
  - skip quickly to any part of the disc
  - create playlists of recorded movies and television programmes
  - edit or re-order programmes recorded on the disc
  - automatically search for empty space on the disc to avoid over-recording
  - access websites and download subtitles and other interesting features.

Finally, Table 3.1 summarises the main differences between CDs, DVDs and Blu-ray discs.

▼ **Table 3.1** Comparison of CD, DVD and Blu-ray

Disk type	Laser colour	Wavelength of laser light	Disk construction	Track pitch (distance between tracks)
CD	red	780 nm	single 1.2 mm polycarbonate layer	1.60 μm
DVD (dual-layer)	red	650 nm	two 0.6 mm polycarbonate layers	0.74 μm
Blu-ray (single-layer)	blue	405 nm	single 1.2 mm polycarbonate layer	0.30 μm
Blu-ray (dual-layer)	blue	405 nm	two 0.6 mm polycarbonate layers	0.30 μm

(NOTE: nm = 10^{-9} metres and μm = 10^{-6} metres.)

(Blu-ray can currently go up to six-layer technology, but this is outside the scope of this book.)

Uses of Blu-ray discs

- Home video consoles.
- Storing and playing back movies (one high definition movie of two hours duration uses up 25 GB of memory).
- Computers can use this technology for data storage or backing up hard drives.
- Camcorders can use this media (in cartridge form) to store movies.

Advantages of Blu-ray discs

- Very large storage capacity, therefore ideal for storing high definition movies.
- Very fast data transfer rate.
- The data access speed is also greater than with other optical media.
- Blu-ray discs automatically come with a secure encryption system, which helps to prevent piracy and copyright infringement.

Disadvantages of Blu-ray discs

- Relatively expensive discs.
- Encryption problems (which are used to stop piracy) when used to store video.
- Introduction of HD (high definition) DVD players has reduced the advantages of using Blu-ray disc technology.

Exercise 3a

Review all of the uses, advantages and disadvantages of optical media. Produce a table comparing CD formats, DVD and Blu-ray. Once you have completed the table, choose which optical media could you use for the following (include a reason for your choice):

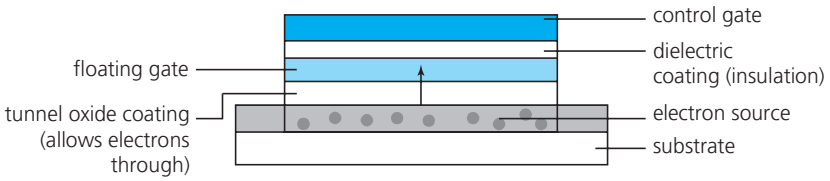
a Supplying software for use on a computer.
b Backing up your files at the end of the day.
c Recording or playing back a high definition movie.
d Saving data that you do not want to be changed for any reason.
e Saving word-processing files.

3.3 Solid-state media and solid-state storage devices

Latency is a major issue in HDDs as described earlier. **Solid-state technology** removes this issue because all the data is retrieved at the same rate. Solid state does not rely on magnetic properties and they have no moving parts. The most common type of solid-state technology stores data by controlling the movement of electrons within NAND chips. The data is stored as 0s and 1s in millions of tiny transistors (at each junction one transistor is called a floating gate and the other is called a control gate) within the chip. This effectively produces a non-volatile rewritable memory. Devices that use solid-state technology in this way are often referred to as flash memories or flash drives.

3.3.1 Floating gate and control gate transistors

Floating gate and control gate transistors use CMOS (complementary metal oxide semi-conductor) NAND technology. Flash memories make use of a grid; at each intersection on the grid there is a floating gate and a control gate arranged as follows:



▲ **Figure 3.8** Floating gate and control gate (solid-state memory)

A dielectric coating separates the two transistors, which allows the floating gate transistor to retain its charge (which is why the memory is non-volatile). The floating gate transistor has a value of 1 when it is charged and a value of 0 when it is not. To program one of these 'intersection cells' a voltage is applied to the control gate and electrons from the electron source are attracted to it. But due to the dielectric coating, the electrons become trapped in the floating gate. Therefore, we have control over the bit value stored at each intersection. (Note: After about 12 months, this charge can leak away which is why a solid-state device should be used at least once a year to be certain it will retain its memory contents).

3.3.2 Solid-state drives (SSD)

Uses of SSDs

Solid-state drives have revolutionised computers over the last few years, and they are rapidly taking over from HDDs as the main type of backing storage. As the name suggests, they use solid-state media and can be used in the same way as an HDD (that is, as a storage device to store files, applications, operating system, and so on). They have enabled laptop computers to become thinner and much lighter. They have given rise to the development of smartphones and tablets; without solid-state technology, these devices simply would not exist.

Advantages of SSDs

So, when developing a new computer or electronic device (such as a phone or tablet), what are the main benefits of using an SSD rather than an HDD? The main benefits of SSDs are:

- they are more reliable (no moving parts to go wrong)
- they are considerably lighter (which makes them suitable for laptops)
- they do not have to 'get up to speed' before they work properly
- they have a lower power consumption
- they run much cooler than HDDs (both these points again make them very suitable for laptop computers)
- because of no moving parts, they are very thin
- SSD data access time is only 0.1 milliseconds compared to 10 milliseconds for HDD
- data transfer speed for SSDs is also much faster than for HDDs.

Disadvantages of SSDs

The main drawback of SSDs is the longevity of the technology (although this is becoming less of an issue). Most solid-state storage devices are conservatively rated at only 20 GB write operations per day over a three-year period – this is known as **SSD endurance**. For this reason, SSD technology is still not used in all servers, for example, where a huge number of write operations take place every day. However, the durability of these solid-state systems is being addressed by a number of manufacturers to improve them, and they are rapidly becoming more common in applications such as servers and **cloud storage** devices.

3.3.3 Pen drives

Pen drives (memory sticks) are small portable devices that make use of solid-state technology.

They connect to the computer through a USB port. Their main advantage is that they are very small, lightweight portable devices which make them very suitable as a method for transferring files between computers. They can also be used as small backup devices for music or photo files, for example. Pen drives are examples of USB flash drives which draw their power from the computer via the USB connection. Some devices combine the functionality of a **portable media player** with USB flash storage; such devices require a battery to play music on the go.

▲ **Figure 3.9** Pen drive/memory stick

Note: The terms pen drive (memory stick) and flash drive are often incorrectly used to mean the same thing. Essentially, any device that uses solid-state technology can be referred to as a flash drive; a pen drive (memory stick) is a flash drive with a USB connector. In other words, a pen drive is a type of flash drive with a particular purpose. However, flash drives can be used inside many devices to carry out a number of different tasks. These devices may be acting as the controller for a microwave oven, for example, which is certainly a very different task to a pen drive.

Uses of memory sticks/pen drives

- Transporting files between computers or using as a backing store.
- Used as a security device to prevent software piracy (known as a dongle).

Advantages of memory sticks/pen drives

- Very compact and portable media.
- Very robust.
- Does not need additional software to work on most computers.
- They are not affected by magnetic fields.

Disadvantages of memory sticks/pen drives

- Cannot write protect the data/files by making it 'read-only'.
- Easy to lose (due to the small physical size).
- The user needs to be very careful when removing a memory stick from a computer – incorrect removal (for example, while it is still doing a read/write operation) will corrupt the data on the memory stick and make it useless.

3.3.4 Memory cards

A memory card makes use of solid-state technology. They can be inserted into a device which can read the card or allow data to be written to the card. The cards come in various memory sizes. There are many available memory card formats, for example:

- SD cards (**s**ecure **d**igital card)
- XD cards (e**x**treme **d**igital card)
- CFast card (**c**ompact**fast** card).

The XD card is a type of removable memory card designed for use in digital cameras. They can be written to or read from the camera or other suitable XD card reader (the card readers can often be attached to a computer to allow the memory card to be read directly).

The SD card is a type of very small card with a very high-capacity memory. SD cards are primarily used in portable devices such as digital video recorders, digital cameras, audio players, smartphones and tablets.

A CFast card is a memory card format which was developed to allow solid-state technology to be used in a very small portable device. It has no moving mechanical parts and does not need a battery to retain data. CFast cards are primarily used as removable memory for higher-end digital photo and video cameras.

Uses of memory cards

- Storing photos on digital cameras.
- Used as mobile phone memory cards.
- Used in **MP3** players to store music files.
- Used as a backing store in hand-held computer devices.

Advantages of memory cards

- Very compact – can be easily removed and used in another device or for transferring photos directly to a computer or printer.
- Because they are solid-state memories (and have no moving parts) they are very durable.
- They can hold large amounts of data.
- Digital devices, such as compact cameras and smartphones, are able to read and write to memory cards, allowing the user to transport large collections of photographs, songs or information with them.

Disadvantages of memory cards

- Expensive per gigabyte of memory when compared to hard disk drives.
- Have a lower storage capacity than hard disks.
- Have a finite life regarding number of times they can be read from or written to.
- Memory cards, specifically the micro SD card, are the smallest storage devices available; this means they are more likely to be lost, stolen or damaged.
- Not all computers come with memory card readers built in; users will often be required to purchase a card reader or USB converter to view the data on a memory card.

3.4 The future of storage devices

In recent times, both the CD and DVD are showing signs of becoming obsolete. Many computer systems now come only with USB connectors and no internal DVD or CD drive. The main method of transferring files between devices has become the flash memory. Many people now store all their music in the following ways:

- on hard disk drive systems (set up as sound systems, as shown in Figure 3.10)
- in MP3 format on:
  - a computer/tablet
  - their mobile/smartphone
  - a portable music player (such as an iPod)
- using the **cloud** to store all their files so they can access their music from anywhere in the world
- by **streaming** their music from the internet; provided the user has an internet connection, they can access music through a laptop computer, smartphone, tablet or any other receiving device.

▲ **Figure 3.10** Sound system

It is also a similar story for movies, where streaming is becoming increasingly more common. Many television sets are now set up as **smart televisions** – this means it is now possible to simply stream movies or television programmes **on demand** without the need for any DVD or Blu-ray players. In effect, the television set has become the central computer with a link to the internet using a wireless connection.

Exam-style questions

1 CD, DVD and Blu-ray are types of optical storage media.
Tick (✓) the most appropriate optical storage medium for each of the statements. [4]

	CD (✓)	DVD (✓)	Blu-ray (✓)
Stores lower quality audio files			
Has the highest storage capacity			
The RAM version of this medium is used to record and play recorded images at the same time			
Stores high definition movies			

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2 Tick (✓) whether the following are optical, magnetic or solid-state storage media. [4]

	Optical (✓)	Magnetic (✓)	Solid state (✓)
SSD			
Blu-ray			
Pen drive			
Portable hard disk drive			

3 **a** Explain what is meant by the term optical media. [2]
b Hard disk drives (HDD) are being replaced by solid-state drives (SSD).
Give four reasons why this is happening. [4]

4 Six descriptions are shown on the left and six computer terms are shown on the right.
By drawing lines, connect each description to its correct term. [5]

Areas on a DVD surface where 1s and 0s are stored	Serial access
Two individual recording layers sandwiched together to form a single DVD	Pits and lands
Technology that makes use of floating gates and control gates	Memory cards
Device that uses solid-state memories and plugs into the USB port of a computer	Solid-state memory
Media that comes in XD, SD or CFast formats	Dual-layering
System whereby all the previous data needs to be read before the required data is found	Pen drive

5 Fifteen words or phrases are listed below:

- actuator
- Blu-ray discs
- cards
- data access time
- data transfer rate
- direct access
- flash drives
- latency
- media
- memory sticks
- platters
- serial access
- SSD endurance
- storage device
- three-year period

Use words or phrases from this list to complete the following paragraph. Note that each word or phrase can be used once, more than once or not at all.

_____ is used by magnetic disks, optical disks and solid-state media when locating data. _____ is the name given to the hardware on which the data is actually stored. Magnetic disks in an HDD are better known as _____; the time taken for a specific block of data on a data track to rotate around to the read/write head is called _____. _____ is the time taken to send data from a device to a computer's memory. _____ is how long it takes to locate data on any type of media. Some optical media use laser light of 405 nm; this media is called _____. Solid-state drives are rated at 20 GB write operations per day over a _____; this is known as _____. Solid-state devices that plug into a computer USB port are known as _____. [10]

6 Indicate whether the following ten statements are True or False by putting a tick (✓) in the appropriate box. [10]

Statements	True (✓)	False (✓)
Both DVDs and Blu-ray discs can make use of dual-layering technology		
CD-RW can act as the same as a ROM chip		
Solid-state drives wear out very quickly due to rapid electron movements in the transistors that make up the memory matrix		
Cloud storage makes use of Blu-ray disks to store customers' music and photo files		
Platters on an HDD can be recorded on both the bottom and top surface		
HDDs suffer from latency due to the time taken for a specific block of data on a data track to rotate around to the read/write head		
Magnetic tapes make use of serial data access		
The data transfer rate is the time taken to locate data on an HDD platter		
The areas on a DVD where 1s and 0s are stored are called pits and lands		
A memory stick is another name for a flash drive		

7 a i Blu-ray and DVD are two types of optical media.
Give **three** differences between Blu-ray and DVD. [3]

ii Give one application that uses Blu-ray discs and one application that uses DVD disks. [2]

b i Hard disk drives (HDD) and solid-state drives (SSD) are two types of storage device.
Give **three** differences between HDDs and SSDs. [3]

ii Give **one** application that uses an HDD and **one** application that uses an SSD. [2]

8 a Describe the changes in technology which have led to the disappearance of the hard disk drive (HDD) as the main backing store on a computer. [4]

b Describe the changes in technology which have led to the reduction in the use of CD and DVD drives being installed on modern laptop computers. [4]