# How does a laser printer work?

In the beginning, there was the impact printer (dot matrix or daisywheel). Almost everyone understood this type of printer because it worked just like a typewriter. Something hard struck an inked ribbon and made a mark on the page. Then came the inkjet printer, which was only a little bit more complicated: Ink squirted out of a nozzle onto the paper.

Laser printing, however, involves a multistep process, and what's happening is not obvious from watching the printer operate. Many end users (and even some technicians) see it as a mysterious activity. Paper goes in blank; paper comes out printed. But how does it happen?

If any of you still remember mimeograph machines, their operation provides a rough analogy to a laser printer's. The entire page on a mimeograph was printed on a master sheet that clung to a rotating cylinder. As you turned the handle, the cylinder rotated past ink and paper, transferring the image to the document. Laser printers work much the same way. The main difference is that the image on the laser printer's cylinder is created with lasers and electrical charges.

**Step 1: Incoming data**
First, the computer sends data to the printer. But it doesn't just barrel ahead—it queries the output port to make sure a printer is attached and ready. The printer sends a signal back on the strobe line (pin 1) for parallel or DTR (line 20) for serial interface, indicating it is ready for data.

Next, if the print job needs any fonts that the printer does not have in residence (such as TrueType fonts), those are sent to the printer and stored in its memory. Then, the print job itself is sent and stored. If the job is larger than the printer's memory can accommodate, the OS either waits (as with single-tasking OSs such as DOS) or uses its own print spooler to feed the remainder of the job to the printer (as with Windows). Some printers come with their own custom software that includes a print spooler that takes over instead of the one in the OS.

Laser printers fall under the category of page printer because they compose the entire page in their memory and then transfer it to paper. A full page with graphics occupies on average 512 KB of memory, so a decent laser printer should have at least 1 MB of memory to store at least one page plus any associated fonts. Printers with more memory can hold multiple pages of a print job in their memory, which offloads the print job more quickly from the OS.

**Step 2: Drum preparation**
The single largest part of the laser printer is the drum, an aluminum cylinder coated with photosensitive material. In preparation for printing, the drum must be cleaned to remove any traces of previous pages. First, a rubber blade wipes the excess toner from the drum, and then erase lamps (in older models) or a charged drum (in newer models) electrostatically clean it by neutralizing residual electrical charges on it.

Note

The drum's photosensitivity can be damaged by exposure to light, so erase lamps are red-filtered. On some models of laser printers, red plastic is placed over the lamps to accomplish this.

After the cleaning, the printer conditions the drum to receive the next image by applying a uniform negative charge of -600v to its surface. The primary corona (in the toner cartridge) performs this function in some printers; in other models another charged drum does it. The primary corona is a thin wire; there are several corona wires involved in the print process. The primary corona must emit a charge of -6,000v in order to apply a -600v charge to the drum. That is some seriously high voltage!

Note

The negative charge applies evenly across the photosensitive drum because a varistor grid filters it. Varistor gets its name from the term variable resistor: It does not conduct electricity until a specific voltage level is achieved.

**Step 3: Drum writing**

Now comes the important part: The data in the printer's memory is written to the drum using a laser. Rather than writing it with ink or toner, however, it writes by shining a very precise laser on the photosensitive drum in certain spots, changing the electrical charge in those spots. As the drum cylinder rotates past the laser, it sweeps across the surface, turning on and off to neutralize certain areas to about -100v. These neutralized areas will be the spots where toner adheres to the drum later in the process and then transfers to the paper.

In the early laser printers, the on/off status of the laser could be changed 300 times per inch, and the drum rotated 1/300 of an inch with each horizontal sweep of the laser, resulting in a 300 dots per inch (dpi) maximum resolution. Today's laser printers can achieve 600 dpi or even 1200 dpi.

**Step 4: Paper feed**

Now it's time for the paper to join in. Feed rollers draw the paper into the printer from the paper tray. Registration rollers hold the paper until it's time for it to be released, making sure that the top of the paper feeds in exactly at the moment when the laser image of the page that's on the drum rotates past it.

**Step 5: Toner pickup**

Steps four and five occur more or less simultaneously: As the paper is being drawn in, the toner is being applied to the drum.

The toner cartridge contains a rotating, magnetic, metal-developing cylinder, a toner reservoir, and a height control mechanism that limits the amount of toner the cylinder can pick up at a time. Toner consists of plastic resin particles (the particles that melt to produce the image on paper) and iron oxide (the particles that are affected by magnetic attraction and electrical charges). The toner's metal particles adhere to the magnetic cylinder, and the cylinder presents the toner to the drum as it passes by. The developing cylinder is charged to -600v, like the blank portions of

the photosensitive drum, and the toner adhering to the cylinder also takes on that same charge.

Tip

If you ever get toner on fabric accidentally, you can get it off with a magnet, since the toner is about 50 percent iron oxide.

As the drum passes by the cylinder, the toner ignores all the areas charged to -600v because that's the same charge as itself. It jumps off and clings to the areas with the lesser charge (-100v), however, and that's what makes the toner stick to the drum.

**Step 6: Toner transfer to paper**

At this point, the image exists on the drum, complete with toner. If you could look inside the printer as it operates (you can't, by the way, because of the safety features in place) and stop the drum from rotating for a moment, you could see the page on the drum, just as it is to be printed.

As the paper feeds into the printer, the transfer corona applies a +600v (positive) charge to the paper. When the paper passes by the drum, the -100v charged toner on the drum jumps off onto the positively charged paper. Then, the paper runs past a static charge eliminator, which is a row of teeth with a negative charge that reduces the paper's highly positive charge.

**Step 7: Fusing the toner to the paper**

The image is now on the paper, but it's not secure there; it's just loose toner held in place by gravity and a weak electrostatic charge. For permanent application, it must be fused. Fusing is basically melting the toner's plastic particles so they stick, or fuse, to the fibers in the paper.

The fuser roller is a nonstick cylinder with a high-powered lamp inside it that heats the paper to around 330 to 355 degrees Fahrenheit. As the paper passes by it, the toner melts. A fabric or felt-cleaning pad, in constant contact with the fuser roller, helps keep it clean. With many laser printers, you change the cleaning pad whenever you change the toner cartridge.

Note

If you have ever been warned not to use inkjet-type transparencies in a laser printer, the fuser is the reason. Any material that melts at less than 350 degrees is going to melt inside a laser printer, resulting in a huge mess and the need to replace the fuser roller assembly.

The final part of the fusing assembly is the pressure roller. It's a rubber roller that presses against the fuser roller; the paper feeds between it and the fuser roller on its way through the printer. The fuser roller can leave an indent on the softer pressure roller because of the heat it produces, so the printer's internal software will rotate the assembly periodically to keep this from happening.

That's how a laser printer works. Each printer has built-in sensors at critical points that check whether the paper is in the right place for that step to occur. The printer

knows how long it should take for the paper to move from one sensor to the next, and if the paper is delayed, the printer gives you a paper jam message.

### Troubleshooting problems with laser printers

Now that you are familiar with the printing process, you can probably guess some of the common problems and their causes even before I explain them. The best way to determine the cause is to identify at what point in the process the printer is breaking down.

### Loose or smeared toner

Here's an easy one. If the toner is loose (that is, not fused to the paper), the fuser is not melting the toner, and thus the toner is not fusing with the paper. Make sure the fuser is heating; if not, replace it.

Similarly, smeared toner happens because the nonstick coating on the fusing roller is scratched or has baked-on debris. You can try to clean it with a soft cloth and alcohol, but make sure you let it cool down first!

**Note**

In this article, I recommend replacing certain parts, but unless you are a technician working for an authorized service center for that type of printer, you might not be able to get the needed parts easily.

Smeared output can also result when you refeed a printed page into the printer to make a double-sided page. This happens because the rubber rollers that grip the paper to pull it into the printer can pick up toner from the first side's printing and smear it.

### Vertical white areas

To fix this problem, clean the corona wires. Why? This problem is caused by either the main corona or the transfer corona being covered with toner in a certain spot. A quick fix is to change the toner cartridge, even if it isn't empty. Because the primary corona is located in the cartridge, this will correct problems with a dirty primary corona.

To clean corona wires, use a special felt-lined tool that comes with your printer or use an alcohol-dipped cotton swab. But be very careful! Corona wires are thin and easy to break with too much pressure. To locate the primary corona, remove the toner cartridge and look for an exposed wire. The transfer corona's location depends on the printer, but it is usually protected with a webbing of filament threads. Not all laser printers allow you access to the transfer corona, so check your manual if you can't find it.

### Gray mist

If the white areas look like they have been lightly sprayed with a gray mist, making them look slightly dirty or dingy, the problem is also likely to be a dirty corona wire. (See the preceding section.)

This can also be the result of turning the printer's print density control up too high. The newer the drum, the lower this setting can be. As the drum ages, you must turn up the print density control higher to achieve sharp black printouts. However, if you

turn it up too high, the entire page acquires a dirty gray tinge. Some printers include the drum in the toner cartridge, so you get a new one each time you change toner. On other printers, the drum is separate, and you must eventually replace it when it wears out.

**Printing not dark enough or varied in darkness**
If the print is a dismal gray rather than a sharp black, you are probably almost out of toner. This can manifest itself evenly across the entire page or in splotches or stripes, depending on the printer.

Sometimes you can wring a little bit more out of a toner cartridge by taking it out and gently shaking it from side to side (never up and down, as toner can spill out). You can also try turning up the printer's contrast adjustment, if it has such a knob (usually on the back side if it exists). Faded print can also result from a dirty corona wire, because a dirty wire inhibits a full electrical charge from being passed.

If the printouts are consistently varied in density, and you have to frequently remove the toner cartridge and shake it to redistribute the toner inside it, make sure the printer is sitting on an even, flat surface.

**Horizontal black lines**
A horizontal black line on the printout is probably the result of a dirty or damaged roller. There are lots of rollers in the printer, and you can use the space between the lines on the page to determine which roller is causing the problem. Measure the distance between the errant black lines on the page and then use **Table A** to determine which part might be causing the problem.

Table A

| Distance between lines | Faulty part |
|---|---|
| 0.5” | Registration assembly |
| 1.5” | Upper registration roller |
| 1.75” | Lower registration roller |
| 2.0” | Toner cartridge developer roller |
| 2.56” | Lower fusing assembly roller |
| 3.16” | Upper fusing assembly roller |
| 3.75” | Toner cartridge photo drum |

**Regularly spaced splotches**
If there are evenly spaced black spots but they don't extend all the way across the page, the problem is probably a scratch or flaw in the drum or a build-up of toner on the fusing roller. If the spots are less than three inches apart vertically, it's probably the drum, because the drum has a larger diameter than the fusing roller.

**Vertical black line on edge of page**
This can indicate an almost empty or faulty toner cartridge or (less frequently) some spilled toner inside the printer.

**All-white page**
If nothing appears on the page at all, you might be completely out of toner.

However, most modern laser printers will inform you of this fact and not simply quit producing output. This problem can also be the result of a broken transfer corona. Remember, the transfer corona transfers the toner from the magnetic roller to the drum, so if that wire isn't doing its job, you won't get any toner on the page.

**All-black page**

An all-black page usually means the primary corona is broken. The primary corona applies the -600v charge to the drum, and the toner also receives a -600v charge from the magnetic roller. If the drum isn't charged enough, the toner will jump off onto the drum indiscriminately, resulting in a page full of black toner.

**Summary**

Now that you know how a laser printer works and a few simple fixes for common problems, you are well on your way to handling most troubleshooting issues. Also, by familiarizing yourself with these concepts, you are sure to have an easier time completing any laser printer question that might pop up on the A+ exam. Look for my follow-up article to fill you in on other common areas of laser printer confusion: Postscript, interfaces, fonts, and driver settings.

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