Light sources

Daylight

Electric light

- Daylight source

direct sunlight or diffuse skylight)

Indirect light reflected or modified from its primary

- Artificial light source

incandescent lamps (including tungsten-halogen types);

Gaseous discharge lamps (including fluorescent, mercury vapor, metal-halide, high-pressure and low-pressure sodium lamps, and the induction lamp)

Efficacy for daylight and artificial lighting

TABLE 12.1 Efficacy of Various Light Sources

Source	Efficacy (lm/W)
Candle	0.1
Oil lamp	0.3
Original Edison lamp	1.4
1910 Edison lamp	4.5
Incandescent lamp (15–500 W)	8–22
Tungsten-halogen lamp (50–1500 W)	18–22
Fluorescent lamp (15–215 W)[a]	35–80
Compact fluorescent lamp[b]	55–75
Mercury-vapor lamp (40–1000 W)[a]	32–63
Metal-halide lamp (70–1500 W)[a]	80–125
High-pressure sodium lamp (35–100 W)[a]	55–115
Induction lamp[c]	48–70
Sulfur lamp[c]	90–100
Direct sun (low altitude = 7.5°)	90
Direct sun (high altitude > 25°)	117
Direct sun (mean altitude)	100
Sky (clear)	150
Sky (average)	125
Global (average)	115
Maximum source efficacy predicted by the year 2010	150
Maximum theoretical limit of source efficacy	250 (approximate)

The efficiency of a standard incandescent lamp in converting electrical energy to light is approximately 7%; the other 93% is released as heat. Fluorescent lamps are approximately 22% efficient

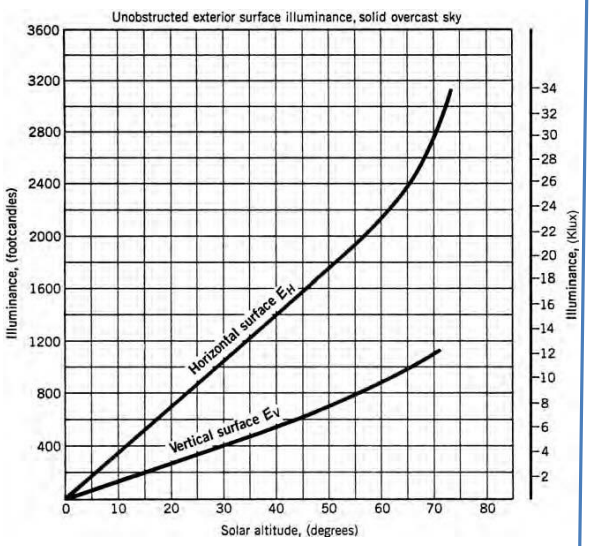
Efficacy measured in lumens per watt (lm/W). Efficacy is the ratio of lumens provided to watts of heat produced by a light source.

Daylight source

(1) solar position, which can be determined if the latitude, date, and time of day are given,
(2) weather conditions (e.g., cloud cover, smog),
(3) effects of local terrain (natural and built obstructions and reflections)

basic sky conditions.
1. Solid overcast sky
2. Clear sky without sun (in the field of view)
3. Clear sky with sun
4. Partly cloudy sky

STANDARD OVERCAST SKY



$$L_A = L_Z \frac{1+2\sin A}{3} \qquad (12.1)$$

where

L_A = luminance at $A°$ above the horizon (in any direction)

L_Z = luminance at the zenith

Thus at the horizon, where $A = 0°$,

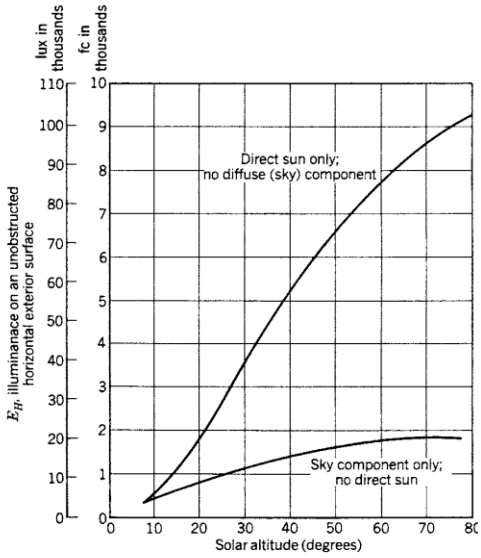
$$L_A = \frac{L_Z}{3}$$

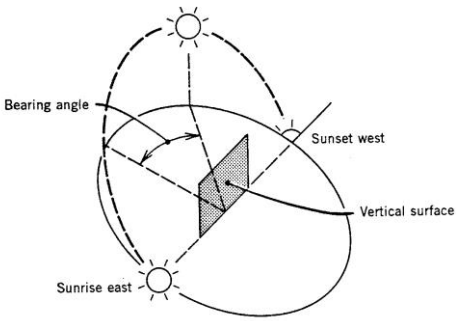
$$E_H = 300 + 21{,}000 \sin A \qquad (12.2)$$

Latitude: 38°
Solar Time: 10:00 A.M.
Dates: Dec. 21, March/Sept. 21, June 21

	Eq. 12.2	Fig. 12.3
Dec 21	8,500 lux (790 fc)	8,608 lux (800 fc)
Mar/Sept 21	14,623 lux (1,359 fc)	15,923 lux (1,480 fc)
June 21	18,669 lux (1,735 fc)	23,134 lux (2,150 fc)

CLEAR SKY





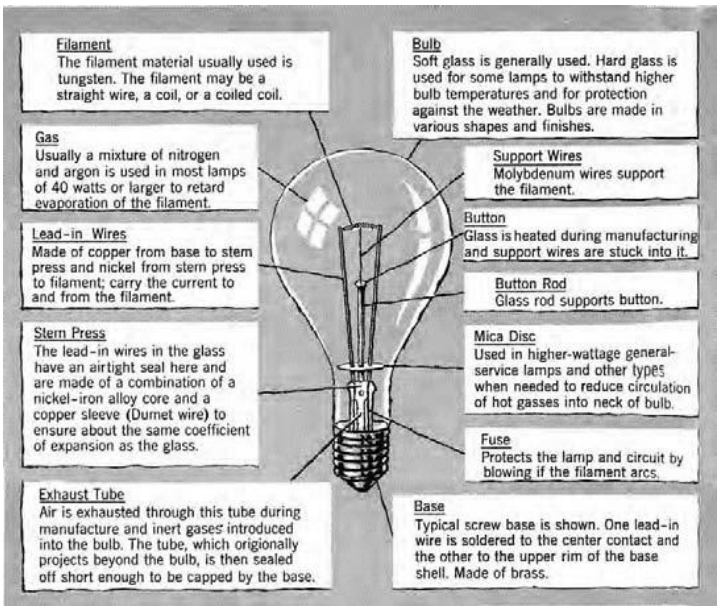
partly cloudy sky

- The luminance of a partly cloudy sky cannot be expressed mathematically because of its infinite variability of conditions.

Artificial light source

1. Incandescent Lamps

Current passing through the high-resistance filament heats it to incandescence, producing light



- Critically dependent upon the supplied voltage, the life, output, and efficiency of a lamp can be markedly altered by even a small change in operating voltage
- *Lumen maintenance. Light output decreases* slowly with lamp life as an incandescent bulb blackens
- *Color. Incandescent light has a large yellow red* component
- Generally, incandescent lamps are impervious to surrounding heat, cold, or humidity
- Incandescent lamps produce light as a by-product of heat; as a result, they are inherently inefficient. Luminous efficacy increases with wattage. Thus, a 60-W general-service lamp produce 890 initial lumens, or 14.8 lm/W,

TABLE 12.2 Comparison of Operating Characteristics

Operation of Lamps	120-V lamp at 125 V (104.2%)	120-V lamp at 115 V (95.8%)
Amount of light (lumens)	16% more	15% less
Power consumption (watts)	7% more	7% less
Efficacy (lumens per watt)	8% higher	8% lower
Life (hours)	42% less	72% more

Incandescent lamp use should be limited to the following applications

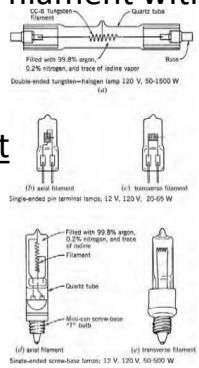
1. Where use is infrequent
2. Where there is frequent short-duration use
3. Where low-cost dimming is required
4. Where the point source characteristic of the lamp is important, as in focusing fixtures
5. Where minimum initial cost is essential
6. Where its characteristically good color rendering is desired

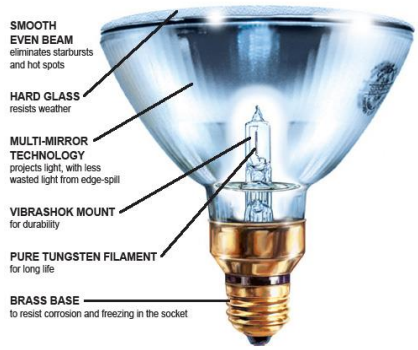
TUNGSTEN-HALOGEN

- is similar to the standard incandescent lamp in that it produces light by heating a filament.
- It differs in that a small amount of halogen gas (iodine or bromine) is added to the inert gas mixture that fills a small capsule constructed of quartz glass that surrounds the filament within the bulb of the lamp

Longer life

Slightly more efficient





2. Gaseous Discharge Lamps

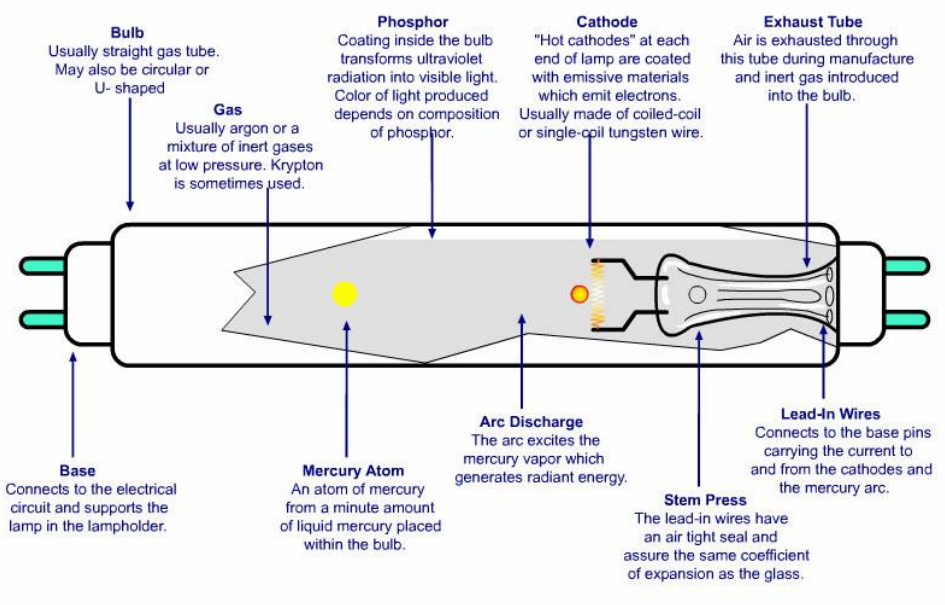
Lamps in this category include fluorescent and high-intensity discharge (HID) lamps (mercury vapor, metal-halide, high-pressure sodium lamp)

They function by producing an ionized gas in a glass tube or container rather than heating a filament.

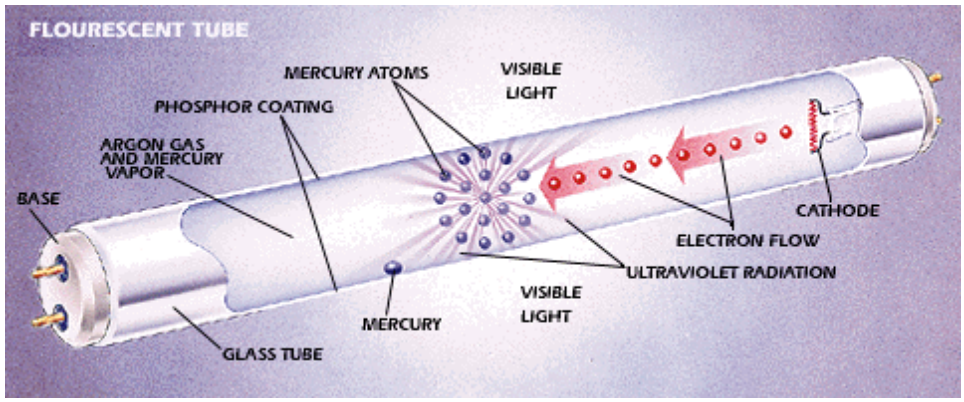
Discharge lamps are known for their

- long life and
- high efficacy.

Fluorescent Lamp components



How it work??



BALLASTS

Is to trigger the lamp with a high ignition voltage and to control the amount of electric current for proper operation.

The function of a ballast is threefold:

1. To supply controlled voltage to heat the lamp filaments in preheat and rapid-start circuits
2. To supply sufficient voltage to start the lamp by striking an arc through the tube
3. To limit the lamp current once the lamp is started

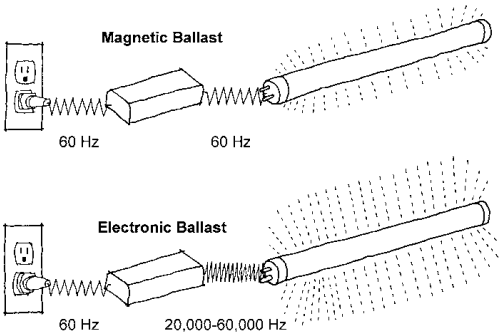
Ballast Types

- ***Magnetic***
- ***Hybrid.***
- ***Electronic.***

Lamp efficacy increases by approximately 10% to 15% compared to operation at 60 Hz.

Electronic ballasts (20 to 60 kHz)are lighter, more energy-efficient, generate less heat, and are virtually silent.

They are also available as dimming ballasts, which allow light output to be controlled between 1% and 100%.



Ballast Performance

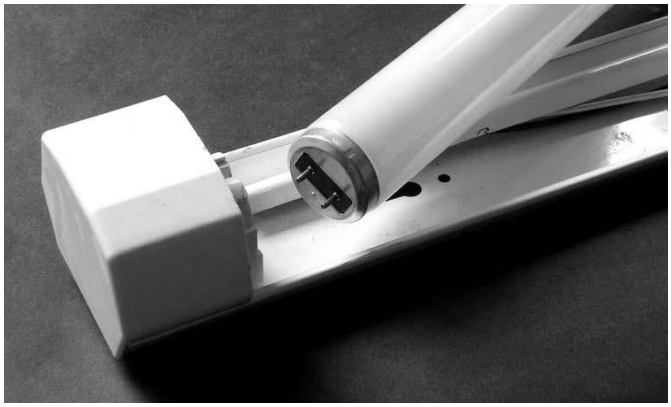
- Heat
- Noise
- Flicker
- Dimming Control

Preheat lamp

preheat technology that heats the gas in order to start the lamp and use a mechanism called a *starter*

Rapid start lamp

This design functions similarly to the traditional preheat lamp, but without a starter switch



Instant start lamp

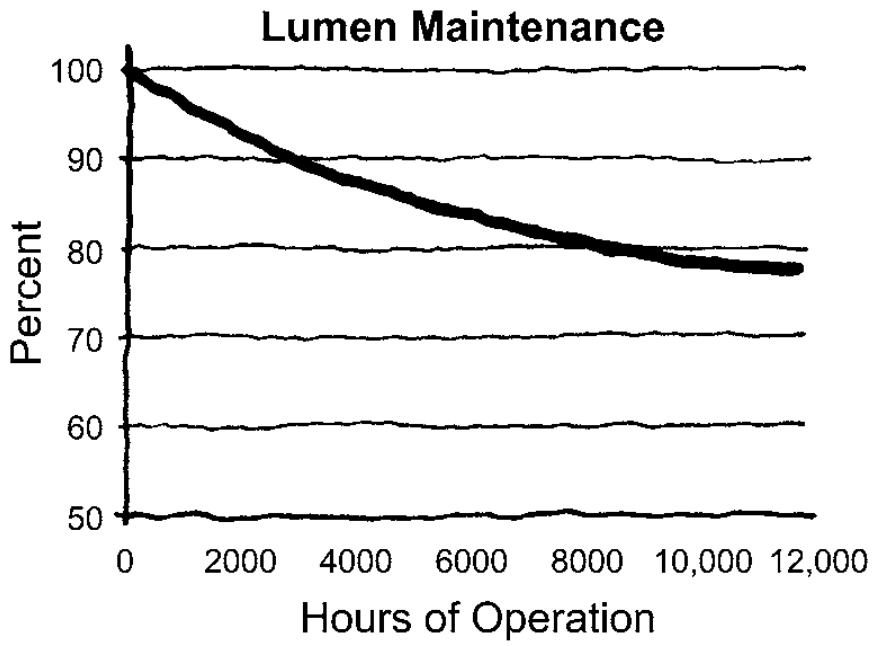
Instant-start fluorescent lamps use a high-voltage transformer to apply a very high initial voltage to the cathodes. An excess of electrons on the cathode surface forces some electrons into the fill gas, which ionizes the gas. This creates an instant voltage difference between the cathodes, establishing an electric arc.

FLUORESCENT LAMP TYPES

TABLE 12.5 Comparative Characteristics of Tubular Fluorescent Lamps[a]

	T12	T8	T5	T5HO
Initial rated light output	3350 lumens	2950 lumens	2900 lumens	5000 lumens
Nominal lamp watts	40W	32 W	28W	54W
Initial lamp efficacy[1]	84 lm/W	92 lm/W	104 lm/W	93 lm/W
Initial system efficacy[2]	88 lm/W	90 lm/W	89 lm/W	85 lm/W
Lumen maintenance[1]	78%	93%	97%	95%
Maintained system efficacy	69 lm/W	84 lm/W	86 lm/W	81 lm/W
Rated life[3]	20,000 hr	20,000 hr	16,000 hr	16,000 hr
CRI	80	85	85	85
Optimum operating temperature	77°F [25°C]	77°F [25°C]	95°F [35°C]	95°F [35°C]

- Efficacy—light output per unit of power input
- Lumen maintenance—the decreasing output of light as a lamp ages
- Lamp life—average (statistically defined) lamp life expectancy
- Temperature and humidity—how a lamp responds to extreme environmental operating conditions.
- Dimming—output reduction of a fluorescent lamp



SPECIAL FLUORESCENT LAMPS

- **Low-Energy Lamps**
- **UV Lamps**
- **COMPACT FLUORESCENT LAMPS**

TABLE 12.7 Cost Comparison for Operation of an Incandescent Lamp and a Compact Fluorescent Lamp

	Incandescent 100 W 1750 lumens	Compact Fluorescent 27 W 1750 lumens
Lamp cost ($)	$0.50	$20.00
Rated life (hours)	750	10,000
Efficacy (lumens per watt)	17	64
Energy cost (@8¢/kWh for 10,000 hrs)	$80	$22
Total cost (lamps + energy)	$85	$42

HIGH-INTENSITY DISCHARGE LAMPS

produce light by discharging electricity through a high-pressure vapor

- Lamps in this category include

mercury-vapor, metal-halide, and high-pressure sodium

- These lamps are characterized by high efficacy, rapid warm-up time, rapid restrike time, and historically poor color rendering capabilities
- HID lamps are typically used when high illuminance is required over large areas and when energy efficiency and/or long life are desired. Typical applications include gymnasiums, large public areas, warehouses, outdoor activity areas, roadways, parking lots, and pathways.