How Laptops Work

by Craig Freudenrich, Ph.D.

Maybe you have been thinking about buying a computer, and it has occurred to you that you might want to buy a laptop version. After all, today's laptops have just as much computing power as desktops, without taking up as much space. You can take a laptop on the road with you to do your computing or make presentations. Perhaps you prefer comfortably working on your couch in front of the TV instead of sitting at a desk. Maybe a laptop is for you. In this edition of **How Stuff Works**, we will examine how these portable computers do the same work as larger computers, but in much smaller packages.

To access all of the different parts of this article, choose from the map below:

You may want to start with How They Work, to learn the basics about laptops. If you are thinking about buying one, be sure to check out the features to learn about which ones will suit your needs.

A Brief History

Alan Kay of the Xerox Palo Alto Research Center originated the idea of a portable computer in the 1970s. Kay envisioned a notebook-sized, portable computer called the **Dynabook** that everyone could own, and that could handle all of the user's informational needs. Kay also envisioned the Dynabook with wireless network capabilities. Arguably, the first laptop computer was designed in 1979 by William Moggridge of Grid Systems Corp. It had 340 kilobytes of bubble memory, a die-cast magnesium case and a folding electroluminescent graphics display screen (click here for a picture). In 1983, Gavilan Computer produced a laptop computer with the following features:

- 64 kilobytes (expandable to 128 kilobytes) of random access memory (RAM)
- Gavilan operating system (also ran MS-DOS)
- 8088 microprocessor
- touchpad mouse
- portable printer
- weighed 9 lb (4 kg) alone or 14 lb (6.4 kg) with printer

The Gavilan computer had a floppy drive that was not compatible with other computers, and it primarily used its own operating system. The company failed.

In 1984, Apple Computer introduced its Apple IIc model (click here for picture). The Apple IIc was a notebook-sized computer, but not a true laptop. It had a 65C02 microprocessor,128 kilobytes of memory, an internal 5.25-inch floppy drive, two serial ports, a mouse port, modem card, external power supply, and a folding handle. The computer itself weighed about 10 to 12 lb (about 5 kg), but the monitor was heavier. The Apple IIc had a 9-inch monochrome monitor or an optional LCD panel. The combination computer/ LCD panel made it a genuinely portable computer, although you would have to set it up once you reached your destination. The Apple IIc was aimed at the home and educational markets, and was highly successful for about five years.

Later, in 1986, IBM introduced its IBM PC Convertible. (click here for a picture.) Unlike the Apple IIc, the PC Convertible was a true laptop computer. Like the Gavilan computer, the PC Convertible used an 8088 microprocessor, but it had 256 kilobytes of memory, two 3.5-inch (8.9-cm) floppy drives, an LCD, parallel and serial printer ports and a space for an internal modem. It came with its own applications software (basic word processing, appointment calendar, telephone/address book, calculator), weighed 12 lbs (5.4 kg) and sold for $3,500. The PC Convertible was a success, and ushered in the laptop era. A bit later, Toshiba was successful with an IBM laptop clone.

Since these early models, many manufacturers have introduced and improved laptop computers over the years. Today's laptops are much more sophisticated, lighter and closer to Kay's original vision.

To learn more about "How They Work" click here, or choose from the map below:

Anatomy of a Laptop Computer

To illustrate the parts of a laptop computer, we will show you the inside of a **Toshiba Satellite Pro** laptop.

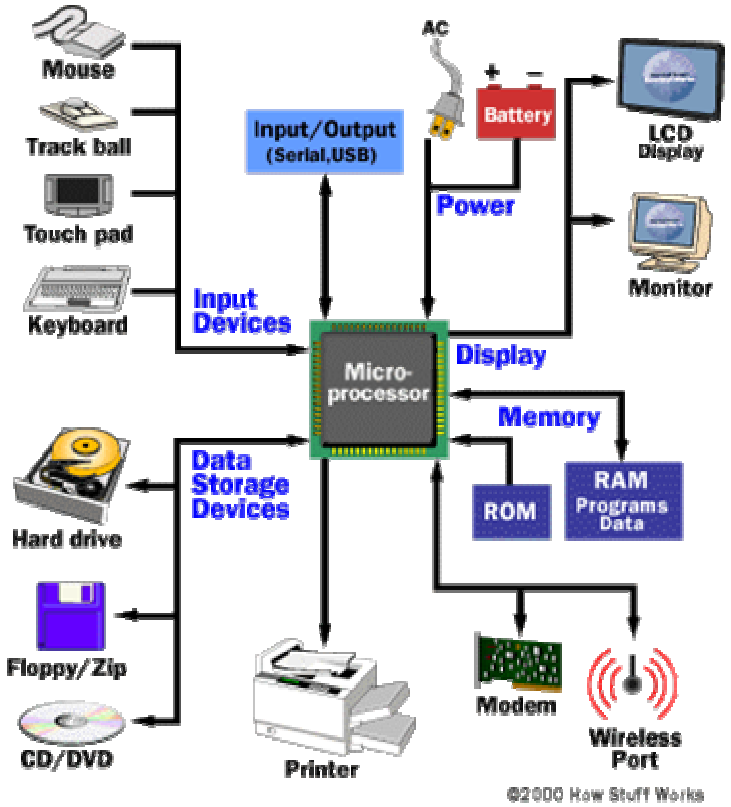
Toshiba Satellite Pro laptop computer

The major parts of the Toshiba Satellite Pro laptop computer.

Like all computers, laptops have a central brain called a microprocessor, which performs all of the operations of the computer.

The microprocessor:

- has a set of internal instructions stored in memory, and can access memory for its own use while working.
- can receive instructions or data from you through a keyboard in combination with another device (mouse, touchpad, trackball, trackstick).
- can receive and store data through several data storage devices (hard drive, floppy drive, Zip drive, CD/DVD drive).
- can display data to you on computer monitors (cathode ray monitors, LCD displays).
- can send data to printers, modems, networks and wireless networks through various input/output ports.
- is powered by AC power and/or batteries.



Schematic diagram showing the various parts of a laptop computer.

To learn more about "How They Work" click here, or choose from the map below:

How Laptops Are Like Desktops

For the most part, laptops have the same major parts as desktops:

- microprocessor
- operating system
- solid-state memory
- disk drives
- input/output ports
- sound cards and speakers

Microprocessors

Like standard desktops, laptops are powered by microprocessors. The microprocessor is the brain of the laptop and coordinates all of the computer's functions according to programmed instructions (that is, the operating system software). The DX-4 processor shown in the photo below is no longer used, but it is typical of modern laptop microprocessors in that it is customized for laptop use. A typical laptop processor has features that reduce power consumption and heat. For example, laptop processors often run at a lower voltage and often have multiple sleep or slow-down modes that significantly increase battery life. Typical laptop microprocessors include Motorola's PowerPC family (used in Apple Macintosh computers), Intel's Pentium and Celeron families (used in PCs) and AMD's K5 and K6 families (used in PCs).

Close-up of the Toshiba's Intel 486 DX4 microprocessor. This microprocessor is no longer used in laptop computers.

Operating Systems

The operating system is the set of pre-programmed instructions that tell the microprocessor what to do. Operating systems on laptops include Windows 98/2000/NT (Microsoft) and Mac OS, depending upon the type of computer (PC vs. Mac), and Linux (Linux is not an option for most consumers, but some third-party developers are writing applications for this operating system on laptops).

Memory

Laptops have memory , both RAM and ROM, just like desktops. The laptop's ROM chip contains the BIOS just as it does in a desktop computer. (See How Bios Works for details.) RAM stores the application software and data files while the computer is on. RAM differs on a laptop in that it uses a different form factor -- that is, the size and shape of the modules that carry the RAM. Manufacturers have to build laptops to be portable (smaller) and to withstand more jostling (durable) than a desktop would ever get, so the memory modules have to be different. While some laptops use a standard Small Outline Dual Inline Memory Module (SODIMM), others use the manufacturer's proprietary memory modules. Most laptops should have at least 64 MB of RAM to have sufficient memory to run operating systems and applications software. Also, some laptops allow you to upgrade the memory of your computer and come equipped with convenient access panels to plug in additional memory chips.

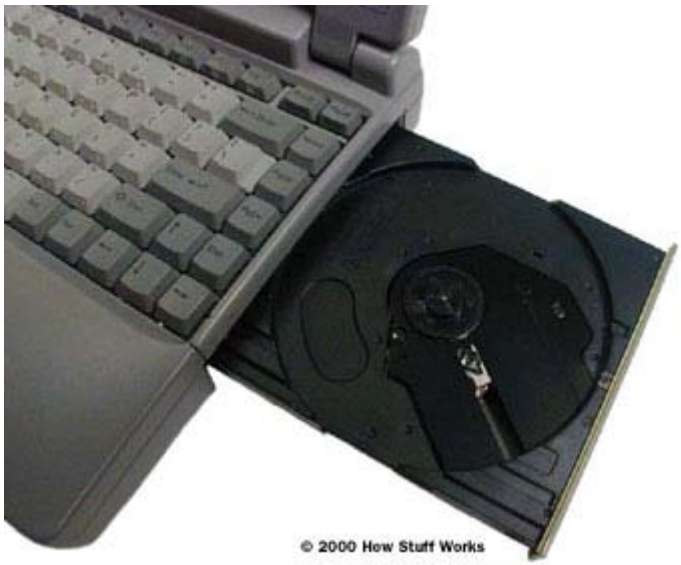
Access panel to the memory chips on the laptop's underside.

Close-up of Toshiba's memory chips.

Disk Drives

Like desktops, laptops have various disk drive storage devices. All laptops have an internal hard disk drive, usually 6 to 20 gigabytes (GB). The hard disk drive stores operating systems, application programs and data files. Although the hard disk drive works the same in a laptop as it does in a desktop, laptops generally have less disk space than desktops and you will have fewer choices for hard disk drives in laptops. The smaller hard disk space is one of the chief limitations of laptops.

Close-up of Toshiba's hard drive.



Close-up of Toshiba's CD-ROM drive.

In addition to hard drives, most laptops have some type of removable disk storage system, such as floppy disks, Zip disks, compact discs (CD) and DVDs. There are three options for disk drives in laptops:

- Some laptops have more than one bay built into the case for disk drives (such as floppy drive and CD-ROM drive).
- Some laptops have one bay that you can swap or interchange various drives. You just pull one drive out and put another in:
    - **"cold-swappable" drive** - You must turn the computer off, change drives, then reboot the computer.
    - **"hot-swappable" drive** - You can change the drives without turning the computer off. This feature saves you the time involved in restarting the computer.
- Some laptops have no internal drives. All drives are external and connected to the computer by cables. This feature allows the laptop to be very small and thin.

Input/Output Ports

Computers need to talk to other devices (such as printers, modems and networks). Computers send and receive information through various input/output ports, which can include serial ports, parallel ports and Universal Serial Bus (USB) ports.

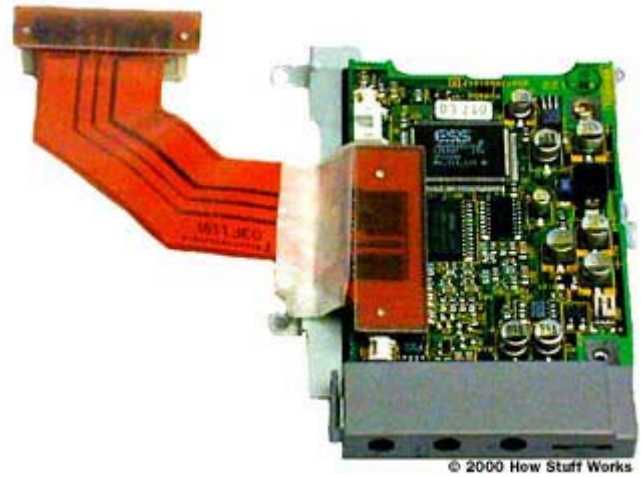
The back panel of the Toshiba Satellite Pro laptop computer, showing the various input/output ports.

In addition to ports, some laptops have expansion slots for PCMCIA standard adapter cards (Type I and Type II) or "PC " cards. These cards can be used to upgrade your laptop by adding memory, a modem, a network connection or a peripheral device (for example, a CD-ROM drive).

The Toshiba Satellite Pro has a PC card for modem/Ethernet connections.

Sound Cards and Speakers

Like desktops, most laptops are equipped with sound cards and speakers so they can play music from CDs. However, the quality of the speakers built into most laptops does not match that of speakers for desktops, because space is a major limitation in a laptop case. The Toshiba laptop that we dissected has a sound card and jacks so you could hook up a microphone or headphones; it also has a small speaker for sound.



Sound card of the Toshiba Satellite Pro laptop.

To learn more about "How They Work" click here, or choose from the map below:

How Laptops Differ from Desktops

Laptops differ from desktops in the following features:

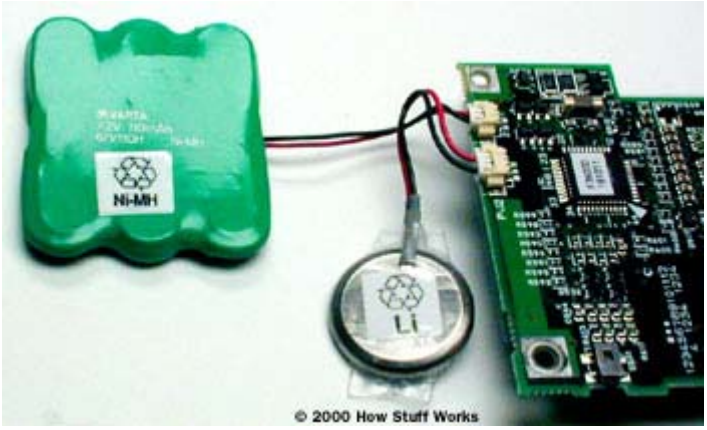
- power supply
- displays
- input devices
- docking connections

Power Supply

Like desktops, laptops can be plugged into the wall to receive AC power from the electric power grid through an AC adapter. But what makes the laptop unique is that it is portable; so, laptops are also powered by batteries. All laptops use some type of rechargeable battery (lithium, nickel-cadmium, nickel-metal hydride).

The Toshiba Satellite Pro's rechargeable battery.

The battery life varies depending on the type of rechargeable battery (lithium batteries tend to hold their charge longer) and how you use your computer (frequent use of disk drives consumes a lot of battery power). In addition to the main battery, laptops have other batteries to run clocks and backup CMOS RAM.



The Toshiba Satellite Pro's backup batteries.

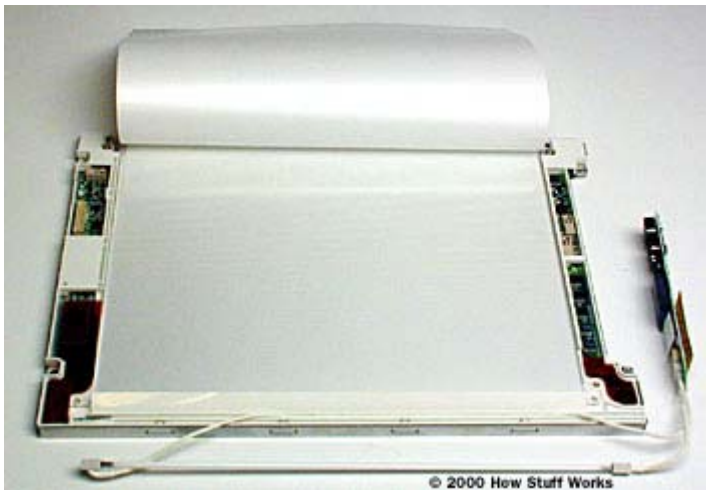
Many laptop computer models have power management software to extend the battery life, or conserve battery power when the battery is low. You may notice that as your battery gets low, your laptop runs slower. This effect is typically the result of internal power management software, and indicates that you should plug in the computer's AC adapter, or quit and re-charge your battery.

Displays

All laptops have some type of LCD display screen. Laptop LCD displays can be:

- 12 to 15 inches
- black-and-white (16 grayscale) or color (65,536 colors)
- passive or active matrix - active matrix displays have sharper images and are easier to read
- reflective or backlit - backlit screens are good for low-level room lighting conditions

Front view of the Toshiba's LCD panel.



Back view of the Toshiba's LCD panel, showing the fluorescent tube that provides the light and the screen that diffuses the light evenly over the surface.

Modern laptop computers have 800 x 600 pixel resolution, which makes for a clear screen; anything less than this resolution should be avoided.

Input Device

For a desktop computer, you typically use a keyboard and mouse to enter data. However, because using a mouse takes up room, other devices are built into laptops to take its place. Laptops come with one of three input devices:

- **trackball** - rotating the ball allows you to move the cursor on the LCD screen
- **trackpoint** - pushing your finger over the point allows you to move the cursor
- **touchpad** - moving your finger across the pad allows you to move the cursor

All of these devices have buttons that act like the right and left buttons on a mouse. Also, most laptops have a port that allows you to hook up a mouse to your laptop if you wish.

Close-up of the Toshiba's keyboard, showing the trackpoint device.

Close-up of a touchpad from another laptop computer.

Docking Connections

Some people find that it is difficult or uncomfortable to use a laptop at their desk. The screen may be too small to see adequately. The keyboard may be slightly smaller than a standard keyboard. The touch pad may not be as comfortable to use as a mouse. Perhaps they want to have access to more than one type of disk drive. To make the laptop more convenient for desktop use, the **docking station** was invented. The docking station has several peripheral devices (full-size computer monitor, full-size keyboard, mouse, disk drives, printer) connected to it. You just plug your laptop into the station to use it as a desktop computer; in other words, you make one connection to your laptop instead of many. Most laptops have a docking connection.

Close-up view of the docking connection on the back of the

Toshiba Satellite Pro.

To learn more about "How They Work" click here, or choose from the map below:

Future Trends

Like any other computer, future laptops will have faster microprocessors with more memory. The storage devices may change from removable disks (floppy, Zip, CD, DVD) to solid state memory, which could make them even lighter and thinner. While some models of laptops already have the ability to send and receive data using infrared and wireless Internet technologies, this feature may become more common. In the future, laptops may eventually be replaced by wearable computers.

What They Can Do

A laptop is a full-blown, genuine computer that can do anything a desktop computer can do. For example, you can do programming, word processing, spreadsheets, databases, accounting and multimedia presentations. In fact, many people in the How Stuff Works office use laptops as their only computer.

The portability of laptops allows you to do many things that you cannot do with a desktop. For example, you can write your sales proposal, article or business presentation while travelling on a plane, or commuting on the bus or train or subway. We will discuss some examples of laptop uses in the following fields:

- education
- entertainment
- law enforcement
- amateur astronomy
- navigation
- business

To learn more about "What They Can Do" click here, or choose from the map below:

Education

Students and educators have found that laptops answer a lot of their needs. In fact, some colleges and universities that require incoming freshmen to have computers recommend laptops. Teachers have found a variety of uses for laptops, too.

Lecture Presentations

In college, where lectures to large classes are commonplace, many professors can use their laptops, along with other audiovisual equipment, to project slides or lecture notes. And as technology creeps further into public elementary, middle and high schools, there is a growing trend toward teachers using laptops in the classroom for lectures.

Notetaking

Students can use laptop computers to take notes during lectures; this is more common in college than in lower schools. However, many special education students do use laptops for notetaking, or to run specialized software, such as hearing interpreters. As another example, if a student is injured and cannot use his/her writing arm, the school system may issue a laptop for notetaking or for downloading notes supplied by the teacher.

Laboratories

In both colleges and lower schools, science students can use laptops for gathering data from

laboratory experiments. Laptops can also be taken into the field to gather data. For example, laptops can be hooked up to probes, such as pH electrodes or temperature probes, and taken to a salt marsh, stream or lake. Students can then measure pH and temperature and use the data to study the environment. In addition to laptops, scientific calculators and PDAs can also be equipped for taking these types of measurements.

To learn more about "What They Can Do" click here, or choose from the map below:

Other uses

Laptops are becoming quite commonly used for business and for pleasure.

Entertainment

Because most laptops either have standard or optional internal CD-ROM or DVD drives, you can play music CDs or movie DVDs on your laptop. Imagine sitting on a long flight or train commute during which you can type your presentation for work, and listen to your own music CD. Or perhaps you're on a plane and you don't like the in-flight movie; if your laptop has a DVD drive, you can just pop in your own movie and enjoy!

Law Enforcement

Many police cars are now equipped with laptop computers. Police officers can use laptops to type incident reports immediately at the scene, rather than take notes and type the reports later. This time saving feature allows them more time to patrol. Furthermore, police can also use laptops with wireless connections to central police headquarters to check such things as criminal records, vehicle registrations and outstanding warrants, which saves time and can assist in making arrests.

Amateur Astronomy

Because laptop computers are so portable, amateur astronomers can take them easily to observing sites. Computers can be used to drive telescopes to various celestial objects. Furthermore, if the telescope is equipped with a CCD camera, the laptop computer can be used to acquire, process and display the image from the CCD.

Navigation

When sailing and boating, it is essential to know precisely where you are on the water. On small boats, space is a premium; they cannot have chartrooms or large chart tables. So, you can use a laptop computer, equipped with appropriate software and a global positioning system (GPS) device, for precise navigation.

Business

Some may say that the business field has benefited the most from the laptop computer. Salespeople can use the laptop to make presentations to customers, access company data over the Internet and process orders while on the road. At trade shows and conventions, it is easy to setup a laptop for a multimedia presentation of your company's products and services.

These are just a few examples of how you can use laptop computers; there are many more. See the Links section for links on some of the subjects we've talked about.

Features

When you shop for a laptop, you should take a look at the features of the models you are considering to figure out what you need. We will look at features that have to do with the performance and the convenience of the computer.

To learn about features click here, or choose from the map below:

Performance

Features that affect the performance of the computer include:

- **microprocessor** - Pentium, Celeron, AMD, or G4
- **operating system** - Windows (98, 2000, NT) or Mac OS
- **RAM**
- **disk drives** - hard, floppy, Zip, CD, DVD
- **display** - color vs. monochrome, active vs. passive
- **battery** - lithium, nickel-cadmium, nickel-metal hydride
- **input/output ports** - parallel, serial , USB
- **fax/modem** - internal vs. external
- **sound cards and speakers**

Microprocessors

Like standard desktops, laptops are powered by microprocessors. The microprocessor is the brain of the laptop and coordinates all of the computer's functions according to programmed instructions (i.e. the operating system software). For Apple Macintosh users, the choice of microprocessor is limited. Most Powerbooks and iBooks are equipped with Motorola's G3 version of the PowerPC family, although some high-end Powerbooks can have the G4 microprocessor. For PC users, there is a wider variety. You can choose from Intel's Pentium and Celeron families or AMD's K5 and K6 families. Pentium III microprocessors tend to be found in high-end laptops, whereas Celeron and AMD chips tend to be found in lower-end models. The choice between these chips depends upon your needs for speed versus cost. Click here for a discussion of the differences between Pentium and Celeron chips.

Operating Systems

The operating system is the set of pre-programmed instructions that tells the microprocessor what to do. Operating systems on laptops include Windows 98/2000/NT (Microsoft) and Mac OS, depending upon the type of computer (PC vs. Mac); some systems can be loaded with Linux, although this is not an option for most consumers. You may also want to consider that the latest operating system (e.g. Windows 2000 or Windows NT) may not be the best one for your laptop. Operating systems vary in their use of power management, security encryptions (in case your laptop is stolen) and cost. See the Links section for information regarding the best operating

system for your notebook computer.

RAM

With all of the options out there, you may be wondering how much memory you need in your laptop. You should probably buy a laptop with a **minimum of 64 MB RAM**. Also, check to see how much VRAM you have, because this will be important in running graphics (**minimum = 2 MB VRAM**). Some laptops allow you to upgrade memory, and may have an easy access panel that provides for convenient switching of memory chips. In other upgradeable laptops, you have to open the case to get under the keyboard to add memory, or send it to a repair technician.

In this Toshiba laptop, there is a convenient access panel underneath that you can access to add memory.

Disk Drives

Like desktops, laptops have various disk drive storage devices. All laptops have an internal hard disk drive, usually 6 to 20 GB. You will have fewer choices in hard disk drives in a laptop than you would in a desktop model, but 10 GB is a reasonable storage capacity.

In addition to hard drives, most laptops have some type of removable disk storage system, such as floppy disks, Zip disks, compact disks (CD) and digital video disks (DVD). There are three options for disk drives in laptops:

- Some laptops have more than one bay built into the case for disk drives (such as a floppy drive or a CD-ROM drive).
- Some laptops have one bay that you can swap or interchange various drives. You just pull one drive out and put another in:
    - **"cold-swappable" drive** - You must turn the computer off, change drives, and then reboot the computer.
    - **"hot-swappable" drive** - You can change the drives without turning the computer off. This feature saves you the time involved in restarting the computer.
- Some laptops have no internal drives. All drives are external and connected to the computer by cables. This feature allows the laptop to be very small and thin.

Displays

All laptops have some type of LCD display screen. Laptop LCD displays can be:

- from 12 to 15 inches
- black-and-white (16 grayscale) or color (65,536 colors)
- passive or active matrix - active matrix displays have sharper images and are easier to read
- reflective or backlit - backlit screens are good for low-level room lighting conditions

- 800 x 600 pixel resolution or less.

Large screen sizes, active matrix and backlighting make a better display, but also increase the price of the computer. A 13- to 14-inch, active matrix, color screen is worth the investment, though, especially if you plan to search the Internet often or make multimedia presentations using your laptop. The screen should have 800 x 600 pixel resolution or higher for clear, crisp displays. You needn't settle for a resolution of 640 x 480 pixels because the higher resolution is fairly standard now.

Batteries

To make laptops portable, they are powered by batteries. All laptops use some type of rechargeable battery (lithium, nickel-cadmium, nickel-metal hydride). The battery life varies, depending upon the type of rechargeable battery (lithium batteries tend to hold their charge longer and have no memory effect) and how you use your computer (frequent use of disk drives consume a lot of battery power). A battery should have a minimum life of 2 hours; of course, 4 hours is even better.

Many laptop computer models have power management software to extend the battery life, or conserve battery power when the battery is low; power management software may be built into the operating system. You may notice that as your battery gets low, your laptop runs slower. This effect is typically the result of internal power management software, and indicates that you should plug in the computer's AC adapter, or quit and re-charge your battery. Laptops can be plugged into the wall to re-charge the battery, or can be connected directly to AC power through an AC adapter.

Laptop computer batteries can cost from $50 - $250 depending upon the type of battery and computer. If you travel frequently, especially if you travel long distances, then you may want to consider buying an extra battery.

Input/Output Ports

Computers need to talk to other devices (e.g. printers, modems, networks). Computers send and receive information through various input/output ports which can include serial ports, parallel ports and Universal Serial Bus (USB) ports. At minimum, you should have a printer port, which is usually a parallel port, and one or two USB ports.

In addition to ports, some laptops have expansion slots for PCMCIA standard adapter cards (Type I and Type II) or "PC " cards. These cards can be used to upgrade your laptop by adding memory, a modem, a network connection or a peripheral device. A PC card slot will help extend the life of your laptop by allowing you to upgrade rather than replace your laptop in the future.

You may want to look for a docking station port on your computer. The **docking station** was invented to make the laptop more convenient for desktop use. The docking station has several peripheral devices (full-size computer monitor, full-size keyboard, mouse, disk drives, printer) connected to it. You just plug your laptop into the station, and you're ready to use it as a desktop computer; in other words, you make one connection to your laptop instead of many. Most laptops have a docking connection.

Fax/Modem

If you have to communicate with your company or customers while on the road, access e-mail, fax documents or access the Internet, you will need a modem. Look for a laptop with an internal fax/modem with a minimum of 56 kps. This will allow you to send and receive information by just hooking up to a phone connection. If your laptop does not have an internal fax/modem, you may be able to add one through a PC card slot.

Sound Cards and Speakers

Like desktops, most laptops are equipped with sound cards and speakers so they can play music from CDs. However, the quality of the speakers built into most laptops does not match that of speakers for desktops, because space is a major limitation in a laptop case. If your laptop has no sound equipment, you can add it through a PC card slot. If sound quality is important to you, you can upgrade it by using external speakers.

To learn more about features click here, or choose from the map below:

Convenience

Now that we have addressed features for performance, let's consider features for convenience:

- **type of input device**
- **keyboard**
- **size**
- **weight**
- **case**
- **feel**
- **software**
- **carrying case**

Input Device

For a desktop computer, you typically use a keyboard and mouse to enter data. However, because using a mouse takes up room, other devices are built into laptops to take its place. Laptops come with one of three input devices that allow you to move the cursor on the LCD screen:

- **trackball** - rotating the ball allows you to move the cursor on the LCD screen (usually built-in, but add-on ones that clip to the side of your laptop are available)
- **trackpoint** - pushing your finger over the point moves the cursor
- **touchpad** - moving your finger across the pad moves the cursor

All of these devices have buttons that act like the right and left buttons on a mouse.

Some laptops have a touchpad input.

The type of device you want is purely a matter of preference. Some people prefer the feel of a trackball over a touch pad. If you can, try out various input devices to see what feels right to you. Remember, most laptops have a port that allows you to hook up a mouse to your laptop; but again, that will be another device to carry around if you want to use it on the go.

Keyboard
Because space is a premium for laptops, their keyboards tend to be smaller than desktop keyboards. Although you won't find an ergonomic keyboard, like the Microsoft natural keyboard, on a laptop, most laptop keyboards have some ergonomic features, such as being located at the back half of the unit to provide wrist support. The arrow keys will most likely be in different places to conserve space, and you may not have a numeric keypad. If you can, try out several laptops to see if the keyboards feel comfortable; this is especially important for touch typists.

Size and Weight
The size of the laptop is an important feature, seeing as the key advantage of a laptop is its portability. Consider the length, width and thickness, and make sure it will fit in whatever you plan to carry it around in, if you have something in mind. If you can, when you are shopping for your laptop, pick it up and carry it as you would a notebook. Does it feel comfortable?

Like size, weight is an important feature. Laptops vary in weight from 4 to 10 lb (2 to 5 kg). If you will be traveling frequently, you will probably want a light laptop (under 5 lb or 2 kg). Again, pick up the laptop that you are interested in. Can you carry it easily?

Case
Because you'll be carrying the laptop, there's a chance that you'll eventually drop it. Find out what material the manufacturer uses for the case. For example, the IBM Thinkpad has a titanium composite cover. This is a hard criteria to test out (the store won't be happy if you drop every laptop you're interested in), but it would still be useful to know.

Feel
Again, check out several models of laptops before you buy. Does the keyboard feel comfortable in combination with the input device? Is the screen large enough to see easily? We have talked about individual features separately, but it is important to check them out together to assess the overall feel of the model. Comfort is key in a laptop.

Software
Keep in mind what you intend to use your laptop for when you're shopping. Many laptops have software packages pre-installed or included in the box. Most tend to be word processing software, like Microsoft Word, or integrated software such as Microsoft Works or ClarisWorks. Check to see if the included software matches your needs; otherwise, you may have to spend several hundred dollars extra to get the appropriate software. Also, does the computer have sufficient memory and microprocessor speed to run the software you plan to use?

Carrying Case
Although carrying cases are not standard with laptop computers, consider spending the extra money to purchase a good one. Look for a carrying case that has the following features:

- lightweight
- rests comfortably on your shoulder (padded shoulder strap)
- waterproof or water-resistant (after all, you may have to walk in the rain)
- has enough space for your computer and accessories (disk drives, disks, AC adapter)
- has a padded compartment to protect the laptop should you drop the carrying case

Cost
Laptop computers vary in price from about $1,000 to $4,000 or more, depending on the various features. Low-end laptops range from $1,200 to $1,600. Many retailers are offering $30 to $400 in rebates if you contract with a particular Internet service provider (ISP). If you do not have a current ISP, this might be a reasonable way to reduce the cost of your laptop. Note that the contracts usually lock you into one particular provider for two to three years.

When You Shop

We've created a Laptop Feature Comparison chart for you to use as you research various models. Take it to the store with you and fill in the blanks for each model you are interested in. You may also want to keep an additional copy near your desk as you research models on the Internet.

The feature comparison chart is available to you as a PDF. You will need the free Adobe Acrobat Reader to view it.

- Download the comparison chart!

Look Out!

When buying a laptop computer, there are several things you should keep in mind to avoid buying one that won't meet all your needs. Here are some of the most important things to think about:

Make sure the microprocessor meets your needs.
If you will be doing lots of graphics or programming, you will probably need the speed of a Pentium III or G4 microprocessor. If you will use your laptop for basic word-processing, Web browsing or office management, then the AMD or Celeron microprocessors will be fine.

The latest operating system may not be the best for your laptop.
Operating systems vary in their use of power management, security encryptions (in case your laptop is stolen) and cost. The best operating system for a desktop may not be the best operating system for a laptop. See the Links section for information regarding the best operating system for your notebook computer.

Make sure you have at least 64 MB of RAM.

Look for easily upgradeable memory.
Does your laptop have an easy access panel to get at the memory chips? Do you have to open the case to get under the keyboard to add memory? Do you have to send it to a repair technician?

Know your battery life!
Your battery is essential to the portability of your laptop. Batteries will die. You will need a minimum of two hours of battery life; of course, four hours is even better. The battery life varies depending on what type of rechargeable battery you use (lithium batteries tend to hold their charge longer and have no memory effect) and how you use your computer (frequent use of disk drives consume lots of battery power). Also, look at the battery gauge in your software frequently so that you are not in the middle of some important project when your battery dies.

Count the input/output ports.
Computers send and receive information through various input/output ports, which can include serial ports, parallel ports and Universal Serial Bus (USB) ports. At minimum, you should have a printer port, which is usually a parallel port, and one or two USB ports.

One or two PC slots will help extend the life of your laptop by allowing you to upgrade rather than replace your laptop in the future.

Look for an internal fax/modem!
If you have to communicate with your company or customers while on the road, access e-mail, fax documents or access the Internet, then you will need a modem. Look for a laptop with an internal fax/modem (minimum 56 kps), because lugging a modem around with you is far from ideal.

Test out the input device.
Laptops use either a trackball, trackpoint or touch-pad to move the cursor across the screen. All of these devices have buttons that act like the right and left buttons on a mouse. The type of device you choose is totally a matter of personal preference. Some people prefer the feel of a trackball to a touch pad. If you can, try out the various input devices to see what feels right for you. Remember, most laptops have a port that allows you to hook up a mouse to your laptop, if you wish, but that will be another device to carry around if you want to use it on the go.

Check the feel of the keyboard.
Laptop keyboards tend to be smaller than desktop keyboards. If you can, try out several laptops and see if the keyboards feel comfortable to you; this is especially important for touch typists.

Look at the software.
Keep in mind what you intend to use your laptop for when you buy it. Many laptops have software packages pre-installed or included in the box. Most tend to be word processing software (Microsoft Word) or integrated software (such as Microsoft Works or ClarisWorks). Check to see if the included software matches your needs; otherwise, you may have to spend several hundred dollars extra to get the appropriate software. Also, does the computer have sufficient memory and microprocessor speed to run the software you intend to use?

Check the warranty
Read the fine print. A good warranty will cover parts and labor for three years. Also, toll-free, around-the-clock technical support is great. Some warranties may have a 24-hour replacement/repair policy (good when you are away from home). If these features are not in your warranty, consider a supplemental extended service contract.

Keep your laptop with you!
Do not entrust your laptop to baggage claim on the airlines -- you will run a high risk of damage. Also, laptop computers are prime targets for thieves. They are easy to carry off and easy to resell.

Manufacturers

- Apple
- Compaq
- Dell
- Gateway
- HP
- IBM
- Sony
- Toshiba

FAQ

What is the best microprocessor?
If you do lots of graphics (computer-aided drafting, engineering design) or programming, then you will probably need the speed of a Pentium III or G4 microprocessors. On the other hand, if you will use your laptop for basic word-processing, Web browsing or office management, then the AMD or Celeron microprocessors will be fine.

How much memory do I need?
You should have at least 64 MB of RAM. Check to see whether your memory is upgradeable. If so, then your laptop should have an easy access panel to get at the memory chips.

How long will my battery last?
You should look for a laptop with a lithium battery, because lithium batteries tend to hold their

charge longer than nickel-cadmium or nickel-metal hydride batteries, and have no memory effect. Whatever battery you choose, you will need a minimum of two hours of battery life; but of course, four hours is even better. The battery life varies depending on what type of rechargeable battery you have and how you use your computer (frequent use of disk drives consumes a lot of battery power).

How much space should my hard drive have?
All laptops have an internal hard disk drive, usually 6 to 20 GB (**10 GB is a reasonable storage capacity**).

What other drives should I have in my laptop?
You should have at least a standard floppy drive; you may want a higher capacity Zip drive as well. Also, if you want to be able to play music or movies on your laptop, you'll need a CD-ROM or DVD-ROM drive.

What is a swappable drive?
To make the laptop smaller and lighter, many models have **"swappable"** or **interchangeable drives**. With a swappable drive, there is only space in the case for one drive (floppy drive, Zip drive or CD/DVD drive). If you want to change from one type of disk drive to another, you just pull one out of the bay and put the other one in. In some laptops with swappable drives, you must turn the computer off first, change the drive and then reboot the computer. Other laptop models may have a **"hot swappable" drive**, in which you can interchange the drives without turning the computer off; this feature saves you the time involved in restarting the computer. While swappable drives allow you to use several types of drives in your laptop, remember that you will have to carry those extra drives with you if you want to use them on the go.

What type of screen should I get?
Large LCD screen sizes, active matrix displays and backlighting will make your laptop's screen easier to see, but these technologies will also increase the price of the computer. A 13- to 14-inch, active matrix, color screen is worth the investment, especially if you plan to search the Internet often or make multimedia presentations.

What type of input/output ports should my laptop have?
Computers send and receive information through various input/output ports, which can include serial ports, parallel ports and Universal Serial Bus (USB) ports. At minimum, you should have a printer port, which is usually a parallel port, and one or two USB ports.

What is a PC card slot?
In addition to ports, some laptops have expansion slots for PCMIA standard adapter cards (Type I and Type II) or "PC " cards. These cards can be used to upgrade your laptop by adding memory, a modem, a network connection or a peripheral device (such as a CD-ROM drive). One or two PC slots will help extend the life of your laptop by allowing you to upgrade rather than replace your laptop in the future.

What is a docking station?
If you will use your laptop as a desktop as well, you may want to look for a docking station. With the docking station, you can connect several peripheral devices (full-size computer monitor, full-size keyboard, mouse, disk drives, printer) permanently. You just plug your laptop into the station, and you're ready to use it as a desktop computer; in other words, you make one connection to your laptop instead of many. Most laptops have a docking connection.

Which type of input device is the best?
Laptops use either a trackball, trackpoint or touchpad technology to move the cursor across the screen. All of these devices have buttons that act like the right and left buttons on a mouse. The type of device you choose in a matter of personal your preference. Some people prefer the feel of a trackball to a touch pad. If you can, try various input devices out to see what feels right for you.

Remember, most laptops have a port that allows you to hook up a mouse to your laptop, if you wish, but that will be another device to carry around if you want to use it on the go.

Do I need to buy a carrying case?
A carrying case provides a single place to store your laptop and its accessories. If you travel frequently, you will definitely need one. Look for a carrying case that has the following features:

- lightweight
- fits comfortably on your shoulder (padded shoulder strap)
- waterproof or water-resistant (After all, you may have to walk in the rain.)
- has enough space for your computer and accessories (disk drives, disks, AC adapter)
- has a padded compartment to protect the laptop should you drop the carrying case

Should I buy an extended warranty?
Read the fine print of your warranty. A good warranty will cover parts and labor for three years. Also, toll-free, around-the-clock technical support is great. Some warranties have a 24-hour replacement/repair policy (good when you are away from home). If these features are not in your warranty, consider a supplemental extended service contract.

Cool Facts

- NASA uses a specialized model of the IBM Thinkpad (running Microsoft Windows 95) for work in the space shuttle and in the International Space Station.
- Apple's Air Port technology allows I-Book laptops, along with Apple desktops, to connect to the Internet over a wireless connection at a high speed.
- Compaq now offers an Eddie Bauer model laptop computer, just as Ford offers Eddie Bauer model vehicles.
- New laptop computers can weigh as little as 3.75 lbs (1.7 kgs).
- Many newer laptops come with pre-assigned buttons that automatically control a CD player or MP3 playing functions.