A display device is an output device that conveys text, graphics, and video information to the user. Information on a display device is called a soft copy because it exists electronically and is displayed only for a temporary period. Display devices can be monochrome, gray scale or colour. Two main types of display devices are CRT monitors and LCD monitors. A video card is required to display colour on a monitor. The quality of a display device depends on its resolution, dot pitch, and refresh rate. Many display devices today also have features that help address ergonomic issues.

**Advantages** of Visual Display devices include
- The time to display the image is fast.
- Screen displays can include text, graphics, and colours.
- Display devices are usually quiet.
- No paper is wasted for obtaining the output.

**Disadvantages** of Visual Display devices include
- Information produced on the screen is only temporary, and will be lost when the power of the display device is turned off.
- Needs a separate device to produce the hard copy.

**Display Screen vs. Monitor**

The term monitor, however, usually refers to the entire box, whereas display screen can mean just the screen. In addition, the term monitor often implies graphics capabilities.

Most display screens work under the same principle as a television, using a cathode ray tube (CRT). Consequently, the term CRT is often used in place of display screen.

**Types of Monitors**

**1. Cathode Ray Tube (CRT)**

CRT, abbreviation of cathode-ray tube, the technology used in most televisions and computer display screens. A CRT works by moving an electron beam back and forth across the back of the screen. Each time the beam makes a pass across the screen, it lights up phosphor dots on the inside of the glass tube, thereby illuminating the active portions of the screen. By drawing many such lines from the top to the bottom of the screen, it creates an entire screenful of images.
2. **Liquid Crystal Display (LCD)**

A type of display used in digital watches and many portable computers (such as laptop computers). LCD displays utilize two sheets of polarizing material with a liquid crystal solution between them. An electric current passed through the liquid causes the crystals to align so that light cannot pass through them. Each crystal, therefore, is like a shutter, either allowing light to pass through or blocking the light.

Most LCD screens used in notebook computers are backlit to make them easier to read.

An **LCD projector** is a device for giving presentations generated on a computer. They are the modern equivalent to the slide projector and overhead projector used in the past. LCD projectors place a small LCD panel, almost always color, in front of a bright lamp, with the imagery on the LCD being provided by an attached computer or other video source such as a VCR, DVD, or a cable box.

3. **Flat Panel Display (FPD)**

Portable, laptop, and notebook computers are microcomputers that have become smaller and smaller in size and weight. **One of the devices that has made their development possible is the flat-panel monitor.** These compact devices consume little power, and their flat profile allows them to provide a full screen in a small display unit. Early flat-panel displays were monochrome, but new technologies allow these screens to display colour.

**Classification of monitors**

There are many ways to classify monitors. The most basic is in terms of colour capabilities, which separates monitors into three classes:

1. **Monochrome**: Monochrome monitors actually display two colours, one for the background and one for the foreground. The colours can be black and white, green and black, or amber and black.
2. **Gray-scale**: A gray-scale monitor is a special type of monochrome monitor capable of displaying different shades of gray.
3. **Colour**: Colour monitors can display anywhere from 16 to over 1 million different colours. Colour monitors are sometimes called RGB monitors because they accept three separate signals -- red, green, and blue.

**Screen size**

After this classification, the most important aspect of a monitor is its **screen size**. Like televisions, screen sizes are measured in **diagonal inches**, the distance from one corner to the opposite corner diagonally. Typical sizes for computer monitors are between 15 inches and 19 inches diagonally. The screen size is sometimes misleading because there is always an area around the edge of the screen that can't be used. Therefore, monitor manufacturers must now also state the viewable area -- that is, the area of screen that is actually used.
**Pixel**
Short for **Picture Element**, a *pixel is a single point in a graphic image*. Graphics monitors display pictures by dividing the display screen into thousands (or millions) of pixels, arranged in rows and columns. The pixels are so close together that they appear connected.

The number of bits used to represent each pixel determines how many colours or shades of gray can be displayed. For example, in 8-bit colour mode, the colour monitor uses 8 bits for each pixel, making it possible to display $2^8$ (256) different colours or shades of gray.

**Resolution**
The **resolution** of a monitor indicates how densely packed the **pixels** are. In general, the more pixels (often expressed in dots per inch), the sharper the image. Most modern monitors can display 1024 by 768 pixels. Some high-end models can display 1280 by 1024, or even 1600 by 1200.

The term is most often used to describe **monitors, printers, and bit-mapped graphic images**. In the case of dot-matrix and laser printers, the resolution indicates the number of **dots per inch**. For example, a 300-**dpi** (dots per inch) printer is one that is capable of printing 300 distinct dots in a line 1 inch long. This means it can print 90,000 dots per square inch.

For graphics monitors, the screen resolution signifies the number of dots (pixels) on the entire screen.
For example, a 640-by-480 pixel screen is capable of displaying 640 distinct dots on each of 480 lines, i.e. 307200 pixels.

**Resolution** describes the sharpness and clearness of an image. The higher the resolution, the better the image quality.
Resolution is often measured in **dots per inch (dpi)**.

**Advantages** of higher resolution include
- Drawings can be produced more accurately, and more detail can be shown.

**Disadvantages** of higher resolution include
- More memory is required to draw the information in higher resolution.
- High resolution pictures take longer time and a fast processor to process.

**Dots per Inch (dpi)**
Indicates the resolution of images. The more dots per inch, the higher the resolution. A common resolution for laser printers is 600 dots per inch. This means 600 dots across and 600 dots down, so there are 360,000 dots per square inch.
**Colour Depth**

The term given to the number of colours, which each PIXEL can display. This depends on the number of bits which make up the pixel.

Colour depth is sometimes referred to as **bit depth** because it is directly related to the number of bits used for each pixel.

<table>
<thead>
<tr>
<th>Colour Depth (bits)</th>
<th>Number of possible colours</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 bit</td>
<td>2 (monochrome)</td>
</tr>
<tr>
<td>2 bits</td>
<td>4</td>
</tr>
<tr>
<td>4 bits</td>
<td>16</td>
</tr>
<tr>
<td>8 bits</td>
<td>256</td>
</tr>
<tr>
<td>16 bits</td>
<td>65,536</td>
</tr>
<tr>
<td>24 bits</td>
<td>16,777,216 (True Colour)</td>
</tr>
<tr>
<td>32 bits</td>
<td></td>
</tr>
</tbody>
</table>

**Palette**

In computer graphics, a palette is the set of available colours. For a given application (program), the palette may be only a subset of all the colours that can be physically displayed.

**Hard Copy**

A printout of data stored in a computer. It is considered hard because it exists physically on paper, whereas a soft copy exists only electronically.

**Soft Copy**

An output which exists electronically and only for a temporary period. Examples of devices which produce a soft copy are Monitors and Speakers.

**Serial & Parallel data transfer**

Data transmission/transfer is the _______________ of data from one device to another. This may be between parts of a computer system or between computer in a network. Data transmission may be either serial or parallel.

Serial data transfer refers to transmitting data one bit at a time. **Parallel data transfer** is the transmission of several bits concurrently (for example 8 bits at one go).
**Buffer**

A buffer is a piece of memory shared by hardware devices that operate at different speeds. The buffer allows each device or process to operate without being held up by the other. Like a cache, a buffer is a "midpoint holding place" but primarily exists to support the coordination of separate activities and not so much to accelerate the speed of an activity. For example the printing speed depends on the speed of the printer and not on the buffer size.

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**Cache Memory**

Cache memory is a type of very fast memory that is used to improve the speed of a computer, doubling it in some cases. It acts as an intermediate store between the CPU and main memory, and works by storing the most frequently or recently used instructions and data so that it will be very fast to retrieve them again. Thus when an item of data is required, a whole block of data will be read into cache in the expectation that the next piece of data required is likely to be in the same block. The amount of cache memory is generally between 1KB and 512 BK.

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**Spooling – (Simultaneous Peripheral Operations On-Line)**

Spooling refers to putting jobs in a buffer, a special area in memory or on a disk where a device can access them when it is ready. Spooling is useful because devices access data at different rates. The buffer provides a waiting station where data can rest while the slower device catches up.

The most common spooling application is print spooling. In print spooling, documents are loaded into a buffer (usually an area on a disk), and then the printer pulls them off the buffer at its own rate.

**Advantages of Print Spooling:**

- Because the documents are in a buffer where they can be accessed by the printer, you can perform other operations on the computer while the printing takes place in the background.
- Spooling also lets you place a number of print jobs on a queue instead of waiting for each one to finish before specifying the next one.