

Computing Fundamentals and Programming
Batch2018 (Electronic Engineering)
Chapter3: Input/Output Hardware

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What Computers Do?

Four basic functions of computers include:

- Receive input – Process information
- Produce output – Store information

InputandOutputHardware

Input Hardware

- o Consists of devices that translated data into a form the computer can process

Output Hardware

- o Consists of devices that translate information processed by the computer into the form that humans can understand

Categories of Input Hardware

There are three main categories of input hardware:

Keyboard

Pointing devices

- Mice, trackballs, joysticks, and touchpads
- Light pens
- Digitizing tablets
- Pen-based systems

Source-data entry devices

- Scanners, including barcodescanners, faxmachines, and imaging systems
- Voice recognition devices
- Audio input devices
- Electronic cameras
- Sensors
- Human-biology input devices

Often keyboard, pointing, and source data input devices are combined in a single computer system.

1)Keyboard Input

A standard computer keyboard has about 100 keys.

Most keyboards use the QWERTY layout, named for the first six keys in the top row of letters.

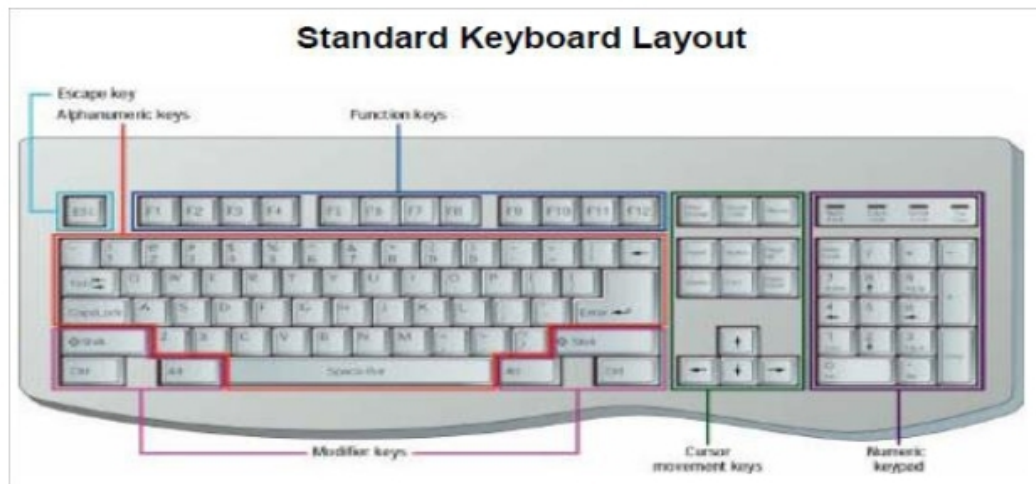
The Omnipresent Keyboard

Do you know where these keys are located on the keyboard and how to use them?

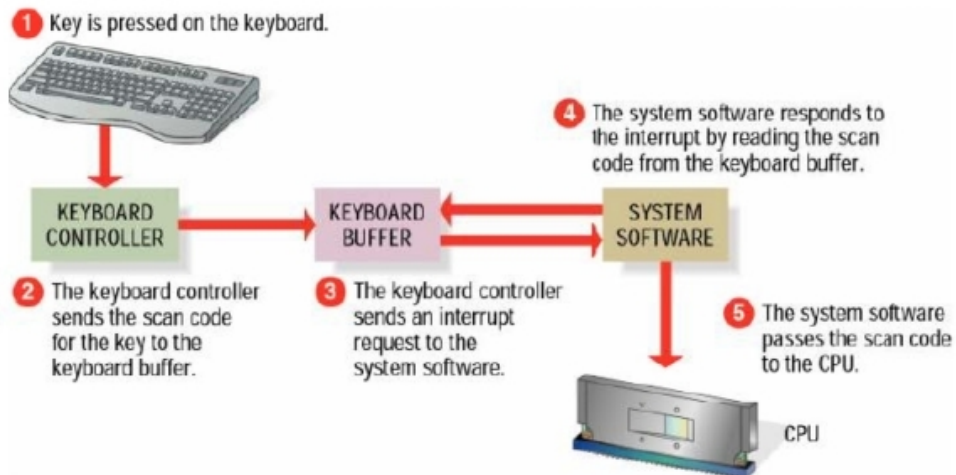
Letters, Numbers, Cursor Keys, Delete Key, Enter(Return) Key, and Function Keys

Most keyboards have keys arranged in five groups:

- Alphanumeric keys
- Numeric keypad
- Function keys
- Modifier keys
- Cursor-movement keys



Working of Keyboard



Ergonomics:

- **Ergonomics** is the study of the physical relationships between people and their work environment; that is, it is the science of designing equipment for a safe and comfortable environment.
- Keyboard manufacturers have created ergonomically sound keyboards as well as input devices for use by physically challenged individuals.

Carpal Tunnel Syndrome (CTS): SelfStudy

2) Pointing Devices



Mouse

The mouse is a pointing device. You use it to move a graphical pointer on the screen.

The mouse can be used to issue commands, draw, and perform other types of input tasks.

Mouse Techniques

Using the mouse involves five techniques:

Pointing

Move the mouse to move the on-screen pointer.

Clicking

Press and release the left mouse button once.

Right-clicking

Press and release the right mouse button.

Double-clicking

Press and release the left mouse button twice.

Dragging

Hold down the left mouse button as you move the pointer.

I-beam: SelfStudy**Do yourself: For left handed people how to change the left and right mouse buttons functions****Other Pointing Devices****Trackballs:**

A trackball is a variant of a mouse.

A trackball is a movable ball, on top of a stationary device, that is rotated with the fingers or palm of the hand

Use your thumb to move the exposed ball and your fingers to press the buttons.

**Joystick:**

It is also a pointing device.

It consists of a vertical handle like a gear shift lever mounted on a base with one or two buttons.

They are primarily used for playing games.

Joysticks are popular for flight simulator and driving games.

Touch pads or Track pads

A touch pad is a touch-sensitive pad that provides the same functionality as a mouse.

○To use a touch pad, you glide your finger across its surface.

○Touch pads provide a set of buttons that function like mouse buttons.

Pros And Cons Of Using Mice,Trackballs, and Touchpad: SelfStudy

AlternativeInputDevices

LightPens
Pen-basedSystems
Touch Screens
DigitizingTablets

LightPens

It is a light sensitive stylus,or pen-like device, connected by a wire to the computer terminal.

The user brings the pen to a desired point on the display screen and presses the pen button.

Digitizing Tablets

An input device that enables you to enter drawings and sketches into a computer.

A digitizing tablet consists of an electronic tablet and a cursor or pen.

A cursor(also called a puck) is similar to amouse, except that it has a Window with cross hairs for pin point placement, and it can have as many buttons.

A pen(called a stylus) looks like a simple ball point pen but uses an electronic head instead of ink.

Pen-basedSystem

With a pen-based system, you use an electronic pen to write on the screen and choose commands.

Pens are common input devices for hand held computers, like "personal digital assistants (PDAs)."

Pens are handy for making notes or selecting commands,not for inputting a lot of text.

The user can point, tap, draw and write on the computer's screen with a Pen



Types of Pen-based Systems:

There are four types of pen-based systems:

- Gesture recognition or electronic check lists: Gesture recognition refers to a computer's ability to recognize various check marks, slashes, or carefully printed block letters/numbers. This type of small computer is used by meter readers, package deliverers, and insurance claims representatives.
- Hand writing stored as scribbling: A second type of pen-based system recognizes and stores hand writing. The hand writing is stored as scribble and is not converted to typed text.
- Hand writing converted, with training, to typed text: Some pen-based devices can recognize your hand writing and transform it in to typed text. The machine has to "learn" your hand writing, and you have to neatly print. But, the advantage of converting writing to typed text is that after conversion the text can be retrieved and later edited.
- Hand writing converted, without training, to typed text: The most sophisticated—and still mostly elusive—application of pen-based computers converts script hand writing to typed text without training.

TouchScreens

Touch-screen systems accept input directly through the monitor. Touch screens use sensors to detect the touch of a finger. They are useful where environmental conditions prohibit the use of a keyboard or mouse. Touch-screen systems are useful for selecting options from menus.



Source-DataEntry

Does not require keystrokes
 Direct entry in to computer often is more accurate
 One of the most common source-data entry devices is scanner.

Scanning devices

Scanners use laser beams and reflected light to translate hardcopy images of text, drawing, photos, and the like into digital form. The images then can be processed by a computer, displayed on a monitor, stored on a storage device, or communicated to other computer. Scanning devices include

- Bar-code readers
- Mark and character recognition devices
- FAX machines
- Imaging systems

Bar-Code

Vertical striped marks on most manufactured products.

Often seen is a Universal Product Code, as seen in North America and Australia

Photo electric scanners that translate code symbols into digital code

The reader emits light, which reflects off the bar code and into a detector in the reader. The detector translates the code into numbers.

Flat bed bar code readers are commonly found in super markets.

Courier services often use hand held readers.



Bar code readers commonly track sales in retail stores

"UPC" stands for Universal Product Code. UPC bar codes were originally created to help grocery stores speed up the check out process and keep better track of inventory, but the system quickly spread to all other retail products because it was so successful. UPCs originate with a company called the Uniform Code Council (UCC).

A manufacturer applies to the UCC for permission to enter the UPC system.

The manufacturer pays an annual fee for the privilege. In return, the UCC issues the manufacturer a six-digit manufacturer identification number and provides guide lines on how to use it.



You can see that the UPC symbol printed on a package has two parts:
The machine-readable bar code
The human-readable 12-digit UPC number

Bar-Code: UPC

Manufacturer identification number is the first six digits of the UPC number 639382. The next five digits --00039— are the item number. A person employed by the manufacturer, called the UPC coordinator, is responsible for assigning item numbers to products, making sure the same code is not used on more than one product, retiring codes as products are removed from the product line, etc. In general, every item the manufacturer sells, as well as every size package and every repackaging of the item, needs a different item code. So a 12-ounce can of Coke needs a different item number than a 16-

Ounce bottle of Coke, as does a 6-pack of 12-ounce cans, a 2-pack, a 24-can case, and so on. It is the job of the UPC coordinator to keep all of these numbers straight!

The last digit of the UPC code is called a check digit. This digit lets the scanner determine if it scanned the number correctly or not.

Bar-Code: Calculation

Add together the value of all of the digits in odd positions (Digits 1, 3, 5, 7, 9 and 11)

$$6+9+8+0+0+9=32$$

Multiply that number by 3.

$$32*3=96$$

Add together the value of all of the digits in even positions (digits 2, 4, 6, 8 and 10).

$$3+3+2+0+3=11$$

Add this sum to the value in step 2.

$$96+11=107$$

Take the number in Step 4. To create the check digit, determine the number that, when added to the number in step 4, is a multiple of 10.

$$107+3=110$$

The check digit is therefore 3.

How is the Price Determined?

As you can see, there is no price information encoded in a bar code. When the scanner at the checkout line scans a product, the cash register sends the UPC number to the store's central POS (point of sale) computer to look up the UPC number. The central computer sends back the actual price of the item at that moment.

This approach allows the store to change the price whenever it wants, for example to reflect sale prices. If the price were encoded in the bar code, prices could never change. On the other hand, not encoding a fixed price gives the store an easy way to rip off customers.

When you hear about "**scanner fraud**" in the news that is what the newsperson is talking about. It is incredibly easy for a store to mistakenly or purposefully overprice an item.

Mark and Character Recognition devices

There are three types of scanning devices that translate certain types of marks and characters. They are usually referred to by their abbreviations: MICR, OMR and OCR.

MICR (Magnetic-ink character recognition)

recognizes numbers such as on checks

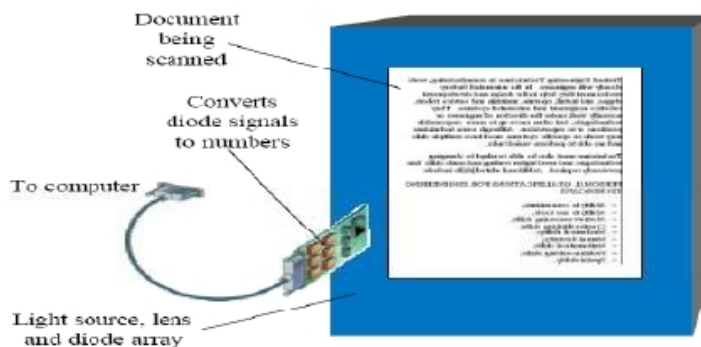
MICR characters, which are printed with magnetized ink, are read by MICR equipment, producing a digitized signal. This signal is used by a bank's reader/sorter machine to sort checks.

OMR (Optical mark recognition)

reads pencils marks and converts them into computer-usable form
can now include black pen as well depending upon the reader
Examples are SAT, GRE tests etc

OCR (Optical character recognition)

uses specific character sets, converting them into machine-readable form
Examples are utility bills and price tags
The wand reader is a common OCR scanning device



Self Study : read further details of OCR from book

FAX machines

Facsimile transmission machine scans an image on paper, and then sends those electronic signals over telephone lines to a receiving fax machine, which recreated the image on paper. It can also scan and send an image to a fax modem(circuit board) inside a remote computer; this fax can be displayed on the screen, stored, or printed out by the computer's printer.

What facsimile means: See from book



At the sending end, there is some sort of sensor to read the paper. Usually, a modern fax machine also has a paper-feed mechanism so that it is easy to send multi-page faxes.
There is some standard way to encode the white and black spots that the fax machine sees on the paper so that they can travel through a phone line.
At the receiving end, there is a mechanism that marks the paper with black dots.

The fax machine typically has a CCD or photo-diode sensing array. It contains 1,728 sensors (203 pixels per inch), so it can scan an entire line of the document at one time. The paper is lit by a small fluorescent tube so that the sensor has a clear view.

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vera3.htm">CCD or photo-diode
contains 1,728 sensors (203 pixels per
n an entire line of the document at on
er is lit by a small fluorescent tube lil
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The scanning process: The scanner in a fax machine looks at one line of the sheet of paper. The scan line is shown here in red. It sees a group of black and white spots, shown blown up in the red rectangle at the bottom of the figure. It encodes the pattern of spots and sends them through the phone line.

The image sensor looks for black or white. Therefore, a single line of the document can be represented in 1,728 bits. In standard mode, there are 1,145 lines to the document.

The total document size is:

1,728 pixels per line * 1,145 lines=approximately 2,000,000 bits of Information

Imaging Systems:

- An **imaging system** converts text, drawings, and photographs into digital form that can be stored, manipulated, output, or sent between computer systems.
- The system scans an image with light and breaks it into light, dark and color dots which are then converted into digital signals.
- Scanners are generally flatbed, drum, or handheld.* The higher the resolution, the crisper the image but the longer the scanning time and image file.
 - Flat bed scanners are used for scanning high-quality color graphics.
 - Drum scanners are fed one sheet at a time; they cannot handle book-bound pages. Drum scanners do not scan at resolutions as high as flat bed scanners.
 - Hand held scanners are rolled by hand over the documents to be scanned. They are usually used to scan small images or parts of images, and their resolution is not very high.

- Some manufacturers are building scanners into portable computers—the user feeds a hard copy document / image into a slot in the computer.

Audio-Visual(Multimedia)Input Devices

Microphones and Speech Recognition
Video Input

Voice Recognition

Using as microphone or telephone
Converts to digital code
Saves typing input
Current technology upto 98%

Voice Recognition

Microphone scan accept auditory input. A microphone requires a sound card in the PC.

A sound card can digitize analog sound signals, and convert digital sound signals to analog form.

With speech recognition software, you can use your microphone to dictate text, navigate programs, and choose commands.



Self Study:Study figure 3.13 and write a note

Audio Input Devices

Records or plays analog sound
Translates for digital storage and processing. There are two ways in which audio is digitized

Audio Boards

Also called sound cards
Some mother boards have built-in audioboard
Three major standards
–SoundBlaster
–AdLib
–Windows

MIDI Boards(pronounced as middle)

It provides a standard for the interchange of musical instruments, synthesizers and computers.

Most support MIDI

Musical Instrument Digital Interface

MIDI boards used for multimedia applications

Analog sound is converted to digital data via sampling; the sampling rate is the number of times per second analog sound is turned into binary number by the computer.

Video and Photographic Input

- Most video cameras are analog, but there are many models of digital video cameras available. There are also many models of digital cameras for photographs available.
- A **digital camera** uses a light-sensitive process or chip to capture photographic images in digital form on a memory card inserted in the camera. Without a digital camera or digital video camera, analog data must be converted to digital form through a special video capture, or digitizing, card installed in the computer. Two types of video cards in common use:

Frame-grabber video card: These video cards can capture and digitize only a single frame at a time.

Full-motion video card: These video cards can convert analog to digital signals at up to 30 frames per second(TV quality), giving the effect of a continuously flowing motion picture.

•Sensors:

A **sensor** is a type of input device that collects specific kinds of data directly from the environment and transmits it to a computer.

Sensors can be used for detecting all kinds of things: speed, movement, weight, pressure, temperature, humidity, wind, current, etc.

•Human-Biology Input Devices:

Characteristics and movements of the human body, when interpreted by sensors, optical scanners, voice recognition, and other technologies, can become forms of input. Here are some examples:

- Biometric systems: Biometric security systems identify a person through a fingerprint, voice intonation, or other biological characteristic.

1.For instance,retinal-identification devices use array of light to identify the distinctive network of blood vessels at the back of a person's eye ball.

- Line-of-sight systems: Line-of-sight systems enable a person to use his/her eyes to point at the screen, a technology that allows users with physical disabilities to direct a computer.

1.This is done using a video camera mounted beneath the monitor in front of the viewer. When the user looks at a

Certain place on the screen, the video camera and computer translate that location into screen coordinates.

- Cyber gloves and body suits: Special gloves and body suits—often used in conjunction with "virtual reality"—use sensors to detect body movements.
 1. The data for these movements is sent to a computer system.

Video Input

Digital video

can be limited to the speed of the computer and its ability to provide a consistent and high enough frames-per-second minimum to provide full-motion is 24 frames per second

Input Controls

Garbage in, garbage out
Manual and computer-based controls
Software often uses internal software tables to validate data input
Reasonableness tests coded
Care should be taken to ensure system is not too restrictive

Output Hardware

One of the most common output devices you will encounter is the monitor; another is the printer
In computer, paper output is sometimes called HardCopy.

Printer Categories

Printers fall into two categories:

Impact printers use a device to strike an inked ribbon, pressing ink from the ribbon on to the paper.

Non-impact printers use different methods to place ink (or another substance) on the page.

Impact Printers

Line Printers

- ③ Used by main frames for massive jobs
- ③ Limited characters available

Dot-Matrix Printers

- ③ Image formed from dots printed on paper
- ③ Good for text and graphics
- ③ Inexpensive

Non-Impact Printers

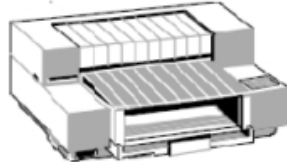
Laser Printers

- ③ Image transferred to paper with laser beam
- ③ Faster and more expensive than dot-matrix
- ③ High-resolution hard copy

Other Non-Impact Printers

Ink-Jet Printers

Dots of ink are sprayed onto the paper to form the image
High-resolution hardcopy
Some models can print color photographs



Other Non-Impact Printers

Plotters

Image transferred to paper with ink pens
Very high resolution
Excellent for scientific and engineering applications
They are mostly used for print-outs that are too large to be printed by Printers



Printer Quality

When evaluating printers, consider four criteria:

Image quality

Measured in dots per inch (dpi). Most printers produce 300–600 dpi.

Speed

Measured in pages per minute (ppm) or characters per second (cps).

Initial cost

Consumer printers cost \$250 or less, but professional printers can cost thousands of dollars.

Cost of operation

This refers to the cost of supplies used by the printer.

Ink-jet Printers

Ink jet printers are an example of non impact printers.

The printer sprays tiny droplets of ink onto the paper.

Ink jet printers are available for color and black-and-white printing.

Ink jet printers offer speeds of (2–4 pages per minute ppm) and resolution (300–600 dots per inch dpi), comparable to low-end laser printers.

Laser Printer

Laser printers are non-impact printers.

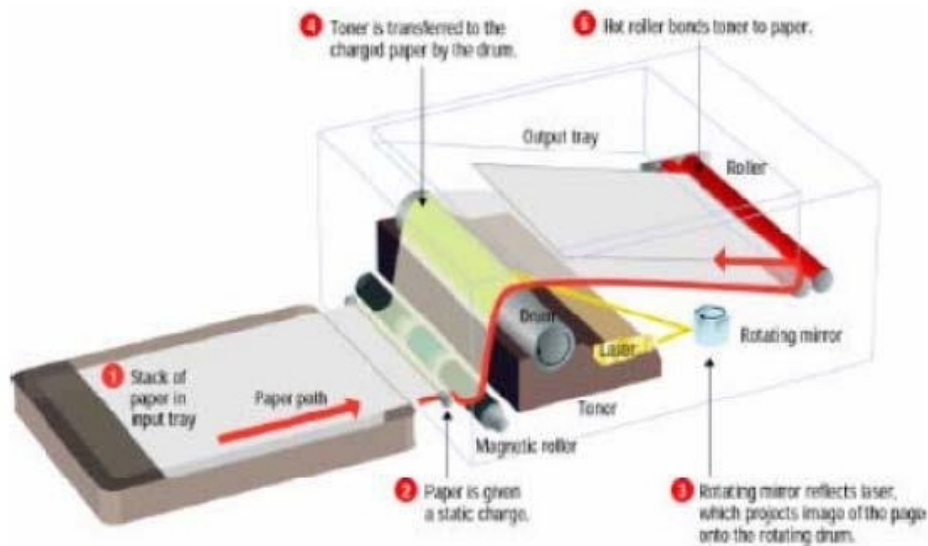
They use heat and pressure to bond particles of toner to paper.

Laser printers provide resolutions from 300–1200 dpi and higher.

Black-and-white laser printers usually produce 4–16 ppm.

Laser printers produce higher-quality print than ink jet printers, but are more costly

Laser Printer Working



Multi function Printer Technology: One for All:

- **Multi function devices** combine several capabilities, such as printing, scanning, copying and faxing, all in one device.
- By doing the work off our separate office machines at a price below the combined cost of buying the devices separately, units such as Office Jet and the Multi Pass offer budgetary and space advantages.
 - However, the multifunction devices can be slower than the separate devices, and the multifunction device might not perform each of its functions as well as the individual hardware devices.

Screen Output

Video Monitor

Also called Video Display Terminal (VDT)

Image exists in video memory—VRAM
Monitor size is measured diagonally across the screen

Pixels

Images are made up of dots called Pixels for picture elements
The number of pixels affects the resolution of the monitor
The higher the resolution, the better the image quality



Classes of Monitors

CRT (Cathode Ray Tube)

A CRT is a television-style monitor. Its features include:

- Clear image
- Quick response time
- Low cost
- Very popular

LCD (Liquid Crystal Display)

LCDs comprise flat-panel monitors. Features of flat-panel monitors include:

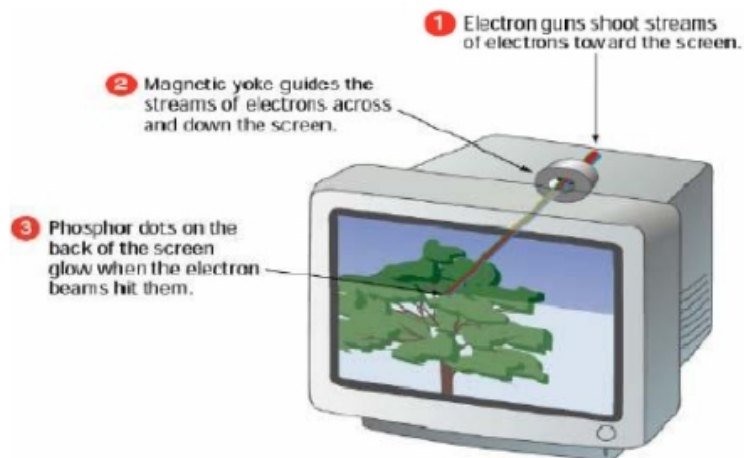
- Lighter weight
- More compact
- More expensive
- Dominate the portable computer market

CRT Monitors

In CRT monitors, electrons are fired at phosphor dots on the screen.

The dots are grouped into pixels, which glow when struck by electrons.

In color CRTs, each pixel contains a red, green, and blue dot. These glow at varying intensities to produce color images.



Flat-Panel Displays Monitors

Most flat-panel monitors use liquid crystal display(LCD) technology or Electroluminescent(EL).

Passive matrix LCD uses a transistor for each row and column of pixels.

Active matrix LCD uses a transistor for each pixel on the screen.

Thin-film transistor displays use multiple transistors for each pixel.

Factors affecting Screen Clarity

- Resolution
- Refresh rate
- Dot pitch

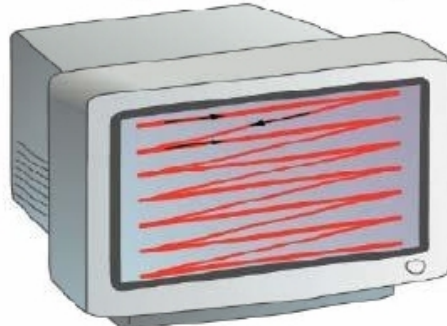
Resolution

- Resolution is the number of pixels on the screen, expressed as a matrix. Example such as 600x800.
- A 17" monitor offers resolutions from 640x480 up to 1280x1024.
- The Video Graphics Array(VGA) standard is 640x480. Super VGA(SVGA) monitors provide resolutions of 800x600, 1024x768 or higher.
- Resolution (image sharpness) is important.

Refresh Rate

- Refresh rate is the number of times each second that the electron guns scan the screen's pixels.
- Refresh rate is measured in Hertz(Hz), or cycles per second.
- Look for a refresh rate of 72Hz or higher. A slower rate may cause eye strain.

1 The electron gun scans from left to right,



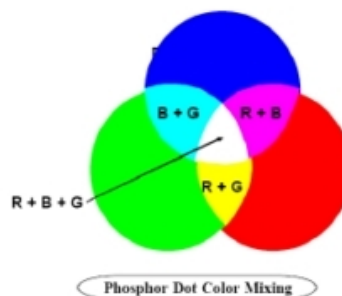
2 and from top to bottom,

3 refreshing every phosphor dot in a zig-zag pattern.

Fast scanning = Quick refresh (less flicker)

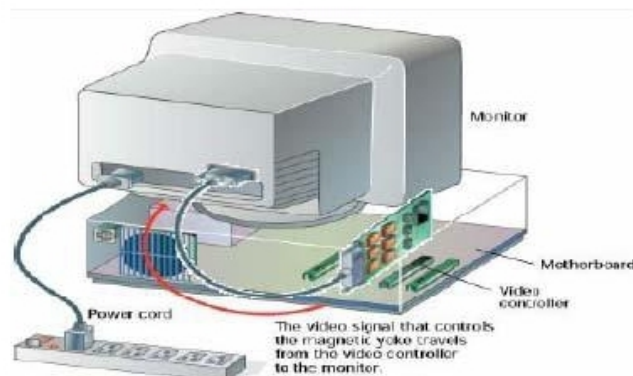
Dot Pitch

- Dot pitch is the distance between the phosphor dots that make up a single pixel.
- In color monitors, three dots(red,green,and blue) comprise each pixel.
- Look for a dot pitch no greater than .31 millimeter.



Video Controllers

- The video controller is an interface between the monitor and the CPU.
- The video controller determines many aspects of a monitor's performance, such as resolution or the number of colors displayed.
- The video controller contains its own on-board processor and memory, called video RAM (VRAM).
- Graphic intensive applications such as games require plenty of VRAM.



Standards of Monitors

VGA: Video Graphic Array

- Supports 16x256 colors depending on the resolution
- At 320x200 pixels : 256 colors
- At 640x480 pixels : 16 colors

SVGA: Super VGA

- 800x600 pixels and 1024x768 pixels—256 colors **XGA: Extended Graphic Array**
- –16.7 million colors at 1024x768 pixels

Bit-Mapped Displays

The computer uses bits(0s and 1s) to describe each pixel's attributes—its color and position.

- On monochrome screens: One bit represents one pixel on the screen.
- On color monitors: Several bits represent one pixel.

Bit-mapped display screens permit the computer to manipulate pixels on the screen individually, enabling the software to create a greater variety of images.

- Today most screens can display text and graphics—icons, charts, graphs, and drawings.

Future Display Technology

HDTV (high-definition television) may create a convergence between the TV and the computer monitor markets.

HDTV specifications call for resolution of up to 1920x1080 pixels, which is more than adequate for desktop computer screen displays.

Before, technical reasons made it difficult to make an image on a computer screen as bright as one on a TV screen.

Another promising new approach for computer screen technology is FED(Field Emission Display).

In FED, dozens or hundreds of tiny electron emitters are placed behind each pixel, in a panel where each pixel is controlled directly—as with an active-matrix LCD— but the light is emitted by the phosphors at that individual pixel, as in a CRT.

Audio Output Hardware

Voice Output

- a. **Voice output devices** convert digital data into speech-like sounds. You hear such forms of voice output on telephones, vending machines, cars, toys and games, etc.
- b. Two types of voice output technology:
 1. Speech coding uses actual human voices speaking words to provide a digital database of words that can be output as voice sounds.
 - a. So, words are codified and stored in digital form to be retrieved later and assembled as needed.
 - b. This method is limited by the words coded in the database, but the voice does sound more convincingly human.
 2. Speech synthesis uses a set of 40 basic speech sounds (called phonemes) to electronically create words.
 - a. No human voices are used to create the database; instead, the computer converts stored text into voices.
 - b. For example, with one Apple Macintosh system, you can type `Wiy l biy ray5t bae5k`, and the computer will speak "We'll be right back." The words are understandable, but clearly not human.
- c. There are silly applications to this technology—sound bytes associated with desktop sounds. There are business applications to this technology—annotation voice clips attached to reports. There are also life altering applications to this technology—enabling people with certain physical disabilities to communicate with spoken language.

Sound Output

- a. **Sound output devices** produce digitized sounds, ranging from beeps and chirps to music. To exercise sound output possibilities, you need both the necessary software and the sound card, or digital audio circuit board (such as Sound Blaster).
- b. There are two types of sound output technology for music:
 1. FM synthesis, where a synthesizer mimics different musical instruments by drawing on a library of stored sounds.
 2. Virtual acoustics, where the device stores a software model of an actual instrument. So, a set of formulas in the software represents aspects of playing the actual instrument.
 - a. By breathing into a sensor or by pressing a pedal, the musician can trigger a special microprocessor to simulate the playing of an actual instrument.
 3. In either case, the digital sounds go through a mixer to balance and control the sounds. The sounds can then flow through stereo speakers or be recorded.

B. Multimedia Output Needs

Information technology is changing the way ideas are communicated. More and more materials are available in poly media form—the same materials might be

Available in print form, audio form, and the form of a multimedia presentation on your computer.

To work with multimedia applications on your computer, you will need the following hardware items:

- a. Sound card
- b. Head phones
- c. Speakers

In & Out: Devices That Do Both.

Terminals

A **terminal** is an input/output device that uses a keyboard for input and a monitor for output. Terminals are either dumb or intelligent:

- a. **Dumb**: A dumb terminal can be used only to input data to and receive information from a computer system; it cannot do any processing on its own. An example is the dumb terminal used by airline clerks at airport ticket and check-in counters.
- b. **Intelligent**: An intelligent terminal has built-in processing capability and RAM but does not have its own storage capacity. Intelligent terminals are not as powerful as micro computers and are not designed to operate as stand-alone machines. They are often found in local area networks in an office. Users share applications software and data stored on a server.

Micro computers are sometimes used in business as terminals—they reduce the processing and storage load on the main computer system.

Some terminals are built to accomplish certain tasks:

- a. A **point-of-sale (POS) terminal** combines the input capabilities of a cash-register-type keypad, an optical scanner for reading price tags, and/or a magnetic stripe reader for reading credit cards with the output capabilities of a monitor and a receipt printer. Some are connected to a central computer; others are stand-alone until they can be downloaded to the main computer. You see POS terminals in most department stores.
- b. The automated teller machine (ATM) reads the encoded magnetic stripe on the ATM card and provides output in the form of display on a monitor and printed records of transactions.

Smart Cards and Optical Cards

Smartcard: A **smart card** looks like a credit card but contains a micro processor and memory chip that are used for identification and financial transactions, as well as storings mall databases, such as an individual's medical records. When inserted into a reader, the card transfers data to and from a central computer; it can store basic financial or other records.

- a. There are many examples of smart cards: telephone debit cards in France, bank cards, medical history cards, student ID cards, the list goes on...

Optical card: The conventional magnetic-stripe credit card holds the equivalent of a half page of data. The smart card with a microprocessor and memory chip holds the equivalent of 30 pages. The optical card presently

Holds 2000 pages of data. Optical cards use the same technology as music CDs, but look like silvery credit cards. Because of the large storage capacity, these cards could become very useful in extensive personal records—text and images.

Now You See It, Now You Don't

Retinal display screens are one example of advancements being made in output hardware technology.

- a. Images are projected pixel by pixel, or point of light by point of light, from an outside source directly on to the retina of a viewer's eye—the image only exists inside the eye of the user.
- b. Potential examples include: Surgeons could access detailed medical images(X-rays, MRIs, etc.) during surgery; mechanics could see color-coded diagrams of the miles of wiring under a jet airplane's skin as they work on it; soldiers could see mine locations displayed as they are projected from helmet-mounted, ground-penetrating radar