# Lighting


Lighting is a significant consumer of energy in a school system. An average school uses about 17 percent of the electricity (9% of the total energy) it consumes to light buildings and outside areas. Most schools are lit mainly with fluorescent lights.

A fluorescent lamp is a glass tube, whose inner surface has a powdered, phosphor coating. The tube is filled with argon gas and a small amount of mercury vapor. At the ends of the tubes are electrodes that emit electrons when heated by an electric current. When electrons strike the mercury vapor, the mercury atoms emit rays of ultraviolet (UV) light. When these invisible UV rays strike the phosphor coating, the phosphor atoms emit visible light. The conversion of one type of light into another is called fluorescence. Fluorescent lights have ballasts that regulate the electricity through the gas inside the bulb. Ballasts are electromagnets that produce a large voltage between the ends of the bulbs so the electricity will flow between them. There are two types of ballasts, magnetic and electronic. Magnetic ballasts produce a frequency of 60 Hertz (Hz), which means the light is flickering on and off 60 times a second. Electronic ballasts produce a frequency of at least 20,000 Hz. Fluorescent lights with electronic ballasts are more energy efficient than those with magnetic ballasts. Electronic ballasts use up to 30 percent less energy than magnetic ballasts. Electronic ballasts operate at a very high frequency that eliminates flickering and noise. Some electronic ballasts even allow you to operate the fluorescent lamp on a dimmer switch, which usually is not recommended with most fluorescents.

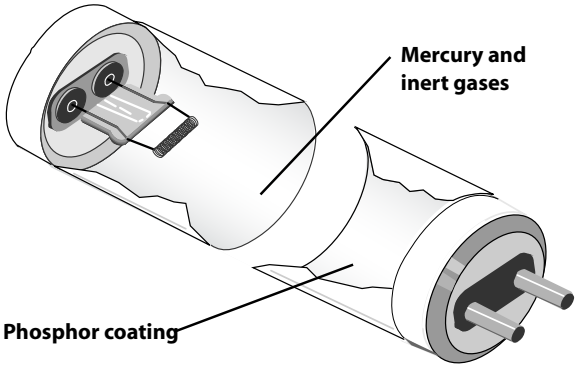
Although fluorescent tubes in ceiling fixtures are always more energy efficient than incandescents, there are new, even more efficient lamps that use better electrodes and coatings. They produce about the same amount of light with substantially lower wattage.

Most light fixtures in schools use four-foot long lamps, although three-foot lamps are common as well. Older fixtures often contain T12 lamps that are 1 1/2" in diameter and consume 34–40 watts. These lamps can be replaced with energy-saving T8 lamps that are 1" in diameter and typically consume 28–32 watts. Some newer systems are now using T5 lamps that are 5/8" in diameter and are even more efficient than the T8 lamps.

Incandescent lighting is sometimes used in schools. Only 10 percent of the energy consumed by an incandescent bulb produces light; the rest is given off as heat. Legislation under the Energy Independence and Security Act of 2007 restricted how much energy light bulbs use. Today, most general use incandescent bulbs have been replaced on store shelves by more efficient lighting options including halogen incandescent bulbs, compact fluorescent light bulbs (CFLs), and light emitting diode bulbs (LEDs).

Halogen light bulbs are sometimes referred to as energy-saving, incandescent bulbs. They work much the same way as a traditional incandescent, but the filament is encapsulated and surrounded by halogen gas, allowing it to last longer and be more efficient.

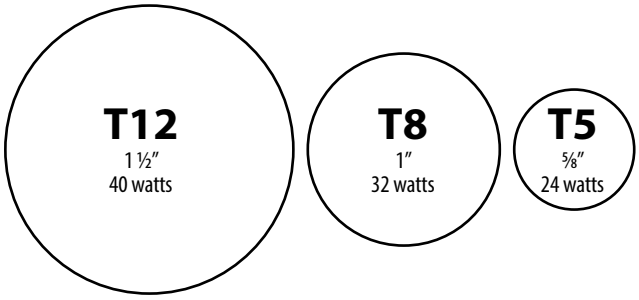
## Fluorescent Tube Lamp

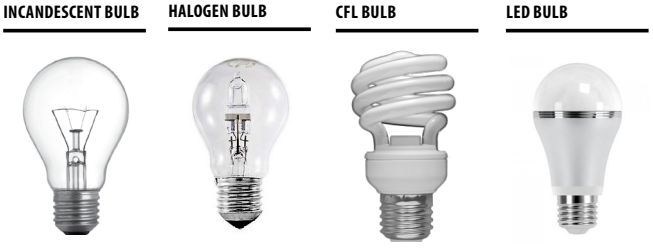



In fluorescent tubes, a very small amount of mercury mixes with inert gases to conduct the electric current. This allows the phosphor coating on the glass tube to emit light.

## Fluorescent Lighting Efficiency

A T12 bulb consumes up to 40 watts of energy to produce a given amount of light. T8 and T5 bulbs use less energy to produce the same amount of light.



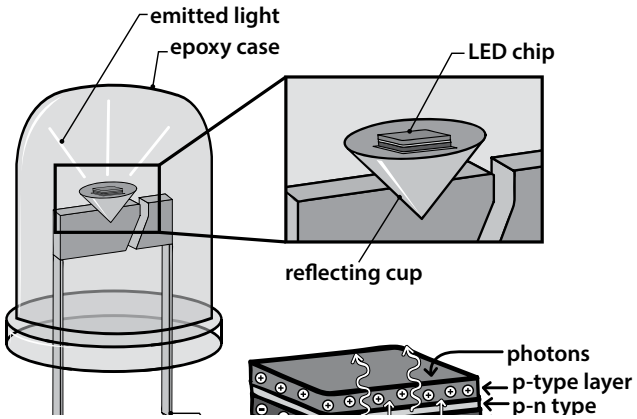

LEDs offer better light quality than incandescent bulbs and halogens, last 25 times as long, and use even less energy than CFLs. LEDs now have a wide array of uses because technology has improved and costs have decreased. CFL use has greatly decreased as LED prices have reached similiar prices as other bulbs.

Fluorescent lights produce very little heat and are much more energy efficient than either type of incandescent bulb. CFLs use the same technology as overhead fluorescent lights, but they are designed to fit into lamps and other fixtures where incandescents are commonly used. All CFL bulbs have electronic ballasts.

Light emitting diode bulbs are even more efficient than CFL bulbs, last about 25 times longer than incandescent bulbs, and more than two and a half times longer than CFLs. One LED bulb has several tiny LEDs inside of it. LEDs contain semiconductors like solar panels and other diodes, however the difference is in the way the electrical energy is used by the LED. Three layers within the LED – p-type, n-type, and a depletion zone – combine to produce light. Basically, a minimum voltage is needed to energize electrons and they move from the n-layer to the p-layer. When the electrons move back to the n-layer again, they emit light that we see. Read more about this process in the graphic "How Light Emitting Diodes Work" below.

Although CFLs and LEDs cost more to buy, they save money in the long run because they use 20-25 percent of the energy of incandescent bulbs and last several times longer. Each CFL or LED installed to replace an incandescent can save about $30-80 over the life of each bulb. Replacing incandescent bulbs with LED or CFL bulbs can also reduce carbon dioxide emissions by hundreds of pounds over the life of the bulb.

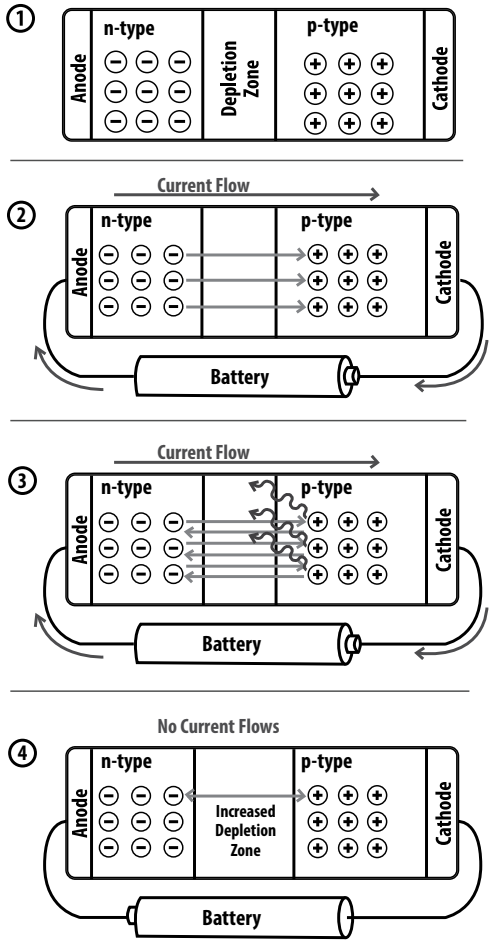
## Inside an LED




## How Light Emitting Diodes Work

1. Diodes are made of semiconductors and conducting materials that need to be added to the semiconductor. In an LED the most common conductor added is aluminum-gallium-arsenide (AlGaAs). The AlGaAs is "doped" by adding small amounts of another material. One material will have more valence electrons than AlGaAs, and another doping material will have fewer electrons. The two doped materials are put together in a crystal. The material with more electrons is the "n-type" (n for negative) and the material with fewer electrons is the "p-type" (p for positive). When these materials are sandwiched together, the electrons move to balance themselves out. The area between the materials, called the p-n junction, is also called the "depletion zone."
2. Connecting a power source to the diode, such as a battery, provides electric current that carries electrical energy. The electrons in the n-type are repelled by the electric current, and move through the depletion zone to the p-type. They are energized, and will want to return to their original, unenergized state in the n-type.
3. When the electrons move back through the depletion zone to the n-type, they release energy as light. This is the light that we see from the LED. This process continues over and over again–electrons absorbing energy, moving, then moving back and releasing the energy, until the power supply is disconnected or depleted.
4. Connecting the power supply in the wrong orientation does not allow the LED to work. Instead, it merely increases the size of the depletion zone. Therefore, it is important that LED's be wired to their power supply in the correct orientation.

## How Light Emitting Diodes Work



## Lighting Controls

Lighting controls are devices that turn lights on and off or dim them. The simplest type is a standard snap switch. Other controls include photocells, timers, occupancy sensors, and dimmers. Snap switches, located in many convenient areas, make it easier for people in large, shared spaces to turn off lights in unused areas. Photocells turn lights on and off in response to natural light levels. Photocells switch outdoor lights on at dusk and off at dawn, for example. Advanced designs gradually raise and lower fluorescent light levels with changing daylight levels.

Mechanical or electronic time clocks automatically turn indoor or outdoor lights on and off for security, safety, and tasks such as janitorial work. An occupancy sensor activates lights when a person is in the area and then turn off the lights after the person has left.

Dimmers reduce the wattage and output of incandescent and fluorescent lamps. Dimmers also significantly increase the service life of incandescent lamps; however, dimming incandescent lamps reduces their light output more than their wattage, making them less efficient as they are dimmed. Dimmers for fluorescents require special dimming ballasts, but do not reduce the efficiency of the lamps.

Even the best lighting system is not efficient if people do not use it wisely. In most schools, more light is used than needed and lights are often left on when no one is present. All lights that are not necessary for safety should be turned off when rooms are not in use. The same is true for outside lights. Using sunlight is a good idea whenever possible. Studies have shown that students learn better in natural light than in artificial light.

Indoor lighting sensor

Outdoor light with photocell