# Printers

*"Faster! Faster! Faster would
be better!"*

—Capt. Malcolm Reynolds, *Serenity*

**In this chapter, you will learn
how to**

- **Describe current printer
technologies**
- **Explain the laser printing process**
- **Install a printer on a
Windows PC**
- **Recognize and fix basic printer
problems**

Despite all of the talk about the "paperless office," printers continue to be a vital part of the typical office. In many cases, PCs are used exclusively for the purpose of producing paper documents. Many people simply prefer dealing with a hard copy. Programmers cater to this preference by using metaphors such as *page*, *workbook*, and *binder* in their applications. The CompTIA A+ certification strongly stresses the area of printing and expects a high degree of technical knowledge of the function, components, maintenance, and repair of all types of printers.

# ■ Printer Technologies

No other piece of your computer system is available in a wider range of styles, configurations, and feature sets than a printer, or at such a wide price variation. What a printer can and can't do is largely determined by the type of printer technology it uses—that is, how it gets the image onto the paper. Modern printers can be categorized into several broad types: impact, inkjet, dye-sublimation, thermal, laser, and solid ink.

## Impact Printers

Printers that create an image on paper by physically striking an ink ribbon against the paper's surface are known as **impact printers**. Although *daisy-wheel* printers (essentially an electric typewriter attached to the PC instead of directly to a keyboard) have largely disappeared, their cousins, **dot-matrix printers**, still soldier on in many offices. Although dot-matrix printers don't deliver what most home users want—high quality and flexibility at a low cost—they're still widely found in businesses for two reasons: dot-matrix printers have a large installed base in businesses, and they can be used for multipart forms because they actually strike the paper. Impact printers tend to be relatively slow and noisy, but when speed, flexibility, and print quality are not critical, they provide acceptable results. PCs that print multipart forms, such as *point of sale* (*POS*) machines, use special *impact paper* that can print receipts in duplicate, triplicate, or more. These POS machines represent the major market for new impact printers, although many older dot-matrix printers remain in use.

Dot-matrix printers use a grid, or matrix, of tiny pins, also known as **printwires**, to strike an inked printer ribbon and produce images on paper (see Figure 28.1). The case that holds the printwires is called a **printhead**. Using either 9 or 24 pins, dot-matrix printers treat each page as a picture broken up into a dot-based raster image. The 9-pin dot-matrix printers are generically called *draft quality*, while the 24-pin printers are known as *letter quality* or **near-letter quality (NLQ)**. The BIOS for the printer (either built into the printer or a printer driver) interprets the raster image in the same way a monitor does, "painting" the image as individual dots. Naturally, the more pins, the higher the resolution. Figure 28.2 illustrates the components common to dot-matrix printers. Many dot-matrix printers use continuous-feed paper with holes on its sides that are engaged by metal sprockets to pull the paper through—this is known as *tractor-feed paper* because the sprockets are reminiscent of the wheels on a tractor.



An Epson FX-880+ dot-matrix printer (photo courtesy of Epson America, Inc.)

## Inkjet Printers

**Inkjet printers** (also called *ink-dispersion printers*) like the one in Figure 28.3 are relatively simple devices. An inkjet printer uses a *printhead* connected to a *carriage* that contains the ink. A belt and motor move the carriage back

Platen          Printhead          Ribbon



Electronics          Power supply          Traverse assembly
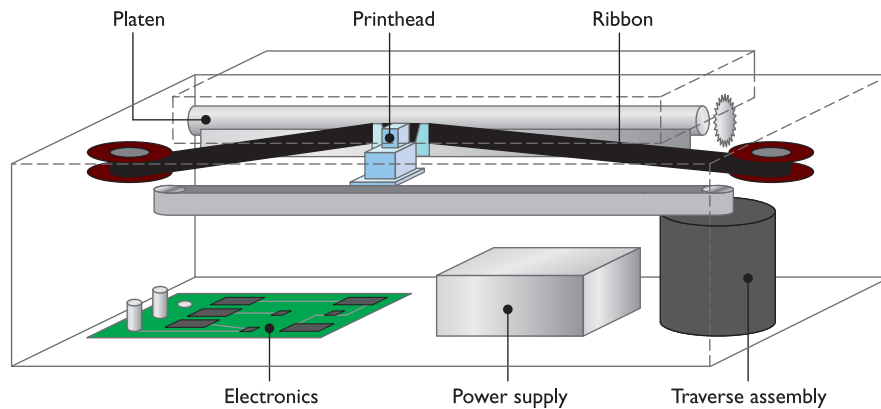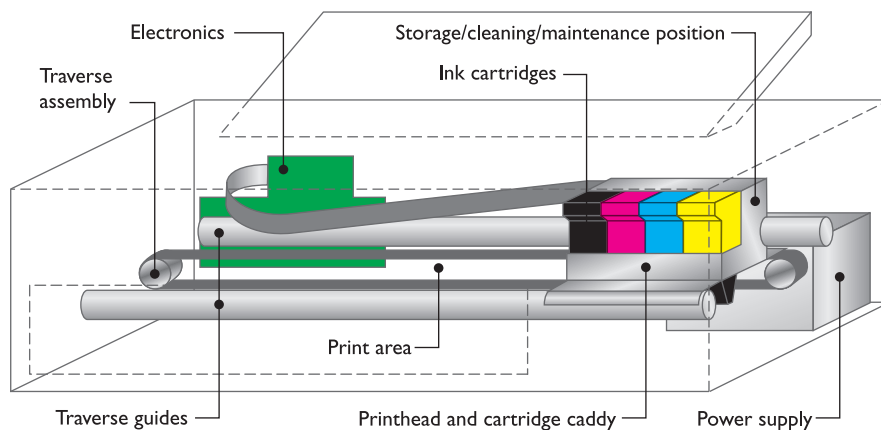
• Figure 28.2    Inside a dot-matrix printer
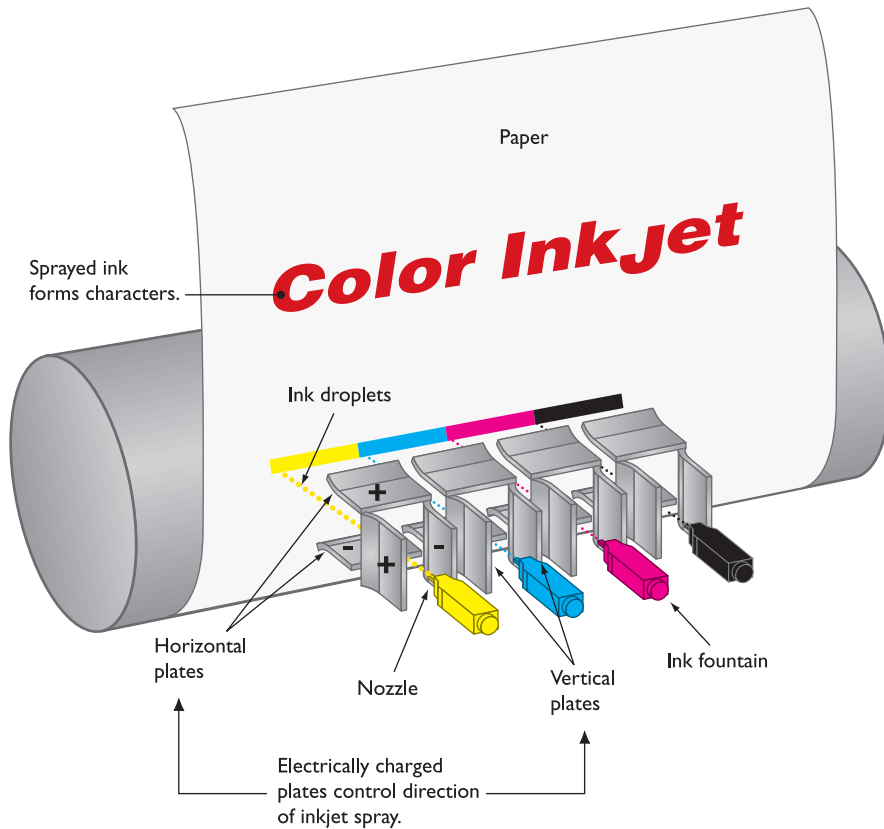


• Figure 28.3    Typical inkjet printer

and forth so the ink can cover the whole page. A *roller* grabs paper from a paper tray (usually under or inside the printer) or feeder (usually on the back of the printer) and advances it through the printer (see Figure 28.4).

The ink is ejected through tiny tubes. Most inkjet printers use heat to move the ink, while a few use a mechanical method. The heat-method printers use tiny resistors or electroconductive plates at the end of each tube that literally boil the ink; this creates a tiny air bubble that ejects a droplet of ink onto the paper, thus creating a portion of the image (see Figure 28.5).

The ink is stored in special small containers called **ink cartridges**. Older inkjet printers had two cartridges: one for black ink and another for colored ink. The color cartridge had separate compartments for cyan (blue), magenta (red), and yellow ink, to print colors by using a method known as CMYK (you'll read more about CMYK later in this chapter). If your color cartridge ran out of one of the colors, you had



Electronics          Storage/cleaning/maintenance position

Traverse assembly          Ink cartridges

Print area

Traverse guides          Printhead and cartridge caddy          Power supply

• Figure 28.4    Inside an inkjet printer

**Color InkJet**

Paper

Sprayed ink forms characters.

Ink droplets

Horizontal plates

Nozzle

Vertical plates

Ink fountain

Electrically charged plates control direction of inkjet spray.

● Figure 28.5    Detail of the inkjet printhead

to purchase a whole new color cartridge or deal with a messy refill kit.

Printer manufacturers began to separate the ink colors into three separate cartridges so that printers came with four cartridges: one for each color and a fourth for black (see Figure 28.6). This not only was more cost-effective for the user, but it also resulted in higher quality printouts. Today you can find color inkjet printers with six, eight, or more color cartridges. In addition to the basic CMYK inks, the other cartridges provide for green, blue, gray, light cyan, dark cyan, and more. Typically, the more ink cartridges a printer uses, the higher the quality of the printed image—and the higher the cost of the printer.

The two key features of an inkjet printer are the **print resolution**—that is, the density of ink, which affects print quality—and the print speed. Resolution is measured in **dots per inch (dpi)**; higher numbers mean that the ink dots on the page are closer together, so your printed documents will look better. Resolution is most important when you're printing complex images such as full-color photos, or when you're printing for duplication and you care that your printouts



● Figure 28.6    Inkjet ink cartridges

look good. Print speed is measured in **pages per minute (ppm)**, and this specification is normally indicated right on the printer's box. Most printers have one (faster) speed for monochrome printing—that is, using only black ink—and another for full-color printing.

Another feature of inkjet printers is that they can support a staggering array of print media. Using an inkjet printer, you can print on a variety of matte or glossy photo papers, iron-on transfers, and other specialty media; some printers can print directly onto specially coated optical discs, or even fabric. Imagine running a T-shirt through your printer with your own custom slogan (how about "I'm CompTIA A+ Certified!"). The inks have improved over the years, too, now delivering better quality and longevity than ever. Where older inks would smudge if the paper got wet or start to fade after a short time, modern inks are smudge proof and of archival quality—for example, some inks by Epson are projected to last up to 200 years.

## Try This!

### Pages per Minute Versus Price

Printer speed is a key determinant of a printer's price, and this is an easy assertion to prove, so Try This!

1. Fire up your browser and head over to the Web site for Hewlett-Packard (www.hp.com), Canon (www.usa.canon.com), Epson (www.epson.com), or Lexmark (www.lexmark.com). These four companies make most of the printers on the market today.

2. Pick a particular printer technology and check the price, from the cheapest to the most expensive. Then look for printers that have the same resolution but different ppm rates.

3. Check the prices and see how the ppm rate affects the price of two otherwise identical printers.

## Dye-Sublimation Printers

The term *sublimation* means to cause something to change from a solid form into a vapor and then back into a solid. This is exactly the process behind *dye-sublimation printing*, sometimes called *thermal dye transfer* printing. **Dye-sublimation printers** are used mainly for photo printing, high-end desktop publishing, medical and scientific imaging, and other applications for which fine detail and rich color are more important than cost and speed. Smaller, specialized printers called *snapshot* printers use dye-sublimation specifically for printing photos at a reduced cost compared to their full-sized counterparts.

The dye-sublimation printing technique is an example of the so-called CMYK (**c**yan, **m**agenta, **y**ellow, blac**k**) method of color printing. It uses a roll of heat-sensitive plastic film embedded with page-sized sections of cyan (blue), magenta (red), and yellow dye; many also have a section of black dye. A printhead containing thousands of heating elements, capable of precise temperature control, moves across the film, vaporizing the dyes and causing them to soak into specially coated paper underneath before cooling and reverting to a solid form. This process requires one pass per page for each color. Some printers also use a final finishing pass that applies a protective laminate coating to the page. Figure 28.7 shows how a dye-sublimation printer works.



Dye-ribbon roll

Thermal printhead

Vaporized dye
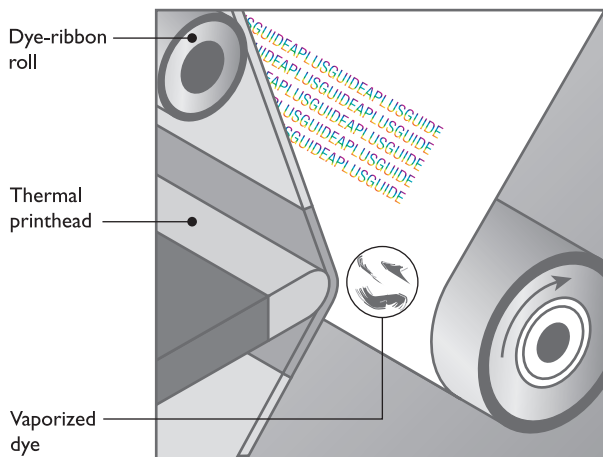
• **Figure 28.7**    The dye-sublimation printing process

Documents printed through the dye-sublimation process display *continuous-tone* images, meaning that the printed image is not constructed of pixel dots but a continuous blend of overlaid differing dye colors. This is in contrast to other print technologies' *dithered* images, which use closely packed, single-color dots to simulate blended colors. Dye-sublimation printers produce high-quality color output that rivals professional photo-lab processing.

## Thermal Printers

**Thermal printers** use a heated printhead to create a high-quality image on special or plain paper. You'll see two kinds of thermal printers in use. The first is the *direct thermal* printer, and the other is the *thermal wax transfer* printer. Direct thermal printers use a heating element to burn dots into the surface of special heat-sensitive paper. If you remember the first generation of fax machines, you're already familiar with this type of printer. Many retail businesses still use it as a receipt printer, using large rolls of thermal paper housed in a feed assembly that automatically draws the paper past the heating element; some can even cut the paper off the roll for you.

Thermal wax printers work similarly to dye-sublimation printers, except that instead of using rolls of dye-embedded film, the film is coated with colored wax. The thermal printhead passes over the ribbon and melts the wax onto the paper. Thermal wax printers don't require special papers like dye-sublimation printers, so they're more flexible and somewhat cheaper to use, but their output isn't quite as good because they use color dithering.

## Laser Printers

Using a process called *electro-photographic imaging*, **laser printers** produce high-quality and high-speed output of both text and graphics. Figure 28.8 shows a typical laser printer. Laser printers rely on the photoconductive properties of certain organic compounds. *Photoconductive* means that particles of these compounds, when exposed to light (that's the "photo" part), will *conduct* electricity. Laser printers usually use lasers as a light source because of their precision. Some lower-cost printers use LED arrays instead.

The first laser printers created only monochrome images. Today, you can also buy a color laser printer, although most laser printers produced today are monochrome. Although a color laser printer can produce complex full-color images such as photographs, they really shine for printing what's known as *spot color*—for example, eye-catching headings, lines, charts, or other graphical elements that dress up an otherwise plain printed presentation.
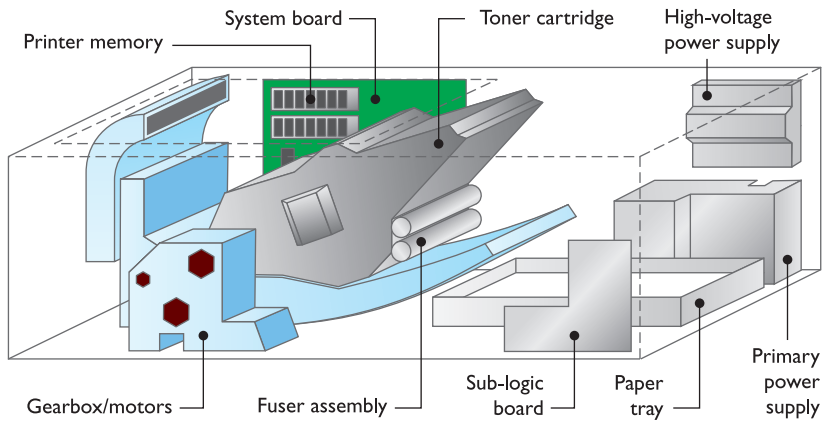
> **Tech Tip**
>
> **Hidden Costs**
>
> *Some printers use consumables—such as ink—at a much faster rate than others, prompting the industry to rank printers in terms of their cost per page. Using an inexpensive printer (laser or inkjet) costs around 4 cents per page, while an expensive printer can cost more than 20 cents per page—a huge difference if you do any volume of printing. This hidden cost is particularly pernicious in the sub-$100 inkjet printers on the market. Their low prices often entice buyers, who then discover that the cost of consumables is outrageous—these days, a* single *set of color and black inkjet cartridges can cost as much as the printer itself, if not more!*



• **Figure 28.8**    Typical laser printer

Figure 28.9 Components inside a laser printer

Labels in figure: Printer memory, System board, Toner cartridge, High-voltage power supply, Gearbox/motors, Fuser assembly, Sub-logic board, Paper tray, Primary power supply

Color laser printers have four toner cartridges: black, cyan, magenta, and yellow.

## Critical Components of the Laser Printer

The CompTIA A+ certification exams take a keen interest in the particulars of the laser printing process, so it pays to know your way around a laser printer (see Figure 28.9). Let's take a look at the many components of laser printers and their functions.

**Toner Cartridge**   The **toner cartridge** in a laser printer is so named because of its most obvious activity: supplying the toner that creates the image on the page (see Figure 28.10). To reduce maintenance costs, however, many other laser printer parts, especially those that suffer the most wear and tear, have been incorporated into the toner cartridge. Although this makes replacement of individual parts nearly impossible, it greatly reduces the need for replacement; those parts that are most likely to break are replaced every time you replace the toner cartridge.

**Photosensitive Drum**   The **photosensitive drum** (also called the *imaging drum*) is an aluminum cylinder coated with particles of photosensitive compounds. The drum itself is grounded to the power supply, but the coating is not. When light hits these particles, whatever electrical charge they may have "drains" out through the grounded cylinder.

**Erase Lamp**   The **erase lamp** exposes the entire surface of the photosensitive drum to light, making the photosensitive coating conductive. Any electrical charge present in the particles bleeds away into the grounded drum, leaving the surface particles electrically neutral.

**Primary Corona/Charge Roller**   The **primary corona** wire (or **primary charge roller**, in newer laser printers), located close to the photosensitive drum, never touches the drum. When the primary corona or primary charge roller is charged with an extremely high voltage, an electric field (or corona) forms, enabling voltage to pass to the drum and charge the photosensitive particles on its surface. The *primary grid* regulates the transfer of voltage, ensuring that the surface of the drum receives a uniform negative voltage of between ~600 and ~1000 volts.

**Laser**   The **laser** acts as the writing mechanism of the printer. Any particle on the drum struck by the laser becomes conductive and its charge is drained away into the grounded core of the drum. The entire surface of the drum has a uniform negative charge of between ~600 and ~1000 volts following its charging by the primary corona wire or charge roller.



Figure 28.10   Laser printer's toner cartridge

When particles are struck by the laser, they are discharged and left with a ~100-volt negative charge. Using the laser, we can "write" an image onto the drum. Note that the laser writes a positive image to the drum.

**Toner**   The **toner** in a laser printer is a fine powder made up of plastic particles bonded to iron particles. The *toner cylinder* charges the toner with a negative charge of between ~200 and ~500 volts. Because that charge falls between the original uniform negative charge of the photosensitive drum (~600 to ~1000 volts) and the charge of the particles on the drum's surface hit by the laser (~100 volts), particles of toner are attracted to the areas of the photosensitive drum that have been hit by the laser (that is, areas that have a *relatively* positive charge with reference to the toner particles).

The toner used in laser printers is typically carbon particles mixed with a polyester resin.

**Transfer Corona/Transfer Roller**   To transfer the image from the photosensitive drum to the paper, the paper must be given a charge that will attract the toner particles off of the drum and onto the paper. In older printers, the **transfer corona**, a thin wire, applied a positive charge to the paper, drawing the negatively charged toner particles to the paper. Newer printers accomplish the same feat using a **transfer roller** that draws the toner onto the paper. The paper, with its positive charge, is also attracted to the negatively charged drum. To prevent the paper from wrapping around the drum, a **static charge eliminator** removes the charge from the paper.

In most laser printers, the transfer corona/roller is outside the toner cartridge, especially in large, commercial-grade machines. The transfer corona/roller is prone to a build-up of dirt, toner, and debris through electrostatic attraction, and it must be cleaned. It is also quite fragile—usually finer than a human hair. Most printers with an exposed transfer corona/roller provide a special tool to clean it, but you can also—very delicately—use a cotton swab soaked in 90 percent denatured alcohol (don't use rubbing alcohol because it contains emollients). As always, never service any printer without first turning it off and unplugging it from its power source.

**Fuser Assembly**   The **fuser assembly** is almost always separate from the toner cartridge. It is usually quite easy to locate, as it is close to the bottom of the toner cartridge and usually has two rollers to fuse the toner. Sometimes the fuser is somewhat enclosed and difficult to recognize because the rollers are hidden from view. To help you determine the location of the fuser, think about the data path of the paper and the fact that fusing is the final step of printing.

The toner is merely resting on top of the paper after the static charge eliminator has removed the paper's static charge. The toner must be permanently attached to the paper to make the image permanent. Two rollers, a pressure roller and a heated roller, are used to fuse the toner to the paper. The pressure roller presses against the bottom of the page, and the heated roller presses down on the top of the page, melting the toner into the paper. The heated roller has a nonstick coating such as Teflon to prevent the toner from sticking to the heated roller.

**Power Supplies**   All laser printers have at least two separate power supplies. The first power supply is called the primary power supply or sometimes just the power supply. This power supply, which may actually be more than one power supply, provides power to the motors that move

the paper, the system electronics, the laser, and the transfer corona/roller. The high-voltage power supply usually provides power only to the primary corona/charge roller. The extremely high voltage of the high-voltage power supply makes it one of the most dangerous devices in the world of PCs! Before opening a printer to insert a new toner cartridge, it is imperative that you *always turn off* a laser printer!

**Turning Gears**   A laser printer has many mechanical functions. First, the paper must be picked up. Next, the photosensitive roller must be turned and the laser, or a mirror, must be moved from left to right. The toner must be evenly distributed, and the fuser assembly must squish the toner into the paper. Finally, the paper must be kicked out of the printer and the assembly must be cleaned to prepare for the next page.

All of these functions are served by complex gear systems. In most laser printers, these gear systems are packed together in discrete units generically called *gear packs* or *gearboxes*. Most laser printers have two or three gearboxes that you can remove relatively easily in the rare case when one of them fails. Most gearboxes also have their own motor or solenoid to move the gears.

**System Board**   Every laser printer contains at least one electronic board. On this board is the main processor, the printer's ROM, and the RAM used to store the image before it is printed. Many printers divide these functions among two or three boards dispersed around the printer (also known as sub-logic boards, as seen in Figure 28.9). An older printer may also have an extra ROM chip and/or a special slot where you can install an extra ROM chip, usually for special functions such as PostScript.

On some printer models, you can upgrade the contents of these ROM chips (the *firmware*) by performing a process called *flashing* the ROM. Flashing is a lot like upgrading the system BIOS, which you learned about in Chapter 8. Upgrading the firmware can help fix bugs, add new features, or update the fonts in the printer.

Of particular importance is the printer's RAM. When the printer doesn't have enough RAM to store the image before it prints, you get a memory overflow problem. Also, some printers store other information in the RAM, including fonts or special commands. Adding RAM is usually a simple job—just snapping in a SIMM or DIMM stick or two—but getting the *right* RAM is important. Call or check the printer manufacturer's Web site to see what type of RAM you need. Although most printer companies will happily sell you their expensive RAM, most printers can use generic DRAM like the kind you use in a PC.

**Ozone Filter**   The coronas inside laser printers generate ozone ($O_3$). Although not harmful to humans in small amounts, even tiny concentrations of ozone will cause damage to printer components. To counter this

problem, most laser printers have a special ozone filter that needs to be vacuumed or replaced periodically.

**Sensors and Switches** Every laser printer has a large number of sensors and switches spread throughout the machine. The sensors are used to detect a broad range of conditions such as paper jams, empty paper trays, or low toner levels. Many of these sensors are really tiny switches that detect open doors and so on. Most of the time these sensors/switches work reliably, yet occasionally they become dirty or broken, sending a false signal to the printer. Simple inspection is usually sufficient to determine if a problem is real or just the result of a faulty sensor/switch.

# Solid Ink

**Solid ink printers** use just what you'd expect—solid inks. The technology was originally developed by Tektronix, whose printer division was acquired by Xerox. Solid ink printers use solid sticks of nontoxic "ink" that produce more vibrant color than other print methods. The solid ink is melted and absorbed into the paper fibers; it then solidifies, producing a continuous-tone output. Unlike dye-sublimation printers, all colors are applied to the media in a single pass, reducing the chances of misalignment. Solid ink sticks do not rely on containers like ink for inkjet printers and can be "topped off" midway through a print job by inserting additional color sticks without taking the printer offline.

These printers are fast, too! A full-color print job outputs the first page in about six seconds. Of course, all that speed and quality comes at a price. Xerox's base model starts at about twice the cost of a laser printer, with the expensive model selling for about six times the cost! Solid ink printers become a bit more affordable when you factor in the cost of consumables. A single stick of ink costs about as much as an inkjet cartridge, for example, but with a print capacity of 1000 pages, that completely beats the cost of inkjet cartridges over time.

# Printer Languages

Now that you've learned about the different types of print devices and techniques, it's time to take a look at how they communicate with the PC. How do you tell a printer to make a letter *A* or to print a picture of your pet iguana? Printers are designed to accept predefined printer languages that handle both characters and graphics. Your software must use the proper language when communicating with your printer, so that your printer can output your documents onto a piece of paper. Following are the more common printer languages.

### ASCII

You might think of the **American Standard Code for Information Interchange (ASCII)** language as nothing more than a standard set of characters, the basic alphabet in upper- and lowercase with a few strange symbols thrown in. ASCII actually contains a variety of control codes for transferring data, some of which can be used to control printers. For example, ASCII code 10 (or 0A in hex) means "Line Feed," and ASCII code 12 (0C) means "Form

Feed." These commands have been standard since before the creation of IBM PCs, and all printers respond to them. Being highly standardized has advantages, but the control codes are extremely limited. Printing high-end graphics and a wide variety of fonts requires more advanced languages.

## PostScript

Adobe Systems developed the **PostScript** page description language in the early 1980s as a device-independent printer language capable of high-resolution graphics and scalable fonts. PostScript interpreters are embedded in the printing device. Because PostScript is understood by printers at a hardware level, the majority of the image processing is done by the printer and not the PC's CPU, so PostScript printers print faster. PostScript defines the page as a single raster image; this makes PostScript files extremely portable—they can be created on one machine or platform and reliably printed out on another machine or platform (including, for example, high-end typesetters).

## Hewlett-Packard Printer Control Language (PCL)

Hewlett-Packard developed its **printer control language (PCL)** as a more advanced printer language to supersede simple ASCII codes. PCL features a set of printer commands greatly expanded from ASCII. Hewlett-Packard designed PCL with text-based output in mind; it does not support advanced graphical functions. The most recent version of PCL, PCL6, features scalable fonts and additional line drawing commands. Unlike PostScript, however, PCL is not a true page description language; it uses a series of commands to define the characters on the page. Those commands must be supported by each individual printer model, making PCL files less portable than PostScript files.

## Windows GDI and XPS

Windows XP uses the **graphical device interface (GDI)** component of the operating system to handle print functions. Although you *can* use an external printer language such as PostScript, most users simply install printer drivers and let Windows do all the work. The GDI uses the CPU rather than the printer to process a print job and then sends the completed job to the printer. When you print a letter with a TrueType font in Windows, for example, the GDI processes the print job and then sends bitmapped images of each page to the printer. The printer sees a page of TrueType text, therefore, as a picture, not as text. As long as the printer has a capable enough raster image processor (explained later in this chapter) and plenty of RAM, you don't need to worry about the printer language in most situations. We'll revisit printing in Windows in more detail later in this chapter.

Windows Vista and Windows 7 support GDI printing, but they also include a printing subsystem called the **XML Paper Specification (XPS) print path**. XPS provides several improvements over GDI, including enhanced color management (which works with Windows Color System) and better print layout fidelity. The XPS print path requires a driver that supports XPS. Additionally, some printers natively support XPS, eliminating the

requirement that the output be converted to a device-specific printer control language before printing.

# Printer Connectivity

Most printers connect to one of two ports on the PC: a DB-25 parallel port or a USB port. The parallel connection is the classic way to plug in a printer, but most printers today use USB. You'll need to know how to support the more obscure parallel ports, cables, and connections as well as the plug-and-play USB connections.

### Parallel Communication and Ports

The **parallel port** was included in the original IBM PC as a faster alternative to serial communication. The IBM engineers considered serial communication, limited to 1 bit at a time, to be too slow for the "high-speed" devices of the day (for example, dot-matrix printers). The standard parallel port has been kept around for backward compatibility despite several obvious weaknesses.

Parallel ports may be far faster than serial ports, but they are slow by modern standards. The maximum data transfer rate of a standard parallel port is still only approximately 150 kilobytes per second (KBps). Standard parallel communication on the PC also relies heavily on software, eating up a considerable amount of CPU time that could be used better.

Parallel ports are hindered by their lack of true bidirectional capability. Although one-way communication was acceptable for simple line printers and dot-matrix printers, parallel communication also became popular for a wide range of external devices that required two-way communication. Although it is possible to get two-way communication out of a standard parallel port, the performance is not impressive.

Many techs confuse the concept of duplex printing—a process that requires special printers capable of printing on both sides of a sheet of paper—with bidirectional printing. They are two different things!

### IEEE 1284 Standard

In 1991, a group of printer manufacturers proposed to the *Institute of Electrical and Electronics Engineers* (*IEEE*) that a committee be formed to propose a standard for a backward-compatible, high-speed, bidirectional parallel port for the PC. The committee was the IEEE 1284 committee (hence the name of the standard).

The **IEEE 1284 standard** requires the following:

- Support for five distinct modes of operation: *compatibility mode*, *nibble mode*, *byte mode*, *EPP*, and *ECP*
- A standard method of negotiation for determining which modes are supported both by the host PC and by the peripheral device
- A standard physical interface (that is, the cables and connectors)
- A standard electrical interface (that is, termination, impedance, and so on)

Because only one set of data wires exists, all data transfer modes included in the IEEE 1284 standard are half-duplex: data is transferred in only one direction at a time.

**Tech Tip**

**IEEE 1284 Transfer Modes**
*The five modes of operation for parallel printing specified in the IEEE 1284 standard (compatibility, nibble, byte, EPP, ECP) are inching closer to obsolescence as USB printers take over the market. If you find yourself needing to optimize the performance of a legacy parallel printer, you can look up these modes by name, using various Web search tools.*

• **Figure 28.11**   Standard parallel cable with 36-pin Centronics connector on one end and DB-25 connector on the other



Some printers come with both USB and parallel connections, but this, like the parallel port in general, has become very rare. If you need a parallel printer for a system, be sure to confirm that the particular model you want will work with your system!



In almost all cases, you must install drivers before you plug a USB printer into your computer. You'll learn about installing printer drivers later in this chapter.

## Parallel Connections, Cabling, and Electricity

Although no true standard exists, *standard parallel cable* usually refers to a printer cable with the previously mentioned male **DB-25 connector** on one end and a 36-pin **Centronics connector** on the other (see Figure 28.11). The shielding (or lack thereof) of the internal wiring and other electrical characteristics of a standard parallel printer cable are largely undefined except by custom. In practice, these standard cables are acceptable for transferring data at 150 KBps, and for distances of less than 6 feet, but they would be dangerously unreliable for some transfer modes.

For more reliability at distances up to 32 feet (10 meters), use proper IEEE 1284–compliant cabling. The transfer speed drops with the longer cables, but it does work, and sometimes the trade-off between speed and distance is worth it.

Installing a parallel cable is a snap. Just insert the DB-25 connector into the parallel port on the back of the PC and insert the Centronics connector into the printer's Centronics port and you're ready to go to press! If your PC didn't include a parallel port, you can always add one with a PCI or PCIe expansion card.

## USB Printers

New printers now use USB connections that you can plug into any USB port on your computer. USB printers don't usually come with a USB cable, so you need to purchase one when you purchase a printer. (It's quite a disappointment to come home with your new printer only to find you can't connect it because it didn't come with a USB cable.) Most printers use the standard USB type A connector on one end and the smaller USB type B connector on the other end, although some use two type A connectors. Whichever configuration your USB printer has, just plug in the USB cable—it's that easy!

## Network Printers

Connecting a printer to a network isn't just for offices anymore. More and more homes and home offices are enjoying the benefits of network printing. It used to be that to share a printer on a network—that is, to make it available to all network users—you would physically connect the printer to a single computer and then share the printer on the network. The downside to this was that the computer to which the printer was connected had to be left on for others to use the printer.

Today, the typical **network printer** comes with its own onboard network adapter that uses a standard RJ-45 Ethernet cable to connect the printer directly to the network by way of a router. Other printers include a built-in Wi-Fi adapter to enable wireless printing over the network. The printer

can typically be assigned a static IP address, or it can acquire one dynamically from a DHCP server. (Don't know what a router, IP address, or DHCP server is? Take a look back at Chapters 5 and 22.) Once connected to the network, the printer acts independently of any single PC. Some of the more costly network printers come with a built-in Wi-Fi adapter to connect to the network wirelessly. Alternatively, some printers offer Bluetooth or infrared (IR) interfaces for networking.

Even if a printer does not come with built-in Ethernet, Wi-Fi, or Bluetooth, you can purchase a standalone network device known as a *print server* to connect your printer to the network. These print servers, which can be Ethernet or Wi-Fi, enable one or several printers to attach via USB cable (or even parallel port, if you still have a printer that old). So take that ancient ImageWriter dot-matrix printer and network it—I dare you!

### Other Printers

Plenty of other connection types are available for printers. We've focused mainly on parallel, USB, and networked connections. Be aware that you may run into an old serial port printer or a SCSI printer. Although this is unlikely, know that it's a possibility.

# ■ The Laser Printing Process

The laser printing process can be broken down into seven steps, and the CompTIA A+ exams expect you to know them all. As a tech, you should be familiar with these phases, as this can help you troubleshoot printing problems. For example, if an odd line is printed down the middle of every page, you know there's a problem with the photosensitive drum or cleaning mechanism and the toner cartridge needs to be replaced.

The seven steps to the laser printing process may be performed in a different order, depending on the printer, but it usually goes like this:

1. Processing
2. Charging
3. Exposing
4. Developing
5. Transferring
6. Fusing
7. Cleaning

## Processing

When you click the Print button in an application, several things happen. First, the CPU processes your request and sends a print job to an area of memory called the print spooler. The **print spooler** enables you to queue up multiple print jobs that the printer will handle sequentially. Next, Windows sends the first print job to the printer. That's your first potential bottleneck—if it's a big job, the OS has to dole out a piece at a time and you'll see the

> The CompTIA A+ 220-801 exam objectives refer to a wireless print connection called "802.11x." This is not a new Wi-Fi standard. It's a generic term used to describe all Wi-Fi standards, including 802.11a, 802.11b, 802.11g, and 802.11n.

> You'll find print servers outside standalone network devices. In fact, your Windows PC is capable of operating as a print server. Anytime you plug a printer into a PC and share the printer over the network, the sharing PC can be referred to as a print server. The CompTIA A+ exams, however, will most likely stick to standalone print server boxes, as opposed to Windows print servers.

little printer icon in the notification area at the bottom right of your screen. Once the printer icon goes away, you know the print queue is empty—all jobs have gone to the printer.

Once the printer receives some or all of a print job, the hardware of the printer takes over and processes the image. That's your second potential bottleneck and has multiple components.

### Raster Images

Impact printers transfer data to the printer one character or one line at a time, whereas laser printers transfer entire pages at a time to the printer. A laser printer generates a **raster image** (a pattern of dots) of the page, representing what the final product should look like. It uses a device (the laser) to "paint" a raster image on the photosensitive drum. Because a laser printer has to paint the entire surface of the photosensitive drum before it can begin to transfer the image to paper, it processes the image one page at a time.

A laser printer uses a chip called the **raster image processor (RIP)** to translate the raster image into commands to the laser. The RIP takes the digital information about fonts and graphics and converts it to a rasterized image made up of dots that can then be printed. An inkjet printer also has a RIP, but it's part of the software driver instead of onboard hardware circuitry. The RIP needs memory (RAM) to store the data that it must process.

A laser printer must have enough memory to process an entire page. Some images that require high resolutions require more memory. Insufficient memory to process the image will usually be indicated by a memory overflow ("MEM OVERFLOW") error. If you get a memory overflow error, try reducing the resolution, printing smaller graphics, or turning off RET (see the following section for the last option). Of course, the best solution to a memory overflow error is simply to add more RAM to the laser printer.

Do not assume that every error with the word *memory* in it can be fixed simply by adding more RAM to the printer. Just as adding more RAM chips will not solve every conventional PC memory problem, adding more RAM will not solve every laser printer memory problem. The message "21 ERROR" on an HP LaserJet, for example, indicates that "the printer is unable to process very complex data fast enough for the print engine." This means that the data is simply too complex for the RIP to handle. Adding more memory would *not* solve this problem; it would only make your wallet lighter. The only answer in this case is to reduce the complexity of the page image (that is, fewer fonts, less formatting, reduced graphics resolution, and so on).

### Resolution

Laser printers can print at different resolutions, just as monitors can display different resolutions. The maximum resolution that a laser printer can handle is determined by its physical characteristics. Laser printer resolution is expressed in dots per inch (dpi). Common resolutions are 600 × 600 dpi or 1200 × 1200 dpi. The first number, the horizontal resolution, is determined by how fine a focus can be achieved by the laser. The second number is determined by the smallest increment by which the drum can be turned. Higher resolutions produce higher-quality output, but keep in mind that higher resolutions also require more memory. In some instances, complex images can be printed only at lower resolutions because of their high

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**Tech Tip**

**Inkjet RIPs**

*Inkjet printers use RIPs as well, but they're written into the device drivers instead of the onboard programming. You can also buy third-party RIPs that can improve the image quality of your printouts; for an example, see www.colorbytesoftware.com.*

memory demands. Even printing at 300 dpi, laser printers produce far better quality than dot-matrix printers because of **resolution enhancement technology (RET)**.
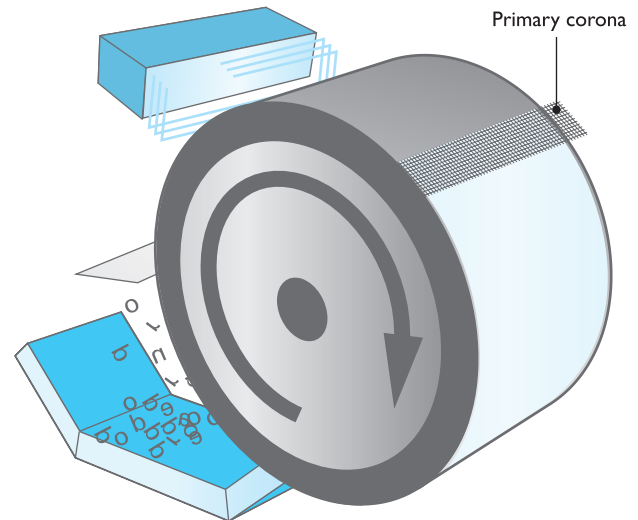
RET enables the printer to insert smaller dots among the characters, smoothing out the jagged curves that are typical of printers that do not use RET (see Figure 28.12). Using RET enables laser printers to output high-quality print jobs, but it also requires a portion of the printer's RAM. If you get a MEM OVERFLOW error, sometimes disabling RET will free up enough memory to complete the print job.
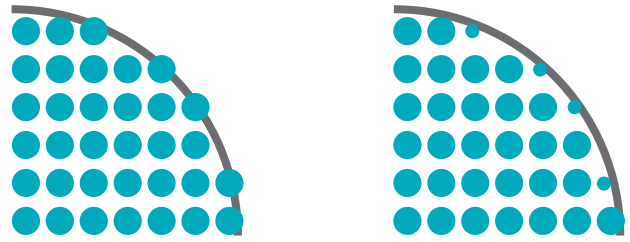


• Figure 28.12    RET fills in gaps with smaller dots to smooth out jagged characters.

## Charging

Now we turn to the physical side of the printing process. To make the drum receptive to new images, it must be charged (see Figure 28.13). Using the primary corona wire or primary charge roller, a uniform negative charge is applied to the entire surface of the drum (usually between ~600 and ~1000 volts).

## Exposing

A laser is used to create a positive image on the surface of the drum. Every particle on the drum hit by the laser releases most of its negative charge into the drum.

## Developing

Those particles with a lesser negative charge are positively charged relative to the toner particles and attracts them, creating a developed image (see Figure 28.14).



• Figure 28.13    Charging the drum with a uniform negative charge
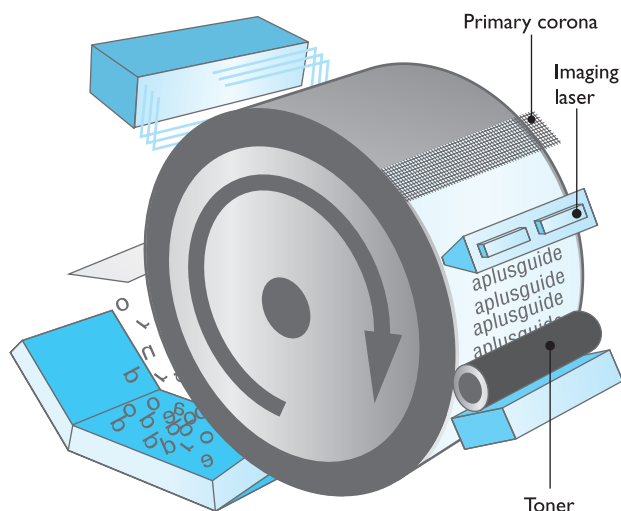


• Figure 28.14    Writing the image and applying the toner
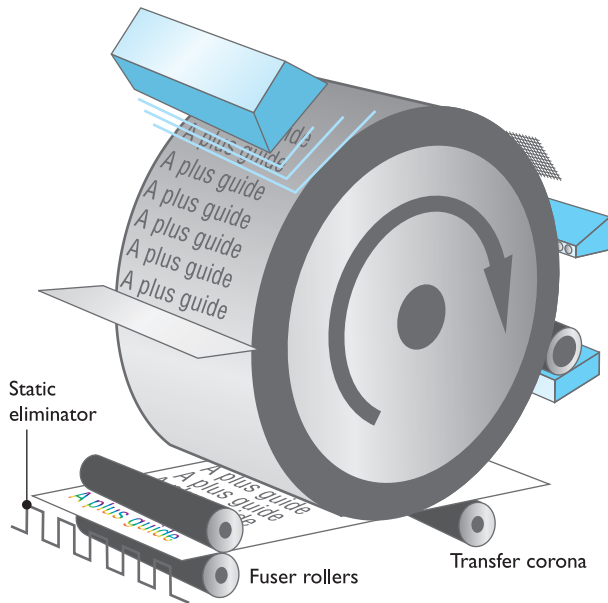
## Transferring

The printer must transfer the image from the drum onto the paper. The transfer corona or transfer roller gives the paper a positive charge; then the negatively charged toner particles leap from the drum to the paper. At this point, the particles are merely resting on the paper and must still be permanently fused to the paper.

## Fusing

The particles have been attracted to the paper because of the paper's positive charge, but if the process stopped here, the toner particles would fall off the page as soon as you lift it. Because the toner particles are mostly composed of plastic, they can be melted to the page. Two rollers—a heated roller coated in a nonstick material and a pressure roller—melt the toner to the paper, permanently affixing it. Finally, a static charge eliminator removes the paper's positive charge (see Figure 28.15). Once the page is complete, the printer ejects the printed copy and the process begins again with the physical and electrical cleaning of the printer.

## Cleaning

The printing process ends with the physical and electrical cleaning of the photosensitive drum (see Figure 28.16). Before printing another new page, the drum must be returned to a clean, fresh condition. All residual toner left over from printing the previous page must be removed, usually by scraping the surface of the drum with a rubber cleaning blade. If residual particles remain on the drum, they will appear as random black spots and streaks on the next page. The physical cleaning mechanism either deposits the residual toner in a debris cavity or recycles it by returning it to the toner supply in the toner cartridge. The physical cleaning must be done carefully. Damage to the drum will cause a permanent mark to be printed on every page.

The printer must also be electrically cleaned. One or more erase lamps bombard the surface of the drum with the appropriate wavelengths of light, causing the surface particles to discharge into the grounded drum. After the cleaning process, the drum should be completely free of toner and have a neutral charge.



● **Figure 28.15**  Transferring the image to the paper and fusing the final image

### Tech Tip

**Laser Printing in Color**

*Color laser printers use four different colors of toner (cyan, magenta, yellow, and black) to create their printouts. Most models send each page through four different passes, adding one color at each pass to create the needed results, while others place all the colors onto a special* transfer belt *and then transfer them to the page in one pass. In some cases, the printer uses four separate toner cartridges and four lasers for the four toner colors, and in others the printer simply lays down one color after the other on the same drum, cleaning after each of four passes per page.*

⚠️ The heated roller produces enough heat to melt some types of plastic media, particularly overhead transparency materials. This could damage your laser printer (and void your warranty), so make sure you're printing on transparencies designed for laser printers!

## ■ Installing a Printer in Windows

You need to take a moment to understand how Windows handles printing, and then you'll see how to install, configure, and troubleshoot printers in these operating systems.

To Windows, a printer is not a physical device; it is a *program* that controls one or more physical printers. The *physical* printer is called a print device by Windows (although I continue to use the term "printer" for most

Erase lamp

Cleaning blade
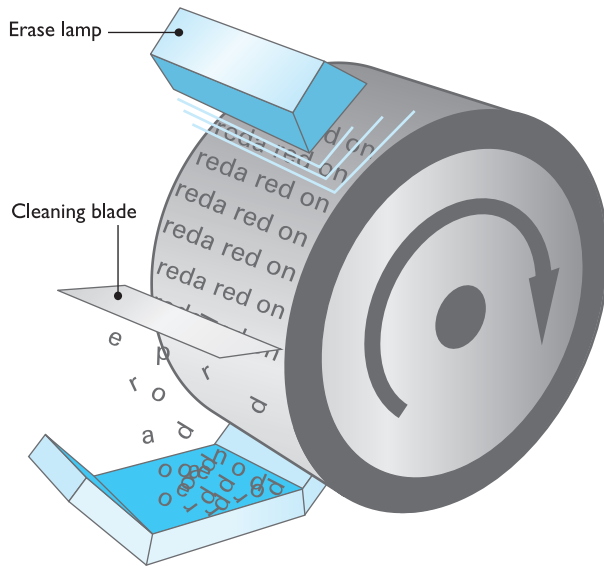
• **Figure 28.16**   Cleaning and erasing the drum

purposes, just like almost every tech on the planet). Printer drivers and a spooler are still present, but in Windows, they are integrated into the printer itself (see Figure 28.17). This arrangement gives Windows amazing flexibility. For example, one printer can support multiple print devices, enabling a system to act as a print server. If one print device goes down, the printer automatically redirects the output to a working print device.

The general installation, configuration, and troubleshooting issues are basically identical in all modern versions of Windows. Here's a review of a typical Windows printer installation. I'll mention the trivial differences among Windows XP, Vista, and 7 as I go along.

## Setting Up Printers

Setting up a printer is so easy that it's almost scary. Most printers are plug and play, so installing a printer is reduced to simply plugging it in and loading the driver if needed. With USB printers (and infrared printers, for that matter), Windows won't even wait for you to do anything—once you connect a printer (or point the IR beam at a compatible PC), Windows immediately detects and installs the printer. If the system does not detect the printer or if the printer is not plug and play, however, click Start | Printers and Faxes in Windows XP to open the Printers applet. In Windows Vista, you need to open the Control Panel and find the Printer menu item—it is either by itself or, in the categorized view, under Hardware. With Windows 7, go to Start | Devices and Printers. As you might guess, you install a new printer by clicking the Add a Printer icon/button (somehow Microsoft has managed to leave the name of this option unchanged through all Windows versions since 9x). This starts the Add Printer Wizard.

The CompTIA A+ exams test you on installing and troubleshooting printers, so read these sections carefully!
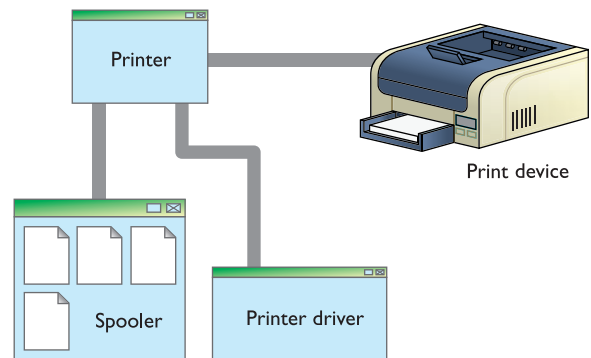


• **Figure 28.17**   Printer driver and spooler in Windows

The Add Printer Wizard enables you to install a local printer or a network printer. This distinction is actually a little misleading. Windows divides printer installation into two scenarios: a printer connected directly to a PC (your local PC or another PC on a network), or a standalone printer directly connected to a switch or router. While you might think the local versus network installation options divide these scenarios nicely, they do not. Let's take a quick look at both local and network installations so you know when to use each.

### Installing a Local Printer

At first glance, you might think the local printer installation option is used to install your standard USB printer, but don't forget that Windows will automatically detect and install USB printers (or any other plug-and-play printer). So what do you use it for? This option is most commonly used to install printers using a parallel connection or to install standalone network printers using an IP address. Using current versions of Windows and a modern printer, you shouldn't need to use the IP address to install a standalone network printer, but it can be a helpful alternative if Windows won't detect it any other way.

For parallel port printers, check the *Automatically detect and install my Plug and Play printer* option in Windows XP (see Figure 28.18). Windows won't automatically detect a new parallel device. When you check this box and click Next, Windows XP will run a search for any plug-and-play printers, including those connected via parallel cables. (Windows Vista and Windows 7 don't include this option; you'll need to configure parallel-connected printers manually by selecting a port and driver.)

If you need to install a standalone network printer using its IP address, uncheck the *Automatically detect and install my Plug and Play printer* option in Windows XP and click Next. In Windows Vista and Windows 7, click *Add a local printer*. In the *Create a new port* drop-down box, select Standard TCP/IP Port. Click Next. Type the IP address here.

Confusingly, you can also get to the IP address entry screen in Windows Vista and Windows 7 via the network installation option, but not directly. Only after the network option fails to automatically detect a networked printer can you enter the IP address manually by clicking *The printer that I want isn't listed* and selecting *Add a printer using a TCP/IP address or hostname*.

You will be unable to install a printer using the drivers that came with a disc unless you have administrative privileges.
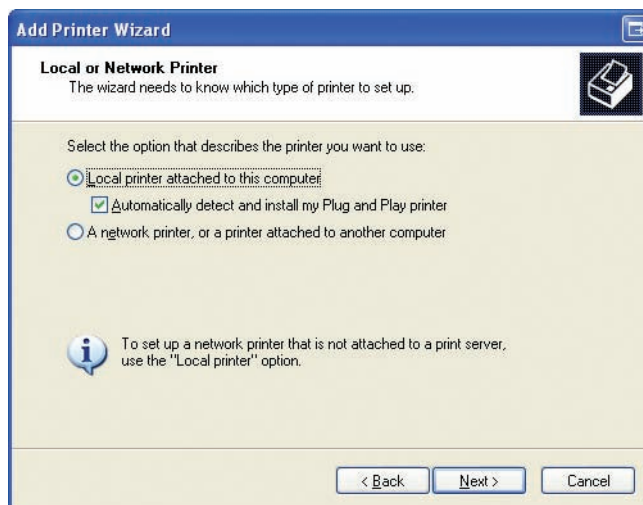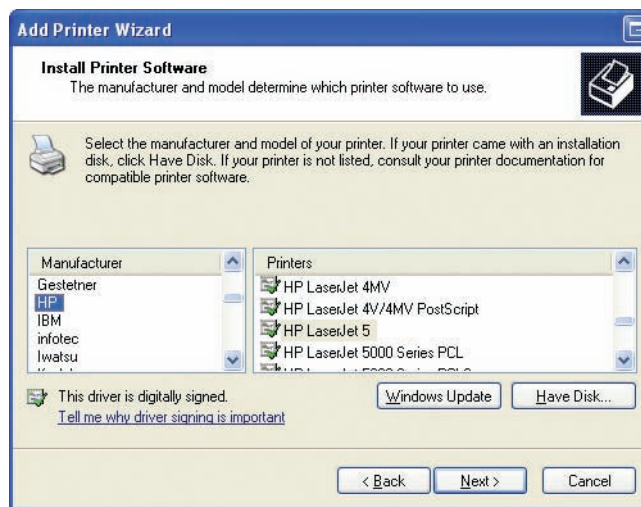


• **Figure 28.18**  Automatically detecting plug-and-play printers in Windows XP

Whether you use a parallel port or a TCP/IP port, you'll need to manually select the proper driver (see Figure 28.19). Windows includes a lot of printer drivers, but you can also use the handy Have Disk option to use the disc that came with the printer. If you use the driver included on the disc, Windows will require administrator privileges to proceed; otherwise, you won't be able to finish the installation. The Windows Update button enables you to grab the latest printer drivers via the Internet.

You'll be asked if the new local printer should be the default printer and whether or not you want to share it with other PCs on the network. And before you ask, yes, you can share a standalone network printer connected to your PC via a TCP/IP port using File and Printer Sharing, though the printer would be disabled for other users any time you turned off your PC. You'll be asked to print a test page to make sure everything works. Then you're done!



• **Figure 28.19**    Selecting drivers

### Installing a Network Printer

Surprisingly, setting up network printers doesn't require much more effort than setting up local printers, unless you're using Windows XP—but isn't that always the case? When you try to install a network printer in Windows Vista or Windows 7, the Add Printer Wizard will scan for any available printers on your local network. More often than not, the printer you are looking for will pop up in a list (see Figure 28.20). When you select that printer and click Next, Windows will search for drivers. If you need to, you

> If you need to search for drivers online, make sure you download the driver designed for your operating system! If you have a 64-bit copy of Windows 7, the 32-bit Windows 7 drivers won't work.

> Remember printer sharing from Chapter 22? Here's the other side of the operation. Keep in mind that after you install a shared printer onto your PC, you can actually share that shared printer with others. Windows considers the shared printer *your* printer, so you can do what you want with it, including sharing it.
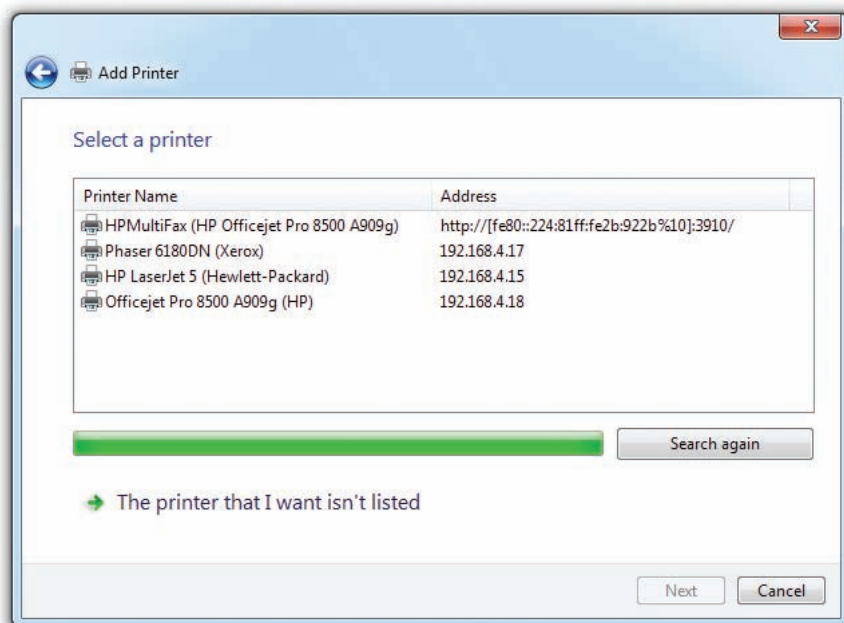


• **Figure 28.20**    List of available shared printers on a network

Depending upon how your network shares printers, you can end up seeing the same printer shared multiple ways. Everyone who has a shared printer installed can share the same printer again as their own printer. This can lead to some confusing printer usage, especially once people start turning off their computers and breaking the connections to the shared printer. Avoid this web of print sharing.

In addition to the Devices and Printers applet, Windows 7 (excluding the Home Premium edition) also includes the Print Management console. This tool enables you to view and modify all the printers and drivers on your PC or connected to your network. You can also manage any Windows print servers connected to the network. Many of Print Management's advanced features go beyond the scope of the CompTIA A+ exams, but know that it centralizes (and in a few cases, enhances) the standard printer controls in Windows 7. You can find Print Management in Control Panel | Administrative Tools | Print Management.

can pick from a list of available drivers or use the disc that came with the printer. Either way, you're already done.

Windows XP doesn't include this automatic discovery feature, and if Windows Vista or Windows 7 fails to find your printer, you'll need to configure the network printer manually. Every version of Windows includes multiple methods of doing this. These methods change depending on whether you are connected to a domain or a workgroup.

If you are on a workgroup, you can browse for a printer on your network, connect to a specific printer (using its name or URL), or use a TCP/IP address or hostname (Windows Vista/7 only), as you can see in Figure 28.21. In a domain, most of those options remain the same, except that instead of browsing the workgroup, you can search and browse the domain using several search parameters, including printer features, printer location, and more. Once you've found your printer, you might be prompted for drivers. Provide them using the usual methods described earlier and then you are finished!

Remember that Windows doesn't always see your network's printers exactly how they are physically arranged. Imagine you have a network with three PCs. Andy's computer has a printer connected via USB, whereas Beth's computer and Carol's computer have no printers. There is, however, a second printer connected directly to their router via Ethernet. Beth has configured her PC to connect directly to the network printer using an IP address. Now that she's done that, she can actually share that printer with the rest of her network, even though it's not attached to her computer—Windows doesn't care where it is. The process for sharing a local printer and a network printer is identical because Windows considers both printers to be installed on your PC and under your control. So now Andy and Beth both share printers. When Carol goes looking for shared printers to use,
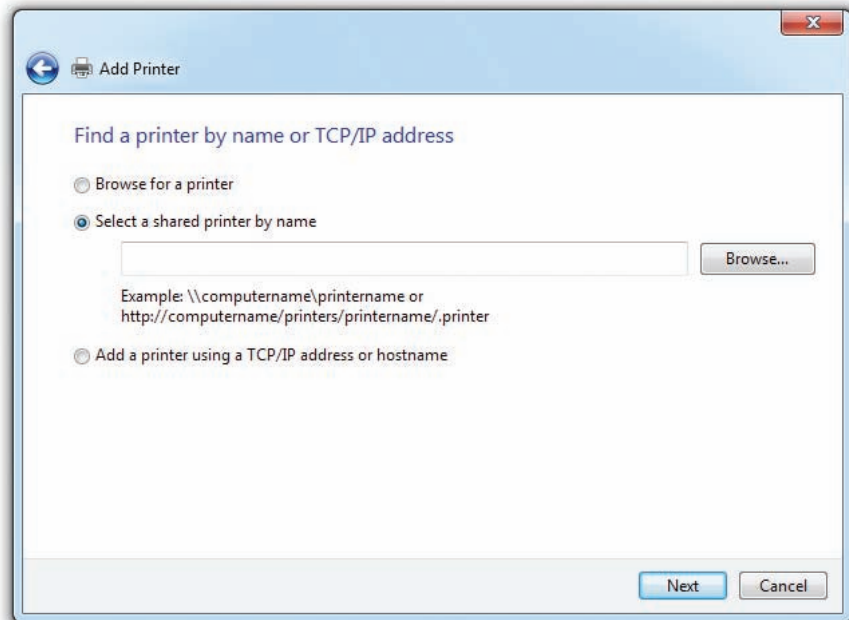


• **Figure 28.21**   Options for finding network printers

the network printer attached to the router will look like Beth's printer, as if it were directly connected to Beth's machine.

Figure 28.22 shows a typical Windows XP Printers and Faxes screen on a system with one printer installed. Note the small checkmark in the icon's corner; this shows that the device is the default printer. If you have multiple printers, you can change the default printer by right-clicking the printer's icon and selecting *Make Default Printer* in Windows XP or *Set as default printer* in Windows Vista/7.

In addition to the regular driver installation outlined previously, some installations use printer emulation. *Printer emulation* simply means using a substitute printer driver for a printer, as opposed to using one made exclusively for that printer. You'll run into printer emulation in two circumstances. First, some new printers do not come with their own drivers. They instead emulate a well-known printer (such as an HP LaserJet 4) and run perfectly well on that printer driver. Second, you may see emulation in the "I don't have the right driver!" scenario. I keep about three different HP LaserJet and Epson inkjet printers installed on my PC because I know that with these printer drivers, I can print to almost any printer. Some printers may require you to set them into an *emulation mode* to handle a driver other than their native one.
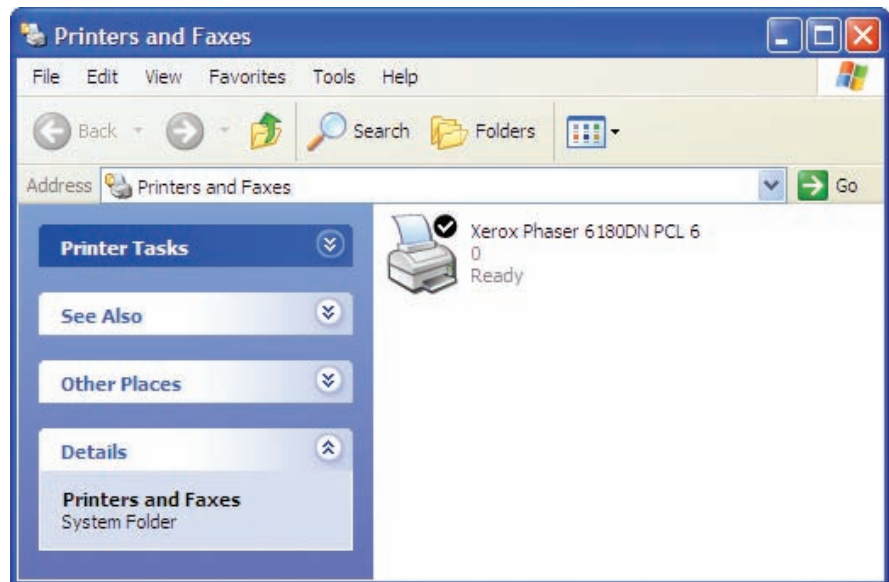


● Figure 28.22   Installed default printer in the Printers and Faxes applet

# Optimizing Print Performance

Although a quality printer is the first step toward quality output, your output relies on factors other than the printer itself. What you see on the screen may not match what comes out of the printer, so calibration is important. Using the wrong type of paper can result in less than acceptable printed documents. Configuring the printer driver and spool settings can also affect your print jobs.

### Calibration

If you've ever tweaked that digital photograph so it looks perfect on your screen, only to discover that the final printout was darker than you had hoped, consider calibrating your monitor. **Calibration** matches the print output of your printer to the visual output on your monitor and governs that through software. All three parts need to be set up properly for you to print what you see consistently.

Computer monitors output in RGB—that is, they compose colors using red, green, and blue pixels, as discussed in Chapter 21—while printers mix their colors differently to arrive at their output. As mentioned earlier, the

## Tech Tip

**Readme Files**

*You've seen how to get your system to recognize a printer, but what do you do when you add a brand-new printer? Like most peripherals, the printer will include an installation disc that contains various useful files. One of the most important but least-used tools on this disc is the Readme file. This file, generally in TXT format, contains the absolute latest information on any idiosyncrasies, problems, or incompatibilities related to your printer or printer driver. Usually, you can find it in the root folder of the installation disc, although many printer drivers install the Readme file on your hard drive so you can access it from the Start menu. The rule here is* read first to avoid a headache later*!*

CMYK method composes colors from cyan (blue), magenta (red), yellow, and black.

The upshot of all this is that the printer tries to output—by using CMYK (or another technique)—what you see on the screen using RGB. Because the two color modes do not create color the same way, you see color shifts and not-so-subtle differences between the onscreen image and the printed image. By calibrating your monitor, you can adjust the setting to match the output of your printer. You can do this manually through "eyeballing" it or automatically by using calibration hardware.

To calibrate your monitor manually, obtain a test image from the Web (try sites such as www.DigitalDog.net) and print it out. If you have a good eye, you can compare this printout to what you see on the screen and make the adjustments manually through your monitor's controls or display settings.

Another option is to calibrate your printer by using an International Color Consortium (ICC) color profile, a preference file that instructs your printer to print colors a certain way—for example, to match what is on your screen. Loading a different color profile results in a different color output. Color profiles are sometimes included on the installation media with a printer, but you can create or purchase custom profiles as well. The use of ICC profiles is not limited to printers; you can also use them to control the output of monitors, scanners, or even digital cameras. Windows Vista/7 include *Windows Color System* (*WCS*) to help build color profiles for use across devices. WCS is based on a new standard Microsoft calls *color infrastructure and translation engine* (*CITE*).

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## ■ Troubleshooting Printers

As easy as printers are to set up, they are equally robust at running, assuming that you install the proper drivers and keep the printer well maintained. But printer errors do occasionally develop. Take a look at the most common print problems with Windows, as well as problems that crop up with specific printer types.

### General Troubleshooting Issues

Printers of all stripes share some common problems, such as print jobs that don't go, strangely sized prints, and misalignment. Other issues include disposing of consumables, sharing multiple printers, and crashing on power-up. Let's take a look at these general troubleshooting issues, but start with a recap of the tools of the trade.

#### Tools of the Trade

Before you jump in and start to work on a printer that's giving you fits, you'll need some tools. You can use the standard computer tech tools in

your toolkit, plus a couple of printer-specific devices. Here are some that will come in handy:

- A multimeter for troubleshooting electrical problems such as faulty wall outlets

- Various cleaning solutions, such as denatured alcohol

- An extension magnet for grabbing loose screws in tight spaces and cleaning up iron-based toner

- An optical disc or USB thumb drive with test patterns for checking print quality

- Your trusty screwdriver—both a Phillips-head and flat-head, because if you bring just one kind, it's a sure bet that you'll need the other

### Print Job Never Prints

If you click Print but nothing comes out of the printer, first check all the obvious things. Is the printer on? Is it connected? Is it online? Does it have paper?
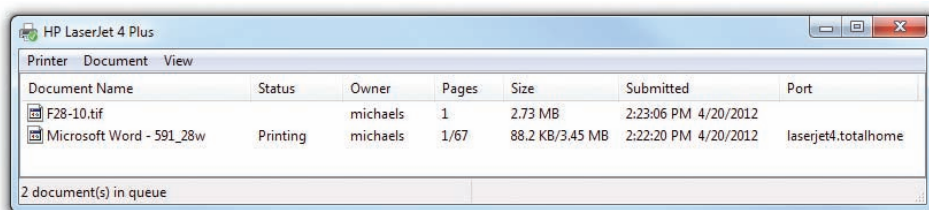
If you can't connect to the printer, check all cables, ports, and power involved. If everything is plugged in and ready to go, check the appropriate printer applet for your version of Windows. If you don't see the printer you are looking for, you'll need to reinstall it using the Add Printer Wizard.

If you attempt to use a printer shared by another PC, but Windows pops up with an "Access Denied" error, you might not have permission to use the printer. Go to the host PC and check the Security tab of the Printer Properties dialog box. Make sure your user account is allowed to use the printer.

Assuming the printer is in good order, it's time to look at the spooler. You can see the spooler status either by double-clicking the printer's icon in the appropriate printer Control Panel applet or by double-clicking the tiny printer icon in the notification area if it's present. If you're having a problem, the printer icon will almost always be there. Figure 28.23 shows the print spooler open.

Print spoolers can easily overflow or become corrupt due to a lack of disk space, too many print jobs, or one of a thousand other factors. The status window shows all of the pending print jobs and enables you to delete, start, or pause jobs. I usually just delete the affected print job(s) and try again.



• Figure 28.23    Print spooler

Print spoolers are handy. If the printer goes down, you can just leave the print jobs in the spooler until the printer comes back online. Some versions of Windows require you to select Resume Printing manually, but others automatically continue the print job(s). If you have a printer that isn't coming on anytime soon, you can simply delete the print job in the spooler window and try another printer.

Print spool settings

If you have problems with the print spooler, you can get around them by changing your print spool settings. Go into the Printers and Faxes/Printers/Devices and Printers applet, right-click the icon of the printer in question, and choose Properties. In the resulting Properties dialog box (see Figure 28.24), choose the *Print directly to the printer* radio button and click OK; then try sending your print job again. Note that this window also offers you the choice of printing immediately—that is, starting to print pages as soon as the spooler has enough information to feed to the printer—or holding off on printing until the entire job is spooled.

If that isn't enough, try restarting the print spooler service. Open the Start menu and right-click on My Computer/Computer. Select Manage—you'll need administrator privileges to continue. In the column on the left, double-click on Services and Applications, and then click on Services. The Services console should appear in the center of the Computer Management window. Scroll down and find the service named Print Spooler. Right-click on the service and select Stop. After it has stopped, right-click on the service again and select Start. You should be able to print using the print spooler again.

Another possible cause for a stalled print job is that the printer is simply waiting for the correct paper! Laser printers in particular have settings that tell them what size paper is in their standard paper tray or trays. If the application sending a print job specifies a different paper size—for example, it wants to print a standard No. 10 envelope, or perhaps a legal sheet, but the standard paper tray holds only 8.5 × 11 letter paper—the printer usually pauses and holds up the queue until someone switches out the tray or manually feeds the type of paper that this print job requires. You can usually override this pause, even without having the specified paper, by pressing the OK or GO button on the printer.

The printer's default paper tray and paper size options will differ greatly depending on the printer type and model. To find these settings, go into the printer's Properties dialog box from the Printers and Faxes/Printers/Devices and Printers applet, and then select the Device Settings tab. This list of settings includes Form To Tray Assignment, where you can specify which tray (in the case of a printer with multiple paper trays) holds which size paper.

### Strange Sizes

A print job that comes out a strange size usually points to a user mistake in setting up the print job. All applications have a Print command and a Page Setup interface. The Page Setup interface enables you to define a number of print options, which vary from application to application. Figure 28.25 shows the Page Setup options for Microsoft Word. Make sure the page is set up properly before you blame the printer for a problem.
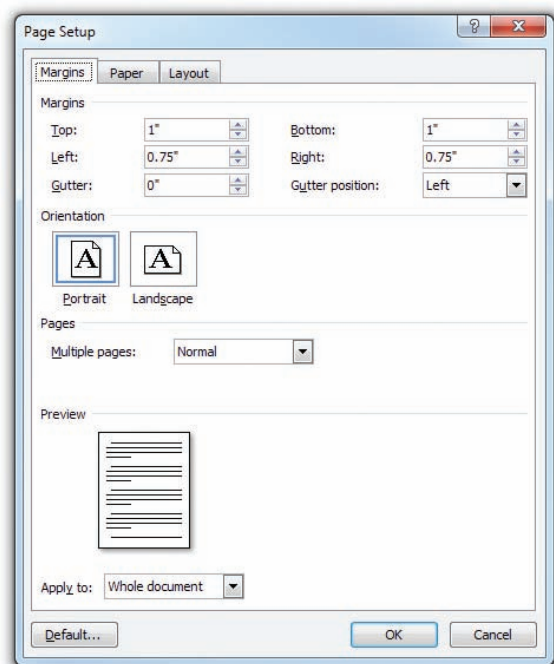


Page Setup options for Microsoft Word

If you know the page is set up correctly, recheck the printer drivers. If necessary, uninstall and reinstall the printer drivers. If the problem persists, you may have a serious problem with the printer's print engine, but that comes up as a likely answer only when you continually get the same strangely sized printouts using a variety of applications.

### Misaligned, Garbled, or Garbage Printouts

Misaligned or garbage printouts invariably point to a corrupted or incorrect driver. Make sure you're using the right driver (it's hard to mess this up, but not impossible) and then uninstall and reinstall the printer driver. If the problem persists, you may be asking the printer to do something it cannot do. For example, you may be printing to a PostScript printer with a PCL driver. Check the printer type to verify that you haven't installed the wrong type of driver for that printer!

### Dealing with Consumables

All printers tend to generate a lot of trash in the form of **consumables**. Impact printers use paper and ribbons, inkjet printers use paper and ink cartridges, and laser printers use paper and toner cartridges. In today's environmentally sensitive world, many laws regulate the proper disposal of most printer components. Be sure to check with the local sanitation department or disposal services company before throwing away any component. Of course, you should never throw away toner cartridges—certain companies will *pay* for used cartridges!

### Problems Sharing Multiple Printers

If you want to use multiple printers attached to the same parallel port, you have to use a switch box. Laser printers should never be used with mechanical switch boxes. Mechanical switch boxes create power surges that can damage your printer. If you must use a switch box, use a box that switches between printers electronically and has built-in surge protection.

### Crashes on Power-up

Both laser printers and PCs require more power during their initial power-up (the POST on a PC and the warm-up on a laser printer) than once they are running. Hewlett-Packard recommends a *reverse power-up*. Turn on the laser printer first and allow it to finish its warm-up before turning on the PC. This avoids having two devices drawing their peak loads simultaneously.

# Troubleshooting Impact Printers

Impact printers require regular maintenance but will run forever as long as you're diligent. Keep the platen (the roller or plate on which the pins impact) clean and the printhead clean with denatured alcohol. Be sure to lubricate gears and pulleys according to the manufacturer's specifications. Never lubricate the printhead, however, because the lubricant will smear and stain the paper. Don't forget to replace the ink ribbon every so often.

## Tech Tip

**Check the MSDS**

*When in doubt about what to do with a component, check with the manufacturer for a* **material safety data sheet (MSDS)**. *These standardized forms provide detailed information about not only the potential environmental hazards associated with different components but also proper disposal methods. For example, surf to www.hp.com/hpinfo/ globalcitizenship/environment/ productdata/index.html to find the latest MSDS for all Hewlett-Packard products. This isn't just a printer issue—you can find an MSDS for most PC components. When in doubt about how to get rid of any PC component, check with the manufacturer for an MSDS.*

MSDSs contain important information regarding hazardous materials such as safe use procedures and emergency response instructions. An MSDS is typically posted anywhere a hazardous chemical is used.

### Bad-looking Text

White bars going through the text point to a dirty or damaged printhead. Try cleaning the printhead with a little denatured alcohol. If the problem persists, replace the printhead. Printheads for most printers are readily available from the manufacturer or from companies that rebuild them. If the characters look chopped off at the top or bottom, the printhead probably needs to be adjusted. Refer to the manufacturer's instructions for proper adjustment.

### Bad-looking Page

If the page is covered with dots and small smudges—the "pepper look"—the platen is dirty. Clean the platen with denatured alcohol. If the image is faded, and you know the ribbon is good, try adjusting the printhead closer to the platen. If the image is okay on one side of the paper but fades as you move to the other, the platen is out of adjustment. Platens are generally difficult to adjust, so your best plan is to take it to the manufacturer's local warranty/repair center.

# Troubleshooting Thermal Printers

Compared to other printer styles, thermal printers are simple to troubleshoot and maintain. With direct thermal printers, you only need to worry about three things: the heating element, the rollers, and the paper. With thermal wax printers, you also need to care for the wax ribbon.

To clean the heating element, turn off the thermal printer and open it according to the manufacturer's instructions. Use denatured alcohol and a lint-free cloth to wipe off the heating element. You might need to use a little pressure to get it completely clean. Clean the rollers with a cloth or compressed air. You want to keep them free of debris so they can properly grip the paper. Replacing the paper is as easy as sliding off the old roll and replacing it with a new one. Remember to feed the paper through the heating element, because otherwise you won't print anything. Replacing the ribbon is similar to replacing the roll of paper; make sure to feed it past the heating element, or the printer won't work properly. Your printer's manufacturer should include any special instructions for installing a new ribbon.

# Troubleshooting Inkjet Printers

Inkjet printers are reliable devices that require little maintenance as long as they are used within their design parameters (high-use machines will require more intensive maintenance). Because of the low price of these printers, manufacturers know that people don't want to spend a lot of money keeping them running. If you perform even the most basic maintenance tasks, they will soldier on for years without a whimper. Inkjets generally have built-in maintenance programs that you should run from time to time to keep your inkjet in good operating order.

## Inkjet Printer Maintenance

Inkjet printers don't get nearly as dirty as laser printers, and most manufacturers do not recommend periodic cleaning. Unless your manufacturer explicitly tells you to do so, don't vacuum an inkjet. Inkjets generally do not have maintenance kits, but most inkjet printers come with extensive maintenance software (see Figure 28.26). Usually, the hardest part of using this software is finding it in the first place. Look for an option in Printing Preferences, a selection on the Start menu, or an icon on your desktop. Don't worry—it's there!

When you first set up an inkjet printer, it normally instructs you to perform a routine (sometimes confusingly referred to as *calibration*) to align the printheads properly, wherein you print out a page and select from sets of numbered lines. If this isn't done, the print quality will show it, but the good news is that you can perform this procedure at any time. If a printer is moved or dropped or it's just been working away untended for a while, it's often worth running the alignment routine.

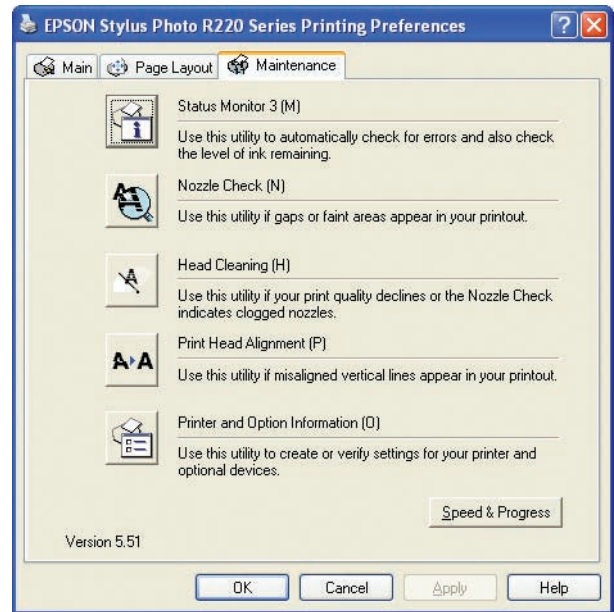• **Figure 28.26**    Inkjet printer maintenance screen

## Inkjet Problems

Did I say that you never should clean an inkjet? Well, that may be true for the printer itself, but there is one part of your printer that will benefit from an occasional cleaning: the inkjet's printer head nozzles. The nozzles are the tiny pipes that squirt the ink onto the paper. A common problem with inkjet printers is the tendency for the ink inside the nozzles to dry out when not used even for a relatively short time, blocking any ink from exiting. If your printer is telling Windows that it's printing and feeding paper through, but either nothing is coming out (usually the case if you're just printing black text) or only certain colors are printing, the culprit is almost certainly dried ink clogging the nozzles.

Every inkjet printer has a different procedure for cleaning the printhead nozzles. On older inkjets, you usually have to press buttons on the printer to start a maintenance program. On more modern inkjets, you can access the head-cleaning maintenance program from Windows.

Another problem that sometimes arises is the dreaded multi-sheet paper grab. This is often not actually your printer's fault—humidity can cause sheets of paper to cling to each other—but sometimes the culprit is an overheated printer, so if you've been cranking out a lot of documents without stopping, try giving the printer a bit of a coffee break. Also, fan the sheets of the paper stack before inserting it into the paper tray.

Finally, check to see if excess ink overflow is a problem. In the area where the printheads park, look for a small tank or tray that catches excess ink from the cleaning process. If the printer has one, check to see how full it is. If this tray overflows onto the main board or even the power supply, it will kill your printer. If you discover that the tray is about to overflow, you can remove excess ink by inserting a twisted paper towel into the tank to soak up some of the ink. It is advisable to wear latex or vinyl gloves while doing this. Clean up any spilled ink with a paper towel dampened with distilled water.

All inkjet inks are water-based, and water works better than alcohol to clean them up.

Cleaning the heads on an inkjet printer is sometimes necessary, but I don't recommend that you do it on a regular basis as preventive maintenance. The head-cleaning process uses up a lot of that very expensive inkjet ink—so do this only when a printing problem seems to indicate clogged or dirty printheads!

# Troubleshooting Laser Printers

Quite a few problems can arise with laser printers, but before getting into those details, you need to review some recommended procedures for *avoiding* those problems.

### Laser Printer Maintenance

Unlike PC maintenance, laser printer maintenance follows a fairly well established procedure. Of course, you'll need to replace the toner cartridge every so often, but keeping your laser printer healthy requires following these maintenance steps.

**Keep It Clean**   Laser printers are quite robust as a rule. A good cleaning every time you replace the toner cartridge will help that printer last for many years. I know of many examples of original HP LaserJet I printers continuing to run perfectly after a dozen or more years of operation. The secret is that they were kept immaculately clean.

Your laser printer gets dirty in two ways: Excess toner, over time, will slowly coat the entire printer. Paper dust, sometimes called *paper dander*, tends to build up where the paper is bent around rollers or where pickup rollers grab paper. Unlike (black) toner, paper dust is easy to see and is usually a good indicator that a printer needs to be cleaned. Usually, a thorough cleaning using a can of compressed air to blow out the printer is the best cleaning you can do. It's best to do this outdoors, or you may end up looking like one of those chimney sweeps from *Mary Poppins*! If you must clean a printer indoors, use a special low-static vacuum designed especially for electronic components (see Figure 28.27).



• Figure 28.27    Low-static vacuum

Every laser printer has its own unique cleaning method, but the cleaning instructions tend to skip one little area. Every laser printer has a number of rubber guide rollers through which the paper is run during the print process. These little rollers tend to pick up dirt and paper dust over time, making them slip and jam paper. They are easily cleaned with a small amount of 90 percent or better alcohol on a fibrous cleaning towel. The alcohol will remove the debris and any dead rubber. If the paper won't feed, you can give the rollers and separator pads a textured surface that will restore their feeding properties by rubbing them with a little alcohol on a nonmetallic scouring pad.

If you're ready to get specific, get the printer's service manual. They are a key source for information on how to keep a printer clean and running. Sadly, not all printer manufacturers provide these, but most do. While you're at it, see if the manufacturer has a Quick Reference Guide; these can be very handy for most printer problems!

**Periodic Maintenance**   Although keeping the printer clean is critical to its health and well being, every laser printer has certain components that you need to replace periodically. Your ultimate source for determining the parts that need to be replaced (and when to replace them) is the printer manufacturer. Following the manufacturer's maintenance guidelines will help to ensure years of trouble-free, dependable printing from your laser printer.

Many manufacturers provide kits that contain components that you should replace on a regular schedule. These **maintenance kits** include sets

of replacement parts, such as a fuser, as well as one or more rollers or pads. Typically, you need to reset the page counter after installing a maintenance kit so the printer can remind you to perform maintenance again after a certain number of pages have been printed.

Some ozone filters can be cleaned with a vacuum and some can only be replaced—follow the manufacturer's recommendation. You can clean the fuser assembly with 90 percent or better denatured alcohol. Check the heat roller (the Teflon-coated one with the light bulb inside) for pits and scratches. If you see surface damage on the rollers, replace the fuser unit.

Most printers will give you an error code when the fuser is damaged or overheating and needs to be replaced; others will produce the error code at a preset copy count as a preventive maintenance measure. Again, follow the manufacturer's recommendations.

The transfer corona can be cleaned with a 90 percent denatured alcohol solution on a cotton swab. If the wire is broken, you can replace it; many just snap in or are held in by a couple of screws. Paper guides can also be cleaned with alcohol on a fibrous towel.

### Laser Printer Problems

Laser printers usually manifest problems by creating poor output. One of the most important tests you can do on any printer, not just a laser printer, is called a *diagnostic print page* or an *engine test page*. You do this by either holding down the On Line button as the printer is started or using the printer's maintenance software.

**Blank Paper**   Blank sheets of paper usually mean the printer is out of toner. If the printer does have toner and nothing prints, print a diagnostic print page. If that is also blank, remove the toner cartridge and look at the imaging drum inside. If the image is still there, you know the transfer corona or the high-voltage power supply has failed. Check the printer's maintenance guide to see how to focus on the bad part and replace it.

**Dirty or Smudged Printouts**   If the fusing mechanism in a laser printer gets dirty, it will leave a light dusting of toner all over the paper, particularly on the back of the page. When you see toner speckles on your printouts, you should get the printer cleaned.

If the printout looks smudged, the fuser isn't properly fusing the toner to the paper. Depending on the paper used, the fuser needs to reach a certain temperature to fuse the toner. If the toner won't fuse to the paper, try using a lighter-weight paper. You might also need to replace the fuser.

**Ghosting**   Ghost images sometimes appear at regular intervals on the printed page. This happens when the imaging drum has not fully discharged and is picking up toner from a previous image or when a previous image has used up so much toner that either the supply of charged toner is insufficient or the toner has not been adequately charged. Sometimes it can also be caused by a worn-out cleaning blade that isn't removing the toner from the drum.

**Light Ghosting versus Dark Ghosting**   A variety of problems can cause both light and dark ghosting, but the most common source of light ghosting is "developer starvation." If you ask a laser printer to print an extremely

Failure of the thermal fuse (used to keep the fuser from overheating) can necessitate replacing the fuser assembly. Some machines contain more than one thermal fuse. As always, follow the manufacturer's recommendations. Many manufacturers have kits that alert you with an alarm code to replace the fuser unit and key rollers and guides at predetermined page counts.

The fuser assembly operates at 200 to 300 degrees Fahrenheit, so always allow time for this component to cool down before you attempt to clean it.

dark or complex image, it can use up so much toner that the toner cartridge will not be able to charge enough toner to print the next image. The proper solution is to use less toner. You can fix ghosting problems in the following ways:

- Lower the resolution of the page (print at 300 dpi instead of 600 dpi).
- Use a different pattern.
- Avoid 50 percent grayscale and "dot-on/dot-off patterns."
- Change the layout so that grayscale patterns do not follow black areas.
- Make dark patterns lighter and light patterns darker.
- Print in landscape orientation.
- Adjust print density and RET settings.
- Print a completely blank page immediately prior to the page with the ghosting image, as part of the same print job.

In addition to these possibilities, low temperature and low humidity can aggravate ghosting problems. Check your user's manual for environmental recommendations. Dark ghosting can sometimes be caused by a damaged drum. It may be fixed by replacing the toner cartridge. Light ghosting would *not* be solved in this way. Switching other components will not usually affect ghosting problems because they are a side effect of the entire printing process.

**Vertical White Lines**    Vertical white lines usually happen when the toner is clogged, preventing the proper dispersion of toner on the drum. Try shaking the toner cartridge to dislodge the clog. If that doesn't work, replace the toner cartridge.

**Blotchy Print**    Blotches are commonly a result of uneven dispersion of toner, especially if the toner is low. Shake the toner from side to side and then try to print. Also be sure that the printer is sitting level. Finally, make sure the paper is not wet in spots. If the blotches are in a regular order, check the fusing rollers and the photosensitive drum for any foreign objects.

**Spotty Print**    If the spots appear at regular intervals, the drum may be damaged or some toner may be stuck to the fuser rollers. Try wiping off the fuser rollers. Check the drum for damage. If the drum is damaged, get a new toner cartridge.

**Embossed Effect**    If your prints are getting an embossed effect (like putting a penny under a piece of paper and rubbing it with a lead pencil), there is almost certainly a foreign object on a roller. Use 90 percent denatured alcohol or regular water with a soft cloth to try to remove it. If the foreign object is on the photosensitive drum, you're going to have to use a new toner cartridge. An embossed effect can also be caused by the contrast control being set too high. The contrast control is actually a knob on the inside of the unit (sometimes accessible from the outside, on older models). Check your manual for the specific location.

**Incomplete Characters**   You can sometimes correct incompletely printed characters on laser-printed transparencies by adjusting the print density. Be extremely careful to use only materials approved for use in laser printers.

**Creased Pages**   Laser printers have up to four rollers. In addition to the heat and pressure rollers of the fuser assembly, other rollers move the paper from the source tray to the output tray. These rollers crease the paper to avoid curling that would cause paper jams in the printer. If the creases are noticeable, try using a different paper type. Cotton bond paper is usually more susceptible to noticeable creasing than other bonds. You might also try sending the output to the face-up tray, which avoids one roller. There is no hardware solution to this problem; it is simply a side effect of the process.

**Paper Jams**   Every printer jams now and then. If you get a jam, always refer first to the manufacturer's jam removal procedure. It is simply too easy to damage a printer by pulling on the jammed paper! If the printer reports a jam but there's no paper inside, you've almost certainly got a problem with one of the many jam sensors or paper feed sensors inside the printer, and you'll need to take it to a repair center.

**Pulling Multiple Sheets**   If the printer grabs multiple sheets at a time, first try opening a new ream of paper and loading that in the printer. If that works, you have a humidity problem. If the new paper angle doesn't work, check the separation pad on the printer. The separation pad is a small piece of cork or rubber that separates the sheets as they are pulled from the paper feed tray. A worn separation pad looks shiny and, well, *worn*! Most separation pads are easy to replace. Check out www.printerworks.com to see if you can replace yours.

**Warped, Overprinted, or Poorly Formed Characters**   Poorly formed characters can indicate either a problem with the paper (or other media) or a problem with the hardware.

Incorrect media cause a number of these types of problems. Avoid paper that is too rough or too smooth. Paper that is too rough interferes with the fusing of characters and their initial definition. If the paper is too smooth (like some coated papers, for example), it may feed improperly, causing distorted or overwritten characters. Even though you can purchase laser printer–specific paper, all laser printers print acceptably on standard photocopy paper. Try to keep the paper from becoming too wet. Don't open a ream of paper until it is time to load it into the printer. Always fan the paper before loading it into the printer, especially if the paper has been left out of the package for more than just a few days.

The durability of a well-maintained laser printer makes hardware a much rarer source of character printing problems, but you should be aware of the possibility. Fortunately, it is fairly easy to check the hardware. Most laser printers have a self-test function—often combined with a diagnostic printout but sometimes as a separate process. This self-test shows whether the laser printer can properly develop an image without actually having to send print commands from the PC. The self-test is quite handy to verify the question "Is it the printer or is it the computer?" Run the self-test to check for connectivity and configuration problems.

Possible solutions include replacing the toner cartridge, especially if you hear popping noises; checking the cabling; and replacing the data cable, especially if it has bends or crimps or if objects are resting on the cable. If you have a front menu panel, turn off advanced functions and high-speed settings to determine whether the advanced functions are either not working properly or not supported by your current software configuration (check your manuals for configuration information). If these solutions do not work, the problem may not be user serviceable. Contact an authorized service center.

# Beyond A+

## Multifunction Peripherals

It's a common theme in computing: why have two devices that do one thing each when you can have one device that does two things? In that spirit, manufacturers started gluing various peripherals together to create *multi-function peripherals*, or *MFPs* (see Figure 28.28). These devices can include printers, scanners, fax machines, photocopiers, and more. All of your standard connection options are available, including USB, parallel, Ethernet, Wi-Fi, and more.

One of the best parts of a multifunction device is that all of these functions are available using a single connection. On the other hand, because a multifunction device is much more complicated than a single-function device, you'll probably need to follow very specific instructions and use the



• Figure 28.28    All-in-one printer/scanner/fax machine/copier/coffee maker/iPod dock

manufacturer-supplied installation disc to get it all working. Many multifunction devices also include functions that don't require a PC at all, such as photocopying and faxing. You can even print files from a digital camera's memory card without plugging the MFP into a PC.

## ■ Chapter Summary

After reading this chapter and completing the exercises, you should understand the following aspects of printers.

### Describe current printer technologies

- Impact printers create an image on paper by physically striking an ink ribbon against the paper's surface. The most commonly used impact printer technology is dot matrix. Dot-matrix printers have a large installed base in businesses, and they can be used for multipart forms because they actually strike the paper. Dot-matrix printers use a grid, or matrix, of tiny pins, also known as printwires, to strike an inked printer ribbon and produce images on paper. The case that holds the printwires is called a printhead. Dot-matrix printers come in two varieties: 9-pin (draft quality) and 24-pin (letter quality).

- Inkjet printers include a printhead mechanism, support electronics, a transfer mechanism to move the printhead back and forth, and a paper feed component to drag, move, and eject paper. They eject ink through tiny tubes. The heat or pressure used to move the ink is created by tiny resistors or electroconductive plates at the end of each tube.

- Ink is stored in ink cartridges. Older color printers used two cartridges: one for black and one for cyan, magenta, and yellow. Newer printers come with four, six, eight, or more cartridges.

- The quality of a print image is called the print resolution. The resolution is measured in dots per inch (dpi), which has two values: horizontal and vertical. An example of a resolution is 600 × 600 dpi. Printing speed is measured in pages per minute (ppm). Modern inkjet printers can print on a variety of media, including glossy photo paper, optical discs, or fabric.

- Dye-sublimation printers are used to achieve excellent print quality, especially in color, but they're expensive. Documents printed through the dye-sublimation process display continuous-tone images, meaning that each pixel dot is a blend of the dye colors. This is in contrast to other print technologies' dithered images, which use closely packed, single-color dots to simulate blended colors.

- Two kinds of thermal printers create either quick one-color printouts such as faxes or store receipts (direct thermal) or higher-quality color prints (thermal wax transfer).

- Using a process called electro-photographic imaging, laser printers produce high-quality and high-speed output. Laser printers usually use lasers as a light source because of their precision, but some lower-cost printers may use LED arrays instead. The toner cartridge in a laser printer supplies the toner that creates the image on the page; many other laser printer parts, especially those that suffer the most wear and tear, have been incorporated into the toner cartridge. Although the majority of laser printers are monochrome, you can find color laser printers capable of printing photographs.

- Be aware of the cost of consumables when purchasing a printer. Some less expensive printers may seem like a good deal, but ink or toner cartridge replacements can cost as much as the entire printer.

- The photosensitive drum (or imaging drum) in a laser printer is an aluminum cylinder coated with particles of photosensitive compounds. The erase lamp exposes the entire surface of the photosensitive drum to light, making the photosensitive coating conductive and leaving the surface particles electrically neutral. When the primary corona or charge roller is charged with an extremely high voltage, an electric field (or corona) forms, enabling voltage to pass to the drum and charge the photosensitive particles on its surface; the surface of the drum receives a uniform negative voltage of between ~600 and ~1000 volts.

- The laser acts as the writing mechanism of the printer. When particles are struck by the laser, they are discharged and left with a ~100 volt negative charge. The toner in a laser printer is a fine powder made up of plastic particles bonded to iron particles. The toner cylinder charges the toner with a negative charge of between ~200 and ~500 volts. Because that charge falls between the original

uniform negative charge of the photosensitive drum (~600 to ~1000 volts) and the charge of the particles on the drum's surface hit by the laser (~100 volts), particles of toner are attracted to the areas of the photosensitive drum that have been hit by the laser. The transfer corona or transfer roller applies a positive charge to the paper, drawing the negatively charged toner particles on the drum to the paper. The toner is merely resting on top of the paper after the static charge eliminator has removed the paper's static charge. Two rollers, a pressure roller and a heated roller, are used to fuse the toner to the paper.

- All laser printers have at least two separate power supplies. The primary power supply, which may actually be more than one power supply, provides power to the motors that move the paper, the system electronics, the laser, and the transfer corona. The high-voltage power supply usually only provides power to the primary corona/charge roller; it is one of the most dangerous devices in the world of PCs. Always turn off a laser printer before opening it up.

- A laser printer's mechanical functions are served by complex gear systems packed together in discrete units generically called gear packs or gearboxes. Most laser printers have two or three. Every laser printer has sensors that detect a broad range of conditions, such as paper jams, empty paper trays, or low toner levels.

- Every laser printer contains at least one electronic system board (many have two or three) that contains the main processor, the printer's ROM, and the RAM used to store the image before it is printed. When the printer doesn't have enough RAM to store the image before it prints, you get a memory overflow problem. Most printers can use generic DRAM like the kind you use in your PC, but check with the manufacturer to be sure.

- Because even tiny concentrations of ozone ($O_3$) will cause damage to printer components, most laser printers have a special ozone filter that needs to be vacuumed or replaced periodically.

- Solid ink printers use sticks of solid ink to produce extremely vibrant color. The inks are melted, absorbed into the paper fibers, and then solidify, producing continuous-tone output in a single pass. The solid ink sticks may be inserted midway through a print job if a certain color needs to be topped off.

- ASCII contains a variety of control codes for transferring data, some of which can be used to control printers; ASCII code 10 (or 0A in hex) means "Line Feed," and ASCII code 12 (0C) means "Form Feed." These commands have been standard since before the creation of IBM PCs, and all printers respond to them; however, the control codes are extremely limited. Utilizing high-end graphics and a wide variety of fonts requires more advanced languages.

- Adobe Systems' PostScript page description language is a device-independent printer language capable of high-resolution graphics and scalable fonts. Because PostScript is understood by printers at a hardware level, the majority of the image processing is done by the printer and not the PC's CPU, so PostScript printers print faster. PostScript defines the page as a single raster image; this makes PostScript files extremely portable.

- Hewlett-Packard's printer control language (PCL) features a set of printer commands greatly expanded from ASCII, but it does not support advanced graphical functions. PCL6 features scalable fonts and additional line drawing commands. PCL uses a series of commands to define the characters on the page, rather than defining the page as a single raster image like PostScript.

- Windows XP use the graphical device interface (GDI) component of the operating system to handle print functions. The GDI uses the CPU rather than the printer to process a print job and then sends the completed job to the printer. As long as the printer has a capable-enough raster image processor (RIP) and plenty of RAM, you don't need to worry about the printer language at all in most situations. Windows Vista/7 include support for the XML Paper Specification (XPS) print path, which requires an XPS-compatible driver. Some devices support XPS natively.

- Most printers connect to one of two ports on the PC: a DB-25 parallel port or a USB port. The parallel connection is the classic way to plug in a printer, but new printers use USB. The parallel port was included in the original IBM PC as a faster alternative to serial communication and has been kept around for backward compatibility. Parallel ports are slow by modern standards, with a maximum data transfer rate of 150 KBps. Parallel ports lack true bidirectional capability. A standard

parallel connection normally manifests as a female DB-25 connector on the PC and a corresponding male connector on the printer cable. The parallel connector on the printer side is called a Centronics connector.

- IEEE 1284 was developed as a standard for a backward-compatible, high-speed, bidirectional parallel port for the PC. It requires support for compatibility, nibble mode, byte mode, EPP, and ECP; a standard method of negotiating compatible modes between printer and PC; standard cables and connectors; and a standard electrical interface.

- USB is the most popular type of printer connection today. USB printers rarely come with the necessary USB cable, so you may need to purchase one at the same time you purchase the printer.

- Network printers come with their own network card and connect directly to a network. This can be an RJ-45 port for an actual cable, or it can be a wireless network card. Some printers offer Bluetooth or infrared adapters for networking.

### Explain the laser printing process

- Laser printing is a seven-step process: processing, charging, exposing, developing, transferring, fusing, and cleaning.

- Laser printers generate a pattern of dots, called a raster image, representing what each page should look like. Laser printers use the laser to "paint" the raster image on the photosensitive drum. Laser printers use a chip called the RIP to translate the raster image sent to the printer into commands to the laser.

- Laser printer resolution is expressed in dots per inch (dpi). Common resolutions are 600 dpi × 600 dpi or 1200 dpi × 1200 dpi. The first number, the horizontal resolution, is determined by how fine a focus can be achieved by the laser. The second number is determined by the smallest increment by which the drum can be turned. Higher resolutions produce higher-quality output but also require more memory. Even printing at 300 dpi, laser printers produce far better quality than dot-matrix printers, because RET enables the printer to insert smaller dots among the characters, smoothing out the jagged curves that are typical of printers that do not use RET.

- Using the primary corona wire or primary charge roller, a uniform negative charge is applied to the

entire surface of the drum (usually between ~600 and ~1000 volts) to make the drum receptive to new images.

- A laser is used to write a positive image relative to the toner particles on the surface of the drum, attracting them and creating a developed image.

- The transfer corona or transfer roller gives the paper a positive charge, making the negatively charged toner particles leap from the drum to the paper.

- The toner particles are mostly composed of plastic, so they can be melted to the page. Two rollers, a heated roller coated in a nonstick material and a pressure roller, melt the toner to the paper, permanently affixing it.

- The printing process ends with the physical and electrical cleaning of the photosensitive drum. All residual toner left over from printing the previous page must be removed, usually by scraping the surface of the drum with a rubber cleaning blade. One or more erase lamps bombard the surface of the drum with the appropriate wavelengths of light, causing the surface particles to discharge completely into the grounded drum.

### Install a printer on a Windows PC

- In Windows, a printer is not a physical device; it is a program that controls one or more physical printers. The physical printer is called a print device. Print drivers and a spooler are still present, but they are integrated into the printer itself.

- To install a printer not automatically detected by Windows, select Start | Printers and Faxes in Windows XP to open the Printers and Faxes applet. In Windows Vista, select the Printers applet from the Control Panel. In Windows 7, go to Start | Devices and Printers. You install a new printer by clicking the Add a Printer icon to start the Add Printer Wizard. You must choose to install a local or a network printer; and you must select a port for a local printer. Windows automatically detects and installs USB printers. You must specify the printer type from the wizard's list, or use the Have Disk option. The wizard also features a Windows Update button you can use to get the latest printer driver via the Internet.

- One printer will always be the default printer. If you have more than one printer installed, you can make any printer the default printer. The icon

for the default printer has a small checkmark in the corner. If you have multiple printers, you can change the default printer by right-clicking the printer's icon in the appropriate printer applet and selecting Make Default Printer (XP) or Set as default printer (Vista/7).

■ Printer emulation means to use a substitute printer driver for a printer, as opposed to one made exclusively for that printer. Some printers are designed to emulate other, more widely supported models. If you don't have the specific driver for a printer, you can often use the driver from a similar model.

■ Your monitor creates colors by using RGB, while a printer outputs in CMYK. This difference can lead to a printed page differing greatly in color and tone from what you see on the monitor. Calibrating your monitor to your printer is an important step in printing the colors you see on your screen. Manually calibrate your monitor by eyeballing it, by using ICC color profiles to instruct the printer to output colors a certain way, or by using calibration hardware and software to automate the process. Windows Vista/7 include Windows Color System to help build color profiles for use across devices.

### Recognize and fix basic printer problems

■ When troubleshooting a printer, first check all the obvious things. Is the printer on? Is it connected? Is it online? Does it have paper? Does the printer display an error code on an LCD display? Then check the spooler status either by double-clicking the printer's icon in the Printers applet or by double-clicking the tiny printer icon in the notification area, if it's present. You may be able to bypass spooler problems by changing the printer's Properties dialog box setting to *Print directly to the printer*.

■ If you see an "Access Denied" error when trying to print using a shared printer, make sure you have permission to use that printer.

■ A print job that comes out a strange size usually points to a user mistake in setting up the print job. Use the program's Page Setup feature to fix these problems. If you know the page is set up correctly, recheck the printer drivers. Misaligned or garbage printouts invariably point to a corrupted or incorrect driver.

■ Printer manufacturers will supply an MSDS for each of their products; they provide detailed information about the potential environmental hazards associated with different components and proper disposal methods. This isn't just a printer issue—you can find an MSDS for most PC components.

■ Turn on the laser printer first and allow it to finish its warm-up before turning on the PC (a reverse power-up). This avoids having two devices drawing their peak loads simultaneously.

■ With regular maintenance, impact printers run forever. White bars going through the text point to a dirty or damaged printhead. Try cleaning the printhead with a little 90 percent or better denatured alcohol. If the characters look chopped off at the top or bottom, you probably need to adjust the printhead.

■ Thermal printers are easy to maintain. Keep the rollers and heating element clean and replace the ribbon and paper as needed.

■ Inkjet printers generally have built-in maintenance programs that you should run from time to time to keep your inkjet in good operating order. A common problem with inkjet printers is the tendency for the ink inside the nozzles to dry out when not used even for a relatively short time, blocking any ink from exiting. To clean the nozzles on older inkjets, you usually have to press buttons on the printer to start a maintenance program. On more modern inkjets, you can access the head-cleaning maintenance program from Windows.

■ Remember to clean your laser printer every time you replace the toner. Many manufacturers provide kits that contain components that you should replace on a regular schedule. These maintenance kits include sets of replacement parts, such as a fuser, as well as one or more rollers or pads.

■ One of the most important tests you can do on any printer, not just a laser printer, is called a diagnostic print page or an engine test page. There are two types of printer test: the Windows test in which you print a test page, and the printer self-test that runs from the printer itself.

■ Over time, excess toner will slowly coat a laser printer. Paper dander will build up where the paper is bent around rollers or where pickup rollers grab paper. Use a small amount of 90

percent or better alcohol on a fibrous cleaning towel to remove the debris and any dead rubber.

- Blank sheets of paper usually mean a laser printer is out of toner. If the printer has toner and nothing prints, print a diagnostic print page. If that is also blank, remove the toner cartridge and look at the imaging drum inside. If the image is still there, you know the transfer corona or the high-voltage power supply has failed. Blotchy print is most commonly due to uneven dispersion of toner, especially if the toner is low; also check that the printer is level and the paper is completely dry.

- Ghost images can be caused either because a laser printer's imaging drum has not fully discharged (and is picking up toner from a previous image) or because a previous image has used up so much toner that either the supply of charged toner is insufficient or the toner has not been adequately charged. Dark ghosting can sometimes be caused by a damaged drum. It may be fixed by replacing the toner cartridge. Light ghosting would *not* be solved in this way.

- The rollers that move the paper from the source tray to the output tray crease the paper to avoid curling that would cause paper jams in the printer. If the creases are noticeable, try using a different paper type. If the printer reports a jam but there's no paper inside, you almost certainly have a problem with one of the many jam sensors or paper feed sensors. If the printer grabs multiple sheets at a time, it may be humidity, or a worn separation pad. Hardware problems are a much rarer source of character printing problems. Most laser printers have a self-test function that shows whether the laser printer can properly develop an image without having to send print commands from the PC. Run the self-test to check for connectivity and configuration problems.

## ■ Key Terms

American Standard Code for Information Interchange (ASCII) *(1067)*

calibration *(1079)*

Centronics connector *(1070)*

consumables *(1083)*

DB-25 connector *(1070)*

dot-matrix printer *(1059)*

dots per inch (dpi) *(1061)*

dye-sublimation printer *(1062)*

erase lamp *(1064)*

fuser assembly *(1065)*

graphical device interface (GDI) *(1068)*

IEEE 1284 standard *(1069)*

impact printer *(1059)*

ink cartridge *(1060)*

Inkjet printer *(1059)*

laser *(1064)*

laser printer *(1063)*

maintenance kit *(1086)*

material safety data sheet (MSDS) *(1083)*

near-letter quality (NLQ) *(1059)*

network printer *(1070)*

pages per minute (ppm) *(1062)*

parallel port *(1069)*

photosensitive drum *(1064)*

PostScript *(1068)*

primary charge roller *(1064)*

primary corona **(***1064***)**

printer control language (PCL) *(1068)*

printhead *(1059)*

print resolution *(1061)*

print spooler *(1071)*

printwire *(1059)*

raster image *(1072)*

raster image processor (RIP) *(1072)*

resolution enhancement technology (RET) *(1073)*

solid ink printer *(1067)*

static charge eliminator *(1065)*

thermal printer *(1063)*

toner *(1065)*

toner cartridge *(1064)*

transfer corona *(1065)*

transfer roller *(1065)*

XML Paper Specification (XPS) print path *(1068)*

## ■ Key Term Quiz

Use the Key Terms list to complete the sentences that follow. Not all terms will be used.

1. The _____ requires support for compatibility mode, nibble mode, byte mode, EPP, and ECP.

2. A standard parallel printer cable normally has a male _____ on one end and a 36-pin _____ on the other.

3. A printer that creates an image on paper by physically striking an ink ribbon against the paper's surface is known as a(n) _____.

4. Laser printers use lasers to create the print image on a(n) _____.

5. The _____ on a standard laser printer contains a pressure roller and a heated roller.

6. Adobe Systems' _____ is a device-independent printer language capable of high-resolution graphics and scalable fonts.

7. Windows XP uses the _____ component of the operating system to handle print functions.

8. The resolution of a printer is measured in _____.

9. A printer's speed is rated in _____.

10. The _____ is responsible for cleaning the photosensitive drum of electrical charge.

## ■ Multiple-Choice Quiz

1. Which part of a laser printer applies a positive charge to the paper that attracts the toner particles to it?
   A. Erase lamp
   B. Transfer corona
   C. Laser
   D. Primary corona

2. What is the approximate maximum data transfer rate of a standard parallel port?
   A. 50 KBps
   B. 150 KBps
   C. 500 KBps
   D. 2 MBps

3. Janet just bought a new computer. She wants to install her three-year-old inkjet printer on the new system but has lost the driver disc. She can't get on the Internet to download the latest drivers. What should she do for drivers?
   A. Install a driver for a similar printer.
   B. She's stuck until she can get on the Internet.
   C. She can use the Mac drivers.
   D. She can install the printer without drivers.

4. John just installed a second printer on his system. When he prints in Microsoft Word, the job goes to the wrong printer. What does he need to do to get print jobs always to go to one printer or the other?
   A. He needs to set the primary printer.
   B. He needs to set the main printer.
   C. He needs to set the default printer.
   D. He needs to set the system printer.

5. Frank's color inkjet printer no longer prints the color yellow, though it prints all the other colors just fine. The printer worked fine last month, the last time he printed in color. Which of the following is the most likely problem?
   A. He turned off the yellow nozzle.
   B. He has run out of yellow ink.
   C. He has a corrupt printer driver.
   D. His printer is set to monochrome mode.

6. Beth's laser printer is printing tiny specks on the paper. What should she do first?
   A. Wipe the paper with bleach.
   B. Run the printer maintenance program.
   C. Clean the nozzles.
   D. Vacuum the printer.

7. Ursula's laser printer has stopped working and is displaying this error message: "Error 81 – Service." What should she do first?

   A. Update the printer's firmware.

   B. Reinstall the printer driver.

   C. Try to find the error in the user's guide or maintenance program or online.

   D. Turn off the printer and call the manufacturer's help line.

8. Kevin's inkjet printer isn't printing blue (cyan). He checks the ink levels and sees that there's plenty of ink. What should he consider next?

   A. A printhead is jammed.

   B. A laser is blocked.

   C. A nozzle is clogged.

   D. An ink cartridge is missing.

9. The output from Diane's laser printer is fading evenly. What should she suspect first?

   A. A laser is blocked.

   B. The printer is out of toner.

   C. A nozzle is clogged.

   D. Her printer is dirty.

10. The dye-sublimation printing technique is an example of what method of color printing?

    A. CMYK

    B. Thermal wax transfer

    C. RGB

    D. Direct thermal

11. The output from your inkjet printer appears much darker than what you see on your screen. What is the problem?

    A. You are using a paperweight that is not supported in the MSDS.

    B. The printer and monitor need to be calibrated.

    C. The color ink cartridges are almost empty.

    D. The black ink cartridge is almost empty.

12. What is the best way to make a printer available to everyone on your network and maintain the highest level of availability?

    A. Use a FireWire printer connected to a user's PC and share that printer on the network.

    B. Use a USB printer connected to a user's PC and share that printer on the network.

    C. Use a network printer connected directly to the network.

    D. Use a mechanical switch box with the printer.

13. Sheila in accounting needs to print receipts in duplicate. The white copy stays with accounting and the pink copy goes to the customer. What type of printer should you install?

    A. Inkjet

    B. Impact

    C. Laser jet

    D. Thermal wax transfer

14. Your laser printer fails to print your print jobs and instead displays a MEM OVERFLOW error. What can you do to rectify the problem? (Select two.)

    A. Install more printer RAM.

    B. Install more PC RAM.

    C. Upgrade the RIP.

    D. Disable RET.

15. What is the proper order of the laser printing process?

    A. Process, clean, charge, expose, develop, transfer, and fuse

    B. Process, charge, expose, develop, transfer, fuse, and clean

    C. Clean, expose, develop, transfer, fuse, process, and charge

    D. Clean, charge, expose, develop, process, fuse, and transfer

## ■ Essay Quiz

1. Your department needs a number of color inkjet printers. At your organization, though, all purchases are handled through professional buyers. Sadly, they know nothing about color inkjet printers. You need to submit a Criteria for Purchase form to your buyers. This is the standard form that your organization gives to buyers so they know what to look for in the products they buy. What are the top three purchasing criteria that you think they need to consider? Write the criteria as simply and clearly as possible.

2. Interview a person who uses a computer for work. Ask what the person does and then write a short description of the type of printer that would most suit that person's needs. Explain why this printer would be the best choice.

3. You have been tasked to make a recommendation for a printer purchase for a busy office of ten people. Make a case for purchasing either an inkjet or laser printer, providing enough information to compare the two technologies. You can choose the type of business, so recommend the appropriate printer, such as a laser printer to an office that primarily produces text documents. Make your recommendation opposite to the one you made for essay question #2.

4. Write a short essay comparing and contrasting inkjet printers with the three less-common print technologies: dye-sublimation, thermal, and solid ink.

5. Your boss is fascinated by the laser printing process. Write a short memo that outlines how it works, in the proper order.

## Lab Projects

### • Lab Project 28.1

Laser printers often have rather complex maintenance procedures and schedules. Select a laser printer—preferably one that you actually have on hand—and answer the following questions.

1. Using the user's guide or online sources, determine the exact cleaning procedures for your laser printer. How often should it be vacuumed? Do any parts need to be removed for cleaning? Does the manufacturer recommend any specialized cleaning steps? Does your printer come with any specialized cleaning tools? Does the manufacturer have any recommended cleaning tools you should purchase?

2. Based on the information you gathered, create a cleaning toolkit for your laser printer. Be sure to include a vacuum. Locate sources for these products and determine the cost of the toolkit.

3. Determine the model number of the toner cartridge. Locate an online company that sells name-brand (such as Hewlett-Packard) toner cartridges. Locate an equivalent third-party toner cartridge. Assuming that the printer uses a toner cartridge every three months, what is your per system annual cost savings using third-party toner cartridges?

4. All toner cartridges have a material safety data sheet (MSDS). Locate the MSDS for your model of toner cartridge and read it. Note any potential hazards of the toner cartridges.

5. Print out the description of the cleaning kit you created as well as the manufacturer's cleaning instructions.

## • Lab Project 28.2

Using the same laser printer you used in the first project, locate and compile, on paper, all of the following information about your printer:

- User's guide
- List of error codes
- Troubleshooting guides
- Location of the latest drivers for Windows