



CNET EDITORS' **Monitor** BUYING GUIDE



CNET's editorial experts tell you everything you need know to get the best picture for the best price.

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2. LCD vs. CRT
3. LCD basics
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5. Judging image quality
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1 WHAT KIND OF MONITOR IS BEST FOR ME?

With so many monitors to choose from, before you buy, it pays to figure out which specs and features will be most important to you. These user profiles will start you off in the right direction.

Home user

Home users need to balance price and performance. Extra features such as speakers or USB ports are an important consideration, and depending on where the computer is located, aesthetics may matter as well.

KEY FEATURES:

Price

Good color performance

Sharp text

Design/appearance

Video input

RECOMMENDATIONS:

▶ [IBM ThinkVision L150p](#)

▶ [BenQ FP767-12](#)

▶ [NEC AccuSync LCD9V](#)

▶ [Samsung SyncMaster 957MB](#)

Business user

Businesses need some bang for the buck, but they are willing to pay for productivity. Bells and whistles are not as important as good image quality and adjustability for viewing comfortably for long stretches.

KEY FEATURES:

Large image area to display more information

Adjustability

Energy efficiency

Compact form factor

Reliability

RECOMMENDATIONS:

▶ [Planar PX212M](#)

▶ [Dell 1901FP](#)

▶ [Planar PE170](#)

▶ [DoubleSight DS-1500](#)

Student

Academic life often means cramped quarters, with a budget to match. Students need a lightweight, portable design, a small footprint, and image quality good enough for both work and play.

KEY FEATURES:

Low cost

Small form factor

Easy to move

Video input optional, but handy

RECOMMENDATIONS:

▶ [IBM ThinkVision L150p](#)

▶ [Samsung SyncMaster 172MP](#)

▶ [Dell 1901FP](#)

Digital photographer/graphic artist

With too many monitors, what you see onscreen is not what you get from your printer. People working with digital images need excellent color fidelity and consistent results, and CRTs are generally superior in these areas.

KEY FEATURES:

Color calibration

Excellent screen geometry

Large display area

High resolution

RECOMMENDATIONS:

In recent years, CRT technology has advanced to the point where there is very little difference in performance among brands. In other words, unless you buy the absolute cheapest CRT, you should be happy with whatever you choose.

Gamer

It's all about speed for serious game players. Eye-popping image quality is essential, but a lightning-fast pixel-response time is the key to keeping images sharp when the action starts. Although LCDs are making strides, CRTs currently offer the best performance for gaming.

KEY FEATURES:

Pixel-response time

Color accuracy

Large image area to display more of the action

RECOMMENDATIONS:

In recent years, CRT technology has advanced to the point where there is very little difference in performance among brands. In other words, unless you buy the absolute cheapest CRT, you should be happy with whatever you choose.

Video editor/movie buff

When digital DeMilles edit the key close-up in their masterwork, they want total artistic control, and they need crisp, accurate images. Movie buffs watching at home will want the same. At this point, CRTs are superior for displaying video.

KEY FEATURES:

Pixel-response time

Color accuracy

Large display area

Alternate signal inputs a plus

RECOMMENDATIONS:

In recent years, CRT technology has advanced to the point where there is very little difference in performance among brands. In other words, unless you buy the absolute cheapest CRT, you should be happy with whatever you choose.

② LCD VS. CRT



In a marketplace full of so many types of displays, in so many sizes, finding the right monitor can be a challenge. CNET provides some basic information to help you get your bearings.

Your budget range

The size of your budget will dictate the size and type of your monitor. Here's a cheat sheet to help you figure out what your options are.

What you'll pay	What you'll get
\$50 to \$100	15-inch CRT
\$100 to \$250	17-inch CRT
\$250 to \$350	15-inch LCD or 19-inch CRT
\$350 to \$500	17-inch LCD or 21-inch CRT
\$500 to \$1,000	18- or 19-inch LCD or 22-inch CRT
\$1,000 and up	20-inch LCD and larger

Note: These ranges reflect the lower end of the price spectrum and are based on the latest street/online prices as of this writing.

What is an LCD?

LCDs, or liquid-crystal displays (also called flat panels or flat screens), are thin sandwiches of glass containing a liquid-crystal material. When exposed to electric current, the molecules of liquid-crystal material change their alignment to either transmit or block light, which ultimately creates an image. Each pixel is composed (in most cases) of red, green, and blue subpixels.



LCD monitors cost more than same-size, old-school CRTs, but they offer a few significant advantages. Here's how LCDs stack up, for better or worse.

Pros	Cons
Thin and stylish	Relatively expensive
Energy efficient	Fragile
Relatively lightweight, especially in larger sizes	Limited viewing angle
Crisp image	Color rendition may be limited or inconsistent
More display area (a 15-inch LCD is equivalent to a 17-inch CRT)	Moving images may smear
No refresh-rate flicker	May flicker from inability to synchronize with signal correctly
Little or no low-frequency electromagnetic emissions compared with a CRT	Image quality is greatly reduced when running in nonnative resolution, because the image must be scaled to match the pattern of physical pixels
Perfect screen geometry	

What is a CRT?

The original CRT (cathode ray tube) technology was invented more than 100 years ago and has been greatly refined since. Inside a color CRT, three electron guns shoot streams of electrons at the screen. A mask blocks the electrons so that the beam from one gun hits only red phosphor dots on the screen, just as the beams from the other guns only hit green or blue phosphors. By controlling the position of the beams and how fast they turn on and off, a CRT can create pixels of varying sizes, so it can produce different-resolution images with little loss of image quality.



Although they're big and boxy, CRTs are inexpensive--and indispensable for some computing tasks such as video-editing and gaming. Here's a look at the good and the bad in CRTs.

Pros	Cons
Relatively inexpensive	Large and bulky
Rugged	Energy inefficient
Unlimited viewing angle	Relatively heavy, especially in larger sizes
Generally good color rendition	Pixels are not clearly defined at any resolution
Moving images do not smear	Less display area (a 15-inch LCD is equivalent to a 17-inch CRT)
No flicker from problems with synchronizing with a signal	Refresh-rate flicker is below 75Hz; flicker is more severe with larger monitors
Can display different-resolution images with relatively little loss of quality	More low-frequency electromagnetic emissions than LCDs
	Nearly impossible to get perfect screen geometry, especially with flat-faced CRT designs
	Almost impossible to get perfect convergence of red, green, and blue beams on all parts of the screen

3 LCD BASICS

Although you'll still pay two or three times as much as for an LCD as you would for a CRT of similar size, the cost of flat panels continues to fall. When shopping for an LCD, some specifications and features are more important than others. Here are a few of the biggies.



Aspect ratio: The standard proportion in width to height for a computer monitor is 4:3, but some new displays have a wider format: 16:9 or 16:10, designed for viewing movies or HDTV in wide format. Note that a 17-inch wide-format panel has about the same vertical dimension and vertical pixel count as a normal 15-inch panel, so you get about 120 percent of the viewing area of a 15-inch panel. A 17-inch standard panel, however, has 130 percent of the viewing area of a standard 15-inch screen

Contrast ratio: A spec much hyped by manufacturers (be suspicious of their claims), this is the difference in light intensity between the brightest white and the deepest black.

Digital and analog connections: LCDs are digital devices and thus have to convert analog (VGA) signals before they can be displayed. A graphics card with a digital video interface (DVI) can send the signal straight to the display in digital format--no conversion required. Most LCDs come with an analog input (featuring a D-shaped connector that has 15 pins arranged in three rows, sometimes labelled D-Sub), some come with both, and only a very few come with just a digital input. Nevertheless, at this point, most monitors do such a good job of signal conversion that digital connections are not as important as they used to be.



Digital input



Analog input

Luminance: Brightness; a measure of how much light a panel can produce. Luminance is expressed either in nits or candelas per square meter (cd/m²). A measurement of 200 to 250 nits is OK for most productivity tasks; 500 nits is better for TV and movies.

Pixel-response rate: This refers to how quickly a pixel can change colors, measured in milliseconds (ms); the fewer the milliseconds, the faster the pixels can change, reducing the ghosting or streaking effect you might see in a moving or changing image. In general, manufacturers' specifications rely on best-case scenarios; real-world performance could be slower. A maximum of a 12ms-to-15ms response time across the spectrum is required for gaming or viewing television and movies without ghosting or streaking. We've only just begun to see LCDs with superfast pixel-response times, such as [Samsung's SyncMaster 172X](#) and [BenQ's FP767-12](#).

Portrait/Landscape modes: Some LCDs pivot so that the longer edge can go horizontal (Landscape mode) or vertical (Portrait mode). This feature can be useful for desktop publishing, Web surfing, and viewing large spreadsheets, but don't pay extra for it if you won't use it.



Portrait mode



Landscape mode

Resolution: Make sure you are comfortable with an LCD's native resolution before you buy it. Remember, an LCD that scales its image to a nonnative resolution will never look as good.

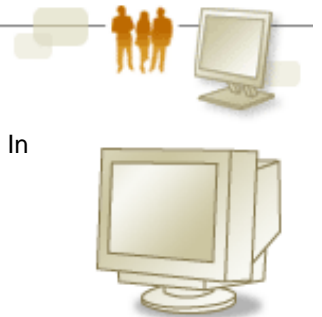
Viewing angle: The physical structure of LCD pixels can cause the brightness and even the color of images to shift if you view them from an angle rather than facing the screen directly. Take manufacturer's specifications with a grain of salt and make your own observations if possible; viewing-angle issues become more critical as panel size increases.

4 CRT BASICS

You can get a lot for your money with CRTs, although they're often much bigger and heavier than LCDs. In recent years, CRT technology has advanced, so there is very little difference in performance among brands. In other words, unless you buy the absolute cheapest CRT, you should be happy with whatever you choose. Here are some key features in CRT specifications.

Bandwidth: The rate in megahertz (MHz) at which a CRT can process information. As you approach the bandwidth limit, thin black or white lines appear gray because the electron beams cannot turn all the way on or off fast enough to keep up. Generally, the higher a CRT's bandwidth is, the faster its refresh rate is at any resolution, and the better its image quality.

Convergence: Color CRTs rely on three separate electrical beams to project simultaneous red, green, and blue images; these combine to form a full-color image. If these beams are not precisely aligned, the red, green, and blue portions of the image may not overlap correctly; the image will look unfocused and will have visible colors along the edges. When the three beams converge correctly at all points on the display, you get a perfect image.



Dot pitch: A smaller dot pitch means that a monitor can display higher-resolution images more accurately. Some manufacturers report the "horizontal dot pitch," which measures only the horizontal component of the diagonal distance between triads and offers an easier comparison to stripe-pitch measurements.



Maximum refresh rate: If an image refreshes too slowly on a CRT, you may notice a flicker. You want at least 70Hz at the resolution you intend to use. This becomes more of a factor as the screen size gets larger, as people are more susceptible to flicker in their peripheral vision.

Power consumption: CRT power consumption is typically specified in watts. A typical 19-inch model may draw 130 watts when operating--that's more than two standard 60-watt lightbulbs--and will generate a good deal of heat.

Screen size: CRTs specify the diagonal dimension of the entire picture tube. This is one to two inches larger than the viewable image size (also measured diagonally).

5 JUDGING IMAGE QUALITY



Image quality, the most important feature of a monitor, is also the hardest to judge. *Good* is a subjective term, so relying on the judgment of reviewers (such as CNET) may not get you exactly what you want. Further, like a snowflake, every monitor is unique. There can be significant differences from one monitor to another--even among the same make and model. It's unrealistic to expect to run a comprehensive diagnostic on a monitor before you buy it, but here are some of the most important qualities to look for when choosing a CRT or an LCD. We've also included a few simple tests you can do in the store to assess image quality.

LCDs: what to look for

- Choose a monitor that automatically adjusts to the timing of an analog (VGA) signal. You want to see stable gray and patterned images with no pixel jitter.
- Find a monitor with good viewing angles. Colors and brightness should not change in the corners of the screen, where the viewing angle is the greatest.
- Pick a monitor that looks uniformly bright when viewing both dark and light images.

Tips and tricks: assessing LCD image quality

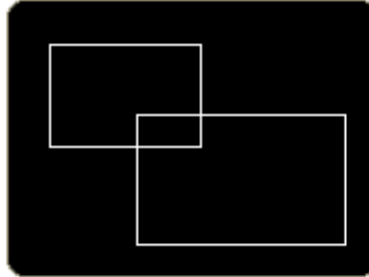
- Check for dead pixels, ones that are always off. It's not uncommon for monitors to have one or two defective pixels--especially larger models--but you want as few as possible. Open Internet Explorer, in the address line type **about:blank**, and press Enter. Then press the F11 key to make it full-screen. Look for small black specks that are not dust or debris on the screen. (Press F11 again to see the Explorer toolbars.)
- Check for stuck pixels, which are always on. Right-click the Windows Desktop, pick Properties, then choose the Screen Saver tab. Choose Blank from the list of screensavers, then hit the Preview button. Look for any glowing red, green, or blue spots. (Press any key to return to the Display Properties window.)

CRTs: what to look for

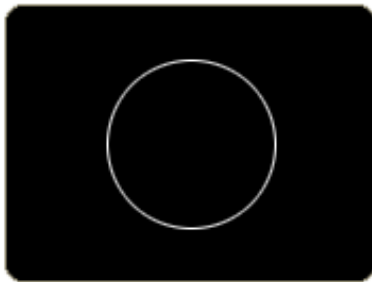
- Find a monitor with good convergence (clean white lines with no colors on the edges), as this increases image sharpness.
- Choose a monitor with good screen geometry, especially if you intend to use it for design or drawing tasks.
- Pick a monitor with good image regulation; you want an image that does not change its dimensions or distort when the content of the image changes. Poor image regulation can be a problem with lower-priced models and displays that are operated at the upper limits of their specifications.

Tips and tricks: assessing CRT image quality

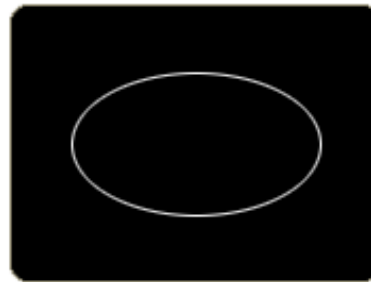
- Check the convergence of the display. Open Windows Paint and start a new image. Choose Image, then Attributes, and change the size of the image to the same number of pixels as the current resolution (to check the resolution, right-click anywhere on the desktop, select Properties, then choose the Settings tab). Use the Fill tool to fill the screen with black. Then choose the Rectangle tool, set the drawing color to white, and draw a box that fills the screen, starting in the upper-left corner. Scroll to the bottom-right corner of the image and draw another box that fills the screen. Now choose View, then View Bitmap to see the image on the full screen. You should see a black screen with two intersecting white rectangles. Check the white lines closely; you should not see any areas where the lines separate into colored lines. A slight color tinge along the edges of a line is acceptable, but a pure white line is best.



- Check the screen geometry. Look to see that the lines drawn in the previous step are straight. You can also draw a circle in the center of the image using the Circle tool (hold Shift down to draw a perfect circle), then copy and paste the circle in the corners and along the edges. Look to see that they are round--not squashed or egg-shaped.



Good geometry



Bad geometry

6 FEATURES AND CONNECTIVITY OPTIONS



As with any high-tech component, monitors come with all sorts of connections, accessories, and extra features. Some add more value than others.

Digital vs. analog

CRTs rarely provide support for digital (DVI) signals; DVI support is found primarily on LCDs. The advantage of digital signals for LCDs is of much less importance now than it was a few years ago. Analog (VGA) signal processing has improved to the point where only the most discerning eye can notice any difference. Most LCDs that support digital signals also support analog signals, so you won't need a special graphics adapter to use a DVI display.



Digital input



Analog input

To take advantage of the digital connection, you'll need a graphics adapter that has a DVI-I or DVI-D connector, and you may also need a DVI cable (many LCD monitors come with only an analog cable). DVI-D refers to a digital-only connection, and DVI-I means that the connector can carry either digital or analog signals. Analog inputs, sometimes labelled D-Sub, have a D-shaped connector with 15 pins arranged in three rows.

Extra features

Adjustability: Most CRTs sit on stands that let you tilt and swivel the screen, but LCDs are generally more flexible. Some include a swivel feature, many offer height adjustability, and most can tilt forward and backward. Some LCDs' panels can also pivot between Portrait and Landscape modes, making legal-size documents and Web pages easier to view. LCDs can be attached to VESA-compatible mounts, which connect to third-party wall mounts or swinging arms.

Audio: Some monitors offer audio functions, either as standard items or as optional accessories. These may include a headset jack, volume control, or embedded speakers. In general, these speakers are of limited quality, and an inexpensive \$30 speaker set from a computer or office supply store will often provide much better sound.

Cable-feed systems: Many LCDs have some mechanism to manage signal and power cords.



Wide-screen format: Some CRTs and LCDs come in wide-screen formats designed to display more information and show HDTV and movies in their full width without *letterboxing* (blacking out the top and bottom of the screen), as would be the case with normally proportioned displays.



Philips 170W4P

USB: Many displays have USB ports. Typically, they are not powered hubs, but simply convenient ports to connect a keyboard or a mouse, thereby reducing the tangle of cables that run back to the computer.



Video/TV: As work and entertainment products continue to converge, many monitors now have features designed to take advantage of television and movie content. Some include TV tuners and connectors for video signals from cable television systems or antennas. Some have connectors that accept composite or S-Video input signals from entertainment devices.

Wireless: Some displays are doing away with cables completely. ViewSonic's Airpanel uses Microsoft's Smart Display technology to establish a wireless connection with a desktop computer. Somewhere between a tablet computer and a remote display, it gives you more freedom to move around.



ViewSonic Airpanel
V110

Other: LCDs using Philips's LightFrame technology and various CRTs using high-brightness features allow you to increase the amount of light for a given window or the entire screen. This can be helpful when viewing movies or other graphics images. BenQ's FP591 has inputs for CompactFlash, SmartMedia, and SD/MMC removable media cards that let digital photo enthusiasts see their pictures without a PC.



BenQ FP591 USB 2.0 ports, compact media slots

7 WARRANTIES



When choosing a monitor, consider the company behind it.

First and foremost, make sure that the company offers a money-back guarantee. Most displays show their problems right out of the box or within the first month or two of use, so you want to be able to return it for a refund or an exchange with a minimum of hassle. Ninety days is standard, but this varies among retailers (many online retailers give you only 30 days). Also, beware of restocking fees.

Next, consider the warranty coverage. Most companies offer at least two to three years of parts-and-labor coverage; anything less is suspect. If you're buying an LCD, make sure that the backlight is covered by the warranty; manufacturers used to exclude them from coverage, but more and more now include them. LCD buyers should also note a company's policy on defective pixels; one or two defects are to be expected, but if there are many, you should be able to return the unit for exchange or a refund. Some companies deal with pixel problems on a "case-by-case" basis, meaning that they don't have a set policy. If you end up with a problematic display, you'll have to negotiate with them. This is where the satisfaction-guaranteed return policy can become very important.

You're far less likely to need technical support for a monitor than for a computer system or a software program. Still, it's good to know that there's someone you can call if trouble arises; look for toll-free support numbers and weekend coverage.

Be sure to keep all the packing material for your monitor. If you should ever need to return it or ship it back for warranty service, you'll need the packaging. Monitors can be bulky, fragile, and extremely difficult to protect adequately. You don't want to end up improvising.

8 GLOSSARY



CRTs and LCDs are complex devices. For readers who don't have a PhD in engineering, we've included explanations of some important terms and concepts.

Terms you should know

Aperture grille: In some CRTs, the aperture grille is a series of wires stretched vertically down the inside of the monitor to mask the beams from the electron guns at the back of the tube. In other types of monitors, this function falls to a perforated metal plate called a *shadow mask*. Some users prefer the image quality of Sony Trinitron monitors, which use an aperture grille; others notice the faint horizontal shadows cast by the grille's tensioning wires and prefer other shadow-mask designs.

Bezel: The frame around a CRT's or LCD's screen.

Convergence: Color CRTs rely on three separate electrical beams to project simultaneous red, green, and blue images; these combine to form a full-color image. If these beams are not precisely aligned, the red, green, and blue portions of the image may not

overlap correctly, degrading the overall image quality. When the three beams converge correctly at all points on the display, you get a perfect image.

CRT: Cathode-ray tube; a big bell of glass with electron guns at one end and a viewing screen at the other. Televisions and computer displays both use this imaging technology and are often simply called CRTs.

Display size: A display's length (in inches or centimeters) taken diagonally from one corner to the opposite corner. Unless it specifically states viewable screen area, a CRT's measurement encompasses the full face of the picture tube, including the part concealed by the bezel. On an LCD, only the viewable screen is measured.

Dot pitch: In CRTs, the distance from one pixel to the next-nearest one. The larger the dot pitch, the grainier an image looks.

Electron gun: A color CRT contains three electron guns that shoot electron beams, causing red (R), green (G), or blue (B) phosphors on the inside front of the screen to light up.

Footprint: The amount of space a monitor takes up on your desk, including the display and its base.

LCD: Liquid-crystal display; created by sandwiching electrically reactive, liquid-crystal material between two electrodes. The substance can be darkened or lightened by applying and removing current.

Liquid crystal: A material with some of the properties of solid crystals, such as diamonds, and some of the properties of liquids, such as water. As a result, the material can both flow as well as affect the path of light, depending on how the individual molecules are aligned.

Molecule: The smallest portion of a material. For some materials, the physical size and shape of the individual molecules affect the overall properties of the material. For example, the individual molecules of liquid-crystal material can alter the path of light and can be induced to align in specific ways in response to physical or electrical influences. It is these characteristics that make them useful in creating displays.

Native resolution: The physical structure of some types of displays, including LCDs and plasma panels, defines how many pixels can be displayed at once. The display produces the sharpest picture when used at its so-called native resolution. Other types of displays, such as CRTs, create pixels independently of the physical structure of their screens and do not have a native resolution. As a result, a CRT's image quality is generally the same across a range of resolutions.

Nits: A unit of measure for luminance (a monitor's brightness); equivalent to candelas per square meter (cd/m^2).

Phosphor: A substance that can produce red, green, or blue light when excited by an energy source, such as the electron beam in a CRT. Phosphors are arranged as either dots or stripes on the inside face of a CRT screen.

Pixel: In a CRT, phosphors grouped in RGB triads (one each of red, green, and blue) are called pixels. The hundreds of thousands to millions of pixels in a display create images.

Refresh rate: The frequency at which a CRT's electron guns redraw the image; measured in hertz (Hz). One hertz equals one cycle per second; a 70Hz refresh rate means that the entire screen is redrawn 70 times per second.

Resolution: For both CRTs and LCDs, the number of pixels in the whole image. For example, a resolution of 1,280x1,024 pixels means that 1,024 lines are drawn from the top to the bottom of the screen, and each of these lines is made up of 1,280 separate pixels.

Screen geometry: A description of how accurately lines and shapes are represented on the display. LCDs almost always have perfect geometry because the display information is mapped to specific physical pixels on the display. CRTs may have problems with screen geometry; larger screens and flat-faced models have particular difficulty controlling electron beams with precision. As a result, vertical lines may be noticeably curved at the edges of the display, and circles may appear oval or egg-shaped. The best CRT monitors include controls that let you adjust the screen geometry; still, it can be difficult to adjust it perfectly in all regions of the screen.

Shadow mask: A metal plate with holes in it that selectively blocks the beams from the electron guns in the back of a CRT.

Stripe pitch: Monitors using an aperture grille or a striped mask have phosphors arranged in vertical stripes. Stripe pitch is the distance from a stripe of a given color to the next stripe of the same color. A smaller stripe pitch means that the monitor can display higher-resolution images more accurately.

Stuck/dead pixel: A pixel on an LCD that is either permanently on (stuck) or permanently off (dead).

Subpixel: Full-color displays are made by combining red, green, and blue light in varying degrees to produce different shades of colors. In a display with a fixed pixel structure, such as LCDs or plasma panels, the red, green, and blue light comes from adjacent cells in the display's physical structure. The light from these three subpixels--one for each color--combine to create a single pixel.

There are also pixel structures that do not rely on three subpixels.

SVGA: Supersvideo graphics array; a display mode with a resolution of 800x600 pixels.

TFT: Thin-film transistor; refers to the switching devices placed in each liquid-crystal cell in an active-matrix LCD. TFT screens are brighter and more readable than passive-matrix LCDs, but they consume more power and are generally more expensive.

Trinitron: A type of CRT developed by Sony that differs from standard tube types in that it employs an aperture grille instead of the usual shadow mask.

SXGA: Superextended graphics array; a display mode with a resolution of 1,280x1,024 pixels.

UXGA: Ultraextended graphics array; a display mode with a resolution of 1,600x1,200 pixels.

VGA: Video graphics array; a display mode with a resolution of 640x480 pixels.

Viewable area: The diagonal length of a CRT's viewable screen.

XGA: Extended graphics array; a display mode with a resolution of 1,024x768 pixels.

+ CNET EDITORS' MONITOR PICKS



TOP 15-INCH LCDS

- ▶ IBM ThinkVision L150p
- ▶ Samsung SyncMaster 152N
- ▶ LG Flatron L1520B
- ▶ HP L1502

TOP 17- AND 18-INCH LCDS

- ▶ Samsung SyncMaster 173P
- ▶ Samsung SyncMaster 171P
- ▶ Sceptre X7SV-Naga
- ▶ UltraSharp 1703FP 17-inch flat-panel LCD
- ▶ NEC MultiSync 17-inch TFT-LCD flat panel

TOP 19- TO 21.3-INCH LCDS

- ▶ Eizo FlexScan L885
- ▶ Planar PX212M
- ▶ Dell 1901FP
- ▶ Dell UltraSharp 2001FP
- ▶ NEC AccuSync LCD9V

TOP 17- AND 19-INCH CRTS

- ▶ Samsung SyncMaster 957MB
- ▶ NEC MultiSync FP912SB
- ▶ Compaq fs7550
- ▶ ViewSonic G70f
- ▶ Samsung SyncMaster 950b
- ▶ BenQ Professional P992