

Working principle of dot matrix, inkjet, laser printers

Dot matrix printer

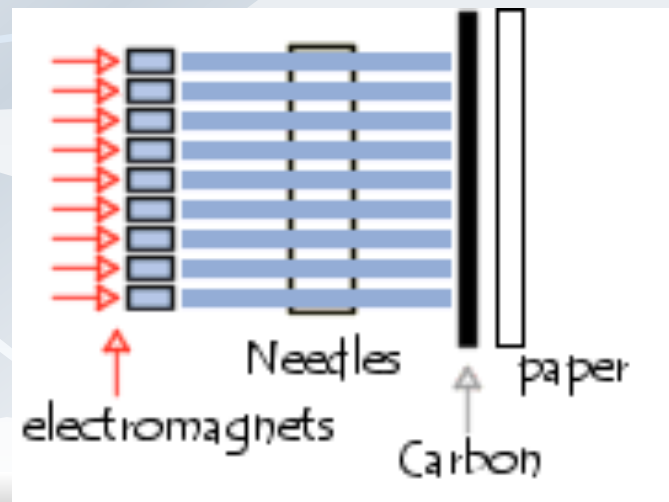
Definition:

- Dot matrix printers are known as impact printers.
- They create an image on paper by striking pins against an inked ribbon.
- The ink is transferred to the paper as closely shaped dots that form each character.
- The more pins, the better the print quality. 24-pin dot matrix printers can print at near letter-quality.

Introduction & Overview of Dot matrix printer

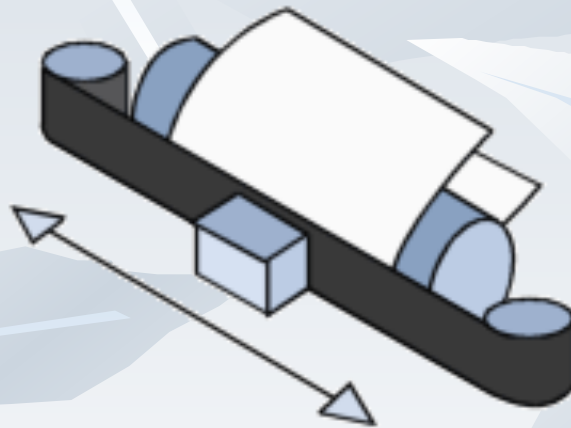
Dot-Matrix Printer

- The **dot-matrix printer** (sometimes called a *matrix printer* or an *impact printer*) allows you to print documents on paper thanks to the "back and forth" motion of a carriage housing a print head.
- The head is made up of tiny metal pins, driven by electromagnets, which strike a carbon ribbon called an "**inked ribbon**", located between the head and the paper.



Continue...

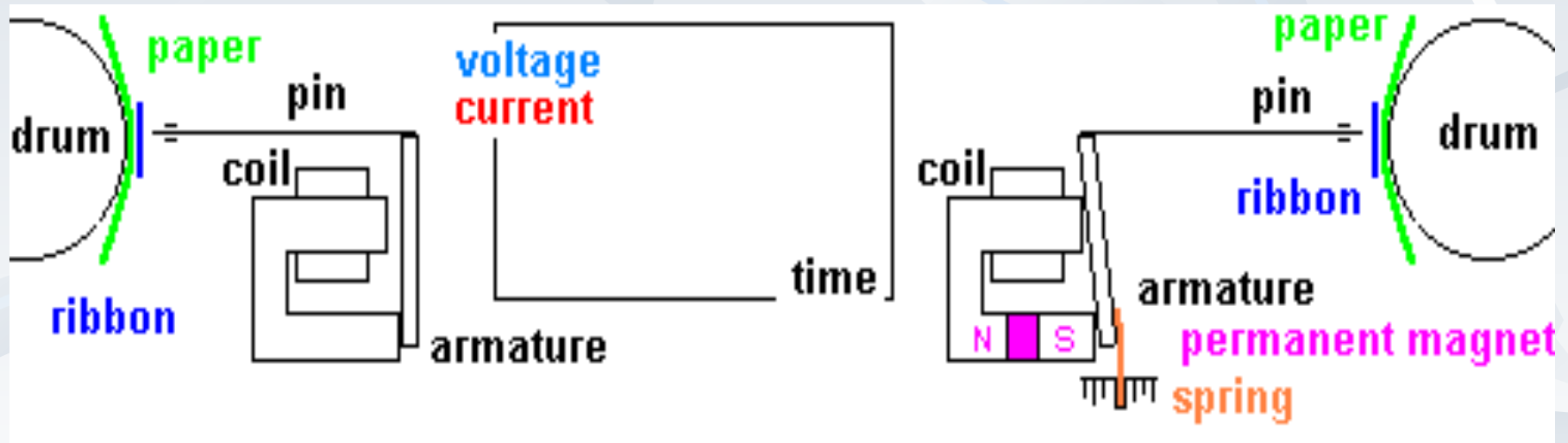
- The carbon ribbon scrolls by so that there is always ink on it. At the end of each line, a roller makes the sheet advance.



- The most recent dot-matrix printers are equipped with 24-needle printer heads, which allows them to print with a resolution of 216 dpi (*dots per inch*).

Working principle of Dot matrix printers

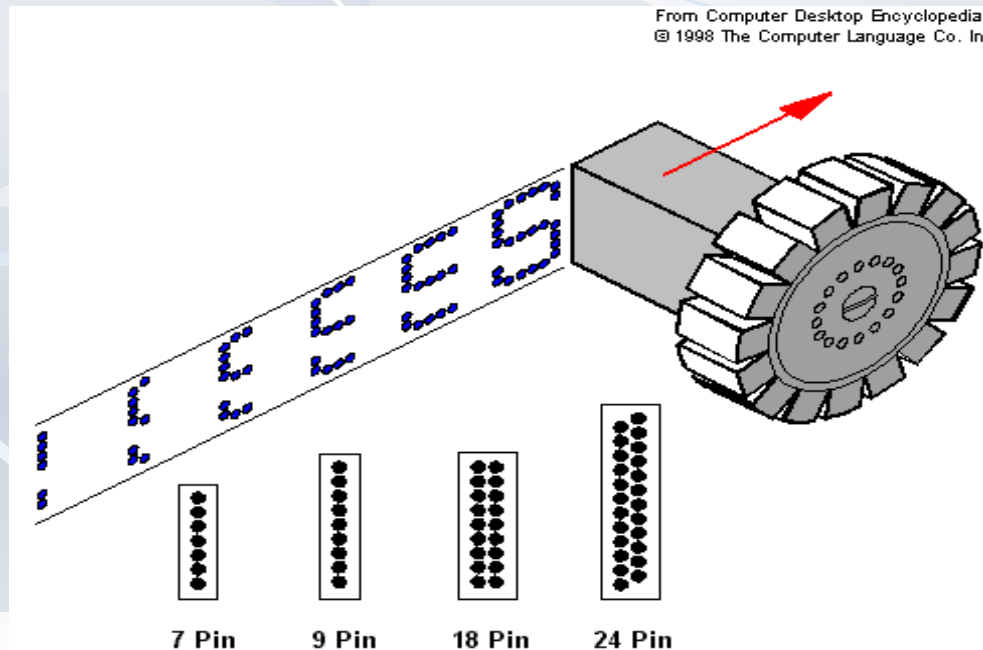
- It is widely used to print multipart forms and address labels. Also known as a "serial dot matrix printer," the tractor and sprocket mechanism in these devices handles thicker media better than laser and inkjet printers.



Continue...

Hammers Hit the Ribbon

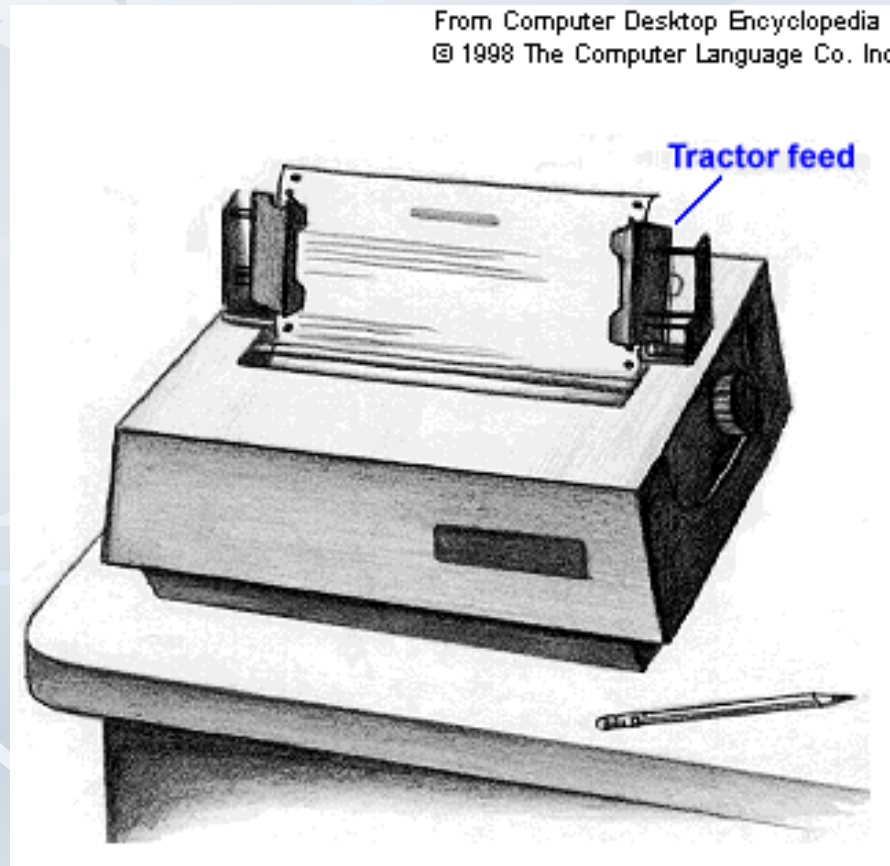
- The dot matrix printer uses one or two columns of dot hammers that are moved across the paper. The hammers hit the ribbon into the paper, which causes the ink to be deposited. The more hammers, the higher the resolution. For example, 9-pin heads produce draft quality text, while 24-pin heads produce typewriter quality output. Speeds range from 200 to 400 cps, which is about 90 to 180 lpm.



Dot Matrix Mechanism

Continue...

- Dot matrix printers print columns of dots in a serial fashion. The more dot hammers (pins), the better looking the printed results.



Dot Matrix Printer

Line Dot Matrix Printers Technology

- There are several printer technologies used in today's home, office and banking printers.
- Dot matrix printers are divided on two main groups:
 - serial dot matrix printers
 - line printers (or **line dot matrix printers**).
- Line printers as well as serial dot matrix printers use pins to strike against the inked **ribbon**, making **dots** on the paper and forming the desired characters.
- The differences are that line printers use **hammer bank** (or **print-shuttle**) instead of print head, this print-shuttle has **hammers** instead of print wires, and these hammers are arranged in a horizontal row instead in vertical column.

Continue...

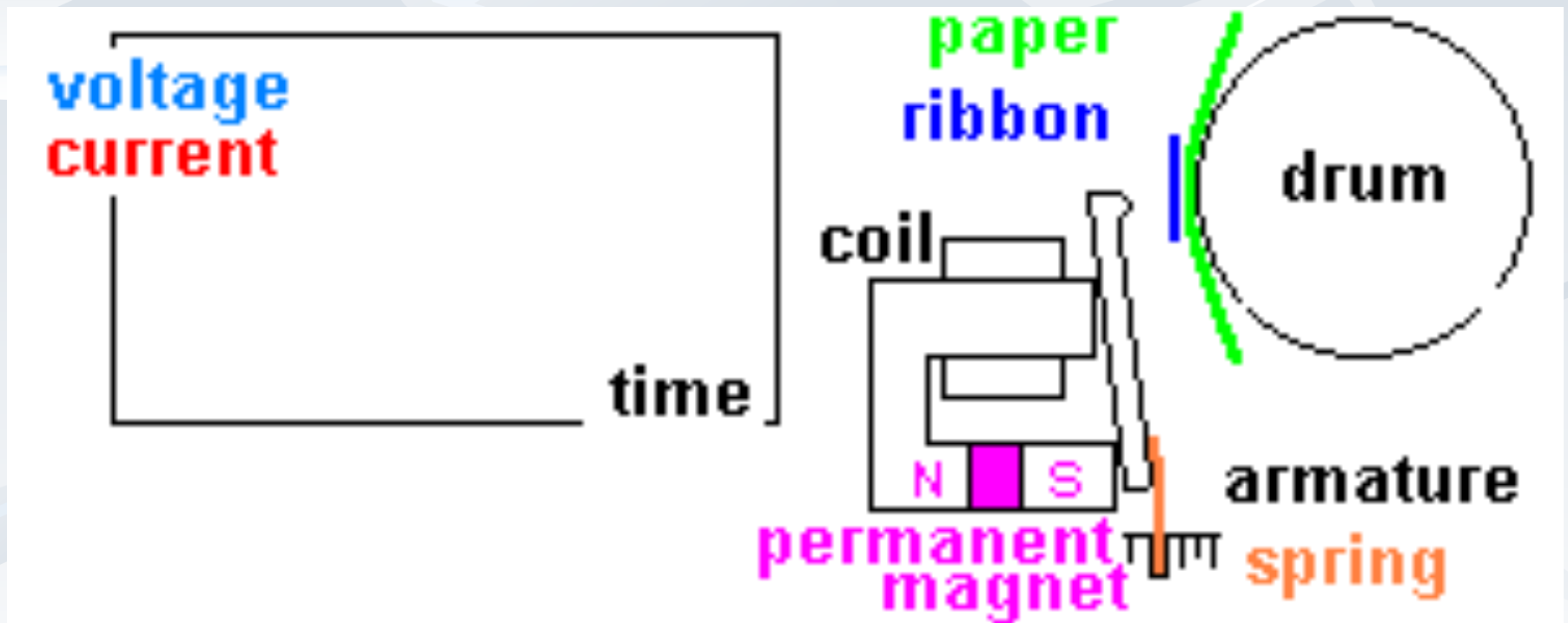
- The hammer bank uses the same technology as the permanent magnet print head with the small difference that instead of print wires the print-shuttle has hammers.

Printing mechanism

- The **printing mechanism** works as follow. The permanent magnetic field holds the hammer spring in stressed, ready to strike position. The driver sends electrical current to hammer coil, which then creates electromagnetic field opposite to the permanent magnetic field. When both fields equalize, the energy stored in the spring is released to strike the hammer against the ribbon and prints a dot on the paper. The hammer printhing mechanism is shown in action at the picture bellow.

Continue...

- The line printer mechanism in action:



How the line dot matrix printers work?

- During printing process the print-shuttle vibrates in horizontal direction with high speed while the print hammers are fired selectively. So each hammer may print a series of dots in horizontal direction for one pass of the shuttle, then paper advances at one step and the shuttle prints the following row of dots

The line printing process



- Line matrix printers are the right solutions for high-volume impact printing and are superior in speed, reliability and quality. As price-performance leaders, line printers cost less to service and less to use. The fastest line matrix printers available on the market are Tally T6218 and Printronix P5220, with a claimed print speed between 1800 and 2000 **lines per minute (lpm)**.

Continue...

Line dot matrix printer Features:	Specifications
Print Technology:	Line impact dot matrix
Print Speed LPM (lines per minute)	500 - 2000 lpm (draft)
Graphics Resolution	60 - 240 DPI
Copies (Original +)	5 - 9
Workload (Duty cycle) PPM (Pages per month)	60,000 - 600,000 PPM
Price [US\$]	3,000 - 13,000 \$
Cost Per Page (Cost/cents ¢)	0.1 - 0.15 ¢

Characteristics of Dot- matrix printers

Dot-matrix printers vary in two important characteristics:

- **speed:** Given in characters per second (cps), the speed can vary from about 50 to over 500 cps. Most dot-matrix printers offer different speeds depending on the quality of print desired.
- **print quality:** Determined by the number of pins (the mechanisms that print the dots), it can vary from 9 to 24. The best dot-matrix printers (24 pins) can produce near letter-quality type, although you can still see a difference if you look closely.
- In addition to these characteristics, you should also consider the noise factor. Compared to laser and ink-jet printers, dot-matrix printers are notorious for making a racket.

Advantages of Dot-matrix printers

The advantages are:

- low purchase cost.
- can handle multipart forms.
- cheap to operate, just new ribbons.
- rugged and low repair cost.

Disadvantages of Dot-matrix printers

The disadvantages are:

- noisy.
- low resolution. You can see the dots making up each character.
- Not all can do colour.
- Colour looks faded and streaky.

Future of dot-matrix printers

- The main use of dot-matrix printers is in areas of intensive transaction-processing systems that churn out quite a lot of printing.
- Many companies who might have started off with dot-matrix printers are not easily convinced to go for printers based on other technologies because of the speed advantage of dot-matrix printers.

Inkjet Printing

Definition:

Typically, **inkjet printing** forms images by spraying tiny droplets of liquid ink onto paper. Small size and precision placement of the dots of ink produce very near photo-quality images.

Some inkjet printers employ a hybrid dye-sublimation process. The color is contained in cartridges, heated, vaporized, and laid down a strip at a time rather a page at a time creating an effect closer to continuous tone than traditional inkjet technology.

Also Known As: bubble jet | thermal ink

Continue...

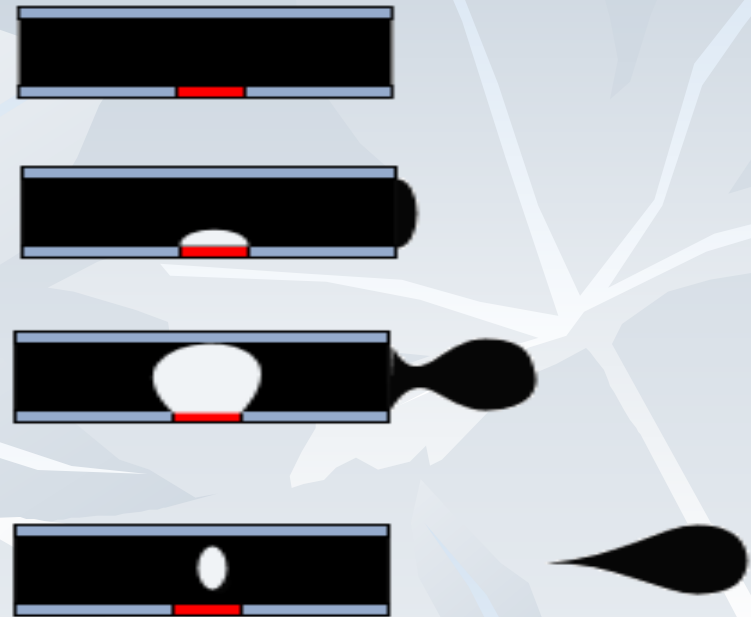
Examples:

- Currently, inkjet printing is the primary printer technology for home, home offices, and many small businesses.
- Inkjet printers are inexpensive and produce good color output but can be slow.
- Best results are normally achieved when printing to specially coated inkjet or photo papers.

Introduction & Overview of Inkjet printer

- **Inkjet Printer and Bubble Jet Printer**
- The **inkjet** printer technology was originally invented by Canon. It is based on the principle that a heated fluid produces bubbles.
- The researcher who discovered this had accidentally brought a syringe filled with ink into contact with a soldering iron. This created a bubble in the syringe that made the ink in the syringe shoot out.
- Today's printer heads are made up of several nozzles (up to 256), equivalent to several syringes, which are heated up to between 300 and 400°C several times per second.
- Each nozzle produces a tiny bubble that ejects an extremely fine droplet. The vacuum caused by the decrease in pressure creates a new bubble.

Continue...



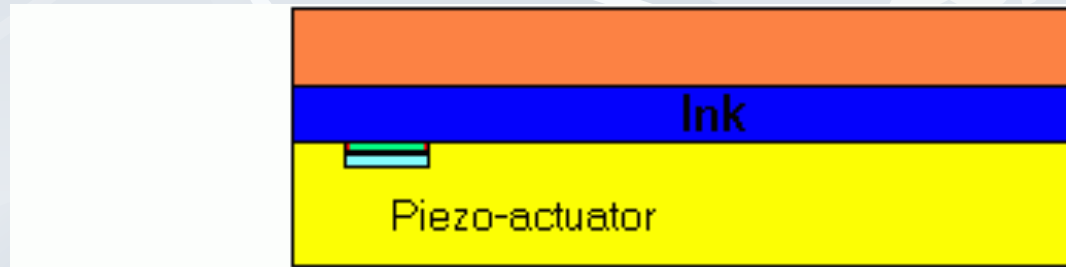
- Generally, we make a distinction between the two different technologies:
- **Inkjet printers** use nozzles that have their own built-in heating element. Thermal technology is used here.
- **Bubble jet printers** use nozzles that have piezoelectric technology. Each nozzle works with a piezoelectric crystal that changes shape when excited by its resonance frequency and ejects an ink bubble.

Inkjet and Bubble-jet Printers Technology

- **Inkjet printers technology** development starts in the early 1960s. The first inkjet printing device was patented by Siemens in 1951, which led to the introduction of one of the first inkjet chart recorders.
- The **continuous inkjet printer** technology was developed later by IBM in the 1970s. The continuous inkjet technology basis is to deflect and control a continuous inkjet droplet stream direction onto the printed media or into a gutter for recirculation by applying an electric field to previously charged inkjet droplets.
- The **drop-on-demand inkjet printer** technology was led to the market in 1977 when Seimens introduced the PT-80 serial character printer. The drop-on-demand printer ejects ink droplets only when they are needed to print on the media. This method eliminates the complexity of the hardware required for the continuous inkjet printing technology. In these first inkjet printers ink drops are ejected by a pressure wave created by the mechanical motion of the piezoelectric ceramic.

Continue...

Inkjet printer drop-on-demand technology with piezoelectric actuator



At the same time Canon developed the **bubble jet printer technology**, a drop-on-demand inkjet printing method where ink drops were ejected from the nozzle by the fast growth of an ink vapor bubble on the top surface of a small heater. Shortly thereafter, Hewlett-Packard independently developed a similar inkjet printing technology and named it **thermal inkjet**.

Continue...

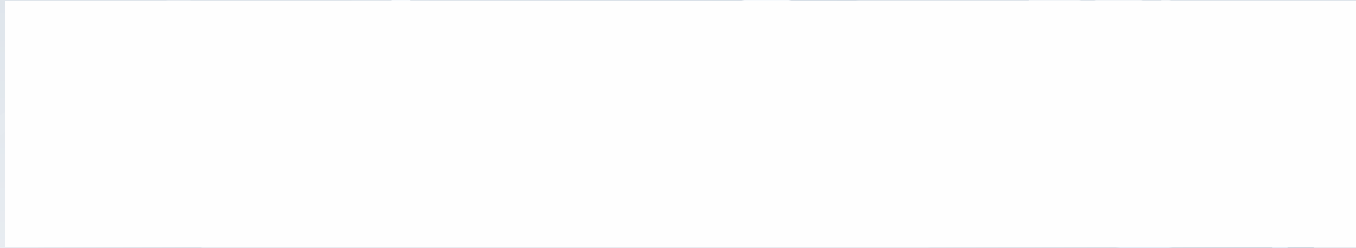
Bubble jet printer drop-on-demand technology



The most popular inkjet and bubble-jet printers use serial printing process. Similarly to dot matrix printers, serial inkjet printers use print heads with a number of nozzles arranged in vertical columns. The printing process is the same as in dot matrix printers.

Continue...

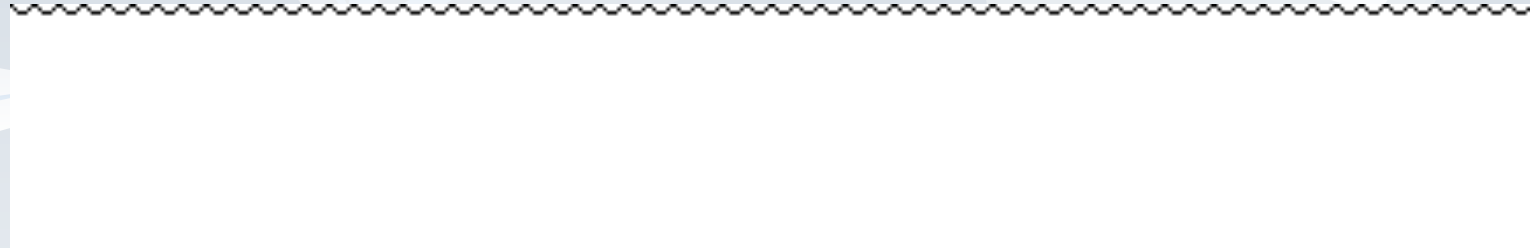
Serial Inkjet printer in action



There are also available inkjet and bubble-jet printers analogous to line dot matrix printers for high speed printing applications. The image printing process is similar to that in LED printers.

Continue...

Line inkjet printer printing process



The greatest advantages of inkjet printers are, quiet operation, capability to produce color images even with photographic quality and the low printer prices. The down side is that although inkjet printers are generally cheaper to buy than lasers, they are far more expensive to maintain. When it comes to comparing the cost per page, ink jet printers work out many times more expensive than laser printers. There are some exceptions of course for some heavy-duty industrial printers. From Tally claim the T3016 SprintJet prints at only 1/3 of a cent per page.

Continue...

Printer Features:	Specifications
Print Technology	Inkjet or Bubble-jet
Print Speed PPM (pages per minute)	1 - 20 PPM
Graphics Resolution	300 - 1200 DPI
Copies (Original +)	0
Workload (Duty cycle) PPM (Pages per month)	6,000 - 60,000 PPM
Price [US\$]	30 - 3,000 \$ For large-format printers up to 19,000 \$
Cost Per Page (Cost/cents ¢)	3.0 - 30.0 ¢

Working principle of Ink-jet printers

- Inkjet printers – let us spray
- Inkjet printers literally spray liquid ink through a miniature nozzle
similar to your garden hose nozzle. These printers are very quiet and are moderately priced, and the print quality rivals that of a laser printer.
- The printhead contains 4 cartridges of different colored ink: cyan (blue),magenta, yellow and black (CMYK). It moves along a bar from one side of the paper to the other, writing as it goes. The formatting information and data sent to it activates the chambers of the ink cartridges.
- When the designated nozzle is selected, an electrical pulse flows through thin resistors in the ink chambers that form the character to be printed.

Continue...

- The resistor is heated and used to heat a thin layer of ink in each selected chamber, causing the ink to boil or expand to form a bubble of vapor.
- This expansion causes pressure on the ink, which pushes it through the nozzle onto the paper. Your page is printed.

Advantages of Inkjet printers

Advantages:

- the colour is perfect.
- it is faster the dot matrix, daisy wheel and laser printers.
- Most models are relatively light weight and compact so they don't take up too much space on the desk.

Disadvantages of Inkjet printers

- Due to the cost of ink, running an inkjet printer over time is a more expensive than a laser printer.
- Prints emerge from the printer slightly wet and may need time to dry.
- Printing is slower and therefore inkjets aren't designed for high volume printing.

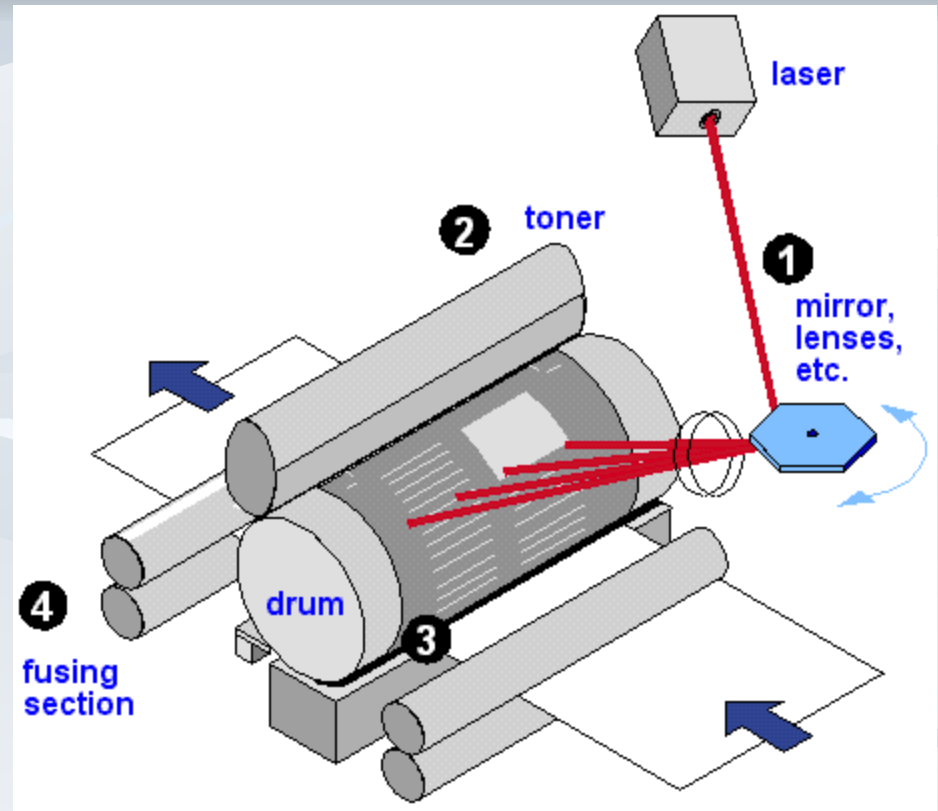
Introduction & Overview of Laser printers

- In 1975, IBM introduced the first laser printer, the model 3800. Later, Siemens came out with the ND 2 and Xerox with the 9700. These self-contained printing presses were online to a mainframe or offline, accepting print image data on tape or disk.

In 1984, HP introduced the LaserJet, the first desktop laser printer, which rapidly became a huge success and a major part of the company's business. Desktop lasers made the clackety daisy wheel printers obsolete, but not dot matrix printers, which are still widely used for labels and multipart forms.

Continue...

The **Laser** Mechanism



The Laser Mechanism

The laser printer uses electrostatic charges to (1) create an image on the drum, (2) adhere toner to the image, (3) transfer the toned image to the paper, and (4) fuse the toner to the paper. The laser creates the image by "painting" a negative of the page to be printed on the charged drum. Where light falls, the charge is dissipated, leaving a positive image to be printed.

Working principle of Laser printers

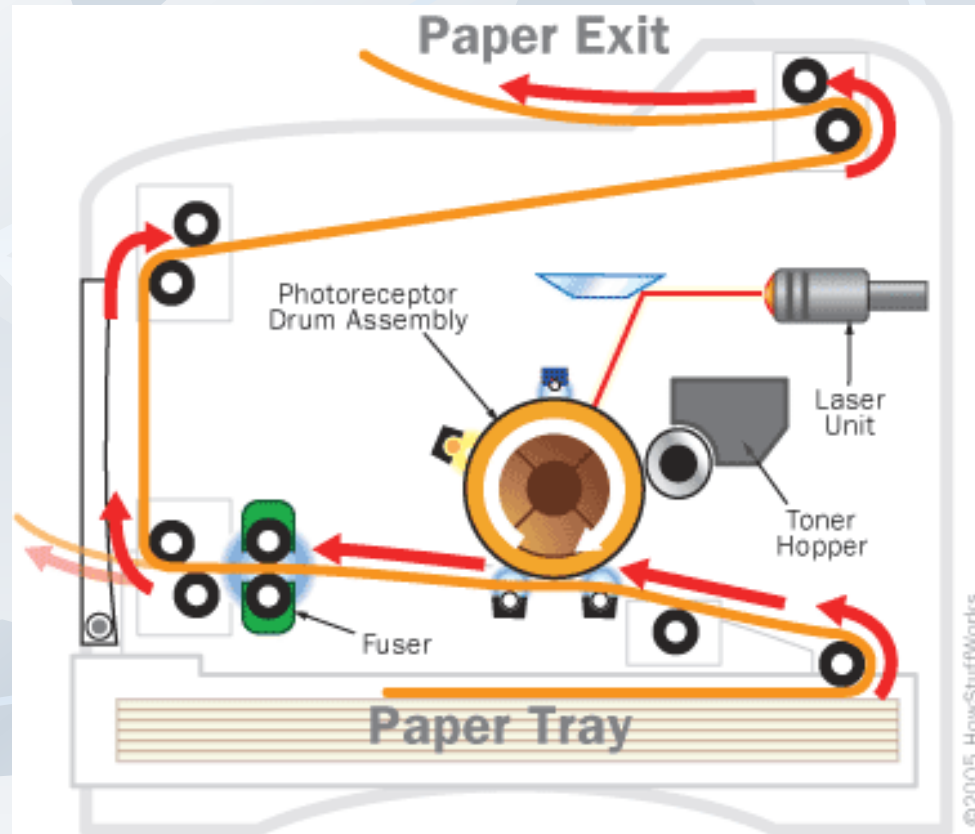
How Laser Printers Work

The Basics: Static Electricity

The primary principle at work in a laser printer is static electricity, the same energy that makes clothes in the dryer stick together or a lightning bolt travel from a thundercloud to the ground. Static electricity is simply an electrical charge built up on an **insulated object**, such as a balloon or your body. Since oppositely charged atoms are attracted to each other, objects with opposite static electricity fields cling together.

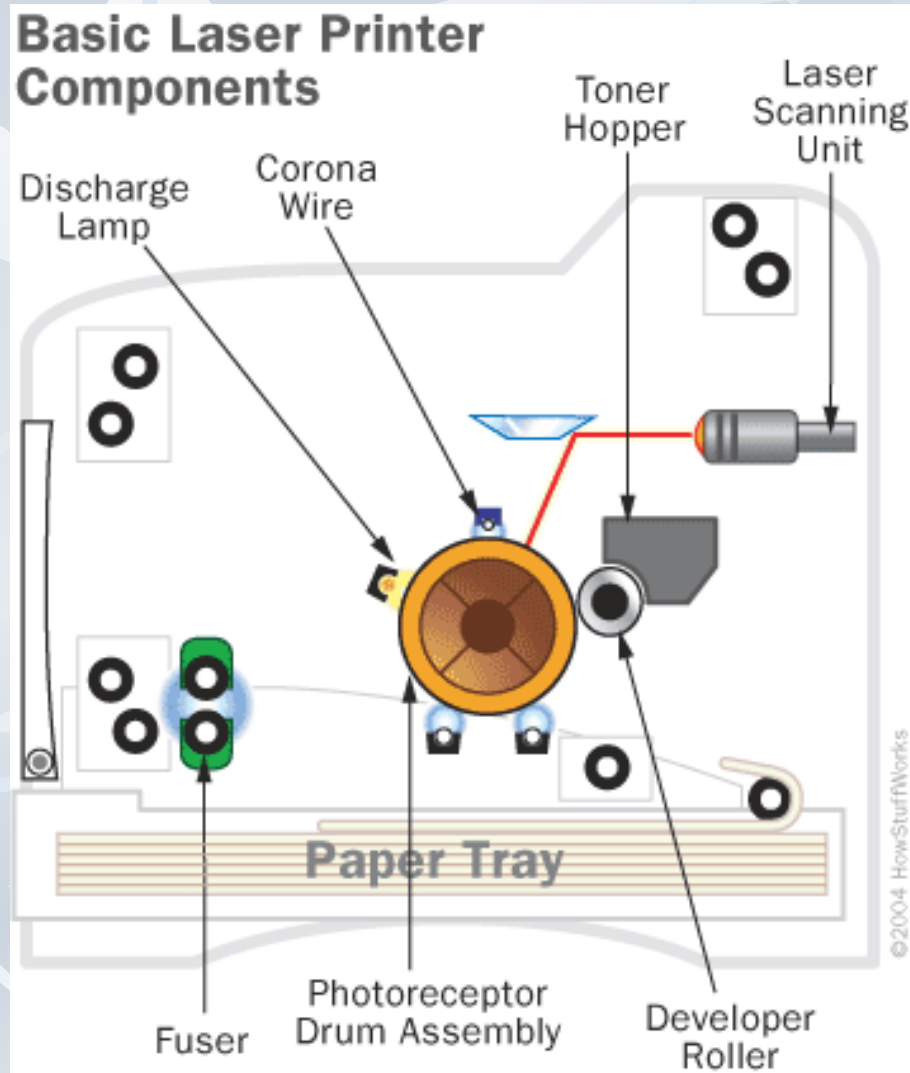
Continue...

The path of a piece of paper through a laser printer



A laser printer uses this phenomenon as a sort of "temporary glue." The core component of this system is the **photoreceptor**, typically a revolving drum or cylinder. This **drum assembly** is made out of highly **photoconductive** material that is discharged by light photons.

Continue...



The basic components of a laser printer

Continue...

■ The Basics: Drum

Initially, the drum is given a total **positive charge** by the **charge corona wire**, a wire with an electrical current running through it. (Some printers use a **charged roller** instead of a corona wire, but the principle is the same.) As the drum revolves, the printer shines a tiny laser beam across the surface to discharge certain points. In this way, the laser "draws" the letters and images to be printed as a pattern of electrical charges -- an **electrostatic image**. The system can also work with the charges reverse electrostatic image on a negative b

The laser "writes" on a photoconductive revolving drum.



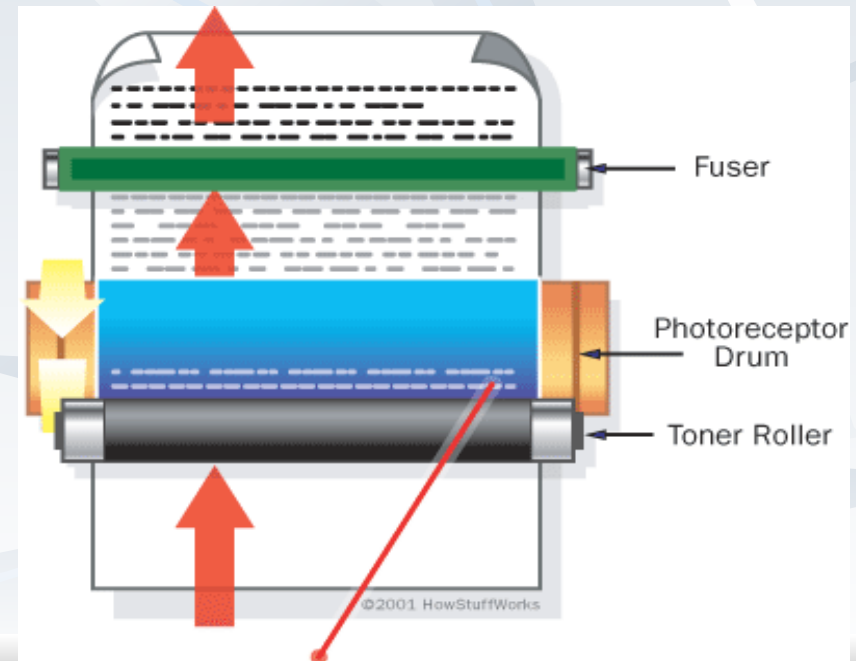
Continue...

- After the pattern is set, the printer coats the drum with positively charged **toner** -- a fine, black powder. Since it has a positive charge, the toner clings to the negative discharged areas of the drum, but not to the positively charged "background." This is something like writing on a soda can with glue and then rolling it over some flour: The flour only sticks to the glue-coated part of the can, so you end up with a message written in powder.
- With the powder pattern affixed, the drum rolls over a sheet of paper, which is moving along a belt below. Before the paper rolls under the drum, it is given a negative charge by the **transfer corona wire** (charged roller). This charge is stronger than the negative charge of the electrostatic image, so the paper can pull the toner powder away. Since it is moving at the same speed as the drum, the paper picks up the image pattern exactly. To keep the paper from clinging to the drum, it is discharged by the **detac corona wire** immediately after picking up the toner.

Continue...

■ The Basics: Fuser

Finally, the printer passes the paper through the fuser, a pair of heated rollers. As the paper passes through these rollers, the loose toner powder melts, fusing with the fibers in the paper. The fuser rolls the paper to the output tray, and you have your finished page. The fuser also heats up the paper itself, of course, which is why pages are always hot when they come out of a laser printer or photocopier.



Continue...

- So what keeps the paper from burning up? Mainly, *speed* -- the paper passes through the rollers so quickly that it doesn't get very hot.
- After depositing toner on the paper, the drum surface passes the discharge lamp. This bright light exposes the entire photoreceptor surface, erasing the electrical image. The drum surface then passes the charge corona wire, which reapplies the positive charge.
- Conceptually, this is all there is to it. Of course, actually bringing everything together is a lot more complex. In the following sections, we'll examine the different components in greater detail to see how they produce text and images so quickly and precisely.

Continue...

The Controller: The Conversation

Before a laser printer can do anything else, it needs to receive the Page data and figure out how it's going to put everything on the paper. This is the job of the **printer controller**.

The printer controller is the laser printer's main onboard computer. It talks to the host computer (for example, your PC) through a communications port, such as a parallel port or USB port. At the start of the printing job, the laser printer establishes with the host computer how they will exchange data. The controller may have to start and stop the host computer periodically to process the information it has received.



A typical laser printer has a few different types of communications ports.

Continue...

- In an office, a laser printer will probably be connected to several separate host computers, so multiple users can print documents from their machine. The controller handles each one separately, but may be carrying on many "conversations" concurrently. This ability to handle several jobs at once is one of the reasons why laser printers are so popular.

The Controller: The Language

- For the printer controller and the host computer to communicate, they need to speak the same **page description language**. In earlier printers, the computer sent a special sort of text file and a simple code giving the printer some basic formatting information. Since these early printers had only a few fonts, this was a very straightforward process.

Continue...

- These days, you might have hundreds of different fonts to choose from, and you wouldn't think twice about printing a complex graphic. To handle all of this diverse information, the printer needs to speak a more advanced language.
- The primary printer languages these days are Hewlett Packard's **Printer Command Language** (PCL) and Adobe's **Postscript**. Both of these languages describe the page in **vector** form -- that is, as mathematical values of geometric shapes, rather than as a series of dots (a **bitmap** image). The printer itself takes the vector images and converts them into a bitmap page. With this system, the printer can receive elaborate, complex pages, featuring any sort of font or image. Also, since the printer creates the bitmap image itself, it can use its maximum printer resolution.

Continue...

- Some printers use a **graphical device interface** (GDI) format instead of a standard PCL. In this system, the host computer creates the dot array itself, so the controller doesn't have to process anything -- it just sends the dot instructions on to the laser.
- But in most laser printers, the controller must organize all of the data it receives from the host computer. This includes all of the commands that tell the printer what to do -- what paper to use, how to format the page, how to handle the font, etc. For the controller to work with this data, it has to get it in the right order.

The Controller: Setting up the Page

- Once the data is structured, the controller begins putting the page together. It sets the text margins, arranges the words and places any graphics. When the page is arranged, the **raster image processor** (RIP) takes the page data, either as a whole or piece by piece, and breaks it down into an array of tiny dots. As we'll see in the next section, the printer needs the page in this form so the laser can write it out on the photoreceptor drum.

Continue...

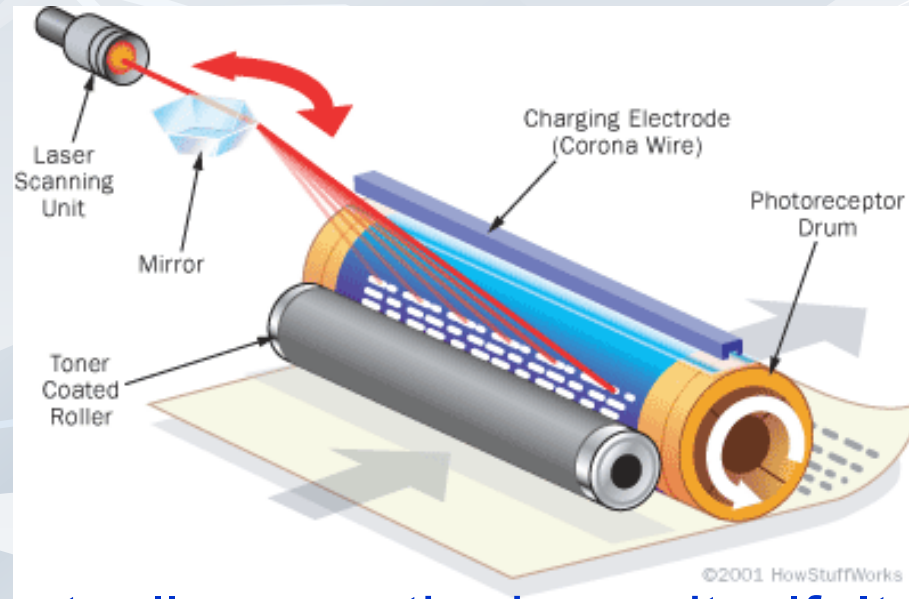
- In most laser printers, the controller saves all print-job data in its own memory. This lets the controller put different printing jobs into a **queue** so it can work through them one at a time. It also saves time when printing multiple copies of a document, since the host computer only has to send the data once.

The Laser Assembly

- Since it actually draws the page, the printer's laser system -- or **laser scanning assembly** -- must be incredibly precise. The traditional laser scanning assembly includes:
 - A **laser**
 - A **movable mirror**
 - A **lens**

Continue...

- The laser receives the page data -- the tiny dots that make up the text and images -- one horizontal line at a time. As the beam moves across the drum, the laser emits a pulse of light for every dot to be printed, and no pulse for every dot of empty space.



The laser doesn't actually move the beam itself. It bounces the beam off a movable **mirror** instead. As the mirror moves, it shines the beam through a series of **lenses**. This system compensates for the image distortion caused by the varying distance between the mirror and points along the drum.

Continue...

Writing the Page

- The laser assembly moves in only one plane, horizontally. After each horizontal scan, the printer moves the photoreceptor drum up a notch so the laser assembly can draw the next line. A small print-engine computer synchronizes all of this perfectly, even at dizzying speeds.
- Some laser printers use a strip of light emitting diodes (LEDs) to write the page image, instead of a single laser. Each dot position has its own dedicated light, which means the printer has one set print resolution. These systems cost less to manufacture than true laser assemblies, but they produce inferior results. Typically, you'll only find them in less expensive printers.

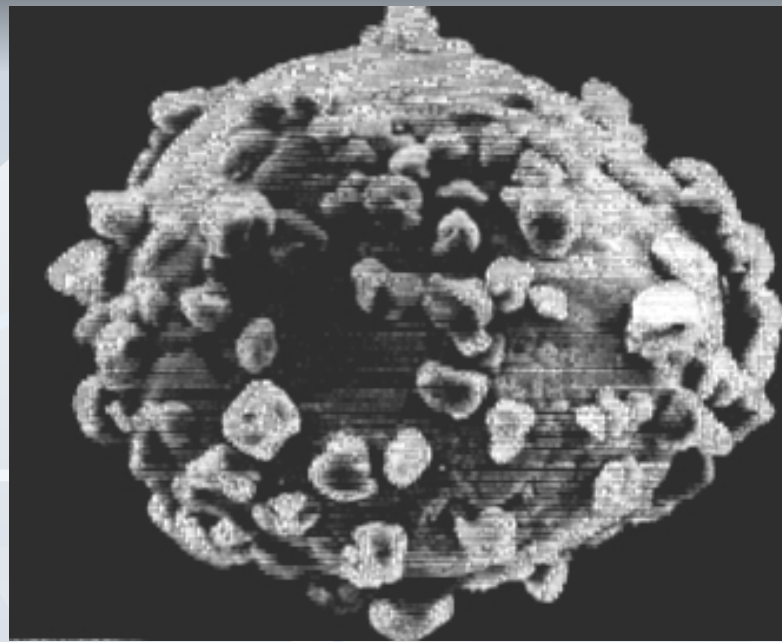
Toner Basics

- One of the most distinctive things about a laser printer (or photocopier) is the toner. It's such a strange concept for the paper to grab the "ink" rather than the printer applying it. And it's even stranger that the "ink" isn't really ink at all.

Continue...

- So what is toner? The short answer is: It's an electrically-charged powder with two main ingredients: **pigment** and **plastic**.
- The role of the pigment is fairly obvious -- it provides the coloring (black, in a monochrome printer) that fills in the text and images. This pigment is blended into plastic particles, so the toner will melt when it passes through the heat of the fuser. This quality gives toner a number of advantages over liquid ink. Chiefly, it firmly binds to the fibers in almost any type of paper, which means the text won't smudge or bleed easily.

Continue...



A developer bead coated with small toner particles

Applying Toner

- So how does the printer apply this toner to the electrostatic image on the drum? The powder is stored in the **toner hopper**, a small container built into a removable casing. The printer gathers the toner from the hopper with the **developer unit**. The "developer" is actually a collection of small, negatively charged magnetic beads. These beads are attached to a rotating metal roller, which moves them through the toner in the toner hopper.

Continue...

- Because they are negatively charged, the developer beads collect the positive toner particles as they pass through. The roller then brushes the beads past the drum assembly. The electrostatic image has a stronger negative charge than the developer beads, so the drum pulls the toner particles away.



In a lot of printers, the toner hopper, developer and drum assembly are combined in one replaceable cartridge.

Continue...

- The drum then moves over the paper, which has an even stronger charge and so grabs the toner. After collecting the toner, the paper is immediately discharged by the detach corona wire. At this point, the only thing keeping the toner on the page is gravity -- if you were to blow on the page, you would completely lose the image. The page must pass through the fuser to affix the toner. The fuser rollers are heated by internal **quartz tube lamps**, so the plastic in the toner melts as it passes through.
- But what keeps the toner from collecting on the fuser rolls, rather than sticking to the page? To keep this from happening, the fuser rolls must be coated with **Teflon**, the same non-stick material that keeps your breakfast from sticking to the bottom of the frying pan.

Color Printers

- Initially, most commercial laser printers were limited to monochrome printing (black writing on white paper). But now, there are lots of color laser printers on the market.

Continue...

- Essentially, color printers work the same way as monochrome printers, except they go through the entire printing process four times -- one pass each for cyan (blue), magenta (red), yellow and black. By combining these four colors of toner in varying proportions, you can generate the full spectrum of color.



Inside a color laser printer

Continue...

- There are several different ways of doing this. Some models have four toner and developer units on a rotating wheel. The printer lays down the electrostatic image for one color and puts that toner unit into position. It then applies this color to the paper and goes through the process again for the next color. Some printers add all four colors to a plate before placing the image on paper.
- Some more expensive printers actually have a complete printer unit -- a laser assembly, a drum and a toner system -- for each color. The paper simply moves past the different drum heads, collecting all the colors in a sort of assembly line.

Advantages of Laser printers

Advantages:

- Colour printing is possible
- Print quality is good
- Noiseless
- Printing speed is high
- Most models are relatively light weight and compact so they don't take up too much space on the desk

Disadvantages of Laser printers

Disadvantages:

- Not be the printer of choice for everyone, Due to the cost of ink, running an inkjet printer over time is a more expensive than a laser printer.
- Prints emerge from the printer slightly wet and may need time to dry.
- Printing is slower and therefore inkjets aren't designed for high volume printing