4.3.6 Display Device Facts

Display devices use a variety of technologies to produce visual information. Because each technology has unique benefits and drawbacks, it is important to understand their differences. The following table describes the most common types of display devices and the technology they use.

Display Type	Description
LCD	LCDs (liquid-crystal displays) use liquid crystal technology to display visual information. LCDs are the most common type of display device and range in size from less than an inch to over 10 feet. Modern LCDs use LEDs (light-emitting diodes) to backlight the screen. ▪ Edge-Lit White LED (EL-WLED or WLED) displays use white LEDs along one edge (usually the top) of the LCD and a light diffuser to backlight the screen. EL-WLED LCDs are the least expensive, thinnest, and most widely used type of LCD. ▪ Full-array WLED displays have an array of white LEDs behind the screen. Full-array WLED LCDs are able to dim specific regions of the screen, resulting in a much higher contrast ratio than LCDs that use EL-WLED technology. ▪ RGB-LED displays have an array of special LEDs that are able to emit red, green, and blue light, resulting in superior color accuracy. RGB-LED displays are the most expensive type of backlighting technology. Older LCD monitors and some LCD HDTVs use cold cathode fluorescent lamps (CCFLs) for backlighting. CCFLs are able to produce better colors than EL-WLED and full-array WLED technologies, but consume a lot more energy and require an internal inverter. LCDs use one of the following panel technologies: ▪ TN (twisted nematic) panels are the most common technology used by LCDs. TN panels have very good response times (1–5 ms) and refresh rates (60–144 Hz), so are great for PC gaming. ▪ TN panels have imperfect color reproduction because only six bits per color can be displayed. They mimic true 24-bit color using dithering and other techniques. ▪ TN panels have poor viewing angles and contrast ratios. ▪ IPS (In-plane switching) panels have the best color reproduction quality and viewing angles among LCDs, making them well suited for graphic artists, designers, and photographers. ▪ IPS panels have relatively slow response times (5–16 ms) and refresh rates (60 Hz) and have a slight purple tint when viewed from a wide angle. ▪ High-end IPS LCDs are very expensive (over $1000). Because of how they draw frames, LCDs suffer from motion blur when fast movements occur on the display. While motion blur can be reduced with higher refresh rates and lower response times, it can't be eliminated entirely. LCD screens are used in the following devices: ▪ HDTVs ▪ Computer displays ▪ Tablets ▪ Smart phones ▪ Mobile devices ▪ Wearable technology Display devices that are called LED monitors or LED TVs are simply LCDs that use LED backlighting.
Plasma	Plasma displays use millions of small cells that contain electrically charged ionized gases. When electrical current is applied to a plasma cell, the gas within the cell forms a plasma and emits a photon of light. Each pixel in a plasma display is made up of a red, green, and blue cell. As with OLED monitors, plasma monitors don't require a backlight. Plasma displays have several advantages: ▪ Plasma displays usually display colors more accurately than LCD displays. ▪ Because no backlighting is used, plasma displays have high contrast and can produce true black (displays that use backlighting can only display very dark grey). ▪ Plasma displays have almost no motion blur due to the speed of the gas reaction and the way they draw frames. Because of this, most plasma displays do not specify response times. Plasma displays have several disadvantages: ▪ Plasma displays consume two to three times as much power as LCDs. ▪ They generate much more heat than other display types.

	▪ The gasses inside the cells are sensitive to air pressure fluctuations. ▪ Plasma displays also suffer from a problem known as image retention (IR). Static images that are displayed for a long time cause the phosphors to overheat, which creates a temporary shadow of the image that is visible even when the display is turned off. If the static image was displayed for too long, screen burn-in can occur, and the shadow image will be permanent. Plasma displays smaller than 32 inches are not sold because manufacturing them is not profitable.
OLED	OLED displays use a thin layer of an organic compound (called an OLED) that lights up in response to an electrical current. OLED displays are more efficient, offer a wider viewing angle, and provide faster response times (< 0.01 ms). However, they are costly to manufacture; OLEDs are the most expensive type of display device. In addition, the pixels in OLEDs (the organic compound) wears out faster than the pixels in LED or plasma displays. OLEDs can be used in any device that uses a flat-panel display. And because of their size, OLEDs can even be used in textiles (clothing and upholstery). Flexible materials can be used to create OLED screens, resulting in a bendable—sometimes even foldable—screen. These types of OLEDs are called FOLEDs (flexible OLEDs).

Projector	Projectors use a powerful light source (either an LED or laser diode) and a lens to project visual content onto a surface, which is typically a specialized screen. Visual output is achieved by controlling the flow of light.
	
	▪ LCD projectors use a small internal LCD screen to control light and create images. LCD projectors are inexpensive and can be very compact; some can fit inside a pocket.
	  ▪ At larger projection sizes, LCD projectors suffer from what is called the screen door effect. This is when each RGB pixel of the display is easily seen.
	  ▪ LCD projectors also suffer from motion blur due to the way liquid crystal technology functions.
	▪ DLP projectors use a spinning color wheel to create RGB color and a DMD (digital micromirror device) to control light. The DMD is a small chip that contains millions of tiny mirrors that can redirect light extremely fast. DLP projectors are capable of very high-resolution output at even large projection sizes.
	  ▪ DLP projectors are much more expensive than LCD projectors.
	  ▪ DLP projectors are not as compact as LCD projectors and also use more energy and generate more heat.
	
	Projectors are affected by environmental factors, such as physical obstructions, ambient light, and the surface being projected onto. As such, projectors are only practical in controlled environments.

Display devices that use glass panels (such as plasma displays, OLED displays, and some LCDs) can suffer from a problem known as glare, where the shiny screen reflects light and reduces visibility. This is mostly a problem for mobile devices that are used outdoors. To reduce this effect, you can use anti-glare filters, which are made of a special non-reflective surface.